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 - V SECTORAL REPORT (2/3)

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

GE
JR
13-202

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 - V SECTORAL REPORT (2/3)

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

FINAL REPORT

List of Reports

EXCHANGE RATE

US$1.00 = KSh 85.24 = ¥79.98

as of November 1, 2012

Sectoral Report (E)
Agriculture and Irrigation

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

FINAL REPORT
VOLUME – V SECTORAL REPORT (2/3)

E: AGRICULTURE AND IRRIGATION

Abbreviation

Table of Contents

Page

List of Tables

Page

List of Figures

Page

List of Abbreviations and Acronyms

ACA	:	Athi Catchment Area
ADB	:	Asian Development Bank
AfDB	:	African Development Bank
AIA	:	Actual Irrigated Area
ASAL	:	Arid and Semi-arid Land
BADEA	:	Arab Bank for African Economic Development
BHN	:	Basic Human Need
CA	:	Catchment Area
CBO	:	Community Based Organization
CDA	:	Coast Development Authority
CI	:	Cropping Intensity
CRI		Climate Region Index
D/D	:	Detailed Design
DIO	:	District Irrigation Office
EC	:	European Commission
ECE	:	Economic Commission for Europe
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EMCA	:	Environmental Management and Coordination Act
ENN	:	Ewaso Ng'iro North
ENNCA	:	Ewaso Ng'iro North Catchment Area
ENNDA	:	Ewaso Ng'iro North Development Authority
ENSDA	:	Ewaso Ng'iro South Development Authority
ET		Evapotranspiration
ETcrop		Crop Evapotranspiration
EU	:	European Union
F/S	:	Feasibility Study
FAO	:	Food and Agriculture Organization
FY	:	Financial Year
GDP	:	Gross Domestic Product
GOJ	:	Government of Japan
GOK	:	Government of Kenya
GW	:	Groundwater
HQ	:	Headquarters
IDA	:	International Development Association
IDD	:	Irrigation and Drainage Department
IDMP	:	Irrigation and Drainage Master Plan
IFAD	:	International Fund for Agricultural Development
IRR	:	Internal Rate of Return
IWRM	:	Integrated Water Resources Management
IWUA	:	Irrigation Water Users Association
JBIC	:	Japan Bank for International Cooperation
JICA	:	Japan International Cooperation Agency
KfW	:	German Development Bank
KIDDP	:	Kenya Italian Debt Swap for Development

KVDA	:	Kerio Valley Development Authority
LBDA	:	Lake Basin Development Authority
LVB	:	Lake Victoria Basin
LVN	:	Lake Victoria North
LVNCA	:	Lake Victoria North Catchment Area
LVS	:	Lake Victoria South
LVSCA	:	Lake Victoria South Catchment Area
M/P	:	Master Plan
MDG	:	Millennium Development Goals
MOA	:	Ministry of Agriculture
MOFD	:	Ministry of Fisheries Development
MOFW	:	Ministry of Forestry and Wildlife
MOL	:	Ministry of Lands
MOLD	:	Ministry of Livestock Development
MOLG	:	Ministry of Local Government
MOPW	:	Ministry of Public Works
MORDA	:	Ministry of Regional Development Authorities
MWI	:	Ministry of Water and Irrigation
NGO	:	Non-Governmental Organization
NIB	:	National Irrigation Board
NWMP (1992)	:	National Water Master Plan in 1992
NWMP 2030	:	National Water Master Plan 2030
O&M	:	Operation and Maintenance
PS	:	Permanent Secretary
RAP	:	Resettlement Action Plan
RDA	:	Regional Development Authority
RV	:	Rift Valley
RVCA	:	Rift Valley Catchment Area
SB		Sub-basin
SW	:	Surface Water
TARDA	:	Tana and Athi River Development Authority
TCA	:	Tana Catchment Area
UN	:	United Nations
USAID	:	United States Agency for International Development
WB	:	World Bank
WRMA	:	Water Resources Management Authority
WUA	:	Water 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

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

Weight

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

Time

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

Money

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

Energy

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

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

1.1 Objectives of the Agriculture and Irrigation Study

The National Water Master Plan 2030 (NWMP 2030) aims to update the previous master plan, the National Water Master Plan executed by JICA in 1992 (NWMP (1992)), based on the latest information and data, and to formulate development plans with a focus on realization of the national development target set in the Kenyan Vision 2030. The objective of the agriculture and irrigation study as a part of the NWMP 2030 is to evaluate the irrigation development potential by catchment area, to formulate irrigation development plans toward 2030, and to propose an implementation program.

1.2 Approach to the Study

The promotion of irrigation development is one of the key agricultural policies of Kenya aiming to increase production of food crops and horticultural crops, thus to strengthen the national economy and peoples' welfare. Kenya has ample land resources but water resources for irrigation are quite limited except for LVNCA and LVSCA.

Reflecting the limitation of water resources available for irrigation, the general approach for the study on agriculture and irrigation toward the NWMP 2030 has been set as follows:

- To maximise irrigation areas in each catchment considering the development target set in the Kenya Vision 2030, i.e. new irrigation development of 1.2 million ha toward 2030;
- To improve water productivity by introducing/promoting water saving irrigation methods so as to expand irrigation areas under the limitation of available water resources; and
- To improve water management through strengthening the O&M of irrigation systems with a cooperation of government agencies and active water users associations by farmers.

The study flow of formulation of the irrigation development plan is shown in Figure 1.2.1.

The main outputs of this study will be (a) a future irrigation development area for each catchment area to contribute to agricultural production increases, (b) future irrigation water demands, (c) proposed irrigation development plans with priority, and (d) implementation program of the proposed irrigation projects.

1.3 Review of the Previous Water Master Plan: NWMP (1992)

1.3.1 Proposed Development Plan

In the previous water master plan (NWMP (1992)), the target year for irrigation development was set for 2010. To evaluate the irrigation potential in Kenya, suitable area for major crops were evaluated by district based on land classification criteria for crop production shown in Table 1.3.1. The results of suitable area classification by crop and by county are shown in Table 1.3.2.

A development strategy was proposed taking into account the government policy and social and economic conditions of the country as below.

- Small scale irrigation schemes (less than 500 ha) would be given top priority for implementation;
- Irrigation area adjoining densely populated district or location would be given higher priority; and
- Those areas where irrigation is indispensable for farming would be given higher priority.

Under the above strategy, small scale irrigation projects and some selected large scale irrigation projects were recommended to be implemented as follow:

- Small scale project: About 140 small scale projects with irrigation area of 7,000 ha in total (50 ha per project on average)
- Large scale project: 18 large scale projects (more than 500 ha) with an irrigation area of 111,300 ha in total, which were selected from 160 schemes proposed by various agencies for further development plan.
- Private scheme: Proposed extension of private schemes was inferred to be 13,700 ha.

The total proposed irrigation area in 2010 was estimated at 197,000 ha as tabulated below.

Irrigation Area in 1990 and 2010 Estimated by NWMP (1992)

Sector	Existing in 1990	Proposed by 2010	Total in 2010	Increase
Large scale Scheme (Public)	12,000 ha	111,300 ha	123,300 ha	1028%
Small scale Scheme (Smallholder)	27,200 ha	7,000 ha	34,200 ha	126%
Private Scheme	25,800 ha	13,700 ha	39,500 ha	153%
Total	65,000 ha	132,000 ha	197,000 ha	303%

Source: NWMP (1992)

For the selected 18 large scale irrigation projects, priority order for implementation was assessed through the aspects of (a) water availability, (b) project preparation level, (c) impact to the people (population), (d) environmental impacts, and (e) economic viability (EIRR). As a result, the following ranking was presented in the NWMP (1992).

Priority Ranking of Large Scale Projects Proposed by NWMP (1992)

Priority Ranking	Name of Project	County	Catchment Area	Irrigation Area (ha)
1	Kano Plain	Nyamira/Kericho	LVS	25,640
2	Bunyala Extension	Siaya	LVN	10,480
3	Mwea Extension	Kiriyaga	Tana	2,900
4	Kunati	Meru	Tana	1,050
5	Lower Kuja	Migori	LVS	1,900
6	Lower Rupingazi	Embu	Tana	1,800
7	Kanzal	Machakos	Athi	4,055
7	Kimira	Homa Bay	LVS	2,000
7	Tana Delta	Tana river	Tana	12,000
10	Yala Swamp	Siaya	LVN	7,540
11	Arror	Elgeyo Marakwet	RV	1,340
11	Sabaki Extension	Kirifi	Athi	3,000
13	Thanantu	Meru	Tana	2,520
14	Kibwezi Extension	Makueni	Athi	13,200
14	Upper Nzoia	Bungoma	LVN	7,550
16	Turkwel	West Pokot	RV	600
17	Taita Taveta	Taita Taveta	Athi	3,780
18	Lower Ewaso Ng'iro	Kajiado	RV	10,000

Source: NWMP (1992)

The total construction cost of the proposed large and small scale projects under the GOK was estimated at KSh 25,900 million or KSh 218,935/ha (equiv. US$ 8,688/ha, @ US$ 1.0 = KSh 25.2) for 20 years from 1992 to 2010. An alternative development plan was studied based on fund availability. In the case that only 25% of the total fund would be available, it was expected that only three items from proposed schemes would be realised, namely small scale irrigation, Tana Delta and Mwea Extension.

The locations of the existing and proposed irrigation schemes in the NWMP (1992) are illustrated in Figures 1.3.1 to 1.3.4. As seen in the figures, the irrigation schemes are located along the major rivers, shore of Lake Victoria, and the foots of Mt. Kenya and Mt. Kilimanjaro where plentiful spring water is available.

1.3.2 Achievement of Proposed Plans by 2010

(1) Irrigation Area in 2010

At the time of the NWMP (1992), the existing irrigation area was estimated at 65,000 ha in total, consisting of public schemes of 12,000 ha, smallholder schemes of 27,200 ha, and private/commercial schemes of 25,800 ha. Projection of irrigation area for the target year of 2010 in the NWMP (1992) was 197,000 ha in total, consisting of public schemes of 123,300 ha, smallholder schemes of 34,200 ha, and private/commercial schemes of 39,500 ha.

The estimated irrigation area in 2010 is quite different by source ranging between 110,000 ha and 183,900 ha. The following table shows a comparison of irrigation area in 2010 among different source together with a projection by NWMP and the present study (NWMP 2030).

Estimation of Existing Irrigation Area by Various Sources

(Unit: ha)

Scheme	NWMP (1992)		Aquastat	Vision 2030 (2008-12)	I&D Master Plan	National I&D Policy	Water Sector Review 2010	NWMP 2030
	1990	2010	2003	2007	2009	2009	2011	2010
	JICA		FAO	GOK	MWI	MWI	MWI	MWI/JICA
Public	12,000	123,300			18,900	18,200		14,160
Smallholder	27,200	34,200			86,500	47,000		51,900
Private	25,800	39,500			78,500	45,000		75,840
Total	65,000	197,000	103,203	140,000	183,900	110,200	129,127	141,900

Note: I&D: Irrigation and Drainage
Source: JICA Study Team, based on data from different sources

According to the "Annual Water Sector Review Report 2010" by MWI in February 2011, the existing irrigation area at the end of December 2010 was estimated at 129,127 ha in total. On the other hand, Vision 2030 used the figure of 140,000 ha in 2007, which is very close to the inventory survey result of 141,900 ha at the end of 2010 in this study.

Comparing the inventories between 1990 and 2010 compiled by this study, the total irrigation area has been increased by 76,900 ha or 2.2 times that of 1990, but not reaching the area of 197,000 ha as was expected by the NWMP (1992). However, increment of the irrigation area of the public schemes has been slow at only 2,160 ha for about 20 years. While development of smallholders' schemes and private sector realised remarkable achievement at 24,700 ha (1.9 times) and 50,040 ha (2.9 times) respectively.

The poor performance of the public irrigation sector might have been caused for several reasons, such as a very limited budget allocation of the GOK and the development partners (donors), and rather higher cost requirement.

(2) Achievement of Public Irrigation Schemes Proposed in NWMP (1992)

The NWMP (1992) proposed 18 public irrigation schemes with total extent of 111,300 ha and their relative priority ranking. After about 20 years, however, no substantial development was achieved as shown below, due mainly to inadequate or delayed fund arrangement by the government, though the government has acknowledged the necessity of irrigation development for providing stable food supply for the rapidly increasing population.

Performance of 18 Public Schemes Proposed by NWMP (1992)

NWMP (1992)			Dev. by	Status as of 2011
Rank*	Name of scheme	Area (ha)	2010 (ha)	
1	Kano Plain	25,640	0	Waiting for construction of Magwagwa dam
2	Bunyala Extension	10,480	0	Phase I of 3,500 ha will be implemented with World Bank loan
3	Mwea Extension	2,900	0	Construction will start in 2011 with JICA loan for 8,910 ha.
4	Kunati	1,050	0	F/S is expected to be done in 2011.
5	Lower Kuja	1,900	0	Design was completed in 2010.
6	Lower Rupingazi	1,800	0	No development preparation yet.
7	Kanzalu	4,055	0	No development preparation yet.
8	Kimira	2,000	0	Under construction by using AfDB loan fund
9	Tana Delta	12,000	2,000	Development of 2,000 ha was completed in 2002.
10	Yala Swamp	7,540	170	A pilot scheme (170 ha) was developed in 2002.
11	Arror	1,340	0	F/S and D/D are being prepared under Arror multipurpose project
12	Sabaki Extension	3,000	0	No development preparation yet.
13	Thanantu	2,520	0	No development preparation yet.
14	Kibwezi Extension	13,200	0	Seeking fund for D/D. Under Munyu multipurpose dam project.
15	Upper Nzoia	7,550	0	No development preparation yet.
16	Turkwel	600	0	No development preparation yet.
17	Taita Taveta	3,780	0	No development preparation yet.
18	Lower Ewaso Ng'iro	10,000	0	F/S and D/D will start in 2011.
Total		111,355	2,170	

Note: * Priority ranked in NWMP (1992)
Source: JICA Study Team based on NWMP (1992)

Although some schemes, such as the Mwea Irrigation Extension Project and Extension, will start the implementation soon, achievement of large scale irrigation schemes for last 20 years is about 2,200 ha only or 1.9% of the planned development of 111,300 ha.

1.3.3 Lessons Learnt and Remarks for NWMP 2030

(1) Smallholder Schemes

Owing to the efforts of the Irrigation and Drainage Department (IDD) of MWI with financial supports of development partners, the irrigation area has gradually increased at an average rate of 1,200 ha per year. New irrigation areas have been developed for 10-100 ha scale projects at locations near water source, since there is difficulty securing land for headrace canals. Farmers have strong intensions to increase their production with irrigation water. Strong assistance for construction of irrigation systems and proper guidance for the O&M of the completed systems are urgently required to realise the target set by the Kenya Vision 2030. Suitable budget allocation as well as the strengthening the organization and staffing of IDD by the government is desired.

(2) Private Sector

The irrigation area has been extended in parallel with the development of export oriented farming. In addition to the traditional irrigation farming for cash crops such as coffee, rice and pineapples, irrigated agriculture for horticultural crops such as cut flowers and beans for export to Europe has increased remarkably. It could be considered that the private sector would have a strong incentive to increase their production if more irrigation water were available, since the export markets are large and its demand is huge especially during the winter season (October to February) in Europe. If irrigation systems are not available, many casual workers suffer layoffs from the private farms in the dry season. From the viewpoints of job creation and maintaining the stable job opportunities in the rural area, the provision of irrigation water is crucial. Some suitable assistance by the government to the private sector to provide a stable irrigation water supply would be needed for earning the foreign exchange, and creating job opportunities in rural areas.

(3) Public Sector

Many challenges are found in the construction of new schemes, O&M, participation of farmers, and irrigation farming. The following is the main lessons that were learnt in the construction of the NIB's schemes:

a) Inadequate Funding for Irrigation Expansion

Although the irrigation sector is expected to play a critical role in stable agricultural development through providing irrigation infrastructure, the government budget has been inadequately allocated.

b) Insufficient Funding for Operation and Maintenance

Due to no revision of the O&M charge for the beneficiaries since 2002, the O&M cost has a large deficit due and increase in fuel cost, machinery and spare parts. Farmers are not willing to pay more for the O&M unless NIB clearly shows what it has done with the money that has been collected.

c) No Fund for Rehabilitation Work

NIB does not have sufficient fund for rehabilitation works, particularly roads. While the government has been funding for replacement of pumps in all the pump-fed public irrigation schemes, it will be difficult to finance the replacement of pumps within several years.

d) Weak Farmer-based Institutions

The Water Users Associations (WUAs) are expected to increasingly play a big role in the O&M of public irrigation systems and activities, but the involvement of the WUAs is still low. Formation and strengthening of the WUAs are the most important issues.

e) Low Cropping Intensities

Rice schemes in the public sector have been growing one crop per year (cropping intensity of 100% or less). This is opposed to some smallholders' schemes which manage to plant 2-3 horticultural crops per year. The non-achievement of higher cropping intensity may be attributed to insufficient water and mismanagement of water distribution.

CHAPTER 2 CURRENT SITUATION OF AGRICULTURE AND IRRIGATION

2.1 Relevant Policies and Strategies

2.1.1 Current Situation

After the issue of the Kenya Vision 2030 in 2007, a great many policies and strategies on the agriculture and irrigation sectors have been issued to indicate the direction of development and the strengthening the sectors. Furthermore, a master plan study "Irrigation and Drainage Master Plan" was prepared with detailed data/information by the Ministry of Water and Irrigation in June 2009. Owing to the government policy to accelerate irrigation development, budget allocation has increased remarkably since 2008. The implementation of feasibility studies, detailed design works and construction works for irrigation systems including rehabilitation and expansion of existing schemes, and new irrigation development have been accelerated. To understand the background of such changing situation in these sectors, key government policies and strategies on the agriculture and irrigation sectors are addressed hereunder.

2.1.2 National Development Policy

The Kenya Vision 2030 has identified agriculture as one of the key sectors to deliver the annual economic growth rate of 10% envisaged under the economic pillar. To achieve this growth, transforming smallholder agriculture from subsistence to an innovative, commercially oriented and modern agricultural sector is critical. This transformation will be accomplished through:

- Transforming key institutions in agriculture, livestock, forestry and wildlife to promote agricultural growth;
- Increasing productivity of crops, livestock and tree cover;
- Introducing land-use policies for better use of high- and medium-potential lands;
- Developing more irrigable areas in arid and semi-arid lands for both crops and livestock;
- Improving market access for smallholders through better supply chain management; and
- Adding value to farm, livestock and forestry products before they reach local, regional and international markets.

The Vision 2030 has identified four major challenges that continue to face the agricultural sector.

a) Productivity: Productivity levels for many crops are below potential and for some agricultural produce yield and value over a 5-year period have either remained constant or are on the decline. Similarly, the production level for most fish and livestock products is below potential. Forest cover and tree productivity have been on the decline while population growth has led to increased human–wildlife conflict.

b) Land use: Land in the high- and medium-potential areas as well as in arid and semi-arid lands (ASALs) remains under-exploited for agricultural production. Much of the available cropland remains under-used with smallholders using only 60% of their land for agricultural production.

c) Markets: The productivity of the agricultural sector is constrained by inefficiencies in the supply chain resulting from limited storage capacity, lack of post-harvest services and poor access to input markets. The Kenya Vision 2030 calls for proactive efforts to maintain existing markets and create new ones to increase Kenya's bargaining power in global agricultural markets.

d) Value addition: In agriculture, value addition determines the competitiveness of the country's produce in world markets. However, Kenyan farmers export semi-processed, low-value produce, which accounts for 91% of total agriculture-related exports. The limited ability to add value to agricultural produce coupled with high production costs make exports less competitive.

The Vision 2030 targets to raise incomes in agriculture, livestock and fisheries even as industrial production and the service sector expand. For realizing the target, the Vision 2030 intends to develop new cultivation land of up to 1.2 million ha particularly, and utilization of one million ha of currently uncultivated land. Specific strategies will include preparation of new land for cultivation by strategically developing more irrigable areas in arid and semi-arid lands for both crops and livestock. The Vision 2030 set the goal of increasing the land under irrigation to 1.2 million ha with construction of water storage facilities.

2.1.3 Agricultural Sector Strategy

In line with the Kenya Vision 2030, the Agricultural Sector Development Strategy 2010-2020 was issued to indicate the development strategy of the agricultural sector. The overall development and growth of the sector was anchored in two strategic thrusts: (a) Increasing productivity, commercialization and comprehensiveness of agricultural commodities and enterprises; and (b) Development and managing the key factor of production.

Target to be achieved by the agricultural sector are:

- To reduce number of people living below the absolute poverty line to less than 25%, to contribute to achieving the MDGs set by the United Nations;
- To reduce food insecurity by 30%, to surpass the MDGs by the United Nations;
- To increase contribution of agriculture to the GDP by more than KSh 80 billion per year as set out in Vision 2030;
- To divert all state corporations dealing with production, processing and marketing that can be better done by the private sector; and
- To reform and streamline agricultural service institutions such as research, extension and regulatory bodies to make them effective and efficient.

For the irrigation development sub-sector, the following interventions are highlighted to increase agricultural production.

- Finalizing and implementing the national irrigation policy and legal framework;
- Intensifying and expanding irrigation;
- Improving rainwater harvesting and storage for agriculture;
- Rehabilitation and protecting water catchments; and
- Implementing the irrigation flagship projects.

2.1.4 Irrigation Policy and Strategy

(1) Irrigation Policy and Strategy of MWI

Kenya promulgated for itself a new constitution in August 2010. One of the main features of the new constitution is the establishment of two levels of governance. One is the national government and the other is the 47 county governments. The irrigation services remain as an important function of the national government because of its important role in food security. The National Irrigation Policy presents a concise set of principles and guidelines, designated to facilitated rapid development and improved performance of the irrigation sector, based on the government's commitment to improve agricultural productivities for food security, poverty reduction, and employment and wealth creation.

The irrigation sector is currently facing many challenges to be solved. These include: (i) inadequate development of irrigation infrastructure; (ii) inadequate funding for development, operation and maintenance; (iii) poor irrigation support services, weak farmers' organizations and participation; and (iv) poorly developed marketing channels. The implementation of the National Irrigation Policy will be realised through accelerated development of irrigation infrastructure, increased productivity per unit volume of water, increased water harvesting and storage, improved scheme management, enhanced stakeholder participation and improved business orientation in the sector.

The Policy has proposed that the irrigation and drainage functions will be performed by the Irrigation and Drainage Department (IDD), while the implementation and related services will be provided by a reformed National Irrigation Board (NIB), namely the National Irrigation Service (NIS).

Past development approaches in irrigation schemes aimed to provide employment and settlement for the landless. In these schemes, NIB played a central role in providing water conveyance, land preparation, etc. However, following liberalization of financial markets and removal of marketing restrictions, farmers' participation in identification, development, operation and maintenance of the schemes through Irrigation Water Users Associations (IWUAs) has increased. The new policy has been espoused in the Kenya Vision 2030, and seeks to stimulate and guide irrigation development by addressing the challenges and constraints. The new policy includes; (i) proposed institutional and legal arrangement, (ii) suggested effective ways of resource mobilization, (iii) identified broad development strategy, (iv) new areas for capacity building and research, (v) proposed emerging water sources and technologies, and (vi) proposed mechanism for coordination, monitoring and evaluation.

The vision of the new policy (2010) is "Efficient, sustainable and manageable irrigation scheme for prosperity, wealth creation and food security in Kenya". The mission is "To provide guidance and support for the development and management of irrigation, drainage and water storage in Kenya".

A policy goal is to "accelerate development and performance improvement of irrigation, drainage and water storage to contribute to the national aspirations of wealth and employment creation, food security and poverty reduction.

The main objectives of the policy are:

a) Expand land under irrigation by 40,000 ha per year in line with Kenya Vision 2030, and put an additional 800 ha (2,000 acres) of irrigation per each constituency in the country;
b) Increase water harvesting and storage, and contribute to achieving a national average of 16 m^3 water storage per capita up from the current 5.3 m^3;
c) Improve the overall performance and service delivery of the sector; and
d) Mobilise resources and investments by various stakeholders, and increase the government's financial allocation from the current 0.2% for irrigation to at least 2% of the annual national budget.

Details of the increase and expansion of land under irrigation are as below.

a) Additional area with irrigation potential will be identified in order to increase land put under irrigation area at a rate of 800 ha (2,000 acres) of irrigation per each constituency as required by parliament;
b) About 32,000 ha per year of new irrigation schemes and rehabilitation of 8,000 ha per year of the existing ones are targeted to be developed, as part of achieving the target set by Kenya Vision 2030; and
c) An irrigation development master plan will be developed and to properly guide and fast track irrigation development.

It was confirmed that there is no scheme list of development under public and smallholders schemes with priority, although the ministry is responsible to guide and support the development. The policy of the MWI presents the concepts and principals of development does not include the actual development program to realise the concept so far.

(2) Irrigation and Drainage Master Plan of MWI in 2009

In response to the proclamation of the Kenya Vision 2030, the IDD/MWI prepared the Irrigation and Drainage Master Plan (IDMP) through consultancy in 2009. The objectives of the Master Plan were to identify and map out the irrigation and drainage potential and formulate an irrigation and drainage sector master plan to guide and facilitate quick development of the potential irrigation land. The specific objectives were set as:

a) Determine and map out surface and ground water resource potential for irrigation including possible water storage for all drainage basins;
b) For each of the water resources identified, delineate and map out all the possible irrigation areas for all the basins in terms of irrigation suitability classes based on the soils and topography and water resources;

c) Identify and map out all the seasonally water logged agricultural areas and classify them on the basis of suitability for drainage / flood protection and water management for purpose of growing crops;

d) Determine unit cost for the development of the irrigation and drainage potential as per irrigation systems;

e) Identify possible constraints that hamper development of irrigation and drainage and recommend possible measures; and

f) Develop short term, medium term and long term development plans and strategies to develop the irrigation and drainage potential and meet or surpass the Kenya Vision 2030 targets.

The studies for water resources for both surface water and groundwater were made based mainly on NWMP (1992), but no recent meteorological and hydrological data after NWMP (1992) was added. The irrigation development potential was estimated at 497,400 ha, considering the environmental demand and without storage facilities, but no potential area with storage capacity was described, although the Kenya Vision 2030 estimates an irrigation development potential of 1.3 million ha with storage facilities. The drainage potential area was estimated at 250,000 ha of which 35,000 ha have been developed.

The irrigation development cost was analyzed based on rather old data from 1985 to 2002. For the development of 100 ha, the unit cost was estimated at US$ 6,700 per ha. This may be a realistic estimate.

2.2 Relevant Organizations

(1) Ministries and Agencies Involved in Irrigation

At the time of NWMP (1992), the following ministries and government agencies were involved in irrigation planning and implementation:

- Office of the President
- Ministry of Planning and National Development
- Ministry of Agriculture (MOA)
    - National Irrigation Board (NIB)
- Ministry of Regional Development (MORD)
    - Lake Basin Development Authority (LBDA)
    - Kerio Valley Development Authority (KVDA)
    - South Ewaso Ng'iro River Basin Development Authority
    - North Ewaso Ng'iro River Basin Development Authority
- Ministry of Water Development (MOWD)
- Ministry of Reclamation and Development of Arid, Semi-Arid and Wasteland
- Ministry of Research, Science and Technology
- Ministry of Energy
    - Tana and Athi River Development Authority (TARDA)

The government reform in 2003 transferred the irrigation function to the Ministry of Water and Irrigation (MWI) from the Ministry of Agriculture (MOA). The irrigation section was upgraded to a full department in 2005, with the creation of IDD in MWI. In 2003, the government consolidated the management of all water related activities under one ministry for regulation, coordination and policy guidance. This consolidation was undertaken to reshape the water sector to play a leading role in national development. The water sector underwent reforms aimed at empowering the private sector and communities to actively participate in the development and management of water resources. This was achieved partly through the operationalization of the Water Act 2002 and the establishment of catchment boards and authorities with responsibilities for management of water resources in their respective areas. The ministries and government agencies involved in irrigation planning and implementation at present are listed below.

- Office of the President
- Ministry of Planning and National Development
- Ministry of Water and Irrigation (MWI)
    - Irrigation and Drainage Department (IDD)
    - National Irrigation Board (NIB)
- Ministry of Agriculture (MOA)
- Ministry of Regional Development Authority (MORDA)
    - Lake Basin Development Authority (LBDA)
    - Kerio Valley Development Authority (KVDA)
    - Tana and Athi River Development Authority (TARDA)
    - Coast Development Authority (CDA)
    - Ewaso Ng'iro South Development Authority (ENSDA)
    - Ewaso Ng'iro North Development Authority (ENNDA)
- Ministry of Development of Northern Kenya and Other Arid Areas

In addition to the above, the following ministries are involved in planning and implementation:

- Ministry of Land
- Ministry of Cooperatives,
- Ministry of Trade and Industry,
- Ministry of Public Health,
- Ministry of Local Government,
- Ministry of Public Works
- Ministry of Gender
- Ministry of Youth Affairs and Children

(2) The Irrigation and Drainage Department of MWI

The overall mandate for the irrigation sector is vested with MWI. The Irrigation and Drainage Department (IDD) of MWI was organised to play the role of leading agency for irrigation and drainage development including the O&M of the existing irrigation and drainage facilities. It has headquarters, provincial offices, district offices and scheme offices. These offices provide services to the irrigators and other stakeholders. NIB was similarly organised with the set up under a Board and general manager and a scheme management at every scheme.

Although MWI, NIB and MRDA are the major players for irrigation development, it seems that a joint ownership of information about irrigation development is insufficient, because of a lack of leadership on the part of MWI. Data and information were collected from various government agencies such as MWI, NIB, MRDA, LBDA, KVDA, TARDA, KVDA, CDA, ENNDA, and ENSDA. MWI is responsible for coordination of development plans for realizing the Kenya Vision 2030.

The MWI has not updated and compiled the list of existing, on-going and proposed schemes, although each field office (PIOs and DIOs) and NIB, as well as concerned government agencies such as MRDA and MOA have their own lists. This study has updated the list through inventory surveys for both DIOs and WRMA during a few months. It was noted that DIOs have no accurate information about private and public sectors in their areas, and just collect and compile the data of smallholders. No strategy and fund preparation could be made without accurate information of the existing, on-going and proposed schemes. A systematic database for the irrigation development is on-going, but not completed yet. Early establishment of monitoring section at the headquarters of MWI is needed.

2.3 Current Situation of Agriculture

2.3.1 Overview

Agriculture is the backbone of Kenya's economy directly contributing to 24% of the GDP, 80% of formal employment and 60% of the export earnings. Further, it contributes 27% of the GDP through links with the manufacturing, distribution and service-related sectors.

In 2011, a total of about 5 million ha of farm land has been cultivated for crop production in Kenya. Cropping area by type of crop in 2011 was 4.3 million ha of food crops, 0.56 million ha of horticultural crops, 0.48 million ha of industrial crops, and 0.10 million ha of oil crops. Maize is a staple food of Kenyan people and self sufficiency of maize has been maintained. Its cropping area is 2.13 million ha (50% of total cropping area) and annual production is 3.5 million tons.

The trend of crop production in the recent five years is shown in Table 2.3.1 and summarised below.

Trend of Cropping Area by Type of Crop (2007-2011) in Kenya

(Unit: 1,000 ha)

Category	Crop	Cropping Area by Year					5-year Trend
		2007	2008	2009	2010	2011	
Food Crop	Maize	1,615	1,794	1,885	2,008	2,132	+44.6 %
	Sorghum	156	104	173	226	254	+63.4 %
	Cowpea	130	148	124	168	198	+52.1 %
	Others	2,125	1,631	1,593	1388	1,725	-18.8 %
	Sub-total	4,026	3,677	3,776	3,790	4,309	+7.0 %
Horticultural Crop	Vegetables	na	na	239	259	258	+7.9%
	Fruits	na	na	161	158	178	+10.6 %
	Others	na	na	113	118	123	+9.1 %
	Sub-total	na	na	513	535	559	+9.0 %
Industrial Crop	Coffee	170	163	160	160	160	-5.9 %
	Tea	149	158	158	172	188	+25.9 %
	Others	132	146	139	129	134	+1.0 %
	Sub-total	452	466	458	461	482	+6.6 %
Oil Crop		109	114	116	96	101	-7.8 %
Grand Total		4,587	4,257	4,863	4,882	5,451	+28.0 %

Source: Economic Review of Agriculture 2012, MOA

The cropping area of major crops by county is shown in Table 2.3.2. Production records of food crops paddy, and horticulture by county are presented in Tables 2.3.3, 2.3.4 and 2.3.5, respectively.

The cropping area of maize, horticulture, beans and rice, by county is illustrated in Figures 2.3.1 to 2.3.4, respectively. Recent production increase in rice and horticulture are remarkable owing to irrigation supply increase On the other hand, most of food crop production has been unstable and yields are stagnated due to the rainfed condition.

Water resources are unevenly distributed in location and time: about 56% of all the country's water resources are in the Lake Victoria basin. Even in the basin, with the exception of the highlands, water availability is scarce. There are two cropping seasons except in the high-altitude areas. The performance of rainfed agriculture varies due to the diverse agroclimatic zones. In the humid, high-altitude areas productivity as well as predictability of a good crop is high. However, the population density in these areas has increased and farming plot has been subdivided into small sizes, and becoming uneconomical for farm enterprises.

In the medium altitude and moderate-rainfall areas, arable rainfed farming is moderately suitable. However, there is a relatively high risk of crop failure due to increased frequency of dry spells and an uneven rainfall distribution. Increasing productivity in these areas will require better selection of crops, adoption of improved technologies, and better crop husbandry. A large proportion of the country, accounting for more than 80%, is semi-arid and arid with an annual rainfall average of 400 mm.

Droughts are frequent and crops fail in one out of every three seasons. Most of the area is rangeland suitable for ranching and pastoralism. Farm enterprises comprise mixed crops and livestock. While there is ample land, farmers tend to grow crops that are not suitable for this rainfall regime or for the soils. These areas require better planning, careful selection of farm enterprises and greater investment in infrastructure. The government will make efforts to harmonise and prioritise the development of arid and semi-arid lands (ASALs).

The country's irrigation-based farming is still limited. Of the total land area under agriculture, 2.9 million ha, irrigation accounts for only 4% but contributes to 3% of the GDP and provides 18% of the value of all agricultural produce, demonstrating its potential in increasing agricultural production and productivity. Irrigated agriculture is carried out mainly in irrigation schemes and in large scale irrigation of crops such as rice and coffee. Individual farmers have developed their own systems of irrigation especially for export crops such as coffee and horticulture. With a national average rainfall of 400 mm, the country should harvest and store adequate water for agriculture and other uses. Groundwater resources that can be exploited for agriculture need to be assessed and quantified. More land can be reclaimed for crop cultivation by developing irrigation infrastructure in the ASALs.

2.4 Current Situation of Irrigation and Drainage

(1) Approach for Clarification

As mentioned in subsection 1.3.2, present irrigation areas reported are quite different by organization or document ranging between 110,000 ha and 184,000 ha. Furthermore, no breakdown of irrigation and drainage areas by counties or drainage basin is available at the headquarters of MWI. To grasp the existing irrigation areas by type of scheme more realistically, the following procedure for clarification has been performed.

a) Existing Smallholder Irrigation and Drainage Areas

To provide basic information to estimate the irrigation water demands in 2010 and 2030, the inventory lists of the irrigation and drainage schemes were collected from the MWI's field offices, i.e. eight Provincial Irrigation Offices (PIOs) and 170 District Irrigation Offices (DIOs). It was clarified that there are 1,071 existing smallholder schemes with actual irrigation area of 51,903 ha in total, 277 on-going smallholder schemes for 23,932 ha (86 ha per scheme), and 805 proposed smallholder schemes for 105,172 ha as shown in Table 2.4.1. These values for smallholders' schemes could be reliable, since PIOs and DIOs are solely responsible for assistance to develop the smallholders' schemes.

The existing drainage schemes were reported in the counties of Kisii, Nyamia, Trans Nzoia, Bungoma, Busia, and Kakamega as shown in Table 2.4.2.

b) Existing Irrigation Areas under Private/Commercial Sector

Due to lack of accurate data on irrigation area of private sector, the irrigation area was estimated based on the inventory data of water permits granted by WRMA. As a result, data on 2,243 water permit was provided by WRMA. Among them, data on 180 water permits with information pertaining to irrigation area were provided by four regional offices of WRMA, namely the regional offices of Lake Victoria South and Lake Victoria North, and subregional offices of Ewaso Ng'iro North and Athi catchment offices. However, data on the remaining 2,060 schemes was provided that noted only the amount of water permitted per day. Considering the above conditions, the average water permit for irrigation users in the private/commercial sector was estimated at 7,413 m^3/ha/year based on the said 180 permits. It is noted that about 76% of the water permit are granted only for the flood season and 3% for the dry season. The other season (may be base flow user) is 21% as shown in Table 2.4.3. Based on the inventory data of the water permits provided by WRMA and the assumed unit water requirement of 7,413 m^3/ha/year, the irrigation area of the private/commercial sector was estimated at 75,840 ha. Five counties have irrigated private/commercial farms more than 5,000 ha in total. They are located at the skirt of Mt. Kenya and Mt. Kilimanjaro.

c) Existing Irrigation Areas under the Public Sector

The irrigation area of the public sector was investigated through the information from NIB and the inventory list of water permits provided by WRMA. As a result, following nine schemes with total irrigation area of 14,157 ha was identified as the present irrigation area under management of the public sector.

Existing Public Irrigation Schemes

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

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

The largest scheme is the Mwea irrigation scheme of 7,400 ha under NIB in Kirinyaga district in the Tana river basin. Most of the schemes are less than 1,000 ha. The majority are irrigated by pump.

(5) Summary of Existing Irrigation Areas

Based on the above studies, the present irrigation area was estimated at 141,900 ha as of December 2010 as shown in Table 2.4.4 and summarised below.

Existing Irrigation Area in 2010

(Unit: ha)

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

Note: * Actual area (AIA) specified by PIO/DIOs thru the Inventory survey made in Jan. to Mar. 2011
**: Estimated based on the water permit granted by WRMA and average water consumption rate
Source: JICA Study Team, based on data from NIB, MOA, KVDA, WRMA, and Inventory Survey in this study

(6) Existing Drainage Areas

As stated above, the data provided by MWI is far different from that identified in NWMP (1992). By referring to the inventory result presented in NWMP (1992), the data provided in 2011 by DIOs is modified. As a result, the existing drainage schemes including on-going status identified by MWI are 6,904 ha under 33 schemes against 171 schemes covering 34,020 ha proposed by DIOs as tabulated below.

Inventory Data of Drainage Scheme under MWI

Status	NWMP (1992)		2010 Inventory	
	Nos	Area (ha)	Nos	Area (ha)
Existing	25	6,470	19	2,243
On-going			14	4,661
Proposed	n/a	n/a	171	34,020
Total	25	6,470	204	40,924

Note: as of December 2010
Source: JICA Study Team, based on Inventory Survey in this study.

The "Annual Water Sector Review Report 2010" of MWI in February 2011 presents the total extent of drainage schemes at 31,894 ha, based on the developed area of 30,000 ha in 2006. Further investigation by MWI is needed for formulating the development policy and strategy.

2.5 Proposed Irrigation Development

2.5.1 Irrigation Development Potential

There are many different projections on irrigation development potential area depending on the study. Among them, the "Provincial Land Use and Potential Study" made in 2009 shows the irrigation potential area as summarised below. Total irrigable area was estimated at 1.3 million ha. This figure has been employed to set an irrigation development target in the Kenya Vision 2030.

Land Use Condition and Potential Irrigation Development Area

Province	Total Area (km^2)	Arable Area (ha)	Cultivated Area (ha)	Irrigable Area (ha)	Irrigated Area (ha)
Western	74,731	726,401	831,554	427,512	715
Nyanza	15,482	974,500	490,200	92,400	9700
Rift Valley	130,452	983,120	519,278	160,106	14,974
Central	12,249	785,243	563,669	93,839	43,609
Nairobi	696	31,436	20,861	7,883	366
Eastern	215,540	2,374,689	1,479,610	294,169	16,642
Coast	82,815	3,452,401	781,464	150,629	18,823
North Eastern	132,360	1,916,912	31,655	78,850	6,619
Total	533,873	10,261,582	4,718,291	1,305,388	111,448

Source: Provincial Land Use and Potential Study Report for KNRMP (Kenya Natural Resource Management Programme), Euroconsult Mott MacDonald, July 2009

2.5.2 Existing Development Plans

(1) Large scale Irrigation Project

A total of 74 large scale irrigation projects (over 500 ha) were proposed by various government agencies such as NIB, LBDA, KVDA, TARDA, CDA, ENSDA, and ENNDA by October 2012 as listed in Table 2.5.1. In addition, eight multipurpose dam irrigation projects were proposed for implementation to maximise irrigation area in 2030. These proposed projects can be classified by present status as of October 2012 as: on-going or financed (six projects), detailed design completed (six projects), detailed design on-going (three projects), feasibility study completed (seven projects), feasibility study on-going (14 projects), and proposed (38 projects). Projects of "proposed status" have no detailed information for project evaluation. The main development partners for on-going large scale irrigation projects are the World Bank and JICA.

(2) Smallholder Schemes and Drainage Development by MWI

The on-going irrigation schemes for smallholders and drainage development projects under MWI number 277 and 14, respectively. The main development partners for small scale irrigation are the World Bank, BADEA, KfW and JICA.

(3) Private/Commercial Sector

No information is available at MWI and NIB for the private/commercial sector so far. MWI has to set up the system to obtain such information through PIOs and DIOs.

2.6 Operation and Maintenance Issues

Operation and maintenance (O&M) has been made by NIB for public irrigation schemes such as Mwea, Bura, Hole. However there are no substantial activities for smallholder schemes due to lack of budget allocation, although the necessity has been recognised by IDD/ MWI and NIB. Even in public irrigation schemes, operation of pump has sometimes been suspended due to lack of budget for repair/ replacement. Aiming at handing over the O&M of smallholder and public schemes to beneficiaries, organizing farmers into water users associations and training them in water management for them has been initiated, but this seems to be limited.

2.7 Challenges and Key Issues

Based on the discussions with concerned officials, field surveys and collection of data/information, present challenges and key issues on irrigation and drainage development might be as follows:

(1) Low Rate of Development Compared to the Target

While the First Mid-Term Development Plan (2008-2012) was set to realise the target of the Kenya Vision 2030, actual irrigation development area under MWI and NIB is far below at about 4,000-6,000 ha per year compared to the yearly target of 20,000 ha per year. In the case of drainage development, the development area is less than 1,000 ha per year while the yearly target was set at 12,000 ha by MWI. Major causes might be inadequate funding for large scale development, less disbursement of government fund for smallholder schemes, and less leadership from MWI for preparing the counter actions against low development rate based on the strict monitoring. It seems that MWI has concentrated on revising and updating the policy but has not prepared an action plan for development. Listing up the priority projects for obtaining the fund from GOK and development partners is urgently needed. Delayed development in construction of water storage facilities due to environmental issues, and un-coordinated development plan by too many agencies involved in irrigation development, are another challenge.

(2) Need for Adequate Water Storage Facilities for Expansion of Irrigation Area

The National Irrigation Policy states as one of its objectives to increase water harvesting and storage, and contribute to achieving a national average of 16 m^3 water storage per capita up from the current 5.3 m^3. The development of adequate water harvesting and storage facilities is essential for the targeted extension of the irrigation areas.

The central government should play a leading role in overcoming the challenges by urgently implementing the large-scale irrigation development projects. It may be considered that easy developments that are cost-effective and employ low technology have already been realised by private and smallholders sectors, thus future developments need more sophisticated planning/design at higher costs. Once the central government provides key infrastructure such as large-scale storage facilities and main irrigation canals, the private and smallholder sectors would be motivated to do further development at rather lower costs and shorter periods. For efficient development of the smallholder sector, the role of county governments is also important. A plan on strengthening the county governments would also be studied.

(3) Need for Introduction of Water Saving Irrigation to Reduce Irrigation Water Demand

The conceivable water saving measures would be the introduction of water-saving irrigation techniques, strengthening of water management practices, and participatory development of beneficiary farmers to ensure the flexible response to climate change.

(4) Delayed Implementation due to Land Acquisition Issue

Issues of land acquisition for construction of headrace channels from the diversion weirs and reservoirs have often delayed implementation of the projects due to less budget arrangement and land ownership issues. According to the information, land ownership is extended to the centre of the rivers. A special arrangement for land ownership for the river area is needed to accelerate the implementation of gravity irrigation system.

(5) Layoff of Rural Agricultural Labours due to Water Shortage

Due to shortage of irrigation water in the winter season from October to February, a commercial company has been forced to fire agricultural labourers in rural areas. To maintain the income of people in rural area as well as social security, the supply of irrigation water in the dry season and dry areas is important. The importance of irrigation for the social security as well as increasing food stuff should be recognised in the government policy.

(6) Improper or Incomplete Standard for Design and Cost Estimate

Although the government and DPs intend to invest in efficient and economical irrigation projects, they have considered that the required cost for the development is rather higher than that they expected. This is one of the causes for stagnation of large scale development in the country. Standardization of the design and cost estimate for realizing efficient and economical irrigation and drainage facilities is needed. The standardization might be realised by preparation of a design standard, public notice of major prices and cost of construction materials and works under public works, and subsidies for construction materials for irrigation development through reduction of taxes and mass pre-fabrication of pipes and related structures.

(7) Need for Setting up of a Periodic Data Collection and Review System at IDD

For preparation and revising of the development policy and strategy, accurate data collection/ updating and analysis are indispensable. However, IDD has not carried out such systematic review for the policy making since the 1990’s, due to absence of a responsible and active section collection of data. Development data including proposal are available at field offices and NIB of IDD, executing agencies of MORDA, and other related agencies. By improving the database system of water permits at WRMA which includes the data for irrigation, database for the inventory of the present, on-going and proposed irrigation and drainage schemes should be prepared.

CHAPTER 3 PRESENT WATER USE AND FUTURE WATER DEMANDS

3.1 General

For projection of the possible maximum irrigation development area by available surface water and groundwater resources, irrigation water demands for the present condition in 2010 and the future condition in 2030 and 2050 were estimated by sub-basin (204 sub-basins) covering the whole country. Because of limitation of available data such as cropping pattern, irrigation efficiencies and exact locations of irrigation schemes, the present and future irrigation water demands were estimated based on several assumptions. As a base for estimation of irrigation water demands, present and future irrigation areas were estimated based on analysis of available data and information from MWI, WRMA, government authorities and counties through DIO offices.

3.2 Available Water Resources for Irrigation

(1) Effective Rainfall

Average rainfall was estimated by sub-basin based on 30 years of data from 1981 to 2010 at 37 rainfall stations in Kenya as presented in the Sectoral Report (B), Section 1.2 Meteorology. Isohyetal map of mean annual rainfall for 1981 to 2010 is as shown in Figure 3.2.1. Based on data above, the effective average rainfall for irrigation was estimated by sub-basin as shown in Table 3.2.1 and summarised below.

Effective Average Monthly Rainfall for Irrigation

(Unit: mm)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
LVNCA	35	34	76	130	119	74	79	94	82	84	73	41	921
LVSCA	54	45	89	126	100	63	59	71	67	72	77	59	881
RVCA	21	17	42	77	60	38	45	50	29	39	49	31	496
ACA	28	17	49	92	76	25	18	16	14	45	88	58	508
TCA	28	14	53	131	84	16	0	0	0	71	121	62	608
ENNCA	15	3	32	74	39	18	22	22	0	46	59	31	371
Total	30	22	57	105	80	39	37	42	32	59	78	47	631

Source: JICA Study Team

(2) Available Surface Water Resources

The available river discharge for irrigation can be calculated by deducting water demands of priority water users (river maintenance flow, domestic and industrial water supply) from the river discharge. Table 3.2.2 shows the available monthly river discharges of the dry year with probability of one in five years, which is the base for a water balance study to determine the potential maximum irrigation area by river water by sub-basin. They are summarised below.

River Discharge Available for Irrigation

(Unit: MCM/year)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
LVNCA	257	395	227	320	1991	1726	1259	1225	1267	1265	803	487	11,222
LVSCA	280	199	172	655	1085	695	425	370	297	464	692	962	6,297
RVCA	39	10	23	48	229	304	404	340	384	411	445	207	2,844
ACA	236	180	226	1218	1120	384	197	195	185	188	178	196	4,503
TCA	721	318	288	498	3490	745	321	248	163	860	2440	2565	12,657
ENNCA	100	16	38	84	165	273	138	81	88	18	138	569	1,710
Total	1634	1119	974	2824	8080	4128	2744	2458	2383	3206	4697	4985	29,233

Source: JICA Study Team

(3) Available Groundwater Resources

The available groundwater resources for irrigation was estimated as shown in Table 3.2.3 by deducting water demands of priority users (domestic and industrial water supply) from sustainable groundwater yield. The total available groundwater resources for irrigation for the whole country were estimated at 1,162 MCM throughout a year.

Available Groundwater Resources for Irrigation

(Unit: MCM/year)

Item	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Sustainable GW Resources	108	188	102	300	567	475	1,740
Available GW for Irrigation	38	78	40	109	506	391	1,162

Source: JICA Study Team

3.3 Present Water Use

(1) Present Irrigation Area

The present irrigation area was estimated under the following conditions:

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

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

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

The existing irrigation areas by county and by type are listed in Section 2.4. The existing irrigation area by sub-basin is shown Table 3.3.1, and summarised below.

Existing Irrigation Area by Type and by Catchment Area in 2010

(Unit: ha)

Catchment Area	Existing Irrigation Area			
	Total	Large scale	Small scale	Private
LVNCA	1,876	363	1,327	186
LVSCA	13,218	1,800	10,225	1,193
RVCA	9,587	774	5,791	3,022
ACA	44,898	0	13,524	31,374
TCA	64,425	11,200	14,823	38,402
ENNCA	7,896	0	6,233	1,663
Total	141,900	14,137	51,923	75,840

Source: JICA Study Team, based on Inventory survey was conducted from Jan.-Mar. 2011 in this study.

(2) Unit Irrigation Water Requirements

The unit irrigation water requirement is estimated from crop evapotranspiration by deducting effective rainfall. The most useful reference on estimation of country-wide evapotranspiration is the document of “Water Requirements for Irrigation in Kenya” prepared by the Irrigation Section of the Ministry of Water Development (MWD) in 1985, which was for estimation by the NWMP (1992). The MWD document shows the monthly evapotranspiration for green grass cover and effective rainfall at 72 selected locations in Kenya. Effective rainfall indicated in the MWD document and the latest figures shown in Table 3.2.1 has almost no difference. Therefore, the basic data in the MWD document such as the iso-annual irrigation water requirement shown in Figure 3.2.4 and unit water requirement data at 72 locations were used for the estimate of irrigation water requirement by sub-basin in this study. As seen in the figure of the iso-annual irrigation water requirement, the highest water requirement zones in the county are located in the lowland area below 500 m elevation. The lowest water requirement zone appears in the highland over 1,500 m elevation.

The unit irrigation water requirement by sub-basin was estimated as shown in Table 3.3.2 assuming 60% irrigation efficiency and full cropping to use as a base for alternative calculation by different irrigation efficiencies and cropping patterns.

(3) Assumed Cropping Pattern and Cropping Intensity

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

Present Cropping Pattern and Cropping Intensity Assumed

(Unit: %)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	*60*	*60*	*80*	*80*	*80*	*80*	*40*		*40*	*60*	*60*	*60*
LVSCA	*60*	*60*	*80*	*80*	*80*	*80*	*40*		*40*	*60*	*60*	*60*
RVCA			*40*	*80*	*80*	*80*	*80*	*40*	*40*	*60*	*60*	*60*
ACA		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*
TCA		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*
ENNCA		*40*	*80*	*80*	*80*	*40*			*40*	*60*	*60*	*60*

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

(4) Present Irrigation Water Demand

Irrigation water demand for existing irrigation area was estimated as shown in Table 3.3.3 and summarised below.

Present Irrigation Water Demand in 2010

(Unit: MCM/year)

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

Source: JICA Study Team

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

3.4 Future Water Demands

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

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

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

Standard Cropping Pattern and Cropping Intensity in 2030

(Unit: %)

Catchment Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	*60*	*60*	*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
LVSCA	*60*	*60*	*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
RVCA			*50*	*100*	*100*	*100*	*50*		*30*	*60*	*60*	*60*
ACA		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*
TCA		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*
ENNCA		*50*	*100*	*100*	*100*	*50*			*30*	*60*	*60*	*60*

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

However, for the weir irrigation projects located in semi-arid zones in RVCA, ACA, TCA and ENNCA, the annual cropping intensity was assumed to be 100~160% depending on available river discharge in the short rainy season.

On the other hand, the annual cropping intensity for large dam irrigation projects was assumed to be 160% from a viewpoint of maximum utilization of available water in the long rainy season and to be able to justify the project economically.

For small dam and water pan irrigation, the annual cropping intensity was assumed at 100%. For groundwater irrigation, the same cropping pattern and intensity as the weir irrigation were applied.

Thus, reflecting the hydrological characteristics and availability of water resources for irrigation in each catchment area, the annual cropping intensity applied for water demand estimation was assumed as follows:

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

(2) Unit Water Requirement

For the estimation of future irrigation water demand, the same procedure and assumptions mentioned in sub-section 3.3 (2) are applied. The introduction of water saving methods is one of the key concepts for irrigation development in order to raise water productivity and to maximise irrigation area within available water resources toward 2030.

The irrigation efficiencies by type of irrigation method and their combination are as follows:

Irrigation Efficiency by Irrigation Method and Combination

Category	Irrigation Method	Efficiency
Type of Method	Basin irrigation (present)	50~55%
	Furrow irrigation (present)	55~60%
	Furrow irrigation (piped)	65%
	Sprinkler irrigation	70~75%
	Drip irrigation	90%
Combination	(1) Furrow (60%) + Sprinkler (20%) + Drip ‘(20%)	67%
	(2) Furrow (50%) + Sprinkler (25%) + Drip ‘(25%)	70%

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

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

Unit irrigation water requirement by sub-basin under 70% irrigation efficiency and a cropping intensity of 160% is shown in Table 3.4.1.

(3) Future Irrigation Area to Meet the Target of the Kenya Vision 2030

To strengthen agricultural sector in order to contribute to national economy, the Kenya Vision 2030 sets a national goal to increase new irrigation area by 1.2 million ha by 2030. This includes large scale (public), small scale (smallholders) and private irrigation schemes. The target of the irrigation development by catchment area to meet the Vision 2030 (1.2 million ha) is envisaged based on the distribution of agricultural potential area proposed by MOA as shown in Table 3.4.2 and Figure 3.4.1, referring to irrigation potential area proposed in the “Irrigation and Drainage Master Plan 2009” by MWI, location of existing and proposed irrigation schemes as well as present cropping area by county as shown in Table 3.4.3. It should be noted that these figures are not confirmed by water availability yet, and will be finalised after the evaluation of available water resources and a water balance study.

Irrigation Development Target Area for 2030 (Provisional)

(Unit: ha)

Catchment Area	LVN	LVS	RV	Athi	Tana	ENN	Total
Existing Irrigation Area (in 2010)	1,876	13,218	9,587	44,898	64,425	7,896	141,900
New Irrigation Area (in 2030)	90,786	186,978	63,493	233,628	482,450	142,665	1,200,000
Total	92,662	200,196	73,080	278,526	546,875	150,561	1,341,900

Source: JICA Study Team, based on data on potential agricultural area proposed by MOA

The irrigation water demand for the above area was estimated by sub-basin as shown in Tables 3.4.4 and summarised below.

Irrigation Water Demand for 1.2 million ha in 2030

(Unit: MCM/year)

Item	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Irrigation Water Demand	799	2,169	932	2,920	7,074	2,552	16,446

Source: JICA Study Team

The total irrigation water demand was estimated at 16,446 MCM per year. However, after the water balance study, it was revealed that available water resources were not enough, especially in LVSCA, ACA, TCA and ENNCA, to fulfill the water demands required for the 1.2 million ha in Kenya above.

(4) Possible Irrigation Area for Future Irrigation Development in 2030

The procedure for projection of future irrigation area in 2030 is described in Section 4.2 in Chapter 4, Irrigation Development Plan. For the purpose to estimate future water demand based on possible irrigation area in 2030, the results of estimate in Chapter 4 was quoted as follows:

Possible New Irrigation Development Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area							
Surface Water Irrigation							
- Weir	95,875	27,977	15,335	5,350	4,961	4,202	153,700
- Large Dam	65,770	73,772	71,850	32,000	131,000	22,000	396,392
Groundwater Irrigation - Borehole	3,568	6,867	2,091	4,618	20,108	14,331	51,583
Water Harvesting Irrigation - Small Dam/Water Pan	3,700	4,590	2,890	4,140	5,730	950	22,000
Sub-total	168,913	113,206	92,166	46,108	161,799	41,483	623.675
Existing Irrigation Area	1,876	13,218	9,587	44,898	64,425	7,896	141,900
Total	170,789	126,424	101,753	91,006	226,224	49,379	765,575

Note: Refer to Table 3.4.9
Source: JICA Study Team

The possible irrigation development area was calculated at 623,675 ha against the target area of 1.2 million ha in the Kenya Vision 2030 as follows.

Comparison between Target and Possible New Irrigation Development Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
1.Target New Irrigation Area	90,786	186,978	63,493	233,628	482,450	142,665	1,200,000
2.Possible New Irrigation Development Area	168,913	113,206	92,166	46,108	161,799	41,483	623,675
Difference (=2-1)	+78,127	-73,772	+28,673	-187,520	-320,651	-101,182	-576,325

Source: JICA Study Team

In LVNCA and RVCA, the possible new irrigation development area exceeds the provisional development target. On the other hand, in the other catchment areas, it is difficult to achieve the provisional development target due to constrain of the available water resources..

It should be noted that the irrigation area in 2030 above was estimated assuming that the water-saving irrigation methods are introduced for the half of irrigation area in 2030 and the overall irrigation efficiency comes to 70% for surface irrigation and 83% for groundwater irrigation. If the water-saving irrigation methods were not introduced, the overall efficiency for surface irrigation decreases from 70% to 60% and that for groundwater irrigation from 83% to 60%. As a result, the possible new surface irrigation area decreases from 550,092 ha to 471,500 ha and the possible new groundwater irrigation area also decreases from 51,600 ha to 37,300 ha. The total new irrigation development area comes to 530,800 ha including water harvesting irrigation area of 22,000, which is about 15% decrease against the possible new irrigation development area with water saving irrigation of 623,700 ha.

(5) Future Irrigation Water Demand in 2030

Based on assumptions for estimation of future irrigation water demand mentioned in Section 3.4 (1) - (2) and maximum irrigation area in 2030 presented in Table 4.2.5, the future irrigation water demand in 2030 was estimated as shown in Table 4.2.6 and summarised below.

Future Irrigation Water Demands in 2030

(Unit: MCM/year)

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

Source: JICA Study Team

Annual total irrigation water demand for future irrigation area of 765,575 ha in 2030 was estimated at 8,063 MCM/year, or overall average unit water demand of 94,949 m^3/ha/year, assuming 70% irrigation efficiency and 160%~100% annual cropping intensity.

(6) Possible New Irrigation Area and Water Demand in 2050

Future irrigation area in 2050 was assumed to be the same as that in 2030, because the estimate irrigation area in 2030 is the maximum irrigation area considering availability of surface water and groundwater resources. Therefore, the future irrigation water demand in 2050 results in the same as 2030.

CHAPTER 4 IRRIGATION DEVELOPMENT PLAN

4.1 Development Target

As mentioned in Section 3.4, after the water balance study, it was revealed that available water resources were not enough to fulfill the water demands required for the 1.2 million ha which is the target in the Kenya Vision 2030. Therefore, the future possible irrigation area was estimated based on the development concept and framework through the water balance study by sub-basin with an aim to maximise irrigation area within availability of water resources for both surface water and groundwater in each catchment area.

The results of the study can be recognised as the development target as follows:

Possible New Irrigation Development Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area							
Surface Water Irrigation							
- Weir	95,875	27,977	15,335	5,350	4,961	4,202	153,700
- Large Dam	65,770	73,772	71,850	32,000	131,000	22,000	396,392
Groundwater Irrigation - Borehole	3,568	6,867	2,091	4,618	20,108	14,331	51,583
Water Harvesting Irrigation - Small Dam/Water Pan	3,700	4,590	2,890	4,140	5,730	950	22,000
Sub-total	168,913	113,206	92,166	46,108	161,799	41,483	623,675
Existing Irrigation Area	1,876	13,218	9,587	44,898	64,425	7,896	141,900
Total	170,789	126,424	101,753	91,006	226,224	49,379	765,575

Note: Refer to Table 3.4.9
Source: JICA Study Team

Based on the above results, the target new irrigation development area for NWMP 2030 was set at 623,675 ha.

4.2 Overall Concept and Framework

(1) Overall Concept

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

a) Irrigation development should be undertaken to the maximum as long as water is available.

b) Water saving methods such as drip and sprinkler irrigation for upland crop cultivation and water saving paddy cultivation (System of Rice Intensification: SRI, etc) should be introduced for efficient water use as much as possible.

(2) Framework for Development Plan Formulation

For projection of possible maximum irrigation area in 2030, all types of irrigation methods are considered, namely, surface water irrigation (by diversion weir and dam), groundwater irrigation, and water harvesting irrigation (by small dam/water pan).

For determination of maximum irrigation area by surface water and groundwater, the water balance study is conducted by sub-basin. It should be noted that the available water resources for irrigation means the remaining water resources after deducting water demands of priority uses such as (i) river maintenance flow and (ii) domestic and industrial water supply, according to "Guidelines for Water Allocation (WRMA, First Edition, March 2010)".

The criteria for determination of future irrigation area is as follows:

Criteria for Determination of Future Irrigation Area

No	Type	Criteria to Determine Irrigation Area
1	Surface Water Irrigation by Weir	Maximum surface water irrigation area by weir is estimated through the water balance study between irrigation water demand and available river discharge for irrigation (after deducting water demand of priority users) in each sub-basin.
2	Surface Water Irrigation by Large Dam	Maximum surface water irrigation area by large dam is estimated through the water balance study between irrigation water demand and available river discharge for irrigation (after deducting water demand of priority users) in each sub-basin. Irrigation projects proposed by the government authorities are taken into account.
3	Groundwater irrigation by Borehole	Maximum irrigation area by groundwater is estimated by dividing available groundwater for irrigation (after deducting water demand of priority users) in each sub-basin by the peak monthly unit water requirement. Average unit water requirement is assumed to be 7,500 m^3/year/ha.
4	Water Harvesting Irrigation by Small Dam /Water Pan	Total irrigation area by water harvesting is assumed to be 4% of the surface irrigation area based on the ratio of actual groundwater irrigation area and then distributed to six catchment areas based on the agricultural potential areas. Average unit water requirement is assumed to be 8,000 m^3/year/ha.

Source: JICA Study Team

Introduction of the water saving irrigation methods is considered reflecting the local climate and agricultural conditions for both upland crop cultivation and paddy cultivation as follows:

Proposed Area Ratio of Water Saving Irrigation and Irrigation Efficiency

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

Source: JICA Study Team

(3) Surface Water Irrigation Area

For surface water irrigation, possible irrigation area is determined for both weir irrigation and dam irrigation, through a water balance study between available river water and irrigation water demand by sub-basin. Existing development plans proposed by the government authorities and by this study will be taken into account for planning as much as possible, if water availability is confirmed. A total of 34 large-scale irrigation projects were selected from proposed 81 projects listed in Table 2.5.1 through the check of water resources availability by the water balance study as listed in Table 4.2.1.

The possible new irrigation area by surface water (weir irrigation plus dam irrigation) was estimated through the water balance study between unit irrigation requirement and available discharge for irrigation (after deducting the water demand of priority users) in each sub-basin as shown in Table 4.2.2 and Figure 4.2.1, and summarised as below.

Possible New Surface Water Irrigation Area Estimated by Water Balance Study

(Unit: ha)

Item	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Existing Irrigation Area	1,876	13,218	9,587	44,898	64,425	7,896	141,900
New Irrigation Area	161,645	101,749	52,185	32,070	135,961	26,202	509,812
Total	163,521	114,967	61,772	76,968	200,386	34,098	651,712

Source: JICA Study Team

In addition to the above, there are proposed projects having water source outside the river basin. They are the Todonyang-Omo irrigation project to be supplied from a dam in Ethiopia and projects outside the Athi river basin in ACA. Including these projects, the total possible new surface water irrigation area was estimated at 550,092 ha as shown in the table below.

Total New Surface Water Irrigation Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
Irrigation Area having Water Source in Kenya	161,645	101,749	52,185	32,070	135,961	26,202	509,812
Irrigation Area having Water Source outside Kenya	0	0	35,000	5,280	0	0	40,280
Grand Total	161,645	101,749	87,185	37,350	135,960	26,202	550,092

Source: JICA Study Team

(4) Groundwater Irrigation Area

The possible new groundwater irrigation area was estimated through the comparison of available groundwater resources for irrigation by sub-basin presented in Table 3.2.3 and unit irrigation water requirement of 7.5 MCM/year/ha, which is the average amount to issue water permit by WRMA. The possible groundwater irrigation area in 2030 was estimated at 51,583 ha for the whole country as shown in Table 4.2.3 and Figure 4.2.2. The possible groundwater irrigation area will be divided into small scale irrigation and private irrigation at a fifty-fifty proportion because no data is available.

(5) Water Harvesting Irrigation Area

For the area having insufficient surface water or groundwater resources, water harvesting irrigation by small dams/water pans will be proposed. As the existing small dam irrigation area is roughly estimated at 1.6% as compared to the total irrigation area, the future small dam/water pan irrigation area was assumed to be 4% of the new irrigation area, or equivalent to 22,000 ha for the whole country. Distribution of the area by catchment will be based on the proportion of the agricultural potential area.

(6) Summary of Future Irrigation Development Area and Water Demand

The possible irrigation area in 2030 is shown in Table 4.2.4 and Figure 4.2.3 by catchment area and summarised below.

Summary of Irrigation Area in 2030

(Unit: ha)

Type of Irrigation	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA	Total
New Irrigation Area							
Surface Water Irrigation							
- Weir	95,875	27,977	15,335	5,350	4,961	4,202	153,700
- Large Dam	65,770	73,772	71,850	32,000	131,000	22,000	396,392
Groundwater Irrigation - Borehole	3,568	6,867	2,091	4,618	20,108	14,331	51,583
Water Harvesting Irrigation - Small Dam/Water Pan	3,700	4,590	2,890	4,140	5,730	950	22,000
Sub-total	168,913	113,206	92,166	46,108	161,799	41,483	623,675
Existing Irrigation Area	1,876	13,218	9,587	44,898	64,425	7,896	141,900
Total	170,789	126,424	101,753	91,006	226,224	49,379	765,575

Note: Refer to Table 3.4.9
Source: JICA Study Team

For the above irrigation area in 2030, the water irrigation water demand was estimated as presented in Table 4.2.5 by catchment area. Table 4.2.6 gives the monthly water demand by sub-basin in 2030.

4.3 Development Plan in Each Catchment Area

4.3.1 Development Plan in Lake Victoria North Catchment Area

(1) Current Situation of Irrigation Development

LVNCA is wholly located on the highland over 1,000 m high with a wet climate. The high and medium potential agricultural areas in LVNCA were estimated at 1.95 million ha by MOA (Table 3.4.2). The present cropping area in LVNCA in 2011 was 776,811 ha in total, consisting of 613,760 ha (79.0%) of maize, 60,655 ha (7.8%) of horticulture crops, 4,514 ha (0.6%) of rice, and 97,882 ha (12.6%) of other food crops (Table 2.3.2). The utilization ratio of high and medium potential agricultural areas by crop production is estimated at about 40%. Most of them are under rainfed agriculture. The existing irrigation area in LVNCA in 2010 was only 1,876 ha in total, comprising 363 ha (19%) of public irrigation schemes, 1,327 ha (71%) of smallholder irrigation schemes, and 186 ha (10%) of private schemes. The share of irrigation area compared to the cropping area was 0.2% only. The existing large and small scale irrigation systems need repair and rehabilitation.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in Section 4.2, the strategy for irrigation development in LVNCA was set as follows:

a) In order to utilise available water resources efficiently for the maximization of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;
b) In order to strengthen the agricultural sector in LVNCA, irrigation should be expanded in rainfed agricultural areas to increase agricultural productivity and production; and
c) Owing to the sufficient land and water resources available for irrigation in LVNCA, the priority to maximise the irrigation area should be given to both dam irrigation and weir irrigation, and then to small scale dam and groundwater irrigation as far as water resources are available

(3) Proposed Development Plan

A water balance study by sub-basin in LVNCA revealed that the possible maximum surface irrigation area would be 163,521 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large-scale irrigation projects (more than 500 ha), five projects proposed by the government authorities and three projects proposed in this study listed in Table 2.5.1 were taken up for the water balance study, and six projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in LVNCA as shown in Table 3.4.7. They are listed below.

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

Among these, three projects, namely the Lower Nzoia, Lower Sio, and Yala Swamp Irrigation Projects, were planned to be irrigated by reliable river water sources. They are technically not difficult and are economically viable, and have no social and environmental problems. In particular, the Lower Nzoia and Lower Sio irrigation projects have a higher implementation priority owing to the completion of detailed designs and construction budget arrangements. On the other hand, the remaining three projects, namely the Upper Nzoia, Moi’s Bridge, and Kibolo Dam Irrigation Projects, were planned to be irrigated by the water from multipurpose dams. As these dams are not well investigated and studied yet, these three dam irrigation projects were considered best to be implemented in the latter stage.

Future maximum groundwater irrigation area in LVNCA was estimated at 3,568 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in LVNCA are estimated at 3,700 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in LVNCA by category are summarised as follows:

Maximum Irrigation Area in 2030 (LVNCA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	363	12,600	65,770	78,370	0	0	78,370	78,733
Small-scale	1,327	41,638	0	41,638	1,784	3,700	47,122	48,449
Private	186	41,637	0	41,637	1,784	0	43,421	43,607
Total	1,876	95,875	65,770	161,645	3,568	3,700	168,913	170,789

Source: JICA Study Team

The irrigation water demands for the new irrigation area in 2030 were estimated at 1,341 MCM/year consisting of 1,284 MCM/year for the surface irrigation, and 27 MCM/year for the groundwater irrigation, and 30 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (LVNCA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	4	133	535	668	0	0	668	672
Small scale	13	308	0	308	14	30	352	365
Private	1	308	0	308	13	0	321	322
Total	18	749	535	1,284	27	30	1,341	1,359

Source: JICA Study Team

4.3.2 Development Plan in Lake Victoria South Catchment Area

(1) Current Situation of Irrigation Development

LVSCA is horseshoe shaped and encloses the bay of Lake Victoria. Many rivers discharge river water to the lake and develop alluvial plains such as the Kano plain. The northern half of the LVSCA has ample annual rainfall (1,000~1,600 mm) and is wet, but the southern half has a semi-arid climate. The high and medium potential agricultural areas in LVSCA were estimated at 1.88 million ha by MOA (Table 3.4.2). The present cropping area in LVSCA in 2011 was 533,655 ha in total, consisting of 343,634 ha (64.4%) of maize, 85,397 ha (16.0%) of horticulture crops, 4,106 ha (0.8%) of rice, and 100,518 ha (18.8%) of other food crops (Table 2.3.2). The utilization ratio of high and medium potential agricultural areas by crop production is estimated at about 28%. Most of them are under rainfed agriculture. The existing irrigation area in LVSCA in 2010 was 13,218 ha in total, consisting of 1,800 ha (14%) of public irrigation schemes, 10,225 ha (77%) of smallholder irrigation schemes, and 1,193 ha (9%) of private schemes. The share of irrigation area compared to the cropping area is 2.4% only. Most of all existing irrigation systems need rehabilitation.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in Section 4.2, the strategy for irrigation development in LVSCA was set as follows:

a) To utilise available water resources efficiently for the maximisation of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;
b) To strengthen the agricultural sector in LVSCA, irrigation should be expanded in rainfed agricultural areas to increase agricultural productivity and production; and
c) Owing to the sufficient land and water resources available for irrigation in LVSCA, the priority to maximise the irrigation area should be given to both dam irrigation and weir irrigation, and then to small scale dam and groundwater irrigation as far as water resources are available

(3) Proposed Development Plan

A water balance study by sub-basin in LVSCA revealed that the possible maximum surface irrigation area would be 114,967 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large scale irrigation projects (more than 500 ha), seven projects proposed by the government authorities and three projects proposed in this study listed in Table 2.5.1 were taken up for the water balance study, and eight projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in LVSCA as shown in Table 3.4.7. They are listed below.

a) Kano Plain Irrigation Project (15,000 ha, Magwagwa Multipurpose Dam);
b) Lower Kuja Irrigation Project (40,500 ha, weir and Katieno Multipurpose Dam);
c) Ahero and West Kano Irrigation Project (1,800 ha, Weir and Pump);
d) Nandi Forest Dam Irrigation Project (7,272 ha, Nandi Forest Multipurpose Dam);
e) Nyando Dam Irrigation Project (3,000 ha, Nyando Multipurpose Dam);
f) Amala Dam Irrigation Project (5,000 ha, Amala Multipurpose Dam); and
g) Ilooiterre Dam Irrigation Project (3,000 ha, Ilooiterre Multipurpose Dam).

The Kano Irrigation Project was planned to irrigate 15,000 ha of fertile flat land in the Kano plain nearby Lake Victoria. The water source for this project is the released water from the Magwagwa Hydropower Dam, which is going to be constructed soon. Owing to the reliable water source by the dam, realization of this project became the top priority in LVSCA.

The Lower Kuja Irrigation Project is planned to develop the low-lying flat plain by using water from the Kuja River, and to contribute to increase agricultural production in the existing huge rainfed agriculture areas. The project is expected to be realised in two phases. Phase-1 is to develop 7,800 ha using water from the Kuja River. The detailed design for Phase-1 was completed in 2011 with assistance from the World Bank. Phase-2 was planned to develop another 32,700 ha (possible maximum irrigable area by a dam through a water balance study) by the Katieno Hydropower Dam which is to be constructed nearby the existing Gogo Falls Hydropower Dam. The Nandi Irrigation Project was planned to be irrigated by water from the proposed Nandi Forest Hydropower Dam which is to be constructed in LVSCA. The remaining four projects, namely the Nyando, Amala, and Ilooiterre Dam Irrigation Projects were planned to be irrigated by the water from multipurpose dams and will require time for project preparation. When the construction of the multipurpose dam commences, the feasibility study and detailed design work should be conducted.

The future maximum groundwater irrigation area in LVSCA was estimated at 6,867 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in LVSCA were estimated at 4,590 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in LVSCA by category are summarised as follows:

Maximum Irrigation Area in 2030 (LVSCA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	1,800	1,800	73,772	75,572	0	0	75,572	77,372
Small-scale	10,225	14,477	0	14,477	3,434	4,590	22,501	32,726
Private	1,193	11,700	0	11,700	3,433	0	15,133	16,326
Total	13,218	27,977	73,772	101,749	6,867	4,590	113,206	126,424

Source: JICA Study Team

The irrigation water demands for the new irrigation area in 2030 were estimated at 1,003 MCM/year consisting of 915 MCM/year for the surface irrigation, 51 MCM/year for the groundwater irrigation, and 37 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (LVSCA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	22	25	732	757	0	0	757	779
Small scale	121	83	0	83	26	37	146	267
Private	12	75	0	75	25	0	100	112
Total	155	183	732	915	51	37	1,003	1,158

Source: JICA Study Team

4.3.3 Development Plan in Rift Valley Catchment Area

(1) Current Situation of Irrigation Development

RVCA stretches 870 km from north to south. The central part of RVCA is highland. Rivers flow from the highland to the north or to the south. The climate in RVCA is widely variable by elevation from wet zones on the highland to semi-arid and arid zones in the lowland. The high and medium potential agricultural areas in RVCA were estimated at 1.36 million ha by MOA (Table 3.4.2). The present cropping area in RVCA in 2011 was 303,856 ha in total, consisting of 220,453 ha (72.6%) of maize, 69,237 ha (22.8%) of horticulture crops, and 14,166 ha (4.6%) of other food crops (Table 2.3.2). The utilization ratio of high and medium potential agricultural area by crop production is estimated at about 22%. RVCA is known as a maize production center. Most of them are under rainfed culture. The irrigation area in RVCA is located mostly on the highland. The existing irrigation area in 2010 was 9,587 ha in total, consisting of 774 ha of public irrigation schemes, 5,791 ha of smallholder irrigation schemes, and 3,022 ha of private schemes. The share of irrigation area compared to the cropping area is 4.3% only.

(2) Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 4.2, strategy for irrigation development in RVCA was set as follows.

a) To utilise available water resources efficiently for the maximisation of irrigation development, the water-saving irrigation methods should be introduced to improve water productivity of all irrigation areas;
b) To strengthen the agricultural sector in RVCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and
c) Owing to the sufficient land resources available, but limited water resources for irrigation in RVCA, priority to maximise irrigation area should be given to dam irrigation in arid and semi-arid lands. Furthermore, small-scale dam irrigation and groundwater irrigation should be developed as far as water resources are available.

(3) Proposed Development Plan

A water balance study by sub-basin in RVCA revealed that the possible maximum surface irrigation area would be 96,772 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large scale irrigation projects (more than 500 ha), 30 projects proposed by the government authorities listed in Table 2.5.1 were taken up for the water balance study, and nine projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in RVCA as shown in Table 3.4.7. They are listed below.

a) Arror Dam Irrigation Project (10,850 ha, Arror Multipurpose Dam);
b) Perkera Irrigation Extension Project (3,000 ha, existing Perkera Dam);
c) Turkwel Irrigation Project (5,000 ha, existing Turkwel Dam);
d) Norera Irrigation Project (2,000 ha, Upper Narok Multipurpose Dam);
e) Lower Ewaso Ng'iro Dam Irrigation Project (15,000 ha, Oletukat Multipurpose Dam);
f) Todonyang-Omo Irrigation Project (35,000 ha, Gibe 3 Hydropower Dam in Ethiopia);
g) Kimwarer Dam Irrigation Project (2,000 ha, Kimware Multipurpose Dam);

h) Oldekesi Irrigation Project (2,000 ha, Weir); and
i) Embobut Dam Irrigation Project (2,000 ha, Embobut Multipurpose Dam).

The Arror Irrigation Project was planned to irrigate 10,850 ha with a water source from the Arror Multipurpose Dam. This is the top priority project in RVCA. The Perkera and Turkwel Irrigation Projects were planned to extend irrigation area through the efficient use of existing dams. In particular, the Turkwel Irrigation Project will contribute greatly to the development of ASAL by using the existing Turkwel Dam which was completed in 1991. The Lower Ewaso Ng'iro Irrigation Project is the largest development in the southern part of RVCA. The water source is expected to be supplied from the proposed Oldorko Multipurpose Dam.

The Todonyang-Omo Irrigation Project was planned to develop ASAL nearby Lake Turkana (saline lake). The water source for the project is the Gibe 3 Hydropower Dam which is under construction on the Omo River in Ethiopia. After the completion of the dam in 2016, regulated water on the Omo River becomes available. This project will contribute to the irrigation development in ASAL greatly. The feasibility study should be conducted as soon as possible. The remaining three irrigation projects, namely Kimwarer, Oldekesi, and Embobut Dam Irrigation Projects, are judged as technically possible, with water sources available by dams, and can contribute to the development of ASAL in RVCA greatly, though detailed information is limited (feasibility study are on-going or pre-feasibility study have been done).

Future maximum groundwater irrigation area in RVCA was estimated at 2,091 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in RVCA are estimated at 2,890 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in RVCA by category are summarised as follows:

Maximum Irrigation Area in 2030 (RVCA)

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total New Irrigation Area	
		Weir	Dam	Total				
Large-scale	774	7,000	71,850	78,850	0	0	78,850	79,624
Small-scale	5,791	5,335	0	5,335	1,046	2,890	9,271	15,062
Private	3,022	3,000	0	3,000	1,045	0	4,045	7,067
Total	9,587	15,335	71,850	87,185	2,091	2,890	92,166	101,753

Source: JICA Study Team

The irrigation water demands for the new irrigation area in 2030 were estimated at 1,250 MCM/year consisting of 1,211 MCM/year for the surface irrigation, 16 MCM/year for the groundwater irrigation, and 23 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (RVCA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	12	49	1,101	1,150	0	0	1,150	1,162
Small scale	90	38	0	38	8	23	69	159
Private	41	23	0	23	8	0	31	72
Total	143	110	1,101	1,211	16	23	1,250	1,393

Source: JICA Study Team

4.3.4 Development Plan in Athi Catchment Area

(1) Current Situation of Irrigation Development

The Ahi River is one of the major river systems in Kenya running from the highland near Nairobi (EL 1,700 m) to the Indian Ocean near Mombasa. The highland in ACA receives ample rainfall and is a wet climate. However, available water is very tight due to large water users such as domestic use in urban areas and irrigated agriculture. The high and medium potential agricultural area in ACA was estimated at 1.65 million ha by MOA (Table 3.4.2). The present cropping area in ACA in 2011 was 876,544 ha in total, consisting of 433,967 ha (49.5%) of maize, 144,199 ha (16.5%) of horticulture crops, 212,069 ha (24.2%) of beans, and 86,309 ha (9.8%) of other food crops (Table 2.3.2). The utilization ratio of high and medium potential agricultural areas by crop production are estimated at about 53%. Most of them are under rainfed agriculture. The existing irrigation area in ACA was estimated at 44,898 ha in 2010, consisting of 13,524 ha of small scale schemes, and 31,374 ha of private schemes. The share of irrigation area compared to the cropping area is 5.1%. Most of all the existing irrigation systems have deteriorated mainly due to poor maintenance. Since 2009, rehabilitation and extension of existing irrigation systems have commenced with government funds.

(2) Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 4.2, strategy for irrigation development in ACA was set as follows:

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

(3) Proposed Development Plan

A water balance study by sub-basin in ACA revealed that the possible maximum surface irrigation area would be 76,968 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large-scale irrigation projects (more than 500 ha), 13 projects proposed by the government authorities listed in Table 2.5.1 were taken up for the water balance study, and four projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in ACA as shown in Table 3.4.7. They are listed below.

a) Taita Taveta 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) Kanzalu Irrigation Project (15,000 ha, Munyu Multipurpose Dam).

Although many projects were proposed by the government authorities, after the water balance study, it was revealed that almost all of the river water are fully utilised by existing irrigation schemes in ACA and there is almost impossible to use river water for new irrigation development. New development of storage dams is a solution to expand new irrigation areas in the Athi River basin.

The Kibwezi Irrigation Project aims to expand irrigation area to 17,000 ha by construction of the Thwake Multipurpose Dam having storage capacity of 594 MCM on the Athi River. TARDA has proposed the construction of the Munyu Multipurpose Dam (storage capacity of 575 MCM) located at about 180 km upstream of the Kibwezi Weir. This dam will be the water source for extension area (15,000 ha) of the existing Kanzalu Irrigation Scheme.

Future maximum groundwater irrigation area in ACA was estimated at 4,618 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in ACA are estimated at 4,140 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in ACA by category are summarised as follows:

Maximum Irrigation Area 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

The irrigation water demands for the new irrigation area in ACA in 2030 were estimated at 419 MCM/year consisting of 351 MCM/year for the surface irrigation, 35 MCM/year for the groundwater irrigation, and 33 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (ACA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	0	40	311	351	0	0	351	351
Small scale	164	0	0	0	18	33	55	215
Private	334	0	0	0	17	0	21	351
Total	498	40	311	351	35	33	419	917

Source: JICA Study Team

4.3.5 Development Plan in Tana Catchment Area

(1) Current Situation of Irrigation Development

The Tana River is the largest river in Kenya, originating from Mt. Kenya, and flows down to the Indian Ocean. The upstream of the Tana River is highland and is densely populated. Owing to ample rainfall and lower temperatures, the private sector for horticulture crop production is active. On the other hand, the lowland area in TCA is a huge unused flat area with an arid or semi-arid climate. The high and medium potential agricultural area in TCA was estimated at 2.71 million ha by MOA (Table 3.4.2). The present cropping area in TCA in 2011 was 1,000,806 ha in total, consisting of 408,934 ha (40.9%) of maize, 151,331 ha (15.1%) of horticulture crops, 261,315 ha (26.1%) of beans, and 179,226 ha (17.9%) of other food crops (Table 2.3.2). The utilization ratio of high and medium potential agricultural areas by crop production are estimated at about 37%. Most of them are under rainfed agriculture. On the highland, there is the Mwea Irrigation Scheme which is the largest existing irrigation scheme and the largest rice bowl in Kenya. The existing irrigation area in TCA is 64,425 ha in 2010, consisting of 11,200 ha (17%) of large scale schemes, 14,823 ha (23%) of small scale schemes, and 38,402 ha (60%) of private schemes. The share of irrigation area compared to cropping area is 6.4%. Existing public irrigation systems have deteriorated due to the lack of budget for repair and maintenance for a long time.

(2) Development Strategy

Following the overall concept and framework for irrigation development mentioned in Section 4.2, the strategy for irrigation development in TCA was set as follows:

a) To utilise available water resources efficiently for the maximization of irrigation development, water-saving irrigation should be introduced to improve water productivity in all irrigation areas;
b) To strengthen the agricultural sector in TCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and

c) 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

(3) Proposed Development Plan

A water balance study by sub-basin in TCA revealed that the possible maximum surface irrigation area would be 200,386 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large-scale irrigation projects (more than 500 ha), 15 projects proposed by the government authorities and one project proposed in this study listed in Table 2.5.1 were taken up for the water balance study, and four projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in LVNCA as shown in Table 3.4.7. They are listed 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 Dam).

The High Grand Falls Irrigation Project aims to develop irrigation area in semi-arid and arid lands (ASALs) using water stored in the proposed High Grand Fall Multipurpose Dam which is to be constructed on the upper reaches of the Tana River. Water released from the dam will be taken at the proposed Nanigi Barrage located at 260 km downstream of the dam. Diverted water will be transported by a 250 km long headrace canal to irrigate an area of 106,000 ha. A feasibility study was completed in 2011 and the overall economic evaluation showed high project viability of 13% EIRR. However, NIB intends to make an alternative plan to expand irrigation area to almost 240,000 ha by dam storage. A feasibility study on the Greater Bura Irrigation Development Project was started in 2012. The Kora Irrigation Project was proposed to irrigate 25,000 ha by the Kora Dam (storage capacity of 537 MCM) to be constructed on the middle reach of the Tana River

Future maximum groundwater irrigation area in TCA was estimated at 20,108 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in TCA are estimated at 5,730 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in TCA by category are summarised as follows:

Maximum 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

The irrigation water demands for the new irrigation area in 2030 were estimated at 2,001 MCM/year consisting of 1,804 MCM/year for the surface irrigation, 107 MCM/year for the groundwater irrigation, and 46 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (TCA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	130	37	1,767	1,804	0	0	1,804	1,934
Small scale	173	0	0	0	76	46	122	295
Private	393	0	0	0	75	0	75	468
Total	696	37	1,767	1,804	151	46	2,001	2,697

Source: JICA Study Team

4.3.6 Development Plan in Ewaso Ng'iro North Catchment Area

(1) Current Situation of Irrigation Development

ENNCA is the driest catchment area in Kenya. Except for highlands at the southwest corner of ENNCA, most of all the areas have an arid climate with annual rainfall of 200~400 mm. The largest river is the Ewaso Ng'iro North River originating at highland but in the downstream section it becomes a dry river. Agricultural activity in this catchment is limited to the highland and northeast corner of the ENNCA along the Kenya-Ethiopia international river (the Galana Daua River). The high and medium potential agricultural area in ENNCA was estimated at 0.50 million ha by MOA (Table 3.4.2). The present cropping area in ENNCA in 2011 was 194,123 ha in total, consisting of 111,118 ha (57.2%) of maize, 55,395 ha (28.5%) of horticulture crops, and 27,610 ha (14.3%) of other food crops (Table 2.3.2). Utilization ratio of high and medium potential agricultural areas by crop production are estimated at about 39%. Most of them are under rainfed agriculture. The existing irrigation area is 7,896 ha in 2010, consisting of 6,233 ha (79%) of small scale schemes, and 1,663 ha (21%) of private schemes. The share of irrigation area compared to the cropping area is 4.1%.

(2) Development Strategy

Following the overall concept and frameworks for irrigation development mentioned in Section 4.2, the strategy for irrigation development in ENNCA was set as follows:

a) To utilise limited water resources efficiently for the maximization of irrigation area, the water-saving irrigation methods should be introduced to improve water productivity in all irrigation areas;
b) To strengthen the agricultural sector in ENNCA, irrigation should be expanded in rainfed agricultural areas in arid and semi-arid lands to increase agricultural productivity and production; and
c) Due to quite limited river water resources 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.

(3) Proposed Development Plan

A water balance study by sub-basin in ENNCA revealed that the possible maximum surface irrigation area would be 34,098 ha including existing irrigation area under the dry-year discharge of one in five years probability, on condition that the water-saving irrigation methods would be introduced in 2030, or the overall irrigation efficiency is 70% as mentioned in Section 4.2.

As for the large-scale irrigation projects (more than 500 ha), three projects proposed by the government authorities and one project proposed in this study listed in Table 2.5.1 were taken up for the water balance study, and three projects were selected for implementation by 2030 as suitable projects to contribute to the maximization of irrigation area in ENNCA as shown in Table 3.4.7. They are listed below.

a) Kieni Irrigation Project (4,202 ha, Weir);
b) Kom (Wajir) Dam Irrigation Project (4,000 ha, Archers' Post Multipurpose Dam); and
c) Kihoto Dam Irrigation Project (18,000 ha, Kihoto Multipurpose dam).

The Kieni Irrigation Project was originally planned to irrigate 3,500 ha by a river water. However, after the water balance study irrigation area was increased to be 4,202 ha as a maximum irrigable area. The project has no technical difficulty, no environmental problems and was evaluated as a viable project. The detailed design is under way. The Kom (Wajir) Irrigation Project is to develop irrigation in the arid zone. The water source is the proposed Archers' Post multipurpose dam which is to be constructed on the middle reaches of the Ewaso Ng'iro North River. The Kihoto Irrigation Project is proposed in the highland of ENNCA. The Kihoto Dam will be constructed at about 50 km north of Mt. Kenya. Owing to ample water resources, this project is viable, but implementation timing will be late due to the delay of the project preparation.

Future maximum groundwater irrigation area in ENNCA was estimated at 14,331 ha in total with a comparison of available groundwater resources for irrigation by sub-basin (Table 3.2.3) and unit irrigation water requirement of 7,500 m^3/year/ha, which is the average amount to issue water permit by WRMA. Irrigation areas by the small dam and water pan in ENNCA are estimated at 950 ha according the criteria mentioned in Section 4.2.

The maximum irrigation development areas in ENNCA by category are summarised as follows:

Maximum 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

The irrigation water demands for the new irrigation area in 2030 were estimated at 447 MCM/year consisting of 333 MCM/year for the surface irrigation, 107 MCM/year for the groundwater irrigation, and 7 MCM/year for the small dam/water pan irrigation as shown below.

Irrigation Water Demand in 2030 (ENNCA)

（Unit：MCM/year）

Category	Present Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Demand in 2030
		Surface Water Irrigation			Ground-water Irrigation (Borehole)	Water Harvesting Irrigation (Small Dam/ Water Pan)	Total	
		Weir	Dam	Total				
Large scale	0	31	302	333	0	0	333	333
Small scale	74	0	0	0	54	7	61	135
Private	18	0	0	0	53	0	53	71
Total	92	31	302	333	107	7	447	539

Source: JICA Study Team

CHAPTER 5 COST ESTIMATE

5.1 Basic Conditions for the Project Cost Estimate

The project cost of irrigation development in this study is assumed to be a summation of: (a) direct construction cost of civil works, (b) physical contingency, (c) costs of engineering services (detailed design and construction supervision), (d) indirect costs associated to the project implementation, and (e) costs of land acquisition and resettlement of people. The cost of government's administration and government taxes were not included in the project cost. In this study, the construction cost means a direct construction cost of civil works.

The construction cost for large scale irrigation projects proposed by the government authorities and small scale irrigation projects proposed by PIO and DIO were taken into consideration in the study with some modification, when necessary. The costs of each project were updated to be the price level as of November 1, 2012. The construction cost of private irrigation schemes was assumed referring to the recent investment cost for drip irrigation system by private investors.

It should be noted that the construction costs presented in the study are an approximate or notional figures with an aim to make a projection of the future financial status.

The basic conditions applied to the cost estimate are: (a) physical contingency as 15% of the direct construction cost, (b) engineering service cost as 10% of the direct construction cost, and (c) land acquisition cost as KSh 100,000 per ha, if no studies/estimates are available. The construction cost of multipurpose dams were allocated on the basis of the existing feasibility studies, the role of leading sub-sector in project implementation, and water storage volume as shown in Sectoral Report (G).

5.2 Cost Estimate

5.2.1 Project Cost

Construction costs of proposed large scale irrigation projects were estimated or assumed referring to the cost estimate provided by the government authorities as shown in Table 3.4.7.

Construction costs for new irrigation projects without feasibility studies were estimated assuming the unit construction cost by type of irrigation as follows.

- Large scale dam irrigation project: KSh 800,000 /ha
- Small scale dam irrigation project: KSh 600,000 /ha.
- Weir irrigation project: KSh 400,000 /ha.
- Groundwater irrigation project: KSh 900,000 /ha
- Small dam/water pan irrigation project: KSh 600,000 /ha
- Private irrigation project: KSh 1.5 million/ha

The construction cost and project cost of the proposed irrigation development was estimated as shown in Table 5.2.1 and summarised below.

Construction Cost for Irrigation Development

(Unit: KSh million)

Category	Total Cost	Construction Cost					
		LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Large scale Irrigation	446,932	48,525	60,931	52,009	15,149	258,418	11,900
Small scale Irrigation	56,640	23,561	11,251	4,636	3,242	7,892	4,058
Private Irrigation	123,245	65,132	22,700	6,068	3,516	15,081	10,748
Total	624,817	137,218	94,881	62,712	21,907	281,391	26,706

Source: JICA Study Team

The project cost of the proposed irrigation development was estimated by catchment area with an assumption as mentioned in section 5.1 above.

Project Cost for Irrigation Development

(Unit: KSh million)

Category	Total Cost	Project Cost					
		LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Large scale Irrigation							
Cost for Irrigation	555,384	62,714	78,869	67,219	19,580	311,620	15,380
Multi-dam cost share	170,183	19,478	49,388	42,740	14,397	13,255	30,925
Sub-total	725,567	82,194	128,257	109,959	33,977	324,875	46,305
Small scale Irrigation	70,617	30,451	14,540	5,991	4,190	10,200	5,245
Private Irrigation	159,283	84,178	29,338	7,842	4,544	19,491	13,890
Total	955,467	196,823	172,135	123,792	42,711	354,566	65,440

Source: JICA Study Team

5.2.2 Operation and Maintenance Cost

Annual operation and maintenance (O&M) costs for completed project facilities are assumed as a fixed rate of percentage to the construction cost, namely 0.3% per year of the construction cost for large-scale irrigation projects, 0.5% for small-scale irrigation projects, and 1.0% for private irrigation projects. The construction costs include costs of main water source facility (dam, diversion weir, etc.) and irrigation systems. The fixed rates were assumed on the basis of actual O&M costs, and composition of source facilities and irrigation systems in the projects.

5.2.3 Replacement Cost

Replacement costs of project facilities such as metal works and pump sets are assumed to be required every 20 years at an amount of 20% of the construction cost.

CHAPTER 6 ECONOMIC EVALUATION

6.1 Evaluation Method and Basic Conditions

The economic viability of the proposed projects was analysed based on the calculation of cash flow of economic costs and the economic benefits for the whole economic life period of project. The results of the economic evaluation are presented in the form of Net Present Value (NPV), Benefit and Cost Ratio (B/C), and Economic Internal Rate of Return (EIRR).

The following assumptions were made for economic analysis.

a) Price Level:

The investment costs and O&M costs are estimated at the price level as of November 1, 2012. The foreign exchange rate was set at KSh 85.24 to US$1.00.

b) Economic Cost:

The prices of internationally tradable goods and services will be valued on the basis of the international border prices, which are often expressed in the World Bank's "Commodity Prices and Price Forecast". The prices of non-traded goods and services will be converted from their financial cost to economic cost 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.

c) 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.

d) Construction Period:

The construction period was assumed to be 2-3 years for rehabilitation/extension type projects, 4-5 years for new weir irrigation projects, and 5-7 years for dam irrigation projects. For large irrigation project with feasibility studies, the construction period in the report will be followed.

e) Economic Life of Projects:

The economic life of the projects was set at 50 years for irrigation projects. However, part of the project facilities such as mechanical gates and pumps are assumed to be replaced in every 20 years within the economic life.

f) Multipurpose Dams:

The project costs and annual O&M costs of multipurpose dams are allocated on the basis of the existing F/S, the role of leading sub-sectors in project implementation, and water storage volume.

An economic evaluation was conducted for 18 large scale irrigation projects, which were selected because (a) detailed information necessary for evaluation is available, (b) they are technically sound, (c) there are no serious environmental and social problems, and (d) priority for implementation by the related government agency is high.

Selected Large-scale Irrigation Project for Economic Evaluation

Catchment Area	No	Name of Irrigation Project	Irrigation Area (ha)	Water Source Facility	Project Cost (KSh mil)*
LVNCA	1	Yala Swamp Drainage & Irrigation	4,600	Weir	2,995
LVSCA	2	Nandi Forest Dam Irrigation	7,272	Dam	25,734
	3	Ahero and West Kano Irrigation	1,800	Weir	1,126
	4	Kano Plain Irrigation	15,000	Dam	24,593
RVCA	5	Arror Dam Irrigation	10,850	Dam	15,663
	6	Lower Ewaso Ng'iro Dam Irrigation	15,000	Dam	29,893
	7	Perkera Irrigarion Extension	3,000	Dam (exist)	2,865
	8	Turkwel Irrigation	5,000	Dam (exist)	4,620
ACA	9	Kanzal Irrigation Extension	15,000	Dam	16,403
	10	Kibwezi Irrigation Extension	17,000	Dam	14,602
	11	Taita Taveta Irrigation Extension	3780	Weir	2,346
TCA	12	High Grand Falls Dam Irrigation	106,000	Dam	290,400
	13	Hola Irrigation Greater Extension	4,161	Weir	4,066
ENNCA	14	Kom (Wajir) Dam Irrigation	4,000	Dam	19,317

Note: *: Project cost includes construction cost, contingency, engineering service, land acquisition, multipurpose dam cost allocation (refer to Table 5.2.1)
Source: JICA Study Team

6.2 Economic Benefit

The economic benefit of irrigation projects derives from the increased agricultural production and change of cropping pattern in the project area under the with-without project conditions. It is assumed that the current rain-fed agricultural land in the without-project conditions is assumed to be cultivated by maize (100% of maize cultivation in LVNCA and LVSCA, 80% of maize cultivation in RVCA, ACA, TCA and ENNCA). In the High Grand Falls Project, this study assumes that only 20% of the dry land is cultivated based on the information from the feasibility study and land use pattern in the project area.

For future agricultural production it was considered desirable for farmers to cultivate a high-value of horticulture crops to maximum the return from the irrigation. Therefore cropping area of maize is assumed during the rainy season in the with-project conditions, while the horticulture crops such as tomato, onion, cabbage, and banana would be grown during the dry season on the irrigated land. The cropping intensity (CI) in dam irrigation projects is set at 160%, since water storage in dam could be utilised during the dry season. On the other hand, weir irrigation projects would not allow a full water availability during the dry season, and therefore, it was assumed at 160% of CI for weir irrigation projects.

The benefits would be starting from the 3rd year in weir irrigation projects and it takes 5 years to reach its full development; 20% of full benefits in the 3rd year, 40% in the 4th year, 60% in the 5th year, 80 % in the 6th year. In dam irrigation projects, the benefit is assumed to build up from the 5th year since the construction of dam normally takes more time. On the other hand, the full project benefits in dam irrigation schemes would be reached in the 9th year of the project life. The following table summarises the current and future cropping and yield pattern in the project area.

Cropping Pattern in With-Without Project Conditions

Category	Season	Without-Project	With-Project			
			Dam Irrigation	Weir Irrigation		
				LVNCA LVSCA	RVCA TCA	ACA ENNCA
Cropping Pattern						
Maize	Long Rain	80%-100%	100%	100%	100%	80%
Horticulture	Short Rain	-	100%	60%	30%	20%
Annual Cropping Intensity		80%-100%	200%	160%	130%	100%
Unit Yield						
Maize	Long Rain	1.8 tons/ha	3.5 tons/ha			
Horticulture	Short Rain	-	22 tons/ha for Onion, 15.5 tons/ha for Tomato, 17.5 tons/ha for Cabbage, 21 tons/ha for Banana			
Yield Increase Rate			Start from the 5rd year, build up in 5 years	Start from the 5th year, build up in 5 years		

Source: JICA Study Team, based on data from NIB and F/S for High Grand Falls Project

The crop price is an important factor for farmers to decide which crop to irrigate in order to maximise the return from irrigation. In this study, the farm gate price was calculated using the data from the Economic Review of Agriculture 2012 for the annual wholesale commodity prices between 2008 and 2011 and the Daily Business for wholesale price as of November 1, 2012 in order to obtain the average prices in the past 5 years. The latest 5-year average prices are applied in this study because agricultural prices change yearly due to drought, commodity market fluctuation and so on.

Local agricultural wholesale prices vary from region to region, as described in Sectoral Report (A), but the details of local prices are not certain at this preliminary stage, therefore the study uses the national average prices for economic evaluation. Wholesale price is further deducted by 20% for maize and banana and 30% for horticulture assuming the middleman’s margin prevailing in the country. The following table shows the wholesale prices in selected commodities in Kenya.

Wholesale Prices for Selected Agricultural Commodities between 2008 and 2012

Commodity	Unit (kg)	Wholesale Prices					
		2008	2009	2010	2011	2012	Average
Maize dry	90	2,016	2,667	1,652	2,907	2,900	2,428
Banana	14	391	562	482	557	496	498
Cabbage	99	1,269	1,971	1,528	1,618	1,600	1,597
Onion	13	583	738	736	621	848	705
Tomato	64	1,796	2,133	2,486	2,752	4,040	2,641

Note: * Wholesale commodity price as of November 1, 2012
Source: Ministry of Agriculture, Economic Review of Agriculture 2012; The Business Daily, November 2, 2012

6.3 Economic Cost

(1) Project Cost

For economic evaluation, the economic investment cost is converted to their equivalent economic value to remove transfer payments such as taxes and subsidies. Land acquisition cost is calculated for the irrigated area and estimated reservoir area.

(2) Annual Operation and Maintenance (O&M) Cost

The annual O&M cost for this study was set at 0.3% of the initial construction cost for large-scale irrigation projects, 0.5% for small-scale irrigation projects and 1.0% for private irrigation projects. The initial construction cost includes cost of the irrigation system and water source facilities (dam, weir, tubewell). The O&M cost is further converted to economic value.

(3) Replacement Cost

The replacement cost is required for project facilities such as mechanical gates every 20 years, and set at 20% of initial construction cost.

6.4 Economic Evaluation

The results of economic evaluation for selected large scale irrigation projects are as follows.

Summary of Economic Evaluation for Selected Large-scale Irrigation Project

Catchment Area	Pjt No	Name of Irrigation Project	NPV (US$ million)*		B/C	EIRR
			Cost	Benefit		
LVNCA	1	Yala Swamp Drainage & Irrigation	21	62	3.02	25.4%
LVSCA	2	Nandi Forest Dam Irrigation	188	72	0.38	3.7%
	3	Ahero and West Kano Irrigation	9	24	2.63	22.0%
	4	Kano Plain Irrigation	196	165	0.84	8.6%
RVCA	5	Arror Dam Irrigation	87	119	1.38	12.9%
	6	Lower Ewaso Ng'iro Dam Irrigation	69	165	2.38	19.0%
	7	Perkera Irrigarion Extension	18	33	1.79	15.3%
	8	Turkwel Irrigation	41	55	1.36	12.8%
ACA	9	Kanzal Irrigation Extension	194	232	1.25	12.1%
	10	Kibwezi Dam Irrigation Extension	170	263	1.55	14.5%
	11	Taita Taveta Irrigation Extension	20	29	1.24	12.1%
TCA	12	High Grand Falls Dam Irrigation	1,713	1,121	0.65	6.2%
	13	Hola Irrigation Greater Extension	27	37	1.31	12.8%
ENNCA	14	Kom (Wajir) Dam Irrigation	204	67	0.22	1.4%

Note: * = Social discount rate of 10% p.a. is assumed.
Source: JICA Study Team

Of 14 selected irrigation projects, ten irrigation projects exceeded 10% of EIRR. However other four irrigation projects were found to be marginally viable with an EIRR rate of less than 10%. The Nandi Forest Multipurpose Dam Project (the dam is in LVNCA but irrigation area is in LVSCA) was hardly economically viable, mainly due to high cost of both the dam and the irrigation system, which may suggest a review of the irrigation system plan and design. The Kano Plain Irrigation Project is a promising project but economic evaluation shows lower EIRR due to high cost allocation of the Magwagwa Multipurpose Dam. The irrigation development plan under the High Grand Falls Multipurpose Dam was made to irrigate 106,000 ha downstream of the Tana River. The EIRR is low due to the high cost of the long headrace canal. However, the economic viability of this irrigation project may become higher if the on-going feasibility study under NIB can propose attractive development plans. The Kom (Wajir) Multipurpose Dam project in ENNCA was also found to be low EIRR, mainly because of very high dam cost, though this was proposed as a national flag project. This project is located in an arid area where irrigation would be important for providing food production in the future and should be reviewed and promoted from a food security viewpoint in this area.

The economic evaluation for the whole of the large scale irrigation projects including on-going projects proposed by government authorities was examined by catchment area. Results of economic evaluation are summarised in the following table.

Summary of Economic Evaluation for Proposed Large-scale Irrigation Projects by Catchment Area

Catchment Area	Irrigation Area (ha)			NPV (US$ million)*		B/C	EIRR
	Dam Irri.	Weir Irri.	Total	Cost	Benefit		
LVNCA	65,770	12,600	78,370	604	1,185	1.96	17.2%
LVSCA	73,772	1,800	75,572	979	1,063	1.09	10.7%
RVCA	71,850	7,000	78,850	826	1,176	1.42	13.5%
ACA	32,000	5,280	37,280	330	336	1.02	10.2%
TCA	131,000	4,961	135,961	2,582	2,131	0.83	8.3%
ENNCA	22,000	4,202	26,202	337	333	0.99	9.9%
Total	396,392	35,843	432,235	5,657	6,224	1.10	10.9%

Note: * = Social discount rate of 10% p.a. is assumed.
Source: JICA Study Team

Overall large irrigation projects are economically viable with a B/C of 1.10 and an EIRR of 10.9%. The difference of economic viability by catchment area is as follows:

LVNCA: The economic viability for the whole of the catchment area is good owing to low-cost large projects such as the Lower Nzoia, Lower Sio, and Yala Swamp Irrigation Projects. The sufficient water availability and high cropping intensity for weir irrigation also increased the EIRR in this catchment.

LVSCA: The economic viability for the whole of the catchment area is higher than the standard threshold of EIRR 10% mainly due to the sufficient water availability and high crop intensity, although the high cost of the Nandi Multipurpose Dam Irrigation Project lowered the EIRR in this catchment.

RVCA: The economic viability of irrigation project for the whole of the catchment area is high owing to the relative low unit construction costs of irrigation system. Furthermore, some of the dam irrigation projects, such as the Turkana (dam is existing), and the Todonyang-Omo (a hydropower dam is under construction in Ethiopia) Projects, are weir irrigation in reality because dam cost sharing is not necessary.

ACA: The economic viability of irrigation projects for the whole of the catchment area is higher than the EIRR 10% owing to the relative low unit construction cost of irrigation system, but the low water availability and the resulting lower cropping intensity for weir irrigation lowered the economic feasibility in this catchment.

TCA: The cost of irrigation system under the High Grand Falls Multipurpose Dam Project is very high. This significantly influenced the overall economic viability of the whole of the catchment area.

ENNCA: The high cost allocation of proposed multipurpose dams (Kom Dam and Kihoto Dam) for irrigation resulted in a lower EIRR for the whole of the catchment area.

CHAPTER 7 IMPLEMENTATION PROGRAMME

7.1 General

The implementation programme for irrigation development was prepared based on the principle: (i) to complete all projects and development plans proposed by the end of fiscal year 2030/31, (ii) to make an implementation schedule with three terms, i.e. Short term from 2013/14 to 2017/18 (five years), Medium term from 2018/19 to 2022/23 (five years), and Long term from 2023/24 to 2030/31 (eight years), (iii) to give implementation priority based on maturity and readiness of projects/plans for construction, and (iv) to equalise annual expenditure for construction as much as possible.

The general criteria for project implementation scheduling by type is as follows.

(a) Rehabilitation of existing irrigation systems should have higher priority for implementation.

(b) Large scale irrigation project will be implemented by prioritization criteria (section 7.2).

(c) Small scale irrigation projects in each county are to be implemented progressively following expected budget increase by the end of 2030/31.

(d) Private irrigation schemes are assumed to be implemented progressively following expected GDP growth rate by the end of 2030/31.

The individual projects will have EIAs which will address all issues including land acquisition and compensation.

7.2 Prioritization Criteria for Implementation of Large scale Irrigation Projects

Prioritization for implementation of large scale irrigation projects will be done as follows.

1st Priority: Projects with finance.

2nd Priority: Projects with a completed detailed design.

3rd Priority: Projects with feasibility completed, and with higher economic viability.

4th Priority: Projects with feasibility completed, and with lower economic viability.

5th Priority: Projects other than the above.

7.3 Implementation Schedule of Irrigation Development toward 2030

Based on the criteria mentioned above, the implementation schedule of the irrigation projects are prepared as shown in Figures 7.3.1 to 7.3.6 by catchment area. They are briefed hereunder.

7.3.1 Lake Victoria North Catchment Area

Top priority for implementation was given to the two large scale irrigation projects, i.e. the Lower Nzoia and Lower Sio Irrigation Projects. Newly proposed projects are four, i.e. the Yala Swamp, Upper Nzoia, Moi's Bridge and Kiboro Irrigation Projects. It is assumed that four multipurpose dams, Nzoia (42A) dam, Nzoia (34) dam, Moi's Bridge dam, and Kibolo dam, be completed by 2030.

Small scale irrigation projects of 47,122 ha and private irrigation projects of 43,421 ha in total are assumed to be implemented progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (LVNCA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	78,370	14,282	8,788	55,300
Small scale Irrigation	47,122	9,425	14,136	23,561
Private Irrigation	43,421	8,684	13,026	21,711
Total	168,913	32,391	35,950	100,572

Note: Refer to Figure 7.3.1
Source: JICA Study Team

7.3.2 Lake Victoria South Catchment Area

A total of seven large scale irrigation projects will be realised by 2030. The Lower Kuja Irrigation Project was regarded as on-going status because construction of a part of the project has started by GOK fund already. Furthermore, the Lower Kuja Irrigation Project (Stage-2) was proposed to implement immediately after the Katieno Multipurpose Dam has been decided for implementation. Other new projects proposed are the Kano Plain, Ahero and West Kano, Nandi, Nyando, Amala, and Ilooiterre Projects. The Kano Plain Irrigation Project will be implemented following the construction of the Magwagwa Dam. The Nandi Forest Hydropower Dam to be constructed in LVN is a water source for the Nandi Irrigation Project in LVS.

Small scale irrigation projects of 22,501 ha and private irrigation projects of 15,133 ha in total are assumed to be implemented progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (LVSCA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	75,572	7,800	16,800	50,972
Small scale Irrigation	22,501	4,500	6,750	11,251
Private Irrigation	15,133	3,027	4,540	7,566
Total	113,206	15,327	28,090	69,789

Note: Refer to Figure 7.3.2
Source: JICA Study Team

7.3.3 Rift Valley Catchment Area

A total of nine large-scale irrigation projects would be realised by 2030. There are four projects to be completed in the medium term (2018/19 - 2022/23), i.e. Perkera, Turkwel, Arror, and Norea Projects, while there are another five projects scheduled to be completed in the long term (2023/24 - 2030/31), i.e. Lower Ewaso Ng'iro, Todonyang-Omo, Kimwarer, Oldekesi, and Embobut Projects. Water source for these five projects are multipupose dams. Timely project preparation for these dams is critical in order to realise irrigation development.

Small scale irrigation projects of 9,271 ha and private irrigation projects of 4,045 ha in total are assumed to be implemented progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (RVCA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	78,850	2,000	17,850	59,000
Small scale Irrigation	9,271	1,854	2,782	4,635
Private Irrigation	4,045	809	1,214	2,022
Total	92,166	4,663	21,846	65,657

Note: Refer to Figure 7.3.3
Source: JICA Study Team

7.3.4 Athi Catchment Area

A total of four large scale irrigation projects will be realised by 2030, namely the Tarita Taveta, Mt. Kilimanjaro, Kibwezi, and Kanzalu Projects. The Tarita Taveta and Mt. Kilimanjaro Irrigation Projects are located outside the Athi river basin and available water resources are ample. Urgent realization is expected. Both Kibwezi and Kanzalu Prrigation Projects are an extension of existing schemes supplying irrigation water from proposed multipurpose dams to be constructed on the Athi river. Proper and timely project preparation for these dams are necessary to realise these irrigation projects by 2030.

Small scale irrigation projects of 6,484 ha and private irrigation projects of 2,344 ha in total are assumed to be realised progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (ACA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	37,280	0	5,280	32,000
Small scale Irrigation	6,484	1,325	1,935	3,224
Private Irrigation	2,344	497	693	1,154
Total	46,108	1,822	7,908	36,378

Note: Refer to Figure 7.3.4
Source: JICA Study Team

7.3.5 Tana Catchment Area

A total of four large scale irrigation projects will be realised by 2030, namely the Hola Pump, Hola Greater Extension, High Grand Falls, and Kora Projects. Both Hola Pump and Hola Greater Extension Projects area rehabilitation and extension of existing Hola Irrigation Scheme to divert water from the Tana River, and recommended to implement with priority. The irrigation area by the High Grand Falls Multipurpose Dam may be increased according to the results of the on-going feasibility study titled the Greater Bura Irrigation Development Project under NIB to be completed in 2014. The construction of irrigation system under the High Grand Falls Dam was assumed to be completed in 12 years. The Kora Irrigation Project was planned to irrigate 25,000 ha by a newly proposed Kora Dam on the Tana River. The irrigation area can cover several existing irrigation schemes.

Small scale irrigation projects covering 15,784 ha and private irrigation projects of 10,054 ha in total are assumed to be implemented progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (TCA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	135,961	0	40,294	95,667
Small scale Irrigation	15,784	3,157	4,735	7,892
Private Irrigation	10,054	2,011	3,016	5,027
Total	161,799	5,168	48,045	108,586

Note: Refer to Figure 7.3.5
Source: JICA Study Team

7.3.6 Ewaso Ng'iro North Catchment Area

A total of three large scale irrigation projects will be realised by 2030, namely Kieni, Kom (Wajir), and Kihoto Projects. The Kom (Wajir) Dam Irrigation Project is a national flagship project to develop ASAL in ENNCA and expected to be commenced within the medium term. The Kiboho Dam Irrigation Project is expected to be realised by 2030 owing to its great project benefits.

Small scale irrigation projects covering 8,166 ha and private irrigation projects of 7,165 ha in total are assumed to be implemented progressively by 2030.

The expected term-wise achievement rates of proposed new irrigation development are shown below.

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development (ENNCA)

(Unit: ha)

Category	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
Large scale Irrigation	26,202	0	4,202	22,000
Small scale Irrigation	8,116	1,623	2,435	4,058
Private Irrigation	7,165	1,433	2,150	3,582
Total	41,483	3,056	8,787	29,640

Note: Refer to Figure 7.3.6
Source: JICA Study Team

7.3.7 Summary of Term-Wise Achievement Rates

The expected term-wise achievement rates of proposed new irrigation development by catchment area are summarised as follows:

Expected Term-Wise Achievement Rates of Proposed New Irrigation Development by Catchment Area

(Unit: ha)

Catchment Area	Total	Short Term (2013/14 - 2017/18)	Medium Term (2013/14 - 2017/18)	Long Term (2013/14 - 2017/18)
LVNCA	168,913	32,391	35,950	100,572
LVSCA	113,206	15,327	28,090	69,789
RVCA	92,166	4,663	21,846	65,657
ACA	46,108	1,822	7,908	36,378
TCA	161,799	5,168	48,045	108,586
ENNCA	41,483	3,056	8,787	29,640
Total	623,675	62,427	150,626	410,622

Source: JICA Study Team

7.4 Recommendations for Further Surveys and Studies for NWMP2030

In the course of projection of irrigation water demand and formulation of the irrigation development plan, several assumptions had to be introduced due to lack or insufficiency of the required data and information. For the further study, the following actions are recommended.

(1) Review of Basic Conditions for Planning

For the projection of irrigation water demand and formulation of the irrigation development plan, the basic conditions for planning were assumed as follows:

a) Surface water irrigation efficiency (70%)
b) Cropping intensity (100%-160%)
c) Water-saving irrigation (50% of irrigation area; 25% by drip irrigation and 25% by sprinkler irrigation)
d) Groundwater irrigation efficiency (83%)
e) Water harvesting irrigation (4% of new irrigation area)

Items a) and b) are mostly based on the empirical values, but they should be confirmed by actual values at sites. Items c), d) and e) are assumptions for the planning and they will be different from region to region. The policies and strategies for introduction of water-saving irrigation, groundwater irrigation and water harvesting irrigation will be required.

As the above conditions are related to irrigation water demand and finally water resources development and management, it is recommended to review the above basic conditions by accumulating the actual data.

(2) Incentives for Introduction of Water-saving Irrigation

In Kenya, efficient use of the limited water resources is important to increase water productivity and agricultural productivity. The water-saving irrigation methods proposed in this study are low-head drip irrigation, low-head sprinkler irrigation and piped irrigation, which are cost effective. To promote introduction of such water-saving methods, it is recommended to set up a government policy i) to give incentive to farmers for introduction of water-saving methods, and ii) to make a guidelines in which the introduction of water-saving irrigation is a condition to approve a new irrigation project.

(3) Review of Existing Irrigation Development Plans

Most of all weir irrigation projects proposed by the government authorities seems to be planned to utilise available river water without considering WRMA's guidelines for water allocation. WRMA's guidelines states that the priority of river water use has been given to reserve, domestic/industrial water supply and livestock water supply.

It is recommended to review the existing irrigation development plans based on the WRMA's guidelines.

(4) Establishment of Irrigation Database

For preparation and revision of the irrigation development policy and strategy, accumulation of the accurate data and analysis of them are essential. However, such activities have not been enough since the 1990's. The irrigation development data including proposals are available at the field offices, NIB, executing authorities of MORDA and other related authorities. MWI has recently started to establish a database for the inventory of the existing, on-going and proposed irrigation and drainage schemes. It is recommended to accelerate to the establishment of the irrigation database to share the irrigation data effectively among the relevant agencies.

Tables

Table 1.3.1 Land Classification Criteria for Crop Cultivation

A. Upland Crops

Land Classification	Land Class		
	S1	S2	S3
Texture (s)	Sandy loam to friable clay loam	Sandy loam to very permeable clay, non-compacted	Loamy sand to permesble clay
Depth (s) To Sand. Gravel	90cm. plus and greater than 150cm.to impermeable	60cm. plus and greater than 120cm. to impermeable horizon	45cm. plus and greater than 100cm to impermeable horizon
Alkalinity (reaction)	pH-H2O less than 7.5 for noncalacareous soils and less than 8.6 for calcareous soils	pH-H2O less than 9.0 unless soils is calcareous and non sodic	pH-H2O less than 9.0 unless soils is calcareous and non sodic
Salinity (ECe)	Total salts not to exceed 0.2%, ECe less than 4mhos/cm	Total salts not to exceed 0.5% Ece less than 8mhos/cm	Total salts not to exceed 0.5% Ece less than 8mhos/cm
Slopes (t)	Flat to very gently undulating (less than 2%)	Flat to very gently undulating (less than 5% in general)	Flat to undulating (less than 8% in general)
Surface (Micro Relief)	Even enough to require only small amounts of leveling and no heavy grading	Moderate grading required but in amounts found feasible at reasonable cost	Heavy and expensive grading required
Vegetation	Woody cover less than 20% Clearing small cost	Woody cover less than 40%. Clearing required but at a moderate cost	Woody cover less than 80%. Expensive clearing costs
Drainage (d)	Well drained to moderately well drained. No flooding	Well drained to imperfectly drained. May have surface water for short periods	Well drained to poorly drained, may have surface water for several months

B. Paddy

Land Classification	Land Class		
	S1	S2	S3
Texture (s) Top soil	fine sandy loam to clay.	fine sandy loam to clay loam.	sandy loam to clay loam.
Sub soil	clay but non-compacted	clay but non-compacted	Sclay to clay loam but non-compacted
Depth (land development.)			
To clear sand-gravel	Over 80cm	Over 50cm	Over 30cm
To permeable rock.	Over 80cm	Over 50cm	Over 30cm
To relatively impermeable zone	Less than 210cm	Less than 210cm	Less than 210cm
Alkalinity (Reaction)	pH-H2O less than 7.5 for noncalacareous soils and less than 8.6 for calcareous soils	pH-H2O less than 9.0 unless soils is calcareous and non sodic	pH-H2O less than 9.0 unless soils is calcareous and non sodic
Salinity (ECe)	Total salts not to exceed 0.2%, ECe less than 4mhos/cm	Total salts not to exceed 0.5% Ece less than 8mhos/cm	Total salts not to exceed 0.5% Ece less than 8mhos/cm
Slopes (t)	Less than 1%	Less than 1%	Less than 2%
Surface (Micro Relief)	Smooth except for gilgal and minor undulations	Smooth except for gilgal and minor undulations (sink holes)	Somewhat irregular but no major gulleys, sink holes or dissections.
Vegetation	Woody cover less than 20% Clearing small cost	Woody cover less than 40%. Clearing required but at a moderate cost	Woody cover less than 80%. Expensive clearing costs
Drainage (d)	Well drained to imperfectly drained. May have surface water but only for short periods	Well drained to poorly drained, may have surface water for several months	Well drained to poorly drained, may have surface water or be water logged for major parts of the year.

Source: NWMP (1992), Sectoral Report (E)

Table 1.3.2 Suitable Area for Major Crops by County (1/5)

(Unit: km^2)

Province	County	Maize				Wheat				Rice			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
Texture (s)	Bungoma	34	1,261	869	2,164	0	81	0	81	0	0	730	730
	Busia	0	155	777	932	0	0	0	0	0	0	960	960
	Kakamega	8	1,862	405	2,276	0	0	13	13	0	0	1,004	1,004
	Vihiga	3	621	135	759	0	0	4	4	0	0	335	335
Nyanza	Homa Bay	20	69	2,053	2,141	0	0	0	0	0	0	1,608	1,608
	Kisii	0	1,083	123	1,207	0	129	12	141	0	0	11	11
	Kisumu	0	190	1,117	1,307	0	13	0	13	0	0	1,057	1,057
	Migori	17	58	1,748	1,824	0	0	0	0	0	0	1,370	1,370
	Nyamira	0	753	86	838	0	90	8	98	0	0	7	7
	Siaya	0	229	1,805	2,034	0	0	0	0	0	0	1,967	1,967
Rift Valley	Baringo	0	368	542	910	39	161	46	246	0	0	1	1
	Bomet	1	549	1,216	1,765	43	150	120	313	0	0	77	77
	Elgeyo Marakwet	0	183	146	329	38	89	53	180	0	0	0	0
	Kajiado	0	39	655	694	0	32	178	210	0	0	0	0
	Kericho	0	431	955	1,387	34	117	95	246	0	0	60	60
	Laikipia	0	239	6	245	0	334	691	1,025	0	0	0	0
	Nakuru	0	540	699	1,239	0	1,063	786	1,849	0	0	0	0
	Nandi	4	1,707	291	2,002	339	156	158	653	0	0	10	10
	Narok	0	1,039	2,994	4,033	223	620	2,891	3,734	0	0	10	10
	Samburu	0	0	0	0	0	0	253	253	0	0	0	0
	Trans Nzoia	33	1,162	286	1,481	81	354	245	680	0	0	0	0
	Turkana	0	0	0	0	0	0	0	0	0	0	0	0
	Uasin Gishu	34	620	1,679	2,333	272	287	1,600	2,159	0	0	0	0
	West Pokot	0	3	92	95	0	0	132	132	0	0	0	0
Central	Kiambu	252	574	250	1,076	27	260	44	331	0	0	0	0
	Kirinyaga	159	592	150	901	0	0	0	0	0	0	153	153
	Muranga	345	640	244	1,229	0	43	0	43	0	0	61	61
	Nyandarua	0	43	30	73	0	0	0	0	0	0	0	0
	Nyeri	328	575	4	907	0	361	278	639	0	0	2	2
Nairobi	Nairobi	0	82	202	284	0	2	0	2	0	0	0	0
Eastern	Embu	94	449	239	782	0	0	0	0	0	0	187	187
	Isiolo	0	0	0	0	0	0	0	0	0	0	0	0
	Kitui	0	0	0	0	0	0	0	0	0	0	0	0
	Machakos	0	385	905	1,289	0	10	13	23	0	0	188	188
	Makueni	0	489	1,151	1,641	0	13	16	29	0	0	240	240
	Marsabit	0	17	44	61	0	0	0	0	0	0	21	21
	Meru	266	1,094	701	2,061	92	52	150	294	0	0	659	659
	Tharaka-Nithi	103	426	273	802	36	20	58	114	0	0	256	256
Coast	Kilifi	0	66	1,865	1,931	0	0	0	0	0	280	24	304
	Kwale	0	625	741	1,366	0	0	0	0	0	873	64	937
	Lamu	0	1	2,679	2,680	0	0	0	0	0	562	0	562
	Mombasa	0	0	120	120	0	0	0	0	0	10	21	31
	Taita Taveta	0	23	242	265	0	0	4	4	0	0	0	0
	Tana River	0	0	440	440	0	0	0	0	0	237	0	237
North Eastern	Garissa	0	0	51	51	0	0	0	0	0	0	0	0
	Mandera	0	0	0	0	0	0	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0	0	0	0	0	0	0
Total		1,701	19,242	29,010	49,953	1,224	4,437	7,848	13,509	0	1,962	11,083	13,045

Source: NWMP (1992), Sectoral Report (E)

Table 1.3.2 Suitable Area for Major Crops by County (2/5)

(Unit: km^2)

Province	County	Sorghum & Millet				Potato				Beans			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
Western	Bungoma	0	279	1,634	1,913	164	75	0	239	304	1,085	669	2,058
	Busia	0	0	932	932	0	0	0	0	47	324	508	879
	Kakamega	1	310	1,891	2,201	18	0	54	72	220	1,724	339	2,283
	Vihiga	0	103	630	734	6	0	18	24	73	575	113	761
Nyanza	Homa Bay	0	23	2,192	2,216	0	0	0	0	23	789	639	1,451
	Kisii	0	0	630	630	408	64	76	548	10	606	516	1,132
	Kisumu	0	39	1,296	1,335	0	0	15	15	62	175	0	237
	Migori	0	20	1,868	1,887	0	0	0	0	20	672	544	1,236
	Nyamira	0	0	437	437	284	45	52	381	7	421	358	786
	Siaya	0	0	2,041	2,041	0	0	0	0	30	1,519	394	1,943
Rift Valley	Baringo	75	119	962	1,156	0	160	105	265	0	421	320	741
	Bomet	1	1	505	506	790	128	210	1,128	4	250	1,036	1,290
	Elgeyo Marakwet	18	9	351	378	43	318	91	452	0	37	204	241
	Kajiado	4	172	3,330	3,506	0	18	101	119	0	301	296	597
	Kericho	0	0	397	398	621	100	165	886	3	197	814	1,014
	Laikipia	0	35	870	905	0	0	334	334	0	13	226	239
	Nakuru	0	237	571	808	0	171	1,262	1,433	0	427	625	1,052
	Nandi	95	335	441	871	277	105	673	1,055	9	860	1,092	1,961
	Narok	109	306	2,636	3,051	320	645	2,440	3,405	0	327	2,101	2,428
	Samburu	0	0	333	333	0	0	0	0	0	1	2	3
	Trans Nzoia	17	682	353	1,052	0	108	492	600	48	374	514	936
	Turkana	0	0	30	30	0	0	0	0	0	0	0	0
	Uasin Gishu	0	266	118	384	11	503	1,819	2,333	0	383	1,679	2,062
	West Pokot	0	0	803	803	0	53	126	179	3	4	122	129
Central	Kiambu	0	10	828	838	0	60	241	159	336	309	237	882
	Kirinyaga	139	87	554	780	123	0	0	375	159	469	273	901
	Muranga	49	283	907	1,239	0	0	43	0	375	705	206	1,286
	Nyandarua	0	0	0	0	0	0	983	983	0	0	57	57
	Nyeri	117	1	508	626	84	78	424	586	328	299	280	907
Nairobi	Nairobi	0	28	276	304	0	0	2	2	0	80	2	82
Eastern	Embu	10	150	1,041	1,201	44	0	0	44	94	457	245	796
	Isiolo	0	0	0	0	0	0	0	0	0	0	0	0
	Kitui	0	436	11,122	11,558	0	0	0	0	0	250	1,822	2,072
	Machakos	16	328	2,944	3,289	0	4	10	14	0	844	501	1,345
	Makueni	21	418	3,748	4,186	0	4	13	17	1	1,074	637	1,712
	Marsabit	38	0	1,500	1,538	0	0	0	0	0	21	39	60
	Meru	106	392	2,406	2,903	13	8	136	157	268	1,214	566	2,048
	Tharaka-Nithi	41	152	935	1,129	5	3	53	61	104	472	220	796
Coast	Kilifi	0	1,335	2,107	3,442	0	0	0	0	0	0	0	0
	Kwale	0	194	2,277	2,471	0	0	0	0	0	0	0	0
	Lamu	0	1,680	2,568	4,248	0	0	0	0	0	0	0	0
	Mombasa	0	20	100	120	0	0	0	0	0	0	0	0
	Taita Taveta	0	159	1,909	2,068	0	0	0	0	0	265	0	265
	Tana River	0	95	811	906	0	0	0	0	0	0	0	0
North Eastern	Garissa	0	51	668	719	0	0	0	0	0	0	0	0
	Mandera	0	0	0	0	0	0	0	0	0	0	0	0
	Wajir	0	0	101	101	0	0	0	0	0	0	0	0
Total		857	8,755	62,561	72,173	3,211	2,650	9,938	15,866	2,528	17,944	18,196	38,668

Source: NWMP (1992), Sectoral Report (E)

Table 1.3.2 Suitable Area for Major Crops by County (3/5)

(Unit: km^2)

Province	County	Coffee				Tea				Cotton			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
Western	Bungoma	32	347	293	672	164	122	67	353	0	60	735	795
	Busia	0	0	0	0	0	0	0	0	0	108	595	703
	Kakamega	0	601	173	774	0	90	1,230	1,320	0	0	290	290
	Vihiga	0	200	58	258	0	30	410	440	0	0	97	97
Nyanza	Homa Bay	4	4	59	66	0	1	46	47	0	31	1,684	1,716
	Kisii	0	92	489	581	155	62	644	861	0	0	11	11
	Kisumu	4	33	9	46	0	0	71	71	0	4	1,075	1,079
	Migori	3	3	50	57	0	1	39	40	0	27	1,435	1,461
	Nyamira	0	64	339	403	108	43	448	599	0	0	7	7
	Siaya	0	15	0	15	0	0	168	168	0	31	1,177	1,208
Rift Valley	Baringo	0	0	153	153	0	0	1	1	0	1	316	317
	Bomet	0	128	73	200	187	128	19	334	0	0	77	77
	Elgeyo Marakwet	0	0	0	0	38	0	0	38	0	0	121	121
	Kajiado	0	0	1	1	0	0	0	0	0	0	180	180
	Kericho	0	100	57	158	147	100	15	262	0	0	60	60
	Laikipia	0	0	0	0	0	0	0	0	0	0	0	0
	Nakuru	0	0	0	0	0	0	0	0	0	0	0	0
	Nandi	0	44	370	414	221	44	470	735	0	0	10	10
	Narok	0	0	225	225	36	0	220	256	0	0	10	10
	Samburu	0	0	0	0	0	0	0	0	0	0	0	0
	Trans Nzoia	33	15	35	83	0	0	0	0	0	0	0	0
	Turkana	0	0	0	0	0	0	0	0	0	0	0	0
	Uasin Gishu	0	0	3	3	11	0	0	11	0	0	0	0
	West Pokot	0	3	1	4	0	0	0	0	0	0	0	0
Central	Kiambu	252	84	265	601	0	0	0	0	0	0	9	9
	Kirinyaga	159	145	83	387	123	145	0	268	0	153	150	303
	Muranga	345	30	284	659	0	0	0	0	0	37	156	193
	Nyandarua	0	0	0	0	0	0	0	0	0	0	0	0
	Nyeri	328	46	131	505	84	46	0	130	0	2	0	2
Nairobi	Nairobi	0	0	53	53	0	0	0	0	0	0	0	0
Eastern	Embu	94	98	86	278	44	98	0	142	0	147	227	374
	Isiolo	0	0	0	0	0	0	0	0	0	0	0	0
	Kitui	0	0	0	0	0	0	0	0	0	0	1,815	1,815
	Machakos	0	0	91	92	0	10	13	23	0	34	568	602
	Makueni	0	1	116	116	0	13	16	29	0	44	722	766
	Marsabit	0	0	0	0	0	0	0	0	0	17	44	61
	Meru	299	69	276	644	13	67	0	80	0	574	564	1,138
	Tharaka-Nithi	116	27	107	250	5	26	0	31	0	223	220	443
Coast	Kilifi	0	0	0	0	0	0	0	0	0	151	2,681	2,832
	Kwale	0	0	0	0	0	0	0	0	0	632	1,039	1,671
	Lamu	0	0	0	0	0	0	0	0	0	1	2,686	2,687
	Mombasa	0	0	0	0	0	0	0	0	0	0	171	171
	Taita Taveta	0	0	0	0	0	0	4	4	0	0	198	198
	Tana River	0	0	0	0	0	0	0	0	0	0	513	513
North Eastern	Garissa	0	0	0	0	0	0	0	0	0	0	51	51
	Mandera	0	0	0	0	0	0	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0	0	0	0	0	0	0
Total		1,669	2,149	3,880	7,698	1,336	1,026	3,881	6,243	0	2,277	19,693	21,970

Source: NWMP (1992), Sectoral Report (E)

Table 1.3.2 Suitable Area for Major Crops by County (4/5)

(Unit: km^2)

Province	County	Sugarcane				Pyrethrum				Sisal			
		S1	S2	S3	Total	S1	S2	S3	Total	S1	S2	S3	Total
Western	Bungoma	0	0	544	544	0	75	0	75	0	70	494	564
	Busia	0	0	666	666	0	0	0	0	0	0	108	108
	Kakamega	2	0	1,002	1,004	0	0	17	17	1	88	269	357
	Vihiga	1	0	334	335	0	0	6	6	0	29	90	119
Nyanza	Homa Bay	0	0	820	820	0	0	0	0	0	4	231	235
	Kisii	0	0	11	11	0	41	0	41	0	0	84	84
	Kisumu	0	22	671	693	0	0	13	13	0	0	106	106
	Migori	0	0	699	699	0	0	0	0	0	4	197	201
	Nyamira	0	0	7	7	0	29	0	29	0	0	59	59
	Siaya	0	0	1,191	1,191	0	0	0	0	0	0	31	31
Rift Valley	Baringo	0	0	0	0	35	114	116	265	75	0	637	712
	Bomet	0	0	77	77	40	87	399	526	0	1	227	227
	Elgeyo Marakwet	0	0	0	0	0	89	321	410	18	0	321	339
	Kajiado	0	0	0	0	0	0	148	148	4	5	1,494	1,503
	Kericho	0	0	60	60	31	68	314	413	0	0	178	179
	Laikipia	0	0	0	0	0	103	245	348	0	13	722	735
	Nakuru	0	0	0	0	14	104	1,645	1,763	0	1	258	259
	Nandi	0	0	79	79	7	75	603	685	95	0	384	479
	Narok	0	0	10	10	0	199	3,234	3,433	109	0	1,746	1,855
	Samburu	0	0	0	0	0	0	0	0	0	0	40	40
	Trans Nzoia	0	0	0	0	14	131	445	590	17	641	77	735
	Turkana	0	0	0	0	0	0	0	0	0	0	30	30
	Uasin Gishu	0	0	0	0	136	90	2,096	2,322	0	129	139	268
	West Pokot	0	0	0	0	0	0	179	179	0	0	126	126
Central	Kiambu	0	0	0	0	35	121	145	301	0	10	265	275
	Kirinyaga	0	0	0	0	0	0	0	0	139	87	238	464
	Muranga	0	0	0	0	43	0	0	43	49	283	321	653
	Nyandarua	0	0	0	0	253	39	1,330	1,622	0	0	0	0
	Nyeri	0	0	0	0	207	55	242	504	117	1	134	252
Nairobi	Nairobi	0	0	0	0	0	0	2	2	0	27	54	81
Eastern	Embu	0	0	0	0	0	0	0	0	10	150	374	534
	Isiolo	0	0	0	0	0	0	0	0	0	0	0	0
	Kitui	0	0	0	0	0	0	0	0	0	261	7,118	7,379
	Machakos	0	0	0	0	0	1	13	14	16	52	651	719
	Makueni	0	0	0	0	0	1	16	17	21	67	828	916
	Marsabit	0	0	0	0	0	0	0	0	38	0	1,184	1,222
	Meru	0	0	0	0	0	8	136	144	106	210	1,522	1,838
	Tharaka-Nithi	0	0	0	0	0	3	53	56	41	82	592	715
Coast	Kilifi	0	0	0	0	0	0	0	0	114	412	2,389	2,915
	Kwale	0	0	0	0	0	0	0	0	12	509	1,577	2,098
	Lamu	0	0	0	0	0	0	0	0	0	2,193	1,792	3,985
	Mombasa	0	0	0	0	0	0	0	0	0	0	20	20
	Taita Taveta	0	0	0	0	0	0	4	4	0	89	1,777	1,866
	Tana River	0	0	0	0	0	0	0	0	0	248	469	717
North Eastern	Garissa	0	0	0	0	0	0	0	0	0	51	646	697
	Mandera	0	0	0	0	0	0	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0	0	0	0	0	18	18
Total		3	22	6,171	6,196	815	1,433	11,722	13,970	982	5,717	30,016	36,715

Source: NWMP (1992), Sectoral Report (E)

Table 1.3.2 Suitable Area for Major Crops by County (5/5)

(Unit: km^2)

Province	County	Horticulture				Fodder Crop			
		S1	S2	S3	Total	S1	S2	S3	Total
Western	Bungoma	285	721	1,041	2,047	239	1,056	880	2,175
	Busia	0	248	633	881	47	108	777	932
	Kakamega	207	1,059	687	1,953	5	1,862	415	2,281
	Vihiga	69	353	229	651	2	621	138	760
Nyanza	Homa Bay	45	444	952	1,441	3	117	2,105	2,225
	Kisii	804	202	113	1,119	8	1,044	185	1,237
	Kisumu	0	208	177	385	51	139	1,496	1,686
	Migori	39	378	811	1,228	2	100	1,794	1,896
	Nyamira	559	140	79	778	6	725	128	859
	Siaya	0	1,041	902	1,943	30	199	1,894	2,123
Rift Valley	Baringo	0	217	628	845	0	329	1,102	1,431
	Bomet	315	847	221	1,383	1	506	1,228	1,734
	Elgeyo Marakwet	38	374	85	497	0	145	780	925
	Kajiado	0	18	532	550	0	6	3,598	3,604
	Kericho	247	665	174	1,086	0	397	965	1,363
	Laikipia	0	104	243	347	0	13	1,196	1,209
	Nakuru	0	973	983	1,956	0	229	1,688	1,917
	Nandi	634	247	1,044	1,925	4	1,317	142	1,463
	Narok	256	1,942	1,582	3,780	0	718	4,717	5,435
	Samburu	0	0	1	1	0	0	531	531
	Trans Nzoia	0	346	1,030	1,376	48	856	454	1,358
	Turkana	0	0	0	0	0	0	30	30
	Uasin Gishu	11	694	2,011	2,716	0	385	704	1,089
	West Pokot	0	153	33	186	3	1	1,133	1,137
Central	Kiambu	0	507	448	955	336	360	451	1,147
	Kirinyaga	269	159	473	901	159	592	152	903
	Muranga	0	417	836	1,253	375	611	371	1,357
	Nyandarua	0	551	431	982	0	0	758	758
	Nyeri	131	631	451	1,213	328	438	249	1,015
Nairobi	Nairobi	0	0	82	82	0	80	231	311
Eastern	Embu	142	94	546	782	94	449	834	1,377
	Isiolo	0	0	0	0	0	0	0	0
	Kitui	0	0	2,010	2,010	0	0	12,073	12,073
	Machakos	0	7	1,244	1,251	0	377	3,090	3,467
	Makueni	0	9	1,584	1,593	1	479	3,933	4,413
	Marsabit	0	0	61	61	0	17	1,675	1,692
	Meru	80	311	1,694	2,085	268	1,029	1,665	2,962
	Tharaka-Nithi	31	121	659	811	104	400	648	1,152
Coast	Kilifi	0	0	1,593	1,593	0	0	2,551	2,551
	Kwale	0	0	849	849	0	0	2,259	2,259
	Lamu	0	0	2,193	2,193	0	0	2,680	2,680
	Mombasa	0	0	20	20	0	0	171	171
	Taita Taveta	0	4	260	264	0	23	1,415	1,438
	Tana River	0	0	248	248	0	0	440	440
North Eastern	Garissa	0	0	51	51	0	0	51	51
	Mandera	0	0	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0	101	101
Total		4,162	14,185	29,924	48,271	2,113	15,727	63,878	81,718

Source: NWMP (1992), Sectoral Report (E)

Table 2.3.1 Trend of Crop Production by Type of Crop in 2007-2011 (1/2)

Crop	2007			2008			2009			2010			2011			Change in 5 Years		
	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)
Food Crops																		
Rice	15,885	62,283	3.92	18,329	51,822	2.83	20,050	54,955	2.74	29,099	110,494	3.80	22,966	91,055	3.96	144.6%	146.2%	101.1%
Maize	1,615,304	2,928,793	1.81	1,793,757	2,367,200	1.32	1,885,071	2,442,823	1.30	2,008,346	3,464,541	1.73	2,131,887	3,376,862	1.58	132.0%	115.3%	87.4%
Wheat	104,176	354,249	3.40	130,273	336,352	2.58	131,594	219,301	1.67	160,043	511,994	3.20	131,509	268,482	2.04	126.2%	75.8%	60.0%
Barley	-	-	-	14,677	44,593	3.04	13,694	34,065	2.49	25,123	64,219	2.56	18,832	65,235	3.46	128.3%	146.3%	114.0%
Beans	846,327	310,996	0.37	610,428	261,111	0.43	960,705	465,363	0.48	689,377	390,598	0.57	1,036,738	577,674	0.56	122.5%	185.7%	151.6%
Sorghum	155,550	147,365	0.95	104,041	54,262	0.52	173,172	94,955	0.55	225,782	164,066	0.73	254,125	159,877	0.63	163.4%	108.5%	66.4%
Millet	128,114	119,599	0.93	53,155	38,424	0.72	104,576	56,417	0.54	99,124	53,881	0.54	111,271	73,396	0.66	86.9%	61.4%	70.7%
Cowpea	130,163	83,251	0.64	148,157	47,953	0.32	124,302	60,152	0.48	168,273	72,274	0.43	197,980	81,534	0.41	152.1%	97.9%	64.4%
Green Gram	82,784	61,953	0.75	91,452	26,713	0.29	112,997	42,333	0.37	147,352	61,248	0.42	159,910	70,225	0.44	193.2%	113.4%	58.7%
Pigeon Peas	846,327	310,996	0.37	610,428	261,111	0.43	118,167	46,474	0.39	158,746	103,234	0.65	138,708	84,313	0.61	16.4%	27.1%	165.4%
Sweet Potato	61,111	811,531	13.28	62,786	894,781	14.25	77,821	1,034,204	13.29	42,312	383,590	9.07	61,902	759,471	12.27	101.3%	93.6%	92.4%
Cassava	53,610	397,705	7.42	54,673	750,964	13.74	70,426	911,074	12.94	61,573	323,389	5.25	60,473	679,167	11.23	112.8%	170.8%	151.4%
Cocoyam	1,896	16,050	8.47	2,254	16,872	7.49	2,588	24,901	9.62	2,774	19,054	6.87	4,549	30,635	6.73	239.9%	190.9%	79.6%
Yam	925	6,905	7.46	808	6,123	7.58	882	4,427	5.02	1,224	8,035	6.56	1,057	9,635	9.12	114.3%	139.5%	122.1%
Total	4,026,287	5,549,394		3,676,889	5,106,458		3,775,995	5,436,489		3,790,049	5,620,121		4,308,941	6,236,506		107.0%	112.4%	
Oil Crops																		
Soya Bean	1,645	1,972	1.20	2,456	1,923	0.78	2,950	2,110	0.72	1,621	1,540	0.95	1,734	4,335	2.50	105.4%	219.8%	208.5%
Sun Flower	5,756	4,112	0.71	6,073	5,540	0.91	6,310	6,000	0.95	3,752	3,128	0.83	5,157	5,613	1.09	89.6%	136.5%	152.4%
Ground Nuts	29,908	16,761	0.56	26,089	14,710	0.56	25,745	15,040	0.58	10,894	11,801	1.08	12,803	12,526	0.98	42.8%	74.7%	174.6%
Coconut	44,057	55,280	1.25	49,669	59,897	1.21	50,956	65,160	1.28	50,143	74,613	1.49	50,663	87,479	1.73	115.0%	158.2%	137.6%
Cashew Nuts	27,921	12,873	0.46	29,950	15,597	0.52	30,297	17,683	0.58	29,837	17,568	0.59	30,455	20,927	0.69	109.1%	162.6%	149.0%
Total	109,287	90,998		114,237	97,667		116,258	105,993		96,247	108,650		100,812	130,880		92.2%	143.8%	
Industrial Crops																		
Coffee (sum)	170,000	48,303	0.28	162,720	42,000	0.26	160,000	54,020	0.34	160,000	42,000	0.26	160,000	36,260	0.23	94.1%	75.1%	79.8%
- Estate	*42,000*	*21,257*	*0.51*	*40,680*	*19,740*	*0.49*	*53,344*	*24,650*	*0.46*	*40,000*	*19,720*	*0.49*	*40,000*	*16,660*	*0.42*	*95.2%*	*78.4%*	*82.3%*
- Smallholders	*128,000*	*27,046*	*0.21*	*122,040*	*22,260*	*0.18*	*106,656*	*29,370*	*0.28*	*120,000*	*22,280*	*0.19*	*120,000*	*19,600*	*0.16*	*93.8%*	*72.5%*	*77.3%*
Tea (sum)	149,196	369,606	2.48	157,720	345,817	2.19	158,394	314,198	1.98	171,916	399,006	2.32	187,855	377,911	2.01	125.9%	102.2%	81.2%
- Estate	*51,011*	*139,992*	*2.74*	*50,605*	*134,963*	*2.67*	*51,126*	*141,593*	*2.77*	*56,893*	*174,025*	*3.06*	*64,470*	*159,358*	*2.47*	*126.4%*	*113.8%*	*90.1%*
- Smallholders	*98,185*	*229,614*	*2.34*	*107,115*	*210,854*	*1.97*	*107,268*	*172,605*	*1.61*	*115,023*	*224,981*	*1.96*	*123,385*	*218,553*	*1.77*	*125.7%*	*95.2%*	*75.7%*
Sugar	59,201	5,204,214	87.91	54,465	5,176,670	95.05	65,774	5,610,702	85.30	68,738	5,475,180	79.65	64,091	5,338,562	83.30	108.3%	102.6%	94.8%
Seed Cotton	35,929	24,993	0.70	43,035	15,093	0.35	39,963	14,886	0.37	24,553	11,822	0.48	32,200	22,000	0.68	89.6%	88.0%	98.2%
Pyrethrum	5,120	846	0.17	3,916	776	0.20	4,084	754	0.18	6,100	462	0.08	8,168	518	0.06	159.5%	61.2%	38.4%
Sizal	32,126	24,602	0.77	44,462	24,494	0.55	29,353	19,048	0.65	29,353	23,924	0.82	29,255	27,560	0.94	91.1%	112.0%	123.0%
Total	451,572	5,672,564		466,318	5,604,850		457,568	6,013,608		460,660	5,952,394		481,569	5,802,811		106.6%	102.3%	

Source: Economic Review of Agriculture 2012, Minsitry of Agriculture

Table 2.3.1 Trend of Crop Production by Type of Crop in 2007-2011 (2/2)

Crop	2007			2008			2009			2010			2011			Change in 3 Years		
	Area (ha)	Produc-tion (ton)	Yield (ton/ha)	Area (ha)	Produc-tion (ton)	Yield (ton/ha)	Area (ha)	Produc-tion (ton)	Yield (ton/ha)	Area (ha)	Produc-tion (ton)	Yield (ton/ha)	Area (ha)	Produc-tion (ton)	Yield (ton/ha)	Area (ha)	Produc-tion (ton)	Yield (ton/ha)
Horticulture																		
Vegetables (sum)							239,350	3,986,159	16.65	258,548	5,006,055	19.36	258,348	4,471,801	17.31	107.9%	112.2%	103.9%
- Irish Potato							*120,246*	*2,299,806*	*19.13*	*121,542*	*2,725,936*	*22.43*	*123,390*	*2,365,263*	*19.17*	*102.6%*	*102.8%*	*100.2%*
- Cabbage							*16,980*	*511,693*	*30.14*	*21,923*	*784,876*	*35.80*	*21,415*	*599,625*	*28.00*	*126.1%*	*117.2%*	*92.9%*
- Tomato							*17,230*	*354,356*	*20.57*	*17,529*	*378,756*	*21.61*	*18,178*	*407,374*	*22.41*	*105.5%*	*115.0%*	*109.0%*
- Carrot							*3,475*	*53,338*	*15.35*	*4,693*	*76,940*	*16.39*	*4,171*	*61,319*	*14.70*	*120.0%*	*115.0%*	*95.8%*
- Kales							*19,035*	*250,145*	*13.14*	*22,494*	*355,280*	*15.79*	*22,548*	*352,491*	*15.63*	*118.5%*	*140.9%*	*119.0%*
Fruits							160,669	2,525,481	15.72	158,291	2,768,435	17.49	177,715	2,848,028	16.03	110.6%	112.8%	102.0%
Flowers							1,947	49,656	25.50	3,419	133,736	39.12	3,213	123,270	38.37	165.0%	248.2%	150.4%
Nuts							91,341	119,306	1.31	94,838	123,221	1.30	99,576	147,583	1.48	109.0%	123.7%	113.5%
African Leafy V.							17,149	115,746	6.75	17,200	120,878	7.03	17,390	149,944	8.62	101.4%	129.5%	127.8%
Herbs & Spices							1,193	7,955	6.67	1,333	10,337	7.75	1,142	9,239	8.09	95.7%	116.1%	121.3%
Asian Vegetables							1,230	13,712	11.15	1,536	17,451	11.36	1,840	20,807	11.31	149.6%	151.7%	101.4%
Total							512,879	6,818,015	13.29	535,165	8,180,113	15.29	559,224	7,770,672	13.90	109.0%	114.0%	104.5%
Total for All Crops	4,587,146	11,312,956					4,862,700	18,374,105		4,882,121	19,861,278		5,450,546	19,940,869		118.8%	176.3%	

Source: Economic Review of Agriculture 2012, Minsitry of Agriculture

Table 2.3.2 Cropping Area of Major Crops by County and Catchment Area in 2011

1) Cropping Area by County (Unit: ha)

Province	County	Horti-culturral Crops	Food Crops: Maize	Rice	Sorghum	Millet	Beans	Sweet Potato	Cassava	Total Cropping Area
Western	Bungoma	18,786	103,408	24	3,660	769	82	5,658	1,515	133,902
	Busia	7,622	52,800	2,296	11,139	4,291	203	10,053	18,279	106,683
	Kakamega	3,360	76,539	22	703	239	92	4,154	804	85,913
	Vihiga	1,891	22,764	0	508	64	94	1,054	228	26,603
Nyanza	Homa Bay	17,223	60,545	590	25,107	8,180	1,618	8,180	2,847	124,290
	Kisii	15,454	58,290	0	128	674	413	674	97	75,730
	Kisumu	4,051	26,790	3,300	10,890	1,658	4,190	1,658	3,477	56,014
	Migori	11,504	50,495	12	9,380	7,060	591	7,060	7,922	94,024
	Nyamira	10,488	63,825	0	104	712	222	712	40	76,103
	Siaya	9,907	59,538	2,335	15,300	5,272	1,940	5,272	3,802	103,366
Rift Valley	Baringo	4,537	31,720	0	820	2,205	964	149	97	40,492
	Bomet	8,570	40,670	0	395	750	0	807	26	51,218
	Elgeyo Marakwet	18,720	28,673	41	11,068	1,230	457	91	198	60,478
	Kajiado	1,953	8,075	0	139	4	288	15	16	10,490
	Keticho	5,756	48,035	17	709	900	0	549	16	55,982
	Laikipia	7,636	35,765	0	1,881	66	145	88	44	45,625
	Nakuru	24,569	91,835	0	849	390	103	132	39	117,917
	Nandi	2,186	75,075	0	131	191	0	198	69	77,850
	Narok	10,795	86,775	0	297	510	22	1,857	29	100,285
	Samburu	182	500	0	4	1	39	2	1	729
	Trans Nzoia	3,450	97,740	0	540	450	0	360	57	102,597
	Turkana	143	1,355	0	2,194	0	324	0	0	4,016
	Uasin Gishu	2,652	83,602	0	95	635	0	105	17	87,106
	West Pokot	2,002	20,450	0	2,290	470	109	35	54	25,410
Central	Kiambu	27,802	57,639	40	225	19	1,059	2,809	658	90,251
	Kirinyaga	10,621	25,560	9,363	366	8	307	568	61	46,854
	Muranga	16,421	50,029	0	239	17	390	666	157	67,919
	Nyandarua	54,110	19,702	0	28	1	49	80	0	73,970
	Nyeri	10,262	29,318	0	116	0	258	359	150	40,463
Nairobi	Nairobi City	288	893	0	13	0	31	34	22	1,281
Eastern	Embu	12,205	45,086	23	6,275	4,161	18,504	185	339	86,778
	Isiolo	198	824	0	56	5	219	10	8	1,320
	Kitui	2,659	71,775	0	57,080	36,920	158,675	523	1,448	329,080
	Machakos	7,441	175,260	0	12,978	1,087	90,614	3,205	3,632	294,217
	Makueni	10,043	109,195	0	37,149	6,578	115,530	992	1,260	280,747
	Marsabit	158	1,731	0	144	10	46	10	4	2,103
	Meru	47,468	118,594	13	16,352	7,906	19,140	1,986	1,092	212,551
	Tharaka	36,821	18,389	0	18,174	17,592	39,955	326	356	131,613
Coast	Kilifi	56,035	79,832	779	2,486	41	11,252	421	8,436	159,282
	Kwale	52,727	52,242	1,486	1,332	47	13,837	597	2,295	124,563
	Lamu	15,589	21,162	191	1,265	78	4,840	59	688	43,872
	Mombasa	1,757	1,203	14	13	0	444	18	275	3,724
	Taita Taveta	5,789	16,838	677	526	28	4,267	143	150	28,418
	Tana River	1,769	8,222	1,720	197	19	3,246	41	119	15,333
North Eastern	Garissa	1,623	453	24	101	13	567	0	0	2,781
	Mandera	878	801	0	380	5	983	0	0	3,047
	Wajir	127	1,876	0	300	17	555	0	0	2,875
Total		566,228	2,131,888	22,967	254,126	111,273	496,664	61,895	60,824	3,705,865

2) Cropping Area by Catchment Area (Unit: ha)

Catchment Area	Horti-culturral Crops	Food Crops: Maize	Rice	Sorghum	Millet	Beans	Sweet Potato	Cassava	Total Cropping Area
Lake Victoria North	60,655	613,760	4,514	31,274	12,392	2,471	27,241	24,505	776,811
Lake Victoria South	85,397	343,634	4,106	58,177	20,086	7,563	19,796	14,896	553,655
Rift Valley	69,237	220,453	9	6,785	3,610	1,820	1,665	276	303,856
Athi	144,199	433,967	2,875	53,159	9,839	212,069	6,376	14,060	876,544
Tana	151,331	408,934	11,449	94,245	61,444	261,315	5,623	6,465	1,000,806
Ewaso Ng'iro North	55,395	111,118	14	10,478	3,895	11,408	1,193	622	194,123
Total	566,228	2,131,888	22,967	254,126	111,273	496,664	61,895	60,824	3,705,865

Source: Economic Review of Agriculture 2012, Ministry of Agriculture

Table 2.3.3 Production of Food Crops by County in 2011 (1/3)

Province / County	Maize			Rice			Sorghum			Millet		
	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)
Western												
Bungoma	103,408	257,087	2.5	24	16	0.7	3,660	3,229	0.9	769	667	9.6
Busia	52,800	62,498	1.2	2,296	3,583	1.6	11,139	9,218	0.8	4,291	3,627	9.4
Kakamega	76,539	168,257	2.2	22	19	0.9	703	665	0.9	239	137	6.4
Vihiga	22,764	33,711	1.5				508	400	0.8	64	39	6.6
Nyanza												
Homa Bay	60,545	80,538	1.3	590	2,745	4.7	25,107	29,321	1.2	8,180	12,485	17.0
Kisii	58,290	120,483	2.1				128	127	1.0	674	977	16.1
Kisumu	26,790	36,829	1.4	3,300	15,930	4.8	10,890	10,872	1.0	1,658	2,238	15.0
Migori	50,495	82,237	1.6	12	54	4.5	9,380	9,716	1.0	7,060	9,461	14.9
Nyamira	63,825	122,242	1.9				104	107	1.0	712	898	14.0
Siaya	59,538	85,520	1.4	2,335	10,508	4.5	15,300	14,684	1.0	5,272	7,459	15.7
Rift Valley												
Baringo	31,720	49,596	1.6				820	607	0.7	2,205	1,236	6.2
Bomet	40,670	90,701	2.2				395	481	1.2	750	767	11.4
Elgeyo Marakwet	28,673	83,707	2.9	41	158	3.9	11,068	1,553	0.1	1,230	1,112	10.0
Kajiado	8,075	3,950	0.5				139	82	0.6	4	2	5.3
Keticho	48,035	111,739	2.3	17	61	3.6	709	530	0.7	900	529	6.5
Laikipia	35,765	65,945	1.8				1,881	1,236	0.7	66	55	9.2
Nakuru	91,835	219,356	2.4				849	817	1.0	390	361	10.3
Nandi	75,075	169,438	2.3				131	148	1.1	191	134	7.8
Narok	86,775	201,373	2.3				297	179	0.6	510	320	7.0
Samburu	500	1,054	2.1				4	1	0.3	1	0	4.0
Trans Nzoia	97,740	409,215	4.2				540	472	0.9	450	350	8.6
Turkana	1,355	1,107	0.8				2,194	2,309	1.1			
Uasin Gishu	83,602	278,557	3.3				95	101	1.1	635	801	14.0
West Pokot	20,450	41,921	2.0				2,290	2,041	0.9	470	393	9.3
Central												
Kiambu	57,639	37,119	0.6	40	151	3.8	225	24	0.1	19	5	2.8
Kirinyaga	25,560	28,301	1.1	9,363	47,057	5.0	366	364	1.0	8	14	19.2
Muranga	50,029	36,301	0.7				239	95	0.4	17	6	4.0
Nyandarua	19,702	36,709	1.9				28	10	0.4	1	0	0.2
Nyeri	29,318	15,356	0.5				116	43	0.4	-		-
Nairobi												
Nairobi City	893	677	0.8				13	3	0.2			
Eastern												
Embu	45,086	26,258	0.6	23	52	2.3	6,275	2,642	0.4	4,161	1,929	5.2
Isiolo	824	158	0.2				56	37	0.7	5	0	0.0
Kitui	71,775	20,225	0.3				57,080	20,542	0.4	36,920	8,349	2.5
Machakos	175,260	100,720	0.6				12,978	5,978	0.5	1,087	323	3.3
Makueni	109,195	38,291	0.4				37,149	18,052	0.5	6,578	2,632	4.4
Marsabit	1,731	201	0.1				144	18	0.1	10		0.0
Meru	118,594	131,755	1.1	13	9	1.0	16,352	10,028	0.6	7,906	3,673	5.2
Tharaka	18,389	19,781	1.1				18,174	10,636	0.6	17,592	12,355	7.8
Coast												
Kilifi	79,832	36,593	0.5	779	357	0.5	2,486	597	0.2	41	5	1.3
Kwale	52,242	51,491	1.0	1,486	1,815	1.2	1,332	938	0.7	47	17	4.0
Lamu	21,162	16,945	0.8	191	23	0.1	1,265	567	0.4	78	21	2.9
Mombasa	1,203	1,063	0.9	14	4	0.3	13	10	0.8			
Taita Taveta	16,838	15,991	0.9	677	2,348	3.5	526	201	0.4	28	12	4.7
Tana River	8,222	11,317	1.4	1,720	6,057	3.5	197	65	0.3	19	5	2.7
North Eastern												
Garissa	453	185	0.4	24	108	4.5	101	20	0.2	13	1	0.7
Mandera	801	197	0.2				380	61	0.2	5	0	1.0
Wajir	1,876	428	0.2				300	50	0.2	17	1	0.9
Total Production	2,131,888	3,403,120	1.6	22,967	91,055	4.0	254,126	159,877	0.6	111,273	73,396	0.7

Source: Economic Review of Agriculture 2012, Ministry of Agriculture

Table 2.3.3 Production of Food Crops by County in 2011 (2/3)

Province / County	Beans (1) Cowpea			Beans (2) Green Gram			Beans (3) Pigeon Peas			Beans (Total)		
	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)
Western												
Bungoma				82	33	0.4				82	33	0.4
Busia				203	83	0.4				203	83	0.4
Kakamega				92	39	0.4				92	39	0.4
Vihiga				94	43	0.5				94	43	0.5
Nyanza												
Homa Bay	875	402	0.5	743	502	0.7				1,618	903	0.6
Kisii	358	164	0.5	55	21	0.4				413	185	0.4
Kisumu	2,537	1,141	0.4	1,653	990	0.6				4,190	2,131	0.5
Migori	275	162	0.6	316	191	0.6				591	352	0.6
Nyamira	192	89	0.5	30	18	0.6				222	107	0.5
Siaya	1,191	673	0.6	749	461	0.6				1,940	1,134	0.6
Rift Valley												
Baringo	578	203	0.4	379	119	0.3	7	3	0.5	964	325	0.3
Bomet										0	0	
Elgeyo Marakwet	248	213	0.9	209	172	0.8				457	385	0.8
Kajiado				0	0	0.0	288	199	0.7	288	199	0.7
Keticho				0	0	0.0				0	0	
Laikipia	32	18	0.6	80	17	0.2	33	22	0.7	145	57	0.4
Nakuru	46	13	0.3				57	31	0.5	103	44	0.4
Nandi	0	0								0	0	
Narok	21	7	0.3				1	0	0.0	22	8	0.3
Samburu	22	5	0.2	15	5	0.3	2	0	0.0	39	10	0.3
Trans Nzoia										0	0	
Turkana	255	40	0.2	69	9	0.1				324	49	0.2
Uasin Gishu										0	0	
West Pokot	25	13	0.5	83	57	0.7	1	0	0.3	109	70	0.6
Central												
Kiambu	163	162	1.0	129	57	0.4	767	558	0.7	1,059	777	0.7
Kirinyaga	146	77	0.5	108	80	0.7	53	18	0.3	307	174	0.6
Muranga	174	138	0.8	14	3	0.2	202	55	0.3	390	197	0.5
Nyandarua	20	68	3.4				29	12	0.4	49	80	1.6
Nyeri	258	354	1.4							258	354	1.4
Nairobi												
Nairobi City				21	2	0.1	10	2	0.2	31	4	0.1
Eastern												
Embu	10,053	2,767	0.3	6,765	2,581	0.4	1,686	874	0.5	18,504	6,222	0.3
Isiolo	120	75	0.6	98	81	0.8	1	1	0.9	219	157	0.7
Kitui	65,015	22,674	0.3	58,905	19,450	0.3	34,755	20,357	0.6	158,675	62,481	0.4
Machakos	29,329	12,606	0.4	12,836	5,127	0.4	48,449	28,571	0.6	90,614	46,303	0.5
Makueni	45,240	17,991	0.4	35,140	16,232	0.5	35,150	22,345	0.6	115,530	56,568	0.5
Marsabit				31	6	0.2	15	5	0.3	46	11	0.2
Meru	6,237	4,184	0.7	6,598	3,389	0.5	6,305	4,902	0.8	19,140	12,475	0.7
Tharaka	9,270	6,002	0.6	20,587	12,682	0.6	10,098	6,076	0.6	39,955	24,760	0.6
Coast												
Kilifi	8,233	3,066	0.4	2,897	1,015	0.4	122	20	0.2	11,252	4,102	0.4
Kwale	8,826	3,593	0.4	4,868	2,665	0.5	143	43	0.3	13,837	6,302	0.5
Lamu	2,727	1,958	0.7	1,930	1,341	0.7	183	57	0.3	4,840	3,356	0.7
Mombasa	415	248	0.6	23	13	0.6	6	2	0.3	444	263	0.6
Taita Taveta	1,668	931	0.6	2,255	1,502	0.7	344	160	0.5	4,267	2,593	0.6
Tana River	1,762	1,030	0.6	1,484	1,028	0.7				3,246	2,058	0.6
North Eastern												
Garissa	289	99	0.3	278	156	0.6				567	255	0.4
Mandera	872	306	0.4	111	96	0.9				983	402	0.4
Wajir	323	37	0.1	232	99	0.4				555	136	0.2
Total Production	197,795	81,509	0.4	160,162	70,365	0.4	138,707	84,313	0.6	496,664	236,187	0.5

Source: Economic Review of Agriculture 2012, Ministry of Agriculture

Table 2.3.3 Production of Food Crops by County in 2011 (3/3)

Province / County	Sweet Potato			Cassava			Cocoyam		
	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Area (ha)	Produc-tion (ton)	Yield (t/ha)
Western									
Bungoma	5,658	47,576	8.4	1,515	12,310	8.1			
Busia	10,053	94,237	9.4	18,279	176,280	9.6			
Kakamega	4,154	32,370	7.8	804	5,193	6.5			
Vihiga	1,054	8,800	8.3	228	1,973	8.7			
Nyanza									
Homa Bay	8,180	138,725	17.0	2,847	31,860	11.2			
Kisii	674	10,860	16.1	97	840	8.7			
Kisumu	1,658	24,870	15.0	3,477	34,770	10.0			
Migori	7,060	105,125	14.9	7,922	80,720	10.2			
Nyamira	712	9,975	14.0	40	220	5.5			
Siaya	5,272	82,875	15.7	3,802	38,252	10.1			
Rift Valley									
Baringo	149	942	6.3	97	1,212	12.5			
Bomet	807	7,936	9.8	26	376	14.5			
Elgeyo Marakwet	91	1,245	13.7	198	5,300	26.8			
Kajiado	15	116	7.7	16	86	5.4			
Keticho	549	5,855	10.7	16	879	54.9			
Laikipia	88	1,056	12.0	44	547	12.6			
Nakuru	132	1,174	8.9	39	553	14.2			
Nandi	198	3,648	18.5	69	1,654	24.1			
Narok	1,857	23,861	12.8	29	222	7.7			
Samburu	2	14	9.3	1	2	3.0			
Trans Nzoia	360	6,010	16.7	57	1,004	17.6			
Turkana									
Uasin Gishu	105	1,338	12.7	17	218	12.8			
West Pokot	35	334	9.5	54	338	6.3			
Central									
Kiambu	2,809	15,201	5.4	658	4,924	7.5	684	5,100	7.5
Kirinyaga	568	10,877	12.1	61	511	8.4	61	511	8.4
Muranga	666	8,873	13.3	157	890	5.7	284	1,590	5.6
Nyandarua	80	918	11.5						
Nyeri	359	3,805	10.6	150	766	5.1	150	766	5.1
Nairobi									
Nairobi City	34	75	2.2	22	30	1.4	29	115	3.9
Eastern									
Embu	185	2,501	13.5	339	5,002	14.8	153	1,530	10.0
Isiolo	10	138	14.5	8	81	10.8			
Kitui	523	2,130	4.1	1,448	27,521	19.0	3	26	8.7
Machakos	3,205	28,255	8.8	3,632	38,560	10.6			
Makueni	992	7,835	7.9	1,260	12,147	9.6	51	224	4.4
Marsabit	10	138	14.5	4	8	2.0			
Meru	1,986	28,700	14.5	1,092	13,840	12.7	731	14,403	19.7
Tharaka	326	2,995	9.2	356	1,328	3.7	96	880	9.2
Coast									
Kilifi	421	2,454	5.8	8,436	137,938	16.4			0.0
Kwale	597	6,279	10.5	2,295	25,603	11.2	10	43	4.2
Lamu	59	1,416	23.9	688	3,444	5.0	1,512	620	0.4
Mombasa	18	136	7.6	275	3,469	12.6	5	59	11.9
Taita Taveta	143	1,006	7.0	150	1,576	10.5	38	575	15.1
Tana River	41	677	16.7	119	7,945	67.0			
North Eastern									
Garissa									
Mandera									
Wajir									
Total Production	61,895	733,351	11.8	60,824	680,392	11.2	3,807	26,442	6.9

Source: Economic Review of Agriculture 2012, Ministry of Agriculture

Table 2.3.4 Trend of Paddy Production by County in 2007-2011 (1/2)

Province / District	2007			2008			2009			2010			2011		
	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion
	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)
Western Province															
Bunyala	1,106	2.7	2,986	1,143	2.6	2,972	1,346	2.7	3,634	1,360	2.7	3,604	1,350	1.9	2,561
Butula	10	2.4	23	18	2.4	44	21	2.4	50	48	2.4	115	264	2.0	516
Busia	84	2.3	193	92	2.3	212	97	2.4	233	12	2.4	29	53	1.5	77
Bumula	8	2.1	17	12	2.2	26	49	2.3	113	57	2.4	134	22	0.7	16
Kakamega Central	2	2.4	5	7	2.6	18	18	2.6	47	20	2.6	52	15	1.1	16
Teso North	550	2.3	1,260	670	2.3	1,534	245	2.3	561	263	2.3	605	114	2.4	275
Teso South	-	-	-	-	-	-	512	2.8	1,434	515	2.8	1,416	412	1.6	648
Samia	-	-	-	-	-	-	-	-	-	-	-	-	3	1.7	5
Matungu	-	-	-	-	-	-	-	-	-	-	-	-	7	1.0	7
Bungoma South	-	-	-	-	-	-	-	-	-	-	-	-	2	1.5	3
Nambale	-	-	-	-	-	-	-	-	-	-	-	-	71	1.4	100
Nyanza Province															
Bondo	293	2.3	674	76	4.5	342	4	0.0	0	5	0.1	1	5	0.6	3
Homabay	-	-	-	346	2.5	865	350	2.5	875	105	3.7	389	520	3.6	1,872
Kisumu East	536	4.5	2,412	1,260	4.5	5,670	2,000	4.5	9,000	2,500	4.4	11,000	2,750	5.5	15,125
Nyando	625	3.4	2,125	340	4.5	1,530	316	4.5	1,422	550	4.7	2,585	900	4.5	4,050
Siaya	-	-	-	1,480	5.1	7,548	1,505	4.5	6,773	1,600	4.4	7,040	2,920	4.5	13,140
Migori	27	1.7	46	42	1.3	55	37	1.3	48	42	1.2	51	55	0.7	40
Nyakach	-	-	-	-	-	-	700	4.5	3,150	325	5.2	1,690	360	5.0	1,800
Muhoroni	-	-	-	-	-	-	1,400	4.5	6,300	1,390	4.7	6,533	1,200	5.0	6,000
Ugenya	-	-	-	-	-	-	140	3.6	504	220	3.6	792	50	4.5	225
Rachuonyo North	-	-	-	-	-	-	-	-	-	-	-	-	30	4.5	135
Uriri	-	-	-	-	-	-	-	-	-	-	-	-	12	1.7	20
Ndhiwa	-	-	-	-	-	-	-	-	-	-	-	-	40	0.3	11
Rift Valley Province															
Marakwet West	-	-	-	-	-	-	1	4.0	5	2	4.1	8	38	4.0	152
Marakwet East	-	-	-	-	-	-	-	-	-	3	3.6	9	3	1.9	6
Keiyo North	-	-	-	-	-	-	1	3.8	3	4	3.6	14	-	-	-
Kericho West	-	-	-	-	-	-	-	-	-	-	-	-	17	3.6	61
Samburu Central	-	-	-	-	-	-	-	-	-	-	-	-	0	0.5	0

Table 2.3.4 Trend of Paddy Production by County in 2007-2011 (2/2)

Province / District	2007			2008			2009			2010			2011		
	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion	Area Planted	Unit Yield	Produc-tion
	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)	(ha)	(t/ha)	(tons)
Central Province															
Kirinyaga Central	13	4.8	60	16	5.5	88	40	3.2	128	56	2.7	151	609	3.3	1,981
Kirinyaga East	30	3.0	90	50	3.5	175	65	4.5	293	70	4.5	315	85	5.8	490
Mwea	10,420	4.8	50,329	10,400	2.8	28,704	9,423	2.0	18,436	11,486	4.0	45,370	8,239	6.0	49,780
Kiharu	3	4.4	12	4	4.4	19	8	4.0	34	10	4.2	42	40	3.8	151
Kirinyaga West	250	2.8	700	282	3.0	846	220	2.5	550	280	2.5	700	430	2.9	1,260
Coast Province															
Kwale	904	0.9	814	100	0.7	70	95	0.8	80	112	1.1	118	128	0.6	74
Lamu West	52	0.5	26	45	0.5	23	146	0.9	132	101	0.1	14	191	0.1	23
Kilifi	78	0.8	62	63	0.8	49	92	0.3	28	66	0.8	52	48	0.1	3
Kaloleni	338	0.5	169	268	1.6	416	256	0.4	102	426	1.4	596	362	0.3	92
Tana River	373	0.5	168	10	0.8	8	34	0.2	7	20	0.8	16	40	1.5	61
Tana Delta	-	-	-	70	0.7	46	170	1.1	187	306	1.1	343	1,680	3.6	5,996
Taveta	172	0.5	77	148	0.8	115	285	0.8	228	275	1.0	261	677	3.5	2,348
Msambweni	-	-	-	1,373	0.3	412	462	1.3	601	1,660	0.9	1,428	1,358	1.3	1,741
Kisauni	-	-	-	-	-	-	-	-	-	-	-	-	11	0.4	4
Changamwe	-	-	-	-	-	-	-	-	-	-	-	-	2	0.0	0
Likoni	-	-	-	-	-	-	-	-	-	-	-	-	2	0.0	0
Rabai	-	-	-	-	-	-	-	-	-	-	-	-	338	0.7	221
Malindi	-	-	-	-	-	-	-	-	-	-	-	-	17	0.2	3
Magarini	-	-	-	-	-	-	-	-	-	-	-	-	14	2.8	39
Eastern Province															
Tigania West	-	-	-	-	-	-	-	-	-	-	-	-	13	0.7	9
Embu East	-	-	-	-	-	-	5	3.0	15	8	3.0	24	15	3.0	45
Embu West	-	-	-	-	-	-	-	-	-	5	0.7	4	8	0.9	7
North Eastern Province															
Balambala	12	3.0	36	12	3.0	36	12	3.0	36	16	4.0	64	24	4.5	108
Grand Total	17,892	3.5	62,283	20,337	2.5	51,822	22,064	2.5	55,006	25,927	3.3	85,563	27,555	4.0	111,300

Source: Rice Production Unit, Ministry of Agriculture, October 2012

	2011 Area Planted (ha)	Unit Yield (t/ha)	Production (tons)
Irrigated paddy:	18,993	5.2	99,500
Rainfed paddy:	8,562	1.4	11,800

Table 2.3.5 Production of Horticultural Crops by County in 2009-2011

Province / County	2009				2010				2011			
	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Value (KSh mil)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Value (KSh mil)	Area (ha)	Produc-tion (ton)	Yield (t/ha)	Value (KSh mil)
Western												
Bungoma	13,083	183,896	14.1	3,042	15,102	226,920	15.0	4,301	18,786	191,174	10.2	3,528
Busia	6,576	66,398	10.1	748	6,890	65,653	9.5	934	7,622	91,009	11.9	1,103
Kakamega	2,751	23,158	8.4	475	2,914	30,579	10.5	525	3,360	26,849	8.0	503
Vihiga	1,698	22,874	13.5	431	1,878	24,012	12.8	456	1,891	18,725	9.9	491
Nyanza												
Homa Bay	11,119	67,287	6.1	1,475	13,696	97,697	7.1	1,587	17,223	114,247	6.6	2,598
Kisii	14,021	261,223	18.6	4,593	14,429	272,751	18.9	5,289	15,454	299,228	19.4	7,202
Kisumu	5,114	46,633	9.1	1,032	4,708	58,234	12.4	1,192	4,051	38,690	9.6	949
Migori	8,542	118,519	13.9	2,048	10,187	148,791	14.6	2,953	11,504	168,682	14.7	4,658
Nyamira	10,833	165,027	15.2	3,726	11,128	166,478	15.0	4,979	10,488	168,726	16.1	3,986
Siaya	9,699	58,767	6.1	893	10,964	101,106	9.2	1,309	9,907	71,941	7.3	951
Rift Valley												
Baringo	3,686	34,338	9.3	578	4,334	47,643	11.0	992	4,537	66,653	14.7	1,062
Bomet	6,853	126,702	18.5	2,615	6,797	100,230	14.7	1,671	8,570	214,842	25.1	4,858
Elgeyo	10,961	252,971	23.1	3,329	11,507	279,382	24.3	3,812	18,720	416,017	22.2	6,427
Kajiado	1,953	44,999	23.0	3,326	1,901	41,822	22.0	2,824	1,953	58,243	29.8	3,332
Keticho	4,680	99,838	21.3	1,218	5,315	114,104	21.5	2,516	5,756	118,622	20.6	2,986
Laikipia	6,387	54,763	8.6	1,948	8,536	67,239	7.9	2,426	7,636	58,504	7.7	2,676
Nakuru	24,556	193,397	7.9	18,974	25,257	300,519	11.9	30,481	24,569	395,653	16.1	30,105
Nandi	2,254	32,928	14.6	570	2,432	35,770	14.7	760	2,186	41,600	19.0	793
Narok	10,014	126,052	12.6	2,306	9,704	800,835	82.5	2,177	10,795	135,184	12.5	2,470
Samburu	157	420	2.7	10	161	756	4.7	16	182	780	4.3	18
Trans Nzoia	3,337	42,314	12.7	1,082	3,457	37,967	11.0	1,318	3,450	83,412	24.2	1,821
Turkana	84	211	2.5	4	135	197	1.5	4	143	217	1.5	5
Uasin Gishu	2,693	45,438	16.9	1,108	2,917	70,019	24.0	2,539	2,652	61,522	23.2	2,384
West Pokot	1,355	10,144	7.5	264	1,874	14,908	8.0	404	2,002	20,713	10.3	604
Central												
Kiambu	23,844	561,130	23.5	15,485	28,480	566,947	19.9	18,129	27,802	551,230	19.8	18,906
Kirinyaga	9,466	234,522	24.8	4,154	10,137	252,395	24.9	4,212	10,621	299,970	28.2	4,512
Muranga	13,566	172,022	12.7	4,459	13,990	209,826	15.0	7,019	16,421	184,588	11.2	6,365
Nyandarua	37,000	1,204,268	32.5	8,850	54,306	1,382,208	25.5	18,926	54,110	1,352,866	25.0	18,796
Nyeri	10,735	191,653	17.9	2,332	12,779	258,870	20.3	3,659	10,262	179,911	17.5	3,153
Nairobi												
Nairobi City	240	2,890	12.0	84	305	11,179	36.7	359	288	10,708	37.2	317
Eastern												
Embu	9,071	298,117	32.9	2,410	11,851	308,585	26.0	3,080	12,205	251,368	20.6	5,556
Isiolo	150	1,630	10.9	42	236	2,519	10.7	63	198	2,782	14.1	77
Kitui	1,711	18,703	10.9	365	2,248	26,597	11.8	625	2,659	32,673	12.3	809
Machakos	5,024	38,366	7.6	949	6,328	51,931	8.2	3,501	7,441	71,600	9.6	3,783
Makueni	4,666	66,886	14.3	1,332	12,603	115,957	9.2	2,871	10,043	92,266	9.2	3,046
Marsabit	95	496	5.2	25	118	595	5.0	30	158	826	5.2	42
Meru	54,008	844,307	15.6	30,054	43,452	657,699	15.1	29,124	47,468	631,474	13.3	30,327
Tharaka	50,480	209,194	4.1	2,611	32,496	258,438	8.0	3,151	36,821	285,461	7.8	5,523
Coast												
Kilifi	52,726	248,615	4.7	3,580	54,567	303,006	5.6	4,536	56,035	324,779	5.8	5,201
Kwale	53,259	296,139	5.6	4,448	49,954	334,543	6.7	5,091	52,727	368,380	7.0	6,182
Lamu	13,256	98,490	7.4	1,568	15,247	90,181	5.9	1,484	15,589	88,872	5.7	1,555
Mombasa	1,617	12,815	7.9	199	1,816	11,179	6.2	273	1,757	15,163	8.6	263
Taita Taveta	7,101	168,770	23.8	3,483	7,444	180,774	24.3	3,680	5,789	127,166	22.0	4,043
Tana River	4,832	81,662	16.9	1,107	2,448	32,234	13.2	523	1,769	24,665	13.9	451
North Eastern												
Garissa	1,190	14,162	11.9	264	1,376	15,004	10.9	279	1,623	18,448	11.4	480
Mandera	675	6,422	9.5	181	835	7,274	8.7	194	878	8,348	9.5	213
Wajir	53	464	8.8	17	99	661	6.7	21	127	874	6.9	32
Total/Average	517,171	6,850,020	13.2	143,794	539,338	8,182,214	15.2	186,295	566,228	7,785,651	13.8	205,142

Source: Economic Review of Agriculture 2012, Ministry of Agriculture

Table 2.4.1 Inventory of Smallholder Irrigation Scheme Area in 2010

Provincial Office	County	Existing (AIA)		On-going (AIA)		Proposed		Total	
		Nos	Area (ha)	Nos	Area (ha)	Nos	Area (ha)	Nos	Area (ha)
Western	Bungoma	2	60	8	653	26	2,146	36	2,859
	Busia	2	50	11	1,171	47	9,801	60	11,022
	Kakamega	3	87	7	370	51	3,651	61	4,108
	Vihiga	0	0	3	175	27	1,200	30	1,375
Nyanza	Kisii	6	132	3	380	47	2,365	56	2,877
	Nyamira	2	253	1	200	16	596	19	1,049
	Kisumu	15	3,620	4	235	44	4,594	63	8,449
	Siaya	30	731	9	1,307	40	10,440	79	12,478
	Homabay	33	5,866	14	3,443	33	3,450	80	12,759
	Migori	4	74	8	155	84	22,142	96	22,371
Rift Valley	kajiado	43	6,002	16	3,162	4	0	63	9,164
	Bomet	2	280	3	224	33	13,615	38	14,119
	kericho	0	0	2	110	23	1,603	25	1,713
	Laikipia	0	0	1	100	6	570	7	670
	Nakuru	0	0	15	640	0	0	15	640
	Narok	3	70	3	317	4	100	10	487
	Trans Nzoia	0	0	0	0	11	1,160	11	1,160
	UASIN GISHU	4	55	3	20	7	31	14	106
	Baringo	19	1,220	1	80	9	1,530	29	2,830
	Malakwet	16	795	5	364	6	163	27	1,322
	Nandi	6	344	4	28	4	0	14	372
	Samburu	2	15	0	0	2	15	4	30
	Turkana	20	2,065	3	200	2	73	25	2,338
	West Pokot	102	1,520	2	20	4	137	108	1,677
Central	Kiambu	2	320	10	1,410	34	5,483	46	7,213
	Kirinyaga	92	3,629	13	1,307	29	2,830	134	7,766
	Murang'a	5	106	16	740	19	1,174	40	2,020
	Nyandarua	7	121	5	197	17	500	29	819
	Nyeri	5	260	18	430	23	2,391	46	3,081
Nairobi	Nairobi	51	100	0	0	0	0	51	100
Eastern	Embu	20	1,810	11	1,019	7	1,700	38	4,529
	Isiolo	10	1,160	5	708	2	220	17	2,088
	Kitui	3	68	2	35	5	70	10	173
	Machakos	41	1,419	8	705	13	1,965	62	4,089
	Makueni	14	751	15	1,043	5	432	34	2,226
	Marsabit	-	-	-	-	-	-	-	-
	Meru	58	6,811	28	1,803	42	2,231	128	10,845
	Tharaka	2	70	3	320	5	1,226	10	1,616
Coast	Kilifi	20	469	3	90	27	1,850	50	2,409
	Kwale	11	608	4	24	13	258	28	890
	Lamu	10	41	2	12	0	0	12	53
	Mombasa	1	2	3	5	6	3	10	9
	Taita Taveta	35	3,854	1	600	2	2,400	38	6,854
	Tana River	11	1,190	0	0	2	160	13	1,350
North Eastern	Garissa	62	818	1	1	3	36	66	855
	Mandera	287	4,858	3	130	18	800	308	5,788
	Wajir	10	200	0	0	3	60	13	260
Total		1,071	51,903	277	23,932	805	105,172	2,153	181,007

Source: JICA Study Team based on data from Inventory Survey in this study

Table 2.4.2 Inventory of Drainage Scheme Area in 2010

Provincial Office	County	Existing (AIA)		On-going (AIA)		Proposed		Total	
		Nos	Area (ha)	Nos	Area (ha)	Nos	Area (ha)	Nos	Area (ha)
Western	Bungoma	3	150	2	110	30	7,238	30	7,238
	Busia	1	30	2	930	25	4,500	25	4,500
	Kakamega	5	320	3	247	25	2,245	25	2,245
	Vihiga	0	0	0	0	7	270	7	270
Nyanza	Kisii	7	1,460	2	310	20	1,254	20	1,254
	Nyamira	2	183	1	309	26	3,055	26	3,055
	Kisumu	0	0	0	0	0	0	0	0
	Siaya	0	0	0	0	0	0	0	0
	Homabay	0	0	0	0	0	0	0	0
	Migori	0	0	0	0	17	4,099	17	4,099
Rift Valley	kajiado	0	0	0	0	0	0	0	0
	Bomet	0	0	0	0	5	8,750	5	8,750
	kericho	0	0	0	0	0	0	0	0
	Laikipia	0	0	0	0	0	0	0	0
	Nakuru	0	0	0	0	0	0	0	0
	Narok	0	0	0	0	0	0	0	0
	Trans Nzoia	1	100	0	0	0	0	0	0
	UASIN GISHU	0	0	0	0	0	0	0	0
	Baringo	0	0	0	0	0	0	0	0
	Malakwet	0	0	0	0	0	0	0	0
	Nandi	0	0	0	0	0	0	0	0
	Samburu	0	0	0	0	0	0	0	0
	Turkana	0	0	0	0	0	0	0	0
	West Pokot	0	0	0	0	0	0	0	0
Central	Kiambu	0	0	1	2,755	7	149	7	149
	Kirinyaga	0	0	0	0	0	0	0	0
	Murang'a	0	0	0	0	0	0	0	0
	Nyandarua	0	0	2	0	7	2,459	7	2,459
	Nyeri	0	0	1	0	1	0	1	0
Nairobi	Nairobi	0	0	0	0	0	0	0	0
Eastern	Embu	0	0	0	0	0	0	0	0
	Isiolo	0	0	0	0	0	0	0	0
	Kitui	0	0	0	0	0	0	0	0
	Machakos	0	0	0	0	0	0	0	0
	Makueni	0	0	0	0	0	0	0	0
	Marsabit	0	0	0	0	0	0	0	0
	Meru	0	0	0	0	0	0	0	0
	Tharaka	0	0	0	0	0	0	0	0
Coast	Kilifi	0	0	0	0	0	0	0	0
	Kwale	0	0	0	0	1	1	1	1
	Lamu	0	0	0	0	0	0	0	0
	Mombasa	0	0	0	0	0	0	0	0
	Taita Taveta	0	0	0	0	0	0	0	0
	Tana River	0	0	0	0	0	0	0	0
North Eastern	Garissa	0	0	0	0	0	0	0	0
	Mandera	0	0	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0	0	0
Total		19	2,243	14	4,661	171	34,020	171	34,020

Source: JICA Study Team based on data from Inventory Survey in this study

Table 2.4.3 Inventory of Private Irrigation Scheme Area in 2010

Province	County	Water Permit Holders (Nos)	Water Permit Volume (m^3/day)				Irrigation Area (ha)*
			Dry Season	Flood Season	Others	Total	
Western	Bungoma	0	0	0	0	0	0
	Busia	0	0	0	0	0	0
	Kakamega	0	0	0	0	0	0
	Vihiga	0	0	0	0	0	0
Nyanza	Homa Bay	3	0	401	0	401	10
	Migori	1	0	90	0	90	5
	Kisii	1	0	1,120	0	1,120	7
	Nyamira	0	0	0	0	0	0
	Kisumu	5		121,448	0	121,448	1,028
	Siaya	1	0	350	0	350	6
Rift Valley	Baringo	36	0	23,905	0	23,905	774
	Kericho	12	0	20,937	0	20,937	143
	Bomet	0	0	0	0	0	0
	Elgeyo Marakwet	0	0	0	0	0	0
	Kajiado	10	1,280	2,612	1,096	4,988	150
	Laikipia	51	0	143,066	0	143,066	1,394
	Nakuru	61	0	48,778	0	48,778	1,579
	Nandi	4	300	65	0	365	8
	Narok	42	0	37,013	0	37,013	335
	Samburu	0	0	0	0	0	0
	Trans Nzoia	6	3,244	4,135	0	7,379	99
	Turkana	4	0	1,647	0	1,647	53
	Uasin Gishu	4	0	1,120	3,475	4,595	73
	West Pokot	6	0	2,409	0	2,409	78
Central	Kiambu	175	0	379,024	0	379,024	9,203
	Kirinyaga	192	0	484,560	0	484,560	11,766
	Muranga	206	0	98,391	0	98,391	2,389
	Nyandarua	5	0	5,770	0	5,770	203
	Nyeri	367	0	186,277	0	186,277	5,316
Nairobi	Nairobi	6	0	7,550	0	7,550	183
Eastern	Embu	151	0	106,544	0	106,544	2,587
	Isiolo	3	0	6,778	0	6,778	269
	Kitui	29	0	15,460	0	15,460	375
	Machakos	42	0	21,005	0	21,005	534
	Makueni	32	0	46,561	0	46,561	2,658
	Marsabit	0	0	0	0	0	0
	Meru	600	0	764,142	0	764,142	10,901
	Tharaka-Nithi	99	0	27,540	0	27,540	3,097
Coast	Kilifi	0	0	0	0	0	0
	Kwale	1	0	1,757		1,757	2
	Lamu	0	0	0	0	0	0
	Mombasa	0	0	0	0	0	0
	Taita Taveta	24	108,475	185,797	775,768	1,070,040	18,644
	Tana River	12	0	34,572	0	34,572	839
North Eastern	Garissa	52	0	46,603	0	46,603	1,132
	Mandera	0	0	0	0	0	0
	Wajir	0	0	0	0	0	0
Total		2,243	113,299	2,827,427	780,339	3,721,065	75,840

Note: * = Estimated from water permit volume by WRMA applying a rate of 7,413 m^3/ha/year
Source: JICA Study Team based on data from Inventory Survey in this study

Table 2.4.4 Existing Irrigation Schemes by County and Catchment Area in 2010

1) Existing Irrigation Schemes by County

Province	County	Large Scale		Small Scale		Private		Total	
		Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)
Western	Bungoma	0	0	2	60	0	0	2	60
	Busia	1	363	2	50	0	0	3	413
	Kakamega	0	0	3	87	0	0	3	87
	Vihiga	0	0	0	0	0	0	0	0
Nyanza	Homa Bay	0	0	33	5,866	3	10	36	5,876
	Migori	0	0	4	74	1	5	5	79
	Kisii	0	0	6	132	1	7	7	139
	Nyamira	0	0	2	253	0	0	2	253
	Kisumu	2	1,800	15	3,620	5	1,028	22	6,448
	Siaya	0	0	30	731	1	6	31	737
Rift Valley	Baringo	1	450	19	1,220	36	774	56	2,444
	Kericho	0	0	0	0	12	143	12	143
	Bomet	0	0	2	280	0	0	2	280
	Elgeyo Marakwet	0	0	16	795	0	0	16	795
	Kajiado	0	0	43	6,022	10	150	53	6,172
	Laikipia	0	0	0	0	51	1,394	51	1,394
	Nakuru	0	0	0	0	61	1,579	61	1,579
	Nandi	0	0	6	344	4	8	10	352
	Narok	0	0	3	70	42	335	45	405
	Samburu	0	0	2	15	0	0	2	15
	Trans Nzoia	0	0	0	0	6	99	6	99
	Turkana	0	0	20	2,065	4	53	24	2,118
	Uasin Gishu	0	0	4	55	4	73	8	128
	West Pokot	1	324	102	1,520	6	78	109	1,922
Central	Kiambu	0	0	2	320	175	9,203	177	9,523
	Kirinyaga	2	7,800	92	3,629	192	11,766	286	23,195
	Muranga	0	0	5	106	206	2,389	211	2,495
	Nyandarua	0	0	7	121	5	203	12	324
	Nyeri	0	0	5	260	367	5,316	372	5,576
Nairobi	Nairobi	0	0	51	100	6	183	57	283
Eastern	Embu	0	0	20	1,810	151	2,587	171	4,397
	Isiolo	0	0	10	1,160	3	269	13	1,429
	Kitui	0	0	3	68	29	375	32	443
	Machakos	0	0	41	1,419	42	534	83	1,953
	Makueni	0	0	14	751	32	2,658	46	3,409
	Marsabit	0	0	0	0	0	0	0	0
	Meru	0	0	58	6,811	600	10,901	658	17,712
	Tharaka-Nithi	0	0	2	70	99	3,097	101	3,167
Coast	Kilifi	0	0	20	469	0	0	20	469
	Kwale	0	0	11	608	1	2	12	610
	Lamu	0	0	10	41	0	0	10	41
	Mombasa	0	0	1	2	0	0	1	2
	Taita Taveta	0	0	35	3,854	24	18,644	59	22,498
	Tana River	2	3,400	11	1,190	12	839	25	5,429
North Eastern	Garissa	0	0	62	818	52	1,132	114	1,950
	Mandera	0	0	287	4,858	0	0	287	4,858
	Wajir	0	0	10	200	0	0	10	200
Total		9	14,137	1071	51,924	2243	75,840	3,323	141,900

2) Existing Irrigation Scheme by Catchment Area

Catchment Area	Large Scale		Small Scale		Private		Total	
	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)	Nos.	Area (ha)
Lake Victoria North	1	363	37	1,327	1	186	39	1,876
Lake Victoria South	2	1,800	45	10,225	5	1,193	52	13,218
Rift Valley	2	774	217	5,791	236	3,022	455	9,587
Athi	0	0	185	13,524	780	31,374	965	44,898
Tana	4	11,200	278	14,823	1,167	38,402	1,449	64,425
Ewaso Ng'iro North	0	0	309	6,233	54	1,663	363	7,896
Total	9	14,137	1,071	51,924	2,243	75,840	3,323	141,900

Source: JICA Study Team based on data from Inventory Survey in this study

Table 2.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (1/2)

A. Project Proposed by Government Authorities (1/2)

No	Name of Project	County	Irrigation Area (ha)	Type of Project*[1]	Water Source Facility*[2]	Project Status as of Oct. 2012*[3]	Executing Agency
LVNCA							
1.	Lower Nzoia Irrigation	Busia & Siaya	10,470	New	Weir	On-going	NIB
2.	Lower Sio Irrigation	Busia	6,600	New	Weir	On-going	NIB
3.	Nandikinya-Magombe-Makunda Irri.	Busia	600	New	Pumping	Proposed	LBDA
4.	Sabwani-Kapsitwet-Namanjalala Irri.	Trans Nzoia	800	Reh+Ext	Weir	Proposed	LBDA
5.	Yala Swamp Drainage & Irrigation	Siaya	4,600	New	Weir	F/S done	LBDA
LVSCA							
1.	Ahero and West Kano Irrigation	Kisumu	1,800	Reh+Ext	Pump/Weir	F/S done	NIB
2.	Kano Plain Irrigation (Magwagwa Multi-dam)	Nyamira/ Kericho	15,000	New	Multi-dam	F/S done	LBDA
3.	Kimira-Oluch Irrigation	Homa Bay	1,474	New	Weir	On-going	LBDA
4.	Lower Kuja Irrigation	Migori	7,800	New	Weir	D/D done	NIB
5.	Nandi Irrigation (Nanndi Forest Multi-dam)	Vihiga/Nandi	7,272	New	Multi-dam	D/D on-going	LBDA
6.	Nyando Irrigation (Nyando Multi-dam)	Kericho	3,000	New	Multi-Dam	Proposed	LBDA
7.	South West Kano Irrigation	Kisumu	1,200	Reh	Weir	On-going	NIB
RVCA							
1.	Ainabkoi Kamwosor Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
2.	Arror Irrigation (Arror Multi-dam)	Elgeyo Marakwet	10,000	New+Ext	Multi-dam	F/S done	KVDA
3.	Chebaram-Kimose Irrigation	Baringo	650	New	Dam	Proposed	KVDA
4.	Chesegon Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
5.	Chesongoch Irrigation	Elgeyo Marakwet	1,000	New	Dam	Proposed	KVDA
6.	Embobut Irrigation	Elgeyo Marakwet	2,000	Ext	Multi-dam	Proposed	KVDA
7.	Embolot Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
8.	Embomon Irrigation	Elgeyo Marakwet	800	New	Dam	Proposed	KVDA
9.	Kakuma Irrigation	Turkana	700	New	Dam	Proposed	KVDA
10.	Katilu Irrigation	Turkana	5,060	Reh+Ext	Weir	Proposed	NIB
11.	Kimwarer Irrigation	Baringo	2,000	New	Multi-Dam	Proposed	KVDA
12.	Kipkukutia Irrigation	Baringo	600	New	Dam	Proposed	KVDA
13.	Lomut Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
14.	Lower Ewaso Ng'iro Irrigation (Oletuka/Oldorko Multi-dam)	Kajiado	15,000	New	Multi-dam	F/S on-going	ENSDA
15.	Mogil Kiptunos Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
16.	Muringa Banana Irrigation	Turkana	1,446	New	Weir	Proposed	KVDA
17.	Murung-Sebit Irrigation	West Pokot	850	New	Dam	Proposed	KVDA
18.	Namerit Irrigation	Turkana	2,000	New	Dam	Proposed	KVDA
19.	Nauwia rrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
20.	Norera Irrigation	Narok	2,000	New	Dam	F/S on-going	ENSDA
21.	Oke-Kipsaa Dam Irrigation	Baringo	1,080	New	Dam	Proposed	KVDA
22.	Oldekesi Irrigation	Narok	2,000	New	Weir	Proposed	ENSDA
23.	Olkejuado Dry Land Irrigation	Kajiado	3,000	New	Dam	Proposed	ENSDA
24.	Perkera Irrigation Extention	Baringo	3,000	Reh+Ext	Weir/Dam	F/S on-ging	NIB
25.	Suswa Flood Mitigation Irrigation	Narok	4,000	New	Weir	Proposed	ENSDA
26.	Todonyang-Omo Irrigation (Gibe 3 Multi-dam in Ethiopia)	Turkana	35,000	New	Multi-dam	Proposed	KVDA
27.	Torok Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
28.	Tunyo Irrigation	Elgeyo Marakwet	500	New	Dam	Proposed	KVDA
29.	Turkwel Irrigation	West Pokot	5,000	New	Dam (E)	F/S done	KVDA
30.	Turkwel & Kerio Valley Irrigation	Elgeyo Marakwet	30,000	New	Weir/Dam	F/S on-ging	NIB
ACA							
1.	Burangi Irrigation	Kilifi	1,200	New	Weir	Proposed	CDA
2.	Ilchilal Irrigation	Kajiado	600	Ext	Weir	Proposed	ENSDA
3.	Kanzal Irrigation Extention	Makueni	3,500	Ext	Weir	Proposed	NIB
4.	Kavunyalalo Irrigation	Kilifi	8,240	New	Weir	F/S on-ging	NIB
5.	Kayatta Irrigation Extention	Machakos	3,500	Ext	Weir	Proposed	NIB
6.	Kibwezi Irrigation Extention (Munyu Muldi-dam)	Makueni	15,000	Ext	Multi-Dam	Proposed	TARDA

Table 2.5.1 Large Scale Irrigation Projects Proposed by Government Authorities and This Study (2/2)

A. Project Proposed by Government Authorities (2/2)

No	Name of Project	County	Irrigation Area (ha)	Type of Project*1	Water Source Facility*2	Project Status as of Oct. 2012*3	Executing Agency
7.	Kibwezi Greater Irrigation Extention (Thwake Muldi-dam)	Makueni	42,000	Ext	Multi-Dam	Proposed	NIB
8.	Mt. Kilimanjaro Irrigation	Kajiado	1,500	Reh+Ext	Springs	Proposed	ENSDA
9.	Olkishunki Irrigation	Kajiado	2,000	New	Multi-Dam	Proposed	ENSDA
10.	Raare Irrigation	Kilifi	700	New	Dam	F/S on-ging	CDA
11.	Rwabura Irrigation Extension	Kiambu	4,360	Ext	Weir/Dam	D/D on-ging	NIB
12.	Sabaki Irrigation Extention	Kilifi	3,000	Ext	Weir	F/S on-ging	NIB
13.	Sabaki Umba River Basins Intgrated Irrigation	Kilifi, Kwale	80,000	New	Weir/Dam	F/S on-ging	CDA
14.	Taita Taveta Irrigation	Taita Taveta	3,780	Reh+Ext	Weir	F/S on-ging	TARDA
TCA							
1.	Bura Pump Irrigation Extenton	Tana river	800	Ext	Weir	On-going	NIB
2.	Bura West Irrigation Extention	Tana river	5,500	Reh+Ext	Weir	D/D done	NIB
3.	High Grand Falls Irrigation (High Grand Falls Multi-dam)	Garissa/ Tana River	106,000	New	Multi-dam	F/S done	TARDA/ NIB
4.	Hola Pump Irrigation Extention	Tana River	800	Ext	Pump	On-going	NIB
5.	Hola Irrigation Greater Extention	Tana River	3,500	Reh+Ext	Weir	D/D on-ging	NIB
6.	Kaggari-Gaturi-Keini Irrigation	Embu	6,600	Ext	Dam	D/D done	NIB
7.	Kanzalu Irrigation	Machakos	4,055	New	Weir/Dam	Proposed	TARDA
8.	Kiambere Irrigation	Embu	10,000	Ext	Weir/Dam	F/S on-ging	TARDA
9.	Kunati Irrigation	Meru	1,050	New	Weir	Proposed	NIB
10.	Masinga Irrigation	Machakos	10,000	New+Ext	Weir/Dam	F/S on-ging	TARDA
11.	Mitunguu Irrigation Extention	Meru	10,000	Reh+Ext	Weir/Dam	F/S done	NIB
12.	Mwea Irrigation Extention (Thiba dam)	Kiriyyaga	9,485	Ext	Weir/Dam	On-going	NIB
13.	Tana Delta Irrigated Sugar	Tana River	20,000	New	Weir	D/D done	TARDA
14.	Tana Delta Irrigatgion Extention (Rice)	Tana River	10,000	Reh+Ext	Weir	D/D done	TARDA
15.	Thanantu Irrigation	Meru	2,500	New	Weir/Dam	Proposed	TARDA
ENNCA							
1.	Kieni Irrigation	Nyeri	3,500	New	Weir	F/S on-ging	NIB
2.	Kom (Wajir) Irrigation (Archer's Post Multi-dam)	Isiolo/Samburu	2,146	New	Multi-dam	F/S on-ging	ENNDA
3.	Lorian Swamp Cotton Irrigation	Wajir	1,800	New	Weir/Dam	F/S on-ging	ENNDA

Note: *1: Reh = Rehabilitation, Ext = Extension; *2: Multi = Multipurpose, E = Existing

*3: On-going = projects financed for construction, Proposed = projects having no detailed information for evaluation.

Source: Information from Government Agencies.

B. Projects Proposed in this Study

No	Name of Project	County	Irrigation Area (ha)	Type of Project*1	Water Source Facility*2	Project Status as of Oct. 2012*3	Executing Agency
LVNCA							
1.	Upper Nzoia Irrigation (Nzoia 34B Multi-dam)	Bungoma	24,000	New	Multi-dam	Proposed	
2.	Moi's Bridge Irrigation	Bungoma	19,800	New	Multi-dam	Proposed	
3.	Kibolo Irrigation	Kakamega	11,500	New	Multi-dam	Proposed	
LVSCA							
1.	Lower Kuja Irrigation (Stage-2) (Katieno Multi-dam)	Migori	32,700	New	Multi-dam	Proposed	
2.	Amala Irrigation (Amala Multi-dam)	Bomet	5,000	New	Multi-dam	Proposed	
3.	Illooiterre Irrigation	Narok	3,000	New	Multi-dam	Proposed	
TCA							
1.	Kora Irrigation (Kora Multi-dam)	Tana river	25,000	New	Multi-dam	Proposed	
ENNCA							
1.	Kihoto Irrigation (Kihoto Multi-dam)	Laikipia	18,000	New	Multi-dam	Proposed	

Source: JICA Study Team based on Information from Government Agencies.

Table 3.2.1 Average Effective Monthly Rainfall for Irrigation by Sub-basin (1/4)

(Unit: mm)

Catchment Area	Sub-basin	Effective Monthly Rainfall												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
LVNCA	1AA	33	36	78	135	129	67	68	83	89	94	77	39	930
	1AB	28	32	70	125	119	68	72	85	82	86	67	34	870
	1AC	33	36	77	136	128	73	73	89	88	92	73	38	935
	1AD	40	41	89	151	143	72	68	85	98	105	89	47	1,029
	1AE	43	43	94	154	149	65	60	79	101	114	98	53	1,054
	1AF	39	41	89	149	141	71	67	83	96	103	87	46	1,013
	1AG	40	41	91	149	140	71	67	83	96	101	89	48	1,016
	1AH	43	40	91	149	138	62	58	75	96	107	96	53	1,007
	1BA	24	21	55	108	89	62	78	78	42	64	65	31	717
	1BB	20	22	53	104	97	71	84	86	53	69	59	26	744
	1BC	18	22	51	103	104	79	90	92	63	74	53	23	772
	1BD	22	24	55	106	93	63	81	90	59	65	55	28	741
	1BE	19	24	54	104	102	68	82	89	67	73	52	25	759
	1BG	21	26	58	110	105	69	80	94	75	75	55	26	793
	1BH	23	28	62	116	109	70	79	96	80	78	58	29	827
	1CA	25	24	55	106	87	62	84	87	50	58	57	32	727
	1CB	27	26	56	107	88	66	88	95	54	57	55	35	755
	1CC	30	28	60	108	92	71	91	98	59	61	60	38	796
	1CD	30	31	65	117	105	80	95	112	76	70	59	34	873
	1CE	27	30	64	119	110	80	88	114	86	76	57	32	885
	1DA	34	36	78	139	128	90	89	118	97	90	69	38	1,006
	1DB	28	32	70	126	118	73	77	94	84	84	65	33	884
	1DC	36	38	82	142	132	81	78	99	93	93	75	41	989
	1DD	38	40	87	146	136	76	73	90	94	96	82	43	1,002
	1EA	42	42	88	146	135	100	98	130	103	91	76	45	1,095
	1EB	44	43	95	152	142	93	89	118	103	95	83	48	1,105
	1EC	40	41	89	152	140	97	92	122	105	97	79	45	1,098
	1ED	42	41	93	152	139	79	76	96	99	98	88	49	1,051
	1EE	42	38	91	148	132	64	62	77	95	98	94	51	991
	1EF	42	37	90	144	127	59	56	71	90	99	93	52	959
	1EG	44	38	93	145	125	66	63	80	91	91	91	53	980
	1FA	33	30	65	110	97	77	96	104	67	65	64	39	847
	1FB	38	37	75	123	114	86	99	114	82	75	68	40	951
	1FC	42	39	80	125	117	88	98	112	84	78	73	43	980
	1FD	42	37	78	118	110	82	95	102	77	74	72	42	929
	1FE	48	43	94	142	127	87	85	108	93	85	81	51	1,045
	1FF	49	40	96	137	116	71	66	85	83	79	82	55	958
	1FG	44	35	89	133	107	55	50	66	78	87	88	54	886
Average for LVNCA		35	34	76	130	119	74	79	94	82	84	73	41	921
LVSCA	1GA	40	34	73	114	95	73	88	96	66	64	66	42	852
	1GB	52	39	89	124	102	74	80	85	73	72	74	48	911
	1GC	43	36	71	112	91	68	83	98	65	66	65	45	843
	1GD	58	41	94	126	95	63	65	70	65	70	73	53	875
	1GE	60	43	94	130	102	66	67	75	69	77	76	56	916
	1GF	58	42	91	127	96	61	59	69	64	73	75	58	872
	1GG	47	38	80	118	96	70	82	92	67	66	68	46	870
	1HA1	53	39	93	125	100	65	63	75	70	68	75	55	882
	1HA2	55	38	91	121	89	58	56	65	62	65	72	55	829
	1HB1	46	34	90	128	100	54	48	62	72	78	83	54	849
	1HB2	51	37	96	126	98	58	50	64	68	69	78	57	853
	1HC	43	32	86	124	95	47	41	55	68	80	83	53	808
	1HD	59	48	97	133	109	71	57	74	73	80	84	66	950
	1HE	56	47	96	134	116	70	52	71	76	83	88	67	955
	1HF	41	34	80	121	99	45	34	49	61	72	77	57	771
	1HG	40	33	78	118	95	42	32	46	58	70	76	57	745
	1JA	54	46	86	128	105	72	78	91	71	76	77	56	939
	1JB	64	54	102	147	124	81	82	92	81	89	86	62	1,063
	1JC	60	48	95	138	120	80	86	97	81	86	82	56	1,029
	1JD	64	51	100	145	121	80	81	92	81	90	84	60	1,050
	1JE	65	58	99	135	104	71	58	73	71	74	85	73	966
	1JF	60	53	94	134	106	73	69	83	72	77	82	64	968

Table 3.2.1 Average Effective Monthly Rainfall for Irrigation by Sub-basin (2/4)

(Unit: mm)

CA	Sub-basin	Effective Monthly Rainfall												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
LVSCA	1JG1	62	51	97	137	111	75	70	84	75	84	82	63	990
	1JG2	59	46	95	130	103	66	56	70	68	75	80	64	911
	1KA	57	50	96	137	122	71	51	70	77	84	91	71	976
	1KB	52	46	88	127	107	56	42	56	64	72	81	68	861
	1KC	59	54	91	127	103	56	42	54	63	67	80	75	871
	1LA1	55	48	84	126	96	64	61	76	63	67	79	62	881
	1LA2	64	59	89	121	92	57	42	53	61	59	76	75	848
	1LA3	54	46	68	99	66	31	23	28	34	37	61	59	608
	1LB1	53	47	78	115	83	54	49	62	52	56	72	60	781
	1LB2	58	51	73	103	70	38	29	35	42	42	64	63	666
Average for LVSCA		54	45	89	126	100	63	59	71	67	72	77	59	881
RVCA	2AA	0	0	21	35	17	0	0	0	0	12	21	12	118
	2AB	0	0	19	30	16	0	0	0	0	0	18	0	83
	2BA	17	20	48	96	97	77	87	87	57	67	51	22	726
	2BB	0	0	38	76	75	56	65	65	41	50	43	19	529
	2BC	0	0	41	79	80	58	68	69	47	53	42	20	556
	2BD	0	0	20	38	32	17	20	22	14	17	21	0	202
	2CA	0	0	18	32	25	0	0	0	0	0	18	0	93
	2CB	27	24	57	113	87	66	85	86	43	58	66	38	750
	2CC	0	0	32	60	51	34	40	41	24	33	36	18	371
	2D	17	0	38	67	49	35	46	47	23	36	47	25	430
	2EA	20	19	40	75	64	52	67	74	42	44	47	33	576
	2EB	20	18	40	74	63	53	69	75	38	40	46	33	570
	2EC	22	20	42	80	65	49	63	76	44	49	51	35	597
	2ED	26	23	50	93	74	64	89	103	52	51	53	36	713
	2EE	22	21	49	92	74	60	82	82	39	45	54	37	658
	2EF	23	21	45	83	67	55	79	91	44	46	49	34	635
	2EG1	27	24	47	88	68	53	71	90	49	52	56	38	664
	2EG2	21	20	43	81	67	53	74	80	39	43	50	34	603
	2EH	24	23	52	104	82	64	86	86	40	49	62	37	711
	2EJ	17	0	35	70	53	39	55	58	25	32	46	30	460
	2EK	18	16	37	73	59	46	65	67	30	34	46	32	522
	2FA	23	20	40	75	57	49	47	56	40	48	49	32	536
	2FB	21	19	41	79	66	48	59	71	44	49	51	33	583
	2FC	23	21	41	77	60	47	52	64	42	48	50	33	559
	2GA	25	20	40	76	57	47	42	52	38	47	49	32	526
	2GB	24	21	42	81	62	51	48	57	42	52	53	34	565
	2GC	29	27	51	108	89	51	39	49	43	70	74	43	674
	2GD	31	26	46	91	71	44	33	42	33	53	60	38	568
	2H1	39	29	54	99	69	21	0	16	0	37	71	47	483
	2H2	37	27	56	101	64	0	0	0	0	33	76	51	445
	2H3	36	25	53	88	50	0	0	0	0	28	75	52	408
	2JA	0	0	19	33	20	0	0	0	0	0	18	12	103
	2KA	45	37	57	88	60	31	27	34	28	33	53	46	539
	2KB	43	33	51	85	54	17	0	0	13	25	53	44	418
	2KC	42	32	53	87	54	0	0	0	0	25	59	46	399
Average for RVCA		21	17	42	77	60	38	45	50	29	39	49	31	496
ACA	3AA	37	27	58	112	73	16	0	0	0	37	84	53	498
	3AB	36	25	54	89	46	0	0	0	0	31	80	55	416
	3AC	36	24	62	114	54	0	0	0	0	39	101	60	490
	3BA	38	28	64	132	88	20	0	0	0	47	99	57	573
	3BB	38	30	68	145	98	24	0	0	0	56	107	60	626
	3BC	39	32	69	152	110	30	20	21	19	67	112	62	733
	3BD	39	31	69	150	104	28	19	20	17	65	111	61	714
	3CB	38	30	70	149	95	25	16	17	16	64	113	61	693
	3DA	35	22	64	116	42	0	0	0	0	40	113	64	495
	3DB	35	18	58	106	35	0	0	0	0	41	141	78	511
	3EA	37	22	56	95	35	0	0	0	0	33	108	68	454
	3EB	37	21	59	99	37	0	0	0	0	36	128	73	490
	3EC	37	21	58	95	37	0	0	0	0	35	129	73	485
	3ED	36	19	59	100	36	0	0	0	0	38	149	80	517

Table 3.2.1 Average Effective Monthly Rainfall for Irrigation by Sub-basin (3/4)

(Unit: mm)

Catchment Area	Sub-basin	Effective Monthly Rainfall												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
ACA	3FA	32	20	50	76	31	0	0	0	0	27	106	68	409
	3FB	29	0	46	56	20	0	0	0	0	21	104	80	357
	3G	30	18	54	65	28	0	0	0	0	24	83	65	366
	3HA	26	0	48	58	27	0	0	0	0	27	78	75	339
	3HB	20	0	39	56	60	25	18	16	16	39	66	58	413
	3HC	0	0	26	62	105	52	36	27	21	51	51	39	470
	3HD1	0	0	26	68	126	61	42	30	25	57	49	38	522
	3HD2	0	0	26	71	124	61	41	29	22	53	50	38	515
	3J	28	18	61	75	37	0	0	0	0	27	71	59	376
	3K	21	0	35	87	133	55	40	34	27	61	66	43	602
	3LA	20	0	41	63	70	28	20	17	18	44	66	56	444
	3LB	0	0	27	73	134	62	43	30	26	60	48	37	541
	3MA-1	24	17	58	73	44	0	0	0	0	38	79	65	397
	3MA-2	22	0	45	71	82	33	24	23	20	50	72	53	496
	3MB	18	0	33	83	126	51	37	31	26	59	61	41	567
	3MC	22	0	34	86	132	55	41	35	27	62	65	42	601
	3MD-1	0	0	31	104	162	63	47	35	30	66	61	39	638
	3MD2	18	0	32	99	156	62	45	37	29	67	64	41	651
	3N	32	22	50	69	30	0	0	0	0	24	86	59	372
Total for ACA		28	17	49	92	76	25	18	16	14	45	88	58	508
TCA	4AA	33	21	53	132	108	17	18	18	18	79	106	57	659
	4AB	30	24	49	114	100	27	27	26	25	72	86	51	632
	4AC	33	28	54	128	111	32	28	29	28	79	93	55	697
	4AD	35	30	59	142	123	37	31	33	31	87	103	58	768
	4BA	31	22	56	156	121	19	17	17	16	81	112	55	704
	4BB	32	20	56	147	116	16	0	16	16	81	113	57	672
	4BC	28	18	57	159	112	15	0	0	0	80	117	52	639
	4BD	36	30	63	166	133	35	28	31	27	92	118	61	818
	4BE	35	28	67	172	124	29	22	24	21	88	124	61	794
	4BF	31	23	66	157	90	16	0	0	0	66	115	56	620
	4BG	28	18	65	146	66	0	0	0	0	56	112	52	544
	4CA	41	35	70	163	129	46	33	38	33	91	118	64	859
	4CB	41	35	73	174	132	38	27	30	26	91	128	68	863
	4CC	33	22	68	137	59	0	0	0	0	50	112	58	538
	4DA	28	17	61	160	99	0	0	0	0	80	123	53	621
	4DB	31	17	67	174	105	0	0	17	0	98	145	60	713
	4DC	33	18	70	186	110	0	0	19	16	109	160	65	785
	4DD	27	16	62	154	70	0	0	0	0	72	131	56	587
	4DE	29	17	61	129	43	0	0	0	0	47	113	58	496
	4EA	47	21	76	207	99	0	0	0	0	143	218	101	913
	4EB	45	21	78	212	112	0	0	0	0	137	210	91	905
	4EC	36	17	70	185	90	0	0	0	0	102	173	72	746
	4ED	32	15	57	137	42	0	0	0	0	59	145	70	558
	4FA	46	20	72	194	82	0	0	0	0	135	213	104	866
	4FB	42	17	69	186	70	0	0	0	0	117	206	99	805
	4GA	33	0	57	155	51	0	0	0	0	97	174	84	650
	4GB	27	0	48	130	38	0	0	0	0	70	150	71	535
	4GC	16	0	28	70	17	0	0	0	0	33	89	44	297
	4GD	19	0	32	77	26	0	0	0	0	36	98	50	339
	4GE	25	0	39	88	30	0	0	0	0	41	121	65	408
	4GF	21	0	34	71	45	21	0	0	0	36	102	62	392
	4GG	0	0	24	68	111	57	37	25	19	47	56	46	489
	4HA	31	0	49	86	23	0	0	0	0	33	142	84	448
	4HB	23	0	36	62	39	17	0	0	0	31	103	68	379
	4HC	22	0	37	54	45	18	0	0	0	31	76	64	348
	4JA	0	0	21	56	52	24	0	0	0	29	60	36	279
	4JB	0	0	19	65	137	66	33	20	17	36	49	41	483
	4KA	0	0	20	60	110	54	27	17	14	34	51	40	429
	4KB	0	0	21	62	108	54	29	19	15	37	53	42	440
Average for TCA		28	14	53	131	84	16	0	0	0	71	121	62	608

Table 3.2.1 Average Effective Monthly Rainfall for Irrigation by Sub-basin (4/4)

(Unit: mm)

Catchment Area	Sub-basin	Effective Monthly Rainfall												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
ENNCA	5AA	20	16	37	71	56	49	61	66	36	41	46	32	529
	5AB	20	0	35	71	51	43	53	56	31	41	48	30	482
	5AC	16	0	31	70	45	34	44	43	20	33	44	26	404
	5AD	19	0	31	67	42	32	41	40	21	37	47	27	404
	5BA	27	20	43	94	83	24	27	26	24	63	74	43	547
	5BB	25	19	41	86	73	31	34	35	28	58	65	39	534
	5BC1	24	0	38	80	61	26	32	32	22	54	65	38	471
	5BC2	19	0	31	65	40	28	34	32	19	42	51	29	389
	5BD	20	0	34	68	47	36	45	46	26	42	49	30	441
	5BE	30	0	44	90	53	21	22	23	18	72	91	51	514
	5CA	0	0	31	60	38	31	43	43	19	29	41	23	358
	5CB	17	0	35	61	33	25	34	31	0	34	48	25	343
	5CC	16	0	34	62	35	24	33	32	0	33	46	24	340
	5DA	39	19	58	118	43	10	9	10	9	96	136	75	624
	5DB	29	0	45	81	34	19	20	19	14	64	86	49	460
	5DC	17	0	33	63	36	30	36	32	16	35	49	26	374
	5DD	21	0	38	68	32	23	29	26	0	42	60	33	374
	5EA	0	0	19	63	22	0	0	0	0	36	40	19	199
	5EB	0	0	23	80	33	0	0	0	0	42	46	22	245
	5EC	17	0	31	97	36	0	0	0	0	48	65	33	328
	5ED	24	0	44	121	38	0	0	0	0	77	123	62	490
	5FA	0	0	28	80	23	0	0	0	0	44	85	43	304
	5FB	0	0	20	60	14	0	0	0	0	32	55	28	208
	5GA	0	0	17	57	23	0	0	0	0	38	34	0	169
	5GB	0	0	12	49	19	0	0	0	0	37	26	0	143
	5H	0	0	14	53	23	0	0	0	0	37	28	0	155
	5J	0	0	24	67	29	0	0	0	0	28	34	19	200
Average for ENNCA		15	3	32	74	39	18	22	22	0	46	59	31	371
Grand Total		30	22	57	105	80	39	37	42	32	59	78	47	631

Source: JICA Study Team based on data from KMD

Table 3.2.2 Monthly Discharge Available for Irrigation by Sub-basin (1/4)

(Unit: m^3/s)

Catchment Area	Sub-basin	River Discharge Available for Irrigation*												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
LVNCA	1AA	0.1	0.0	0.0	0.5	2.0	1.1	0.8	0.9	2.0	1.2	1.3	0.4	0.9
	1AB	0.2	0.1	0.1	0.2	2.2	2.3	2.8	2.6	2.4	5.8	2.3	0.9	1.8
	1AC	0.0	0.0	0.0	0.0	0.4	0.5	0.3	0.3	0.6	0.4	0.5	0.2	0.3
	1AD	0.2	0.0	0.0	1.6	6.5	4.5	3.3	3.3	6.0	4.5	5.1	1.7	3.1
	1AE	0.1	0.0	0.0	0.1	1.4	0.8	0.3	0.3	0.5	0.4	0.5	1.0	0.5
	1AF	0.2	0.0	0.1	1.0	2.7	1.7	1.2	0.7	1.6	1.8	2.2	0.8	1.2
	1AG	0.0	0.0	0.0	0.0	2.8	2.0	0.7	0.7	0.8	0.5	0.3	0.9	0.7
	1AH	0.2	0.0	0.0	0.5	9.2	6.0	2.1	2.3	3.1	1.9	1.9	3.5	2.6
	1BA	0.0	0.0	0.0	0.0	1.9	3.8	2.2	1.5	0.3	0.0	0.0	0.0	0.8
	1BB	0.5	0.2	0.1	0.1	5.6	3.4	8.6	12.3	7.1	17.2	7.4	3.0	5.5
	1BC	0.0	0.0	0.0	0.0	4.2	3.3	4.6	2.9	2.1	12.0	6.0	1.9	3.1
	1BD	3.4	2.5	2.5	2.4	12.8	9.0	18.7	27.8	25.6	48.3	21.9	8.5	15.3
	1BE	3.0	2.3	2.3	2.3	12.4	8.1	16.8	25.0	22.5	44.4	19.8	7.6	13.9
	1BG	3.1	1.9	2.6	7.9	43.6	20.8	24.7	22.6	16.8	68.9	35.4	13.8	21.8
	1BH	0.5	0.2	0.2	0.5	3.9	3.6	4.4	5.7	7.4	4.7	4.5	1.5	3.1
	1CA	0.7	1.4	0.7	0.2	2.0	2.6	1.3	1.1	1.2	0.6	0.3	0.3	1.0
	1CB	0.0	0.0	1.1	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4
	1CC	0.4	0.1	0.0	0.0	0.2	1.0	3.6	4.3	3.3	4.5	1.8	0.6	1.7
	1CD	6.5	9.0	6.2	3.9	17.0	19.4	10.5	10.9	11.9	7.4	6.6	5.5	9.6
	1CE	2.9	5.1	3.9	1.1	14.1	18.6	6.9	7.0	8.9	4.6	3.6	2.3	6.6
	1DA	14.9	33.8	14.6	6.3	97.5	74.7	34.8	27.9	41.1	27.7	18.1	11.4	33.6
	1DB	0.0	0.0	0.0	0.0	2.3	3.8	6.5	5.6	5.0	11.2	4.0	1.1	3.3
	1DC	16.3	36.4	16.1	6.9	108.5	83.9	39.6	32.1	49.8	34.6	22.2	12.8	38.3
	1DD	16.2	36.2	15.9	6.4	109.6	85.7	40.1	32.3	51.2	35.4	22.6	12.6	38.7
	1EA	1.5	0.9	0.7	3.9	7.6	6.7	6.7	6.6	4.4	2.4	1.6	3.1	3.8
	1EB	2.1	1.2	0.8	5.6	13.0	10.3	10.0	9.5	6.6	3.5	2.2	4.7	5.8
	1EC	0.5	0.3	0.2	1.2	3.4	2.6	2.1	2.0	1.6	0.9	0.5	0.8	1.3
	1ED	3.1	1.8	1.3	7.2	18.3	14.2	13.1	12.5	9.0	4.9	3.1	5.9	7.9
	1EE	7.4	5.0	6.0	24.0	93.6	93.2	75.1	79.5	67.9	47.4	36.0	27.9	46.9
	1EF	9.1	6.1	7.6	32.4	108.9	101.6	79.9	87.0	75.3	52.4	48.2	35.5	53.7
	1EG	2.7	1.5	1.2	0.7	4.4	5.2	2.1	1.0	1.5	1.4	1.3	1.1	2.0
	1FA	0.0	0.0	0.0	0.0	1.7	2.5	2.5	1.6	1.3	0.5	0.2	0.0	0.9
	1FB	1.8	3.2	1.5	0.7	10.0	10.2	4.1	4.3	4.9	1.9	4.2	2.5	4.1
	1FC	1.6	3.3	1.7	0.5	13.1	13.6	4.9	4.9	6.2	2.2	4.7	2.9	5.0
	1FD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1FE	0.0	0.0	0.0	5.4	22.7	15.6	16.4	11.1	11.4	7.9	5.8	4.9	8.4
	1FF	0.0	0.0	0.0	0.0	0.0	2.0	1.6	0.2	0.8	0.8	0.2	0.0	0.5
	1FG	0.0	0.0	0.0	0.0	8.6	23.9	32.3	22.3	26.7	23.8	13.8	6.4	13.2
Total for LVNCA		99	153	87	124	768	666	486	473	489	488	310	188	361
LVSCA	1GA	0.0	0.0	3.4	5.6	8.2	10.5	2.1	0.6	0.5	0.0	4.6	1.1	3.1
	1GB	0.0	0.0	7.8	12.9	16.3	20.0	2.9	0.9	0.8	0.0	8.2	2.2	6.0
	1GC	0.5	0.2	2.4	8.4	10.1	3.5	3.8	9.3	5.8	12.4	6.1	4.1	5.5
	1GD	7.7	15.1	2.4	0.0	42.4	37.9	15.2	6.0	5.9	0.0	2.2	12.6	12.3
	1GE	1.2	0.5	0.0	0.0	3.1	3.3	0.2	0.0	0.0	0.0	0.0	0.1	0.7
	1GF	13.4	18.4	3.2	0.0	54.1	49.3	18.5	6.7	6.5	0.0	2.5	14.7	15.6
	1GG	0.0	0.0	0.0	0.0	1.2	0.9	3.3	3.4	0.1	3.5	4.2	1.4	1.5
	1HA1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.4	0.0	0.2
	1HA2	0.0	0.0	0.0	1.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1HB1	0.8	0.3	0.1	0.0	1.2	1.8	0.6	0.0	0.0	0.0	0.0	0.0	0.4
	1HB2	1.2	0.5	0.1	0.0	1.8	2.7	0.9	0.0	0.0	0.0	0.0	0.0	0.6
	1HC	0.0	0.0	0.0	0.0	0.1	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.1
	1HD	1.3	0.4	0.0	4.9	5.9	10.8	2.8	0.0	0.3	4.1	3.6	0.7	2.9
	1HE	0.0	0.0	0.0	8.3	8.9	3.0	1.7	0.4	0.0	0.7	2.7	5.0	2.6
	1HF	1.3	0.0	0.0	0.0	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.9	0.3
	1HG	1.7	1.3	0.2	0.0	1.6	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.5
	1JA	4.2	3.5	8.0	17.9	15.4	7.0	5.2	9.0	8.5	11.9	7.7	8.9	8.9
	1JB	0.0	0.0	0.0	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1JC	1.9	2.8	0.4	0.0	6.3	5.1	2.9	0.7	0.6	0.1	0.7	1.2	1.9
	1JD	1.4	0.8	7.2	23.1	21.0	7.2	4.1	10.1	9.1	16.0	7.6	8.8	9.7
	1JE	1.4	0.8	0.7	4.7	4.1	1.0	1.2	1.4	5.1	6.5	3.7	2.2	2.7
	1JF	2.2	0.9	9.3	25.4	12.4	5.8	3.9	7.8	9.8	16.3	8.9	14.4	9.7

Table 3.2.2 Monthly Discharge Available for Irrigation by Sub-basin (2/4)

(Unit: m^3/s)

Catchment Area	Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
		River Discharge Available for Irrigation*												
LVSCA	1JG1	6.1	1.2	1.2	13.5	27.6	15.6	20.6	27.3	15.0	17.1	53.7	58.6	21.5
	1JG2	6.9	1.8	1.7	14.0	30.0	16.3	21.3	27.9	15.8	17.9	55.3	61.4	22.5
	1KA	0.6	0.2	1.0	6.3	6.5	2.3	1.6	0.8	0.6	2.1	3.4	5.4	2.6
	1KB	4.6	1.3	1.5	22.7	46.1	22.4	26.7	8.4	11.4	49.9	31.0	43.1	22.4
	1KC	4.8	1.0	2.6	39.8	22.1	8.2	2.6	1.1	0.6	4.3	1.4	1.6	7.5
	1LA1	7.9	16.5	4.4	0.2	4.3	7.4	2.9	0.4	0.0	0.0	1.3	2.4	4.0
	1LA2	13.1	4.2	6.9	24.2	36.6	13.1	8.7	7.3	7.5	4.8	8.6	30.0	13.7
	1LA3	13.1	2.6	1.6	10.7	20.1	9.6	9.7	10.9	7.7	5.9	41.8	73.1	17.2
	1LB1	5.1	1.4	0.2	6.2	6.4	1.2	0.6	2.2	3.0	4.0	6.5	11.1	4.0
	1LB2	5.7	1.2	0.1	2.2	3.1	0.1	0.0	0.0	0.1	0.1	0.2	6.1	1.6
Total for LVSCA		108	77	67	253	419	268	164	143	114	179	267	371	202
RVCA	2AA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2BA	1.1	0.3	0.0	0.0	0.8	2.0	14.2	11.2	11.5	12.6	14.1	3.0	5.9
	2BB	2.8	0.9	0.0	0.0	2.2	5.2	37.2	29.3	30.2	33.0	36.9	8.0	15.5
	2BC	1.0	0.0	0.8	3.3	18.0	13.7	14.1	15.4	6.7	11.3	3.8	3.8	7.7
	2BD	0.6	0.1	0.3	0.4	0.1	2.4	28.9	36.8	39.2	38.9	47.0	8.8	17.0
	2CA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2CB	2.0	0.7	3.9	6.7	4.1	0.7	6.0	4.7	23.7	5.6	11.5	5.4	6.3
	2CC	1.4	0.4	1.0	1.2	21.2	3.6	6.7	6.1	6.7	41.4	23.6	20.3	11.1
	2D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2EA	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.2	0.6	0.7	2.8	0.6	0.5
	2EB	0.0	0.0	0.0	0.0	0.2	0.2	0.5	0.4	1.1	1.3	4.7	1.2	0.8
	2EC	0.1	0.0	0.0	0.0	0.1	0.1	1.1	1.8	2.1	0.6	0.3	0.2	0.5
	2ED	0.0	0.0	0.1	0.3	0.9	6.5	3.6	1.3	1.2	0.1	0.5	0.6	1.3
	2EE	0.1	0.0	0.2	1.2	4.7	34.6	11.5	3.8	3.4	0.1	1.7	1.6	5.2
	2EF	0.0	0.0	0.0	0.3	0.9	6.4	3.2	1.1	1.0	0.0	0.4	0.4	1.1
	2EG1	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.0	1.2	0.1	0.0	0.0	0.3
	2EG2	0.4	0.2	0.0	0.6	0.9	1.0	6.2	7.4	8.3	2.2	1.3	0.4	2.4
	2EH	0.1	0.0	0.0	0.0	0.0	0.0	0.9	0.5	3.0	0.7	1.1	0.8	0.6
	2EJ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2EK	1.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	2FA	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.1
	2FB	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.1	0.0	0.0	0.1
	2FC	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.5	0.0	0.0	0.0	0.0	0.2
	2GA	0.2	0.0	0.0	0.0	0.1	1.5	0.8	0.1	0.0	0.0	0.1	0.3	0.3
	2GB	1.3	0.0	0.4	0.0	3.1	15.7	5.0	0.4	0.3	0.0	5.1	5.8	3.1
	2GC	1.4	0.3	1.0	0.3	3.6	11.3	2.9	0.7	0.7	0.5	5.6	4.1	2.7
	2GD	0.0	0.0	0.0	0.0	0.0	2.8	1.0	0.0	0.0	0.0	0.0	0.0	0.3
	2H1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2H2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2H3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
	2JA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2KA	0.3	0.0	0.0	1.8	7.0	3.1	3.4	2.4	2.3	3.1	3.6	4.7	2.6
	2KB	1.1	0.5	0.6	2.6	10.7	3.6	4.3	3.3	3.2	4.0	4.7	5.8	3.7
	2KC	0.5	0.1	0.3	0.1	9.4	2.2	2.2	1.4	1.3	1.9	3.0	3.9	2.2
Total for RVCA		15	4	9	19	88	117	156	131	148	159	172	80	91
ACA	3AA	0.0	0.0	0.0	10.1	8.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1.5
	3AB	0.0	0.0	0.0	6.7	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
	3AC	0.0	0.0	0.0	56.3	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6
	3BA	0.0	0.0	0.0	32.9	31.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3
	3BB	0.0	0.0	0.0	5.1	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
	3BC	0.0	0.0	0.0	5.5	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
	3BD	0.1	0.0	0.0	5.4	5.4	0.5	0.0	0.0	0.0	0.0	0.0	0.1	1.0
	3CB	0.3	0.1	0.1	5.2	6.3	0.7	0.4	0.2	0.1	0.2	0.3	0.4	1.2
	3DA	9.6	9.0	10.5	75.4	69.7	9.1	9.4	9.9	9.6	9.9	9.5	9.5	20.1
	3DB	9.7	8.7	11.2	89.0	74.5	10.1	9.2	9.6	9.3	9.5	9.1	9.4	21.6
	3EA	0.0	0.0	0.0	12.0	5.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.5
	3EB	0.9	0.1	3.3	33.6	13.5	1.2	0.1	0.1	0.1	0.1	0.1	0.8	4.5
	3EC	0.7	0.1	3.0	22.5	7.6	1.3	0.0	0.0	0.0	0.0	0.0	0.2	2.9
	3ED	1.4	0.1	6.2	65.4	24.0	3.1	0.0	0.1	0.0	0.0	0.0	0.7	8.4

Table 3.2.2 Monthly Discharge Available for Irrigation by Sub-basin (3/4)

(Unit: m^3/s)

Catchment Area	Sub-basin	River Discharge Available for Irrigation*												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
ACA	3FA	10.2	7.9	14.4	10.0	23.1	14.0	8.3	8.6	8.2	8.4	8.1	8.9	10.8
	3FB	10.2	7.7	9.5	8.1	23.9	16.6	8.3	8.3	7.9	8.0	7.6	8.4	10.4
	3G	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	3HA	10.7	8.0	9.1	7.7	23.9	18.9	8.7	8.7	8.2	8.3	7.9	8.7	10.7
	3HB	10.5	7.7	5.2	5.8	5.8	21.4	8.6	8.2	7.7	7.7	7.1	7.9	8.6
	3HC	17.1	13.6	11.8	5.4	22.0	27.7	15.2	14.7	14.0	14.3	13.5	14.4	15.3
	3HD1	9.4	6.5	2.8	3.9	20.4	22.0	7.6	6.8	6.3	6.3	5.5	6.2	8.6
	3HD2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3J	0.0	0.0	0.0	0.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	3K	0.0	0.0	0.0	3.6	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	3LA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3LB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MA-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MA-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MD-1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3MD2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total for ACA		91	69	87	470	432	148	76	75	71	73	69	76	145
TCA	4AA	1.5	0.3	0.2	0.1	0.5	0.2	0.1	0.1	0.1	1.0	6.7	6.1	1.4
	4AB	0.8	0.0	0.0	0.0	1.4	4.6	0.3	0.0	0.0	0.0	0.0	2.1	0.8
	4AC	0.0	0.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0	0.0	12.6	2.0
	4AD	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.0	7.6	1.1
	4BA	0.0	0.0	0.0	0.0	19.7	0.0	0.0	0.0	0.0	0.0	0.0	25.6	3.8
	4BB	0.3	0.1	0.1	1.8	7.7	0.6	0.1	0.0	0.0	0.0	3.0	9.0	1.9
	4BC	0.0	0.0	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0	31.6	4.4
	4BD	1.1	0.0	0.0	2.1	19.9	4.7	0.5	0.0	0.0	0.0	1.9	1.9	2.7
	4BE	0.0	0.0	0.0	0.0	31.5	0.0	0.0	0.0	0.0	0.0	0.0	53.4	7.1
	4BF	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	4BG	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0	0.0	0.0	0.0	61.9	7.7
	4CA	0.6	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	4CB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4CC	0.0	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	4DA	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	18.8	18.2	3.4
	4DB	4.8	2.9	2.9	2.8	3.7	2.8	2.7	2.6	2.5	6.1	18.2	14.4	5.5
	4DC	1.5	0.3	0.2	0.2	1.1	0.2	0.1	0.1	0.0	3.4	7.8	3.7	1.6
	4DD	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	19.7	19.4	3.6
	4DE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	4EA	11.9	2.3	1.6	2.0	5.7	1.7	1.0	0.7	0.5	29.2	77.4	29.0	13.6
	4EB	5.0	0.0	0.0	0.5	3.1	0.0	0.0	0.0	0.0	15.2	38.1	14.6	6.4
	4EC	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	4ED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.7	15.0	3.0
	4FA	0.0	6.6	6.2	2.2	1.7	1.8	2.0	1.9	1.9	58.4	55.4	78.8	18.1
	4FB	3.8	5.7	4.4	0.1	0.1	0.1	0.1	0.1	0.1	63.1	123.1	95.9	24.7
	4GA	6.8	6.7	5.2	0.6	1.1	0.9	0.8	0.9	0.9	64.3	179.8	116.1	32.0
	4GB	25.0	9.1	7.5	58.0	207.0	29.5	9.3	7.3	2.2	2.3	28.3	44.9	35.9
	4GC	27.4	10.2	8.6	49.2	214.8	32.9	10.6	8.5	3.2	3.0	28.7	42.9	36.7
	4GD	32.8	12.9	11.6	34.4	230.0	39.5	14.0	11.5	6.1	5.1	30.3	40.2	39.0
	4GE	31.3	14.5	12.3	6.6	7.9	8.3	7.3	8.1	7.5	45.3	206.5	132.5	40.7
	4GF	46.6	20.1	19.3	10.2	255.7	58.2	23.8	19.8	13.2	10.6	35.3	38.1	45.9
	4GG	59.6	28.3	29.8	16.5	259.9	84.1	42.3	30.9	21.7	17.8	41.9	43.5	56.4
	4HA	0.0	0.0	0.0	4.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
	4HB	0.0	0.0	1.2	0.0	0.0	0.8	2.3	2.8	2.8	2.0	0.0	0.0	1.0
	4HC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4JA	4.8	1.1	0.1	0.0	0.0	5.6	2.2	0.1	0.0	0.0	0.0	10.1	2.0
	4JB	1.9	0.4	0.0	0.0	0.0	2.2	0.9	0.0	0.0	0.0	0.0	3.9	0.8
	4KA	3.0	0.7	0.0	0.0	0.0	3.5	1.4	0.0	0.0	0.0	0.0	6.3	1.3
	4KB	4.4	0.5	0.0	0.0	0.0	5.3	1.7	0.0	0.0	0.0	0.0	10.0	1.8
Total for TCA		278	123	111	192	1,346	288	124	96	63	332	941	990	407

Table 3.2.2 Monthly Discharge Available for Irrigation by Sub-basin (4/4)

(Unit: m^3/s)

Catchment Area	Sub-basin	River Discharge Available for Irrigation*												Annual Total
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
ENNCA	5AA	0.1	0.0	0.0	0.6	0.0	6.0	0.6	0.0	0.0	0.0	0.0	0.7	0.7
	5AB	0.1	0.0	0.0	0.1	0.2	2.5	0.2	0.0	0.0	0.0	0.0	0.3	0.3
	5AC	1.0	0.4	0.4	1.2	0.8	9.6	1.7	0.5	0.4	0.4	0.6	1.7	1.5
	5AD	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.1
	5BA	0.3	0.0	0.0	0.0	0.3	1.3	0.2	0.0	0.0	0.0	0.1	0.9	0.3
	5BB	0.4	0.0	0.0	0.1	1.2	4.0	0.3	0.0	0.0	0.0	1.2	2.2	0.8
	5BC1	2.6	0.7	0.7	1.2	3.8	13.2	2.0	0.7	0.6	0.6	3.3	8.4	3.2
	5BC2	2.6	0.6	0.6	1.2	3.7	13.2	1.9	0.6	0.5	0.5	3.3	8.5	3.1
	5BD	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.2	1.3	1.3	0.4
	5BE	1.0	0.0	0.0	3.7	3.3	7.9	0.1	0.0	0.0	0.0	5.1	5.4	2.2
	5CA	1.2	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
	5CB	0.1	0.0	0.0	0.1	0.3	2.3	0.4	0.0	0.0	0.0	0.0	0.0	0.3
	5CC	3.1	0.1	0.0	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3
	5DA	1.5	0.6	8.9	15.1	25.3	2.5	1.7	4.2	2.4	0.6	21.3	55.6	11.6
	5DB	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	5DC	4.3	1.2	0.9	1.4	2.4	20.8	21.3	11.9	14.3	1.8	4.9	6.3	7.6
	5DD	4.7	1.3	1.0	1.5	2.4	20.9	21.7	12.1	15.0	2.0	4.8	6.8	7.8
	5EA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5EB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5EC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5ED	0.5	0.4	1.5	4.8	18.0	1.1	0.2	0.1	0.1	0.4	6.5	120.2	12.8
	5FA	13.4	0.8	0.8	0.7	0.8	0.0	0.8	0.7	0.4	0.2	0.6	0.5	1.6
	5FB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5GA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5GB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5H	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total for ENNCA		39	6	15	32	64	105	53	31	34	7	53	220	55
Grand Total		630	432	376	1,090	3,117	1,592	1,059	948	919	1,237	1,812	1,923	1,261

Note: * 5-year probable discharge estimated by deducting demands of priority users (river maintenance flow, and domestic and industrial water supply).

Source: JICA Study Team, based on hydrological analysis results in this study

Table 3.2.3 Groundwater Resources Available for Irrigation by Sub-basin (1/4)

Catchment Area	Sub-basin Code	Available GW Resources	Domestic and Industrial Demand	Remaining GW for Irrigation	
		(MCM/year)	(MCM/year)	(MCM/year)	(m^3/s)
LVNCA	1AA	1.9	1.0	0.9	0.0
	1AB	0.3	0.3	0.0	0.0
	1AC	1.4	0.9	0.5	0.0
	1AD	2.8	1.8	1.0	0.0
	1AE	3.2	1.2	2.0	0.1
	1AF	4.7	2.9	1.8	0.1
	1AG	4.9	2.4	2.5	0.1
	1AH	7.7	4.5	3.2	0.1
	1BA	3.9	1.2	2.7	0.1
	1BB	6.2	2.6	3.7	0.1
	1BC	6.4	3.1	3.3	0.1
	1BD	1.6	1.6	0.0	0.0
	1BE	5.6	5.1	0.4	0.0
	1BG	4.0	4.0	0.0	0.0
	1BH	0.6	0.6	0.0	0.0
	1CA	2.9	2.3	0.7	0.0
	1CB	3.6	3.6	0.0	0.0
	1CC	2.5	1.6	0.9	0.0
	1CD	0.6	0.6	0.0	0.0
	1CE	0.3	0.3	0.0	0.0
	1DA	0.7	0.7	0.0	0.0
	1DB	0.9	0.9	0.0	0.0
	1DC	0.5	0.5	0.0	0.0
	1DD	0.5	0.5	0.0	0.0
	1EA	0.6	0.6	0.0	0.0
	1EB	0.5	0.5	0.0	0.0
	1EC	0.3	0.3	0.0	0.0
	1ED	0.1	0.1	0.0	0.0
	1EE	0.4	0.4	0.0	0.0
	1EF	6.3	2.5	3.8	0.1
	1EG	3.4	3.4	0.0	0.0
	1FA	2.5	0.7	1.8	0.1
	1FB	1.5	1.2	0.3	0.0
	1FC	1.9	1.9	0.0	0.0
	1FD	2.6	1.8	0.9	0.0
	1FE	3.2	3.2	0.0	0.0
	1FF	3.7	3.7	0.0	0.0
	1FG	13.5	5.5	8.0	0.3
	1HC	3.1	2.3	0.8	0.0
LVSCA	1GA	1.7	1.3	0.4	0.0
	1GB	3.7	1.9	1.8	0.1
	1GC	4.1	3.7	0.4	0.0
	1GD	10.4	6.4	4.1	0.1
	1GE	6.3	1.4	4.8	0.2
	1GF	8.7	1.2	7.6	0.2
	1GG	1.7	0.8	0.8	0.0
	1HA1	2.2	2.2	0.0	0.0
	1HA2	9.1	1.6	7.6	0.2
	1HB1	2.3	2.3	0.0	0.0
	1HB2	1.2	1.2	0.1	0.0
	1HD	6.3	6.3	0.0	0.0
	1HE	7.6	7.0	0.6	0.0
	1HF	4.1	4.1	0.0	0.0
	1HG	0.7	0.7	0.0	0.0
	1JA	6.8	3.1	3.6	0.1
	1JB	2.2	0.7	1.5	0.0
	1JC	1.2	1.2	0.0	0.0
	1JD	0.7	0.7	0.0	0.0

Table 3.2.3 Groundwater Resources Available for Irrigation by Sub-basin (2/4)

Catchment Area	Sub-basin Code	Available GW Resources	Domestic and Industrial Demand	Remaining GW for Irrigation	
		(MCM/year)	(MCM/year)	(MCM/year)	(m^3/s)
LVSCA	1JE	9.2	3.0	6.2	0.2
	1JF	4.5	4.4	0.1	0.0
	1JG1	0.6	0.6	0.0	0.0
	1JG2	1.1	0.4	0.7	0.0
	1KA	6.2	6.2	0.0	0.0
	1KB	30.5	22.6	8.0	0.3
	1KC	22.7	10.0	12.6	0.4
	1LA1	7.2	6.1	1.1	0.0
	1LA2	1.2	1.2	0.0	0.0
	1LA3	5.7	1.8	3.9	0.1
	1LB1	3.3	2.8	0.5	0.0
	1LB2	12.1	1.4	10.7	0.3
RVCA	2AA	1.4	0.5	0.9	0.0
	2AB	0.7	0.7	0.0	0.0
	2BA	1.0	1.0	0.0	0.0
	2BB	1.7	1.7	0.0	0.0
	2BC	1.3	1.3	0.0	0.0
	2BD	10.4	3.4	7.1	0.2
	2CA	0.2	0.2	0.0	0.0
	2CB	3.7	3.5	0.2	0.0
	2CC	18.4	4.2	14.1	0.4
	2D	12.2	5.3	6.9	0.2
	2EA	0.2	0.2	0.0	0.0
	2EB	0.2	0.2	0.0	0.0
	2EC	0.3	0.3	0.0	0.0
	2ED	0.6	0.6	0.0	0.0
	2EE	0.5	0.5	0.1	0.0
	2EF	0.5	0.5	0.0	0.0
	2EG1	1.8	1.8	0.0	0.0
	2EG2	0.4	0.4	0.0	0.0
	2EH	1.5	0.4	1.1	0.0
	2EJ	1.3	1.3	0.0	0.0
	2EK	0.4	0.4	0.0	0.0
	2FA	0.2	0.2	0.0	0.0
	2FB	0.2	0.2	0.0	0.0
	2FC	1.8	1.8	0.0	0.0
	2GA	0.1	0.1	0.0	0.0
	2GB	0.2	0.2	0.0	0.0
	2GC	3.7	2.2	1.5	0.0
	2GD	5.2	5.2	0.0	0.0
	2H-1	12.7	11.6	1.0	0.0
	2H-2	3.7	3.7	0.0	0.0
	2H-3	0.7	0.7	0.0	0.0
	2J	2.4	2.4	0.0	0.0
	2KA	6.7	4.1	2.6	0.1
	2KB	1.2	0.9	0.3	0.0
	2KC	4.8	0.8	4.0	0.1
ACA	3AA	1.6	1.6	0.0	0.0
	3AB	9.5	9.5	0.0	0.0
	3AC	6.1	6.1	0.0	0.0
	3BA	4.4	4.4	0.0	0.0
	3BB	2.5	2.5	0.0	0.0
	3BC	1.8	1.8	0.0	0.0
	3BD	3.5	3.5	0.0	0.0
	3CB	1.8	1.8	0.0	0.0
	3DA	5.8	5.8	0.0	0.0
	3DB	6.9	1.6	5.2	0.2
	3EA	5.2	5.0	0.2	0.0

Table 3.2.3 Groundwater Resources Available for Irrigation by Sub-basin (3/4)

Catchment Area	Sub-basin Code	Available GW Resources	Domestic and Industrial Demand	Remaining GW for Irrigation	
		(MCM/year)	(MCM/year)	(MCM/year)	(m^3/s)
ACA	3EB	5.8	5.5	0.3	0.0
	3EC	4.1	4.0	0.2	0.0
	3ED	4.6	4.4	0.2	0.0
	3FA	39.9	10.8	29.1	0.9
	3FB	12.6	4.1	8.5	0.3
	3G	15.9	4.9	11.0	0.1
	3HA	2.6	0.2	2.3	0.0
	3HB	15.6	1.0	14.7	0.2
	3HC	10.8	2.9	7.9	0.3
	3HD1	13.8	0.7	13.1	0.4
	3HD2	1.0	0.4	0.6	0.0
	3J	9.6	1.2	8.4	0.1
	3KA	18.7	18.7	0.0	0.0
	3KB	1.9	1.9	0.0	0.0
	3LA	26.0	26.0	0.0	0.0
	3LB	2.6	2.6	0.0	0.0
	3MA-1	18.2	18.2	0.0	0.0
	3MA-2	7.6	7.6	0.0	0.0
	3MB	10.3	10.3	0.0	0.0
	3MC	6.4	6.4	0.0	0.0
	3MD1	12.6	12.6	0.0	0.0
	3MD2	1.3	1.3	0.0	0.0
	3N	9.1	2.0	7.1	0.2
TCA	4AA	0.6	0.6	0.0	0.0
	4AB	0.6	0.6	0.0	0.0
	4AC	0.4	0.4	0.0	0.0
	4AD	0.5	0.5	0.0	0.0
	4BA	0.3	0.3	0.0	0.0
	4BB	0.3	0.3	0.0	0.0
	4BC	0.2	0.2	0.0	0.0
	4BD	0.5	0.5	0.0	0.0
	4BE	0.7	0.7	0.0	0.0
	4BF	0.2	0.2	0.0	0.0
	4BG	0.2	0.2	0.0	0.0
	4CA	0.8	0.8	0.0	0.0
	4CB	0.5	0.5	0.0	0.0
	4CC	0.5	0.5	0.0	0.0
	4DA	0.7	0.7	0.0	0.0
	4DB	0.5	0.5	0.0	0.0
	4DC	0.5	0.5	0.0	0.0
	4DD	0.3	0.3	0.0	0.0
	4DE	0.3	0.3	0.0	0.0
	4EA	1.3	1.3	0.0	0.0
	4EB	2.3	2.3	0.0	0.0
	4EC	0.8	0.8	0.0	0.0
	4ED	1.0	1.0	0.0	0.0
	4FA	25.4	4.1	21.3	0.7
	4FB	117.2	7.8	109.5	2.4
	4GA	32.6	1.4	31.2	0.7
	4GB	37.6	0.8	36.8	0.5
	4GC	10.3	1.9	8.4	0.3
	4GD	34.5	1.1	33.4	1.1
	4GE	58.7	5.3	53.4	1.7
	4GF	70.1	4.6	65.4	2.1
	4GG	63.5	2.1	61.4	1.9
	4HA	28.0	4.4	23.6	0.7
	4HB	38.1	1.7	36.4	0.6
	4HC	12.1	1.4	10.7	0.1
	4JA	6.6	1.6	5.0	0.2

Table 3.2.3 Groundwater Resources Available for Irrigation by Sub-basin (4/4)

Catchment Area	Sub-basin Code	Available GW Resources	Domestic and Industrial Demand	Remaining GW for Irrigation	
		(MCM/year)	(MCM/year)	(MCM/year)	(m^3/s)
TCA	4JB	4.9	0.5	4.4	0.1
	4KA	5.7	0.9	4.8	0.2
	4KB	7.5	7.5	0.0	0.0
ENNCA	5AA	5.1	2.6	2.5	0.1
	5AB	2.1	1.1	1.0	0.0
	5AC	3.1	0.7	2.3	0.1
	5AD	0.6	0.3	0.2	0.0
	5BA	1.4	0.3	1.2	0.0
	5BB	1.1	0.7	0.4	0.0
	5BC-1	7.4	1.5	5.9	0.2
	5BC-2	0.3	0.1	0.2	0.0
	5BD	0.6	0.6	0.0	0.0
	5BE	9.5	5.9	3.6	0.1
	5CA	3.6	1.9	1.7	0.1
	5CB	0.8	0.7	0.1	0.0
	5CC	0.9	0.9	0.0	0.0
	5DA	26.5	2.5	23.9	0.8
	5DB	3.1	0.6	2.4	0.1
	5DC	2.6	0.4	2.2	0.1
	5DD	1.3	0.3	1.0	0.0
	5EA	27.1	11.3	15.8	0.5
	5EB	44.2	5.3	38.9	1.2
	5EC	44.9	3.9	41.0	1.3
	5ED	157.2	12.8	144.4	4.6
	5FA	65.3	6.1	59.2	1.9
	5FB	5.3	1.3	4.0	0.1
	5G	25.1	14.0	11.0	0.4
	5HA	1.8	1.8	0.0	0.0
	5HB	4.6	2.9	1.7	0.1
	5J	29.3	2.9	26.4	0.8
Grand Total		1,740.8	578.9	1,161.9	33.3

JICA Study Team, based on hydrological analysis results in this study

Table 3.3.1 Existing Irrigation Area by Sub-basin in 2010

(Unit: ha)

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area
1AA	28	1GA	67	2AA	0	3AA	1,272	4AA	1,004	5AA	154
1AB	6	1GB	356	2AB	309	3AB	1,523	4AB	1,032	5AB	55
1AC	2	1GC	148	2BA	286	3AC	382	4AC	697	5AC	160
1AD	47	1GD	607	2BB	359	3BA	1,820	4AD	1,557	5AD	393
1AE	44	1GE	428	2BC	748	3BB	729	4BA	738	5BA	206
1AF	50	1GF	730	2BD	782	3BC	1,438	4BB	1,698	5BB	663
1AG	41	1GG	147	2CA	112	3BD	966	4BC	3,271	5BC-1	500
1AH	142	1HA1	800	2CB	559	3CB	2,194	4BD	1,703	5BC-2	477
1BA	119	1HA2	873	2CC	964	3DA	442	4BE	1,593	5BD	93
1BB	87	1HB1	800	2D	866	3DB	217	4BF	455	5BE	1,474
1BC	95	1HB2	792	2EA	90	3EA	275	4BG	548	5CA	154
1BD	24	1HC	165	2EB	155	3EB	291	4CA	1,081	5CB	0
1BE	41	1HD	1,135	2EC	175	3EC	275	4CB	731	5CC	0
1BG	31	1HE	1,012	2ED	93	3ED	237	4CC	3,431	5DA	1,804
1BH	14	1HF	1,650	2EE	137	3FA	3,213	4DA	10,175	5DB	201
1CA	38	1HG	625	2EF	88	3FB	1,944	4DB	6,651	5DC	176
1CB	67	1JA	114	2EG1	86	3G	5,509	4DC	1,880	5DD	47
1CC	50	1JB	25	2EG2	282	3HA	1,120	4DD	700	5EA	86
1CD	50	1JC	33	2EH	136	3HB	1,663	4DE	350	5EB	143
1CE	11	1JD	15	2EJ	274	3HC	1,420	4EA	1,974	5EC	269
1DA	20	1JE	86	2EK	124	3HD1	523	4EB	1,556	5ED	0
1DB	14	1JF	134	2FA	110	3HD2	614	4EC	943	5FA	0
1DC	9	1JG1	200	2FB	31	3J	3,698	4ED	2,443	5FB	29
1DD	9	1JG2	238	2FC	307	3K	436	4FA	3,966	5G	0
1EA	20	1KA	230	2GA	58	3LA	4,706	4FB	4,885	5HA	811
1EB	12	1KB	1,360	2GB	114	3LB	528	4GA	1,179	5HB	0
1EC	8	1KC	91	2GC	94	3MA-1	2,191	4GB	499	5J	0
1ED	2	1LA1	107	2GD	220	3MA-2	3,130	4GC	192		
1EE	109	1LA2	25	2H-1	900	3MB	115	4GD	858		
1EF	109	1LA3	65	2H-2	533	3MC	79	4GE	865		
1EG	106	1LB1	101	2H-3	0	3MD1	43	4GF	1,356		
1FA	10	1LB2	61	2J	0	3MD2	9	4GG	1,578		
1FB	43			2KA	128	3N	1,893	4HA	189		
1FC	33			2KB	127			4HB	829		
1FD	53			2KC	342			4HC	631		
1FE	39							4JA	369		
1FF	2							4JB	143		
1FG	288							4KA	316		
								4KB	359		
Total	1,876	Total	13,218	Total	9,587	Total	44,898	Total	64,425	Total	7,896
Whole Country: 141,900 ha											

Source: JICA Study Team based on data from Inventory Survey in this study

Table 3.3.2 Unit Irrigation Water Requirement by Sub-basin in 2010 (1/4)

(Unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping*											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	1AA	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AB	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AC	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AD	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AE	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AF	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AG	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1AH	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1BA	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BB	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BC	0.81	0.91	0.72	0.25	0.00	0.10	0.00	0.00	0.07	0.25	0.52	0.72
	1BD	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BE	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BG	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1BH	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1CA	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CB	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CC	0.81	0.96	0.91	0.14	0.27	0.03	0.08	0.02	0.79	0.72	0.74	0.85
	1CD	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1CE	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1DA	0.98	0.99	0.92	0.41	0.29	0.22	0.00	0.00	0.41	0.72	0.78	0.89
	1DB	1.01	0.97	0.86	0.48	0.10	0.19	0.00	0.12	0.57	0.44	0.78	0.87
	1DC	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1DD	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EA	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1EB	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1EC	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1ED	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EE	0.83	0.73	0.59	0.05	0.00	0.00	0.34	0.32	0.70	0.37	0.32	0.54
	1EF	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1EG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1FA	0.81	0.96	0.91	0.14	0.27	0.03	0.08	0.02	0.79	0.72	0.74	0.85
	1FB	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FC	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FD	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FE	0.87	0.91	0.78	0.24	0.00	0.00	0.00	0.00	0.14	0.35	0.56	0.69
	1FF	1.02	0.98	0.76	0.34	0.38	0.66	0.82	0.72	0.91	0.97	0.84	0.83
	1FG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
Average for LVNCA		0.90	0.88	0.75	0.26	0.09	0.13	0.20	0.20	0.54	0.49	0.58	0.72
LVSCA	1GA	0.91	0.99	0.93	0.25	0.18	0.02	0.00	0.00	0.00	0.51	0.59	0.86
	1GB	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1GC	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1GD	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GE	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GF	1.11	1.08	0.89	0.27	0.40	0.50	0.72	0.74	0.99	0.86	0.83	0.81
	1GG	0.70	0.78	0.64	0.00	0.00	0.10	0.19	0.28	0.49	0.48	0.53	0.68
	1HA1	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HA2	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HB1	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HB2	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HC	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HD	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HE	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HF	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1HG	0.87	0.94	0.65	0.41	0.16	0.56	0.78	0.76	0.81	0.78	0.71	0.74
	1JA	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JB	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JC	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JD	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JE	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JF	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69

Table 3.3.2 Unit Irrigation Water Requirement by Sub-basin in 2010 (2/4)

(Unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVSCA	1JG1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1JG2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1KA	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1KB	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1KC	1.00	0.96	0.62	0.14	0.21	0.62	0.83	0.83	1.00	0.83	0.69	0.77
	1LA1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LA2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LA3	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LB1	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
	1LB2	0.74	0.66	0.62	0.24	0.34	0.47	0.52	0.66	0.81	0.81	0.73	0.69
Average for LVSCA		0.84	0.83	0.67	0.26	0.24	0.47	0.59	0.65	0.79	0.77	0.71	0.73
RVCA	2AA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2AB	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2BA	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BB	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BC	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2BD	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2CA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2CB	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2CC	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2D	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2EA	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EC	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2ED	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EE	1.13	1.18	1.09	0.83	0.84	0.86	0.75	0.76	1.09	1.01	0.95	1.03
	2EF	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EG1	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EG2	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EH	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EJ	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2EK	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FA	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2FC	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2GA	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2GB	0.69	0.96	0.75	0.36	0.32	0.44	0.44	0.36	0.67	0.60	0.42	0.70
	2GC	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2GD	0.89	0.89	0.77	0.41	0.43	0.49	0.66	0.63	0.79	0.74	0.64	0.78
	2H1	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2H2	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2H3	1.14	1.22	1.01	0.84	0.99	0.96	0.98	0.94	1.19	1.15	1.09	1.15
	2JA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2KA	1.30	1.39	1.28	0.92	1.14	1.18	1.18	1.21	1.37	1.25	1.22	1.23
	2KB	1.28	1.33	1.23	0.92	0.96	1.06	1.15	1.13	1.33	1.30	1.23	1.25
	2KC	1.28	1.33	1.23	0.92	0.96	1.06	1.15	1.13	1.33	1.30	1.23	1.25
Average for RVCA		0.97	1.12	0.95	0.63	0.70	0.75	0.77	0.74	0.98	0.92	0.81	0.95
ACA	3AA	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3AB	0.96	0.91	0.67	0.35	0.56	0.63	0.62	0.66	0.93	0.91	0.29	0.72
	3AC	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3BA	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3BB	0.96	0.91	0.67	0.35	0.56	0.63	0.62	0.66	0.93	0.91	0.29	0.72
	3BC	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3BD	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3CB	0.95	0.86	0.72	0.00	0.00	0.16	0.40	0.46	0.76	0.96	0.38	0.31
	3DA	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3DB	1.04	1.09	0.80	0.16	0.23	0.44	0.50	0.66	1.02	0.91	0.61	0.88
	3EA	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3EB	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3EC	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3ED	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47

Table 3.3.2 Unit Irrigation Water Requirement by Sub-basin in 2010 (3/4)

(Unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ACA	3FA	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3FB	1.03	1.14	0.94	0.70	0.73	0.79	0.81	0.84	1.10	1.06	0.52	0.47
	3G	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HA	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HB	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3HC	1.12	1.19	1.05	0.80	0.68	0.77	0.90	0.99	1.07	1.02	0.94	0.68
	3HD1	1.20	1.21	1.13	0.77	0.02	0.17	0.46	0.68	1.11	1.08	1.12	1.16
	3HD2	1.20	1.21	1.13	0.77	0.02	0.17	0.46	0.68	1.11	1.08	1.12	1.16
	3J	0.96	1.07	0.71	0.44	0.50	0.75	0.75	0.84	1.03	1.04	0.85	0.75
	3K	1.17	1.25	1.14	0.63	0.26	0.44	0.55	0.79	0.95	0.96	1.00	0.84
	3LA	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3LB	0.90	1.15	0.96	0.78	0.80	0.90	0.89	0.89	1.03	1.04	0.88	0.59
	3MA-1	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MA-2	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MB	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	1.04	0.91	0.98
	3MC	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3MD-1	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3MD2	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
	3N	1.15	1.14	1.03	0.83	0.76	0.90	0.86	0.90	1.02	0.96	1.00	0.84
Average for ACA		1.04	1.09	0.92	0.57	0.52	0.65	0.71	0.78	1.00	1.00	0.72	0.69
TCA	4AA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AC	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4AD	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BC	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4BD	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	4BE	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4BF	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4BG	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CA	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CB	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4CC	1.06	1.16	0.78	0.15	0.43	0.51	0.50	0.56	0.93	0.85	0.45	0.69
	4DA	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DB	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DC	1.05	1.14	0.85	0.34	0.34	0.59	0.61	0.84	1.02	0.88	0.42	0.74
	4DD	0.99	0.93	0.72	0.27	0.57	0.50	0.68	0.61	0.95	0.78	0.28	0.50
	4DE	0.99	0.93	0.72	0.27	0.57	0.50	0.68	0.61	0.95	0.78	0.28	0.50
	4EA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4EB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4EC	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4ED	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4FA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4FB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GA	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GB	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GC	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GD	1.07	1.07	1.04	0.96	1.04	0.91	0.98	0.98	1.08	1.09	0.81	0.84
	4GE	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4GF	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4GG	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4HC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	4JA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4JB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4KA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	4KB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
Average for TCA		1.09	1.11	0.93	0.63	0.71	0.74	0.76	0.88	1.05	0.99	0.64	0.78

Table 3.3.2 Unit Irrigation Water Requirement by Sub-basin in 2010 (4/4)

(Unit: m^3/s/1,000 ha)

Catchment Area	Sub-basin	Unit Irrigation Water Requirement under 60% Irrigation Efficiency and Full Cropping											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ENNCA	5AA	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	5AB	1.04	0.95	0.69	0.24	0.00	0.34	0.25	0.62	0.83	0.84	0.41	0.52
	5AC	0.93	1.00	0.97	0.64	0.65	0.60	0.58	0.61	0.93	0.89	0.76	0.83
	5AD	0.93	1.00	0.97	0.64	0.65	0.60	0.58	0.61	0.93	0.89	0.76	0.83
	5BA	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BB	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BC1	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BC2	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BD	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5BE	0.70	0.65	0.52	0.51	0.79	0.69	0.78	0.67	0.95	0.60	0.35	0.50
	5CA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5CB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5CC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DA	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DB	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DC	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5DD	1.16	1.17	1.04	0.96	1.00	0.92	0.98	1.06	1.14	1.05	0.85	0.97
	5EA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5EB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5EC	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5ED	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5FA	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5FB	1.30	1.41	1.33	1.13	1.54	1.39	1.37	1.44	1.51	1.40	1.00	1.08
	5GA	1.22	1.25	1.14	0.86	0.98	1.01	1.01	1.03	1.13	1.00	0.94	1.05
	5GB	1.22	1.25	1.14	0.86	0.98	1.01	1.01	1.03	1.13	1.00	0.94	1.05
	5H	1.21	1.27	1.24	0.85	1.06	1.15	1.12	1.18	1.26	0.95	0.99	1.14
	5J	1.21	1.27	1.24	0.85	1.06	1.15	1.12	1.18	1.26	0.95	0.99	1.14
Average for ENNCA		1.07	1.09	0.98	0.81	0.98	0.93	0.95	1.00	1.15	0.99	0.75	0.87
Overall Average		0.98	1.02	0.86	0.52	0.54	0.61	0.66	0.71	0.92	0.86	0.70	0.79

Note: * : Full amount for every month (no consideration of cropping pattern and intensity)
Source: JICA Study Team based on "Water Requirements for Irrigation in Kenya, Ministry of Water Development, 1985"

Table 3.3.3 Irrigation Water Demand by Sub-basin in 2010 (1/4)

(unit: MCM)

Catchment Area	Sub-basin Code	Irrigation Area (ha)	Present Irrigation Water Demand under 60% Irrigation Efficiency and 140% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LVNCA	1AA	28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1AB	6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1AC	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1AD	47	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1AE	44	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1AF	50	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1AG	41	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1AH	142	0.2	0.2	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	1.0
	1BA	119	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	1.2
	1BB	87	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.9
	1BC	95	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.7
	1BD	24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1BE	41	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
	1BG	31	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1BH	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1CA	38	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
	1CB	67	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.7
	1CC	50	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.5
	1CD	50	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.6
	1CE	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1DA	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1DB	14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1DC	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1DD	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1EA	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1EB	12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1EC	8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1ED	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1EE	90	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.7
	1EF	109	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.3
	1EG	106	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.2
	1FA	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	1FB	43	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1FC	33	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1FD	53	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
	1FE	39	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1FF	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1FG	288	0.4	0.4	0.4	0.2	0.1	0.3	0.2	0.0	0.2	0.3	0.3	0.3	3.3
Total for LVNCA		1,857	2.6	2.6	2.8	1.1	0.4	0.8	0.6	0.0	1.1	1.5	1.8	2.1	17.5
LVSCA	1GA	67	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.6
	1GB	356	0.4	0.4	0.5	0.0	0.0	0.1	0.1	0.0	0.2	0.3	0.3	0.4	2.6
	1GC	148	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	1.1
	1GD	1,426	1.0	1.0	1.1	0.3	0.5	0.6	0.5	0.0	0.6	0.8	0.8	0.8	8.1
	1GE	428	0.7	0.7	0.8	0.2	0.4	0.4	0.3	0.0	0.4	0.6	0.6	0.5	5.7
	1GF	730	1.3	1.2	1.4	0.4	0.6	0.8	0.5	0.0	0.7	1.0	0.9	0.9	9.7
	1GG	147	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	1.1
	1HA1	800	1.1	1.2	1.1	0.7	0.3	0.9	0.6	0.0	0.7	1.0	0.9	0.9	9.3
	1HA2	873	1.2	1.3	1.2	0.7	0.3	1.0	0.7	0.0	0.7	1.1	1.0	1.0	10.1
	1HB1	800	1.1	1.2	1.1	0.7	0.3	0.9	0.6	0.0	0.7	1.0	0.9	0.9	9.3
	1HB2	792	1.1	1.2	1.1	0.7	0.3	0.9	0.6	0.0	0.7	1.0	0.9	0.9	9.2
	1HC	165	0.2	0.2	0.2	0.1	0.1	0.2	0.1	0.0	0.1	0.2	0.2	0.2	1.9
	1HD	1,135	1.5	1.7	1.5	1.0	0.4	1.3	0.9	0.0	1.0	1.4	1.2	1.3	13.2
	1HE	1,012	1.4	1.5	1.4	0.9	0.3	1.2	0.8	0.0	0.9	1.2	1.1	1.2	11.8
	1HF	1,650	2.2	2.4	2.2	1.4	0.5	1.9	1.3	0.0	1.4	2.0	1.8	1.9	19.2
	1HG	625	0.8	0.9	0.8	0.5	0.2	0.7	0.5	0.0	0.5	0.8	0.7	0.7	7.3
	1JA	114	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.2
	1JB	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1JC	33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1JD	15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	1JE	86	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.9
	1JF	134	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.2	0.2	0.1	1.4
	1JG1	200	0.2	0.2	0.3	0.1	0.1	0.2	0.1	0.0	0.2	0.3	0.2	0.2	2.1

Table 3.3.3 Irrigation Water Demand by Sub-basin in 2010 (2/4)

(unit: MCM)

Catchment Area	Sub-basin Code	Irrigation Area (ha)	Present Irrigation Water Demand under 60% Irrigation Efficiency and 140% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LVSCA	1KA	230	0.4	0.3	0.3	0.1	0.1	0.3	0.2	0.0	0.2	0.3	0.2	0.3	2.7
	1KB	1,360	2.1	2.0	1.8	0.4	0.6	1.8	1.2	0.0	1.4	1.8	1.5	1.6	16.1
	1KC	91	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.1
	1LA1	107	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.1
	1LA2	25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	1LA3	65	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.7
	1LB1	101	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.1
	1LB2	61	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.6
Total for LVSCA		14,037	18.5	19.1	18.6	8.8	5.7	14.4	9.9	0.0	11.5	16.1	14.7	15.3	152.5
RVCA	2AA	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2AB	309	0.0	0.0	0.4	0.6	0.7	0.8	0.8	0.4	0.4	0.6	0.6	0.6	5.9
	2BA	286	0.0	0.0	0.3	0.5	0.6	0.6	0.6	0.3	0.4	0.5	0.5	0.5	4.7
	2BB	359	0.0	0.0	0.4	0.6	0.7	0.7	0.7	0.4	0.4	0.6	0.6	0.6	5.9
	2BC	748	0.0	0.0	0.8	1.3	1.5	1.5	1.5	0.7	0.9	1.3	1.3	1.3	12.2
	2BD	782	0.0	0.0	1.0	1.5	1.8	1.9	1.9	1.0	1.1	1.5	1.5	1.5	14.8
	2CA	112	0.0	0.0	0.1	0.2	0.3	0.3	0.3	0.1	0.2	0.2	0.2	0.2	2.1
	2CB	559	0.0	0.0	0.6	1.0	1.2	1.1	1.1	0.5	0.7	1.0	0.9	1.0	9.1
	2CC	964	0.0	0.0	1.0	1.7	2.0	1.9	2.0	0.9	1.2	1.7	1.6	1.7	15.8
	2D	866	0.0	0.0	0.9	1.5	1.8	1.7	1.8	0.8	1.1	1.5	1.5	1.5	14.1
	2EA	90	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.7
	2EB	155	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	1.2
	2EC	175	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.2	1.4
	2ED	93	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.7
	2EE	137	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	2.0
	2EF	88	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.7
	2EG1	86	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.7
	2EG2	282	0.0	0.0	0.2	0.2	0.2	0.3	0.3	0.1	0.2	0.3	0.2	0.3	2.2
	2EH	136	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.1
	2EJ	274	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.3	2.1
	2EK	124	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	1.0
	2FA	110	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.8
	2FB	31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	2FC	307	0.0	0.0	0.2	0.2	0.2	0.3	0.3	0.1	0.2	0.3	0.2	0.3	2.4
	2GA	58	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.6
	2GB	114	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.9
	2GC	94	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.9
	2GD	220	0.0	0.0	0.2	0.2	0.2	0.2	0.3	0.1	0.2	0.3	0.2	0.3	2.1
	2H-1	900	0.0	0.0	0.9	1.6	1.9	1.8	1.8	0.9	1.1	1.6	1.5	1.6	14.7
	2H-2	900	0.0	0.0	0.6	0.9	1.1	1.1	1.1	0.5	0.7	1.0	0.9	1.0	8.7
	2H-3	981	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2J	876	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2KA	128	0.0	0.0	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.2	2.4
	2KB	127	0.0	0.0	0.2	0.2	0.3	0.3	0.3	0.1	0.2	0.3	0.2	0.2	2.3
	2KC	342	0.0	0.0	0.4	0.7	0.7	0.8	0.8	0.4	0.5	0.7	0.7	0.7	6.2
Total for RVCA		11,828	0.0	0.0	9.9	14.6	16.8	17.2	17.5	8.5	10.9	15.4	14.1	15.7	140.5
ACA	3AA	272	0.0	1.4	2.1	0.4	0.6	0.6	0.0	0.0	1.3	1.8	1.2	1.7	11.2
	3AB	523	0.0	1.4	2.1	1.1	1.8	1.0	0.0	0.0	1.5	2.2	0.7	1.7	13.4
	3AC	382	0.0	0.3	0.6	0.0	0.0	0.1	0.0	0.0	0.3	0.6	0.2	0.2	2.3
	3BA	1,420	0.0	1.6	2.7	0.0	0.0	0.3	0.0	0.0	1.4	2.7	1.1	0.9	10.8
	3BB	729	0.0	0.7	1.0	0.5	0.8	0.5	0.0	0.0	0.7	1.0	0.3	0.8	6.4
	3BC	1,438	0.0	1.6	2.4	0.5	0.7	0.7	0.0	0.0	1.5	2.0	1.4	2.0	12.7
	3BD	966	0.0	0.9	1.5	0.0	0.0	0.2	0.0	0.0	0.8	1.4	0.6	0.5	5.7
	3CB	1,194	0.0	2.0	3.3	0.0	0.0	0.4	0.0	0.0	1.7	3.3	1.3	1.0	13.0
	3DA	442	0.0	0.5	0.7	0.1	0.2	0.2	0.0	0.0	0.5	0.6	0.4	0.6	3.9
	3DB	217	0.0	0.2	0.4	0.1	0.1	0.1	0.0	0.0	0.2	0.3	0.2	0.3	1.9
	3EA	275	0.0	0.3	0.5	0.4	0.4	0.2	0.0	0.0	0.3	0.5	0.2	0.2	3.1
	3EB	291	0.0	0.3	0.6	0.4	0.4	0.2	0.0	0.0	0.3	0.5	0.2	0.2	3.3
	3EC	275	0.0	0.3	0.5	0.4	0.4	0.2	0.0	0.0	0.3	0.5	0.2	0.2	3.1
	3ED	237	0.0	0.3	0.5	0.3	0.4	0.2	0.0	0.0	0.3	0.4	0.2	0.2	2.7
	3FA	3,213	0.0	3.8	6.3	4.7	4.9	2.6	0.0	0.0	3.6	5.3	2.6	2.3	36.1
	3FB	1,944	0.0	2.3	3.8	2.8	3.0	1.6	0.0	0.0	2.2	3.2	1.6	1.4	21.9
	3G	5,509	0.0	6.6	11.0	8.9	9.1	5.1	0.0	0.0	5.9	8.9	7.5	5.0	68.0

Table 3.3.3 Irrigation Water Demand by Sub-basin in 2010 (3/4)

(unit: MCM)

Catchment Area	Sub-basin Code	Irrigation Area (ha)	Present Irrigation Water Demand under 60% Irrigation Efficiency and 140% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ACA	3HB	1,663	0.0	2.0	3.3	2.7	2.7	1.5	0.0	0.0	1.8	2.7	2.3	1.5	20.5
	3HC	120	0.0	1.7	3.1	2.4	2.0	1.1	0.0	0.0	1.6	2.3	2.1	1.5	17.7
	3HD1	23	0.0	0.7	1.2	0.8	0.0	0.1	0.0	0.0	0.6	0.9	0.9	0.9	6.2
	3HD2	14	0.0	0.8	1.4	1.0	0.0	0.1	0.0	0.0	0.7	1.0	1.1	1.1	7.2
	3J	3,698	0.0	4.1	5.5	3.4	3.9	2.9	0.0	0.0	4.0	6.0	4.9	4.3	38.9
	3K	436	0.0	0.6	1.0	0.6	0.2	0.2	0.0	0.0	0.4	0.7	0.7	0.6	4.9
	3LA	4,706	0.0	5.6	9.4	7.6	7.8	4.4	0.0	0.0	5.0	7.6	6.4	4.3	58.1
	3LB	28	0.0	0.6	1.1	0.9	0.9	0.5	0.0	0.0	0.6	0.9	0.7	0.5	6.5
	3MA-1	3,000	0.0	2.6	4.7	3.8	3.5	2.0	0.0	0.0	2.3	3.5	3.1	3.3	28.8
	3MA-2	3,130	0.0	3.7	6.7	5.4	4.9	2.9	0.0	0.0	3.3	5.1	4.4	4.8	41.1
	3MB	115	0.0	0.1	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.2	0.2	0.2	1.5
	3MC	79	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	1.0
	3MD1	43	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.6
	3MD2	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	3N	893	0.0	2.2	4.0	3.2	3.0	1.8	0.0	0.0	2.0	2.8	2.9	2.5	24.5
Total for ACA		38,407	0.0	50.8	84.2	54.6	53.9	32.9	0.0	0.0	46.6	70.7	51.2	45.9	490.9
TCA	4AA	1,004	0.0	1.0	1.4	0.5	0.0	0.4	0.0	0.0	0.9	1.3	0.6	0.8	6.9
	4AB	1,032	0.0	1.0	1.5	0.5	0.0	0.4	0.0	0.0	0.9	1.3	0.7	0.8	7.1
	4AC	697	0.0	0.7	1.0	0.4	0.0	0.2	0.0	0.0	0.6	0.9	0.4	0.6	4.8
	4AD	717	0.0	1.5	2.2	0.8	0.0	0.5	0.0	0.0	1.3	2.0	1.0	1.3	10.7
	4BA	738	0.0	0.7	1.1	0.4	0.0	0.3	0.0	0.0	0.6	1.0	0.5	0.6	5.1
	4BB	1,698	0.0	1.7	2.4	0.9	0.0	0.6	0.0	0.0	1.5	2.2	1.1	1.4	11.7
	4BC	3,271	0.0	3.9	5.8	2.3	2.3	2.0	0.0	0.0	3.5	4.5	2.2	3.8	30.1
	4BD	703	0.0	1.7	2.4	0.9	0.0	0.6	0.0	0.0	1.5	2.2	1.1	1.4	11.7
	4BE	1,593	0.0	1.9	2.6	0.5	1.4	0.8	0.0	0.0	1.5	2.1	1.1	1.7	13.7
	4BF	455	0.0	0.5	0.7	0.1	0.4	0.2	0.0	0.0	0.4	0.6	0.3	0.5	3.9
	4BG	548	0.0	0.7	0.9	0.2	0.5	0.3	0.0	0.0	0.5	0.7	0.4	0.6	4.7
	4CA	1,081	0.0	1.3	1.7	0.3	1.0	0.6	0.0	0.0	1.0	1.4	0.8	1.2	9.3
	4CB	731	0.0	0.9	1.2	0.2	0.6	0.4	0.0	0.0	0.7	1.0	0.5	0.8	6.3
	4CC	1,431	0.0	4.1	5.5	1.1	3.0	1.8	0.0	0.0	3.3	4.5	2.4	3.7	29.5
	4DA	10,175	0.0	12.0	18.0	7.2	7.2	6.2	0.0	0.0	10.7	13.9	6.7	11.7	93.7
	4DB	6,651	0.0	7.8	11.7	4.7	4.7	4.1	0.0	0.0	7.0	9.1	4.4	7.6	61.3
	4DC	880	0.0	2.2	3.3	1.3	1.3	1.2	0.0	0.0	2.0	2.6	1.2	2.2	17.3
	4DD	700	0.0	0.7	1.1	0.4	0.8	0.4	0.0	0.0	0.7	0.8	0.3	0.5	5.7
	4DE	350	0.0	0.3	0.5	0.2	0.4	0.2	0.0	0.0	0.3	0.4	0.2	0.3	2.9
	4EA	1,474	0.0	2.2	4.2	3.9	4.2	1.9	0.0	0.0	2.2	3.3	2.5	2.6	27.1
	4EB	1,556	0.0	1.7	3.3	3.1	3.3	1.5	0.0	0.0	1.7	2.6	2.0	2.0	21.4
	4EC	943	0.0	1.0	2.0	1.9	2.0	0.9	0.0	0.0	1.1	1.6	1.2	1.2	13.0
	4ED	1,443	0.0	2.7	5.3	4.9	5.3	2.3	0.0	0.0	2.7	4.1	3.1	3.2	33.6
	4FA	3,966	0.0	4.4	8.5	7.9	8.5	3.7	0.0	0.0	4.4	6.7	5.0	5.2	54.5
	4FB	4,885	0.0	5.4	10.5	9.8	10.5	4.6	0.0	0.0	5.5	8.3	6.2	6.4	67.1
	4GA	1,179	0.0	1.3	2.5	2.4	2.5	1.1	0.0	0.0	1.3	2.0	1.5	1.5	16.2
	4GB	499	0.0	0.6	1.1	1.0	1.1	0.5	0.0	0.0	0.6	0.8	0.6	0.7	6.9
	4GC	192	0.0	0.2	0.4	0.4	0.4	0.2	0.0	0.0	0.2	0.3	0.2	0.3	2.6
	4GD	858	0.0	1.0	1.8	1.7	1.8	0.8	0.0	0.0	1.0	1.5	1.1	1.1	11.8
	4GE	865	0.0	1.1	1.9	1.7	1.8	0.8	0.0	0.0	1.0	1.4	1.1	1.3	12.2
	4GF	1,356	0.0	1.7	2.9	2.7	2.8	1.3	0.0	0.0	1.6	2.2	1.8	2.1	19.1
	4GG	578	0.0	1.9	3.4	3.2	3.3	1.5	0.0	0.0	1.9	2.6	2.1	2.4	22.2
	4HA	189	0.0	0.2	0.4	0.4	0.4	0.2	0.0	0.0	0.2	0.3	0.2	0.3	2.7
	4HB	829	0.0	1.0	1.8	1.7	1.7	0.8	0.0	0.0	1.0	1.4	1.1	1.3	11.7
	4HC	631	0.0	0.8	1.4	1.3	1.3	0.6	0.0	0.0	0.7	1.0	0.8	1.0	8.9
	4JA	369	0.0	0.5	1.0	0.9	1.2	0.5	0.0	0.0	0.6	0.8	0.6	0.6	6.7
	4JB	143	0.0	0.2	0.4	0.3	0.5	0.2	0.0	0.0	0.2	0.3	0.2	0.2	2.6
	4KA	316	0.0	0.5	0.9	0.7	1.0	0.5	0.0	0.0	0.5	0.7	0.5	0.5	5.7
	4KB	359	0.0	0.5	1.0	0.8	1.1	0.5	0.0	0.0	0.6	0.8	0.6	0.6	6.5
Total for TCA		57,085	0.0	73.5	119.9	73.7	78.7	45.4	0.0	0.0	68.0	95.4	58.3	75.8	688.7
ENNCA	5AA	154	0.0	0.2	0.2	0.1	0.0	0.1	0.0	0.0	0.1	0.2	0.1	0.1	1.1
	5AB	55	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.4
	5AC	160	0.0	0.2	0.3	0.2	0.2	0.1	0.0	0.0	0.2	0.2	0.2	0.2	1.8
	5AD	75	0.0	0.4	0.8	0.5	0.5	0.2	0.0	0.0	0.4	0.5	0.5	0.5	4.4
	5BA	206	0.0	0.1	0.2	0.2	0.3	0.1	0.0	0.0	0.2	0.2	0.1	0.2	1.7
	5BB	663	0.0	0.4	0.7	0.7	1.1	0.5	0.0	0.0	0.7	0.6	0.4	0.5	5.6

Table 3.3.3 Irrigation Water Demand by Sub-basin in 2010 (4/4)

(unit: MCM)

Catchment Area	Sub-basin Code	Irrigation Area (ha)	Present Irrigation Water Demand under 60% Irrigation Efficiency and 140% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ENNCA	5BC-2	477	0.0	0.3	0.5	0.5	0.8	0.3	0.0	0.0	0.5	0.4	0.3	0.4	4.0
	5BD	93	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.8
	5BE	1,474	0.0	1.0	1.6	1.5	2.4	1.0	0.0	0.0	1.5	1.4	0.8	1.1	12.3
	5CA	154	0.0	0.2	0.3	0.3	0.3	0.1	0.0	0.0	0.2	0.3	0.2	0.2	2.2
	5CB	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5CC	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5DA	2,204	0.0	2.2	3.9	3.6	3.7	1.7	0.0	0.0	2.1	2.9	2.4	2.7	25.4
	5DB	201	0.0	0.2	0.4	0.4	0.4	0.2	0.0	0.0	0.2	0.3	0.3	0.3	2.8
	5DC	176	0.0	0.2	0.4	0.4	0.4	0.2	0.0	0.0	0.2	0.3	0.2	0.3	2.5
	5DD	47	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.7
	5EA	86	0.0	0.1	0.2	0.2	0.3	0.1	0.0	0.0	0.1	0.2	0.1	0.1	1.6
	5EB	143	0.0	0.2	0.4	0.3	0.5	0.2	0.0	0.0	0.2	0.3	0.2	0.2	2.6
	5EC	269	0.0	0.4	0.7	0.6	0.9	0.4	0.0	0.0	0.4	0.6	0.4	0.5	4.9
	5ED	5,811	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5FA	820	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5FB	29	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.5
	5GA	2,974	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5GB	637	0.0	1.0	1.9	1.4	1.7	0.9	0.0	0.0	1.0	1.3	1.2	1.3	11.7
	5H	1,271	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5J	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total for ENNCA		18,685	0.0	7.8	13.6	11.9	14.6	6.7	0.0	0.0	8.7	10.5	7.8	9.3	90.9
Grand Total		141900	21.1	153.8	249.0	164.7	170.0	117.5	28.0	8.5	146.8	209.6	147.9	164.2	1,602

Source: JICA Study Team

Table 3.4.1 Unit Irrigation Water Requirement by Sub-basin in 2030 (1/4)

(unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin Code	Unit Irrigation Water Requirement under 70% Irrigation Efficiency & 160% Cropping Intensity											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	1AA	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AB	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AC	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AD	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AE	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AF	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AG	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1AH	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1BA	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1BB	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1BC	0.42	0.47	0.31	0.22	0.00	0.09	0.00	0.00	0.02	0.13	0.27	0.37
	1BD	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1BE	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1BG	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1BH	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1CA	0.50	0.51	0.40	0.35	0.25	0.19	0.00	0.00	0.11	0.37	0.40	0.46
	1CB	0.50	0.51	0.40	0.35	0.25	0.19	0.00	0.00	0.11	0.37	0.40	0.46
	1CC	0.42	0.49	0.39	0.12	0.23	0.03	0.03	0.00	0.20	0.37	0.38	0.44
	1CD	0.50	0.51	0.40	0.35	0.25	0.19	0.00	0.00	0.11	0.37	0.40	0.46
	1CE	0.50	0.51	0.40	0.35	0.25	0.19	0.00	0.00	0.11	0.37	0.40	0.46
	1DA	0.50	0.51	0.40	0.35	0.25	0.19	0.00	0.00	0.11	0.37	0.40	0.46
	1DB	0.52	0.50	0.37	0.41	0.09	0.16	0.00	0.00	0.15	0.23	0.40	0.45
	1DC	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1DD	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1EA	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1EB	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1EC	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1ED	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1EE	0.43	0.37	0.25	0.05	0.00	0.00	0.15	0.00	0.18	0.19	0.17	0.28
	1EF	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1EG	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1FA	0.42	0.49	0.39	0.12	0.23	0.03	0.03	0.00	0.20	0.37	0.38	0.44
	1FB	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1FC	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1FD	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1FE	0.45	0.47	0.33	0.21	0.00	0.00	0.00	0.00	0.04	0.18	0.29	0.36
	1FF	0.52	0.50	0.33	0.29	0.32	0.56	0.35	0.00	0.23	0.50	0.43	0.42
	1FG	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
Average for LVNCA		0.46	0.45	0.32	0.22	0.08	0.11	0.08	0.00	0.14	0.25	0.30	0.37
LVSCA	1GA	0.47	0.51	0.40	0.21	0.16	0.01	0.00	0.00	0.00	0.26	0.30	0.44
	1GB	0.36	0.40	0.28	0.00	0.00	0.09	0.08	0.00	0.13	0.25	0.27	0.35
	1GC	0.36	0.40	0.28	0.00	0.00	0.09	0.08	0.00	0.13	0.25	0.27	0.35
	1GD	0.57	0.56	0.38	0.23	0.34	0.43	0.31	0.00	0.25	0.44	0.43	0.42
	1GE	0.57	0.56	0.38	0.23	0.34	0.43	0.31	0.00	0.25	0.44	0.43	0.42
	1GF	0.57	0.56	0.38	0.23	0.34	0.43	0.31	0.00	0.25	0.44	0.43	0.42
	1GG	0.36	0.40	0.28	0.00	0.00	0.09	0.08	0.00	0.13	0.25	0.27	0.35
	1HA1	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HA2	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HB1	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HB2	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HC	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HD	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HE	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HF	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1HG	0.45	0.48	0.28	0.35	0.14	0.48	0.33	0.00	0.21	0.40	0.36	0.38
	1JA	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JB	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JC	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JD	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JE	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JF	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JG1	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1JG2	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35

Table 3.4.1 Unit Irrigation Water Requirement by Sub-basin in 2030 (2/4)

(unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin Code	Unit Irrigation Water Requirement under 70% Irrigation Efficiency & 160% Cropping Intensity											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVSCA	1KA	0.51	0.50	0.27	0.12	0.18	0.53	0.36	0.00	0.26	0.43	0.35	0.39
	1KB	0.51	0.50	0.27	0.12	0.18	0.53	0.36	0.00	0.26	0.43	0.35	0.39
	1KC	0.51	0.50	0.27	0.12	0.18	0.53	0.36	0.00	0.26	0.43	0.35	0.39
	1LA1	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1LA2	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1LA3	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1LB1	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
	1LB2	0.38	0.34	0.27	0.20	0.29	0.41	0.22	0.00	0.21	0.42	0.38	0.35
Average for LVSCA		0.43	0.43	0.29	0.22	0.21	0.40	0.25	0.00	0.20	0.40	0.36	0.37
RVCA	2AA	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2AB	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2BA	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2BB	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2BC	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2BD	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2CA	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2CB	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2CC	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2D	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2EA	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EB	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EC	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2ED	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EE	0.00	0.00	0.47	0.71	0.72	0.73	0.32	0.00	0.28	0.52	0.49	0.53
	2EF	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EG1	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EG2	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EH	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EJ	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2EK	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2FA	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2FB	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2FC	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2GA	0.00	0.00	0.33	0.35	0.37	0.42	0.28	0.00	0.20	0.38	0.33	0.40
	2GB	0.00	0.00	0.32	0.31	0.28	0.37	0.19	0.00	0.17	0.31	0.21	0.36
	2GC	0.00	0.00	0.33	0.35	0.37	0.42	0.28	0.00	0.20	0.38	0.33	0.40
	2GD	0.00	0.00	0.33	0.35	0.37	0.42	0.28	0.00	0.20	0.38	0.33	0.40
	2H-1	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2H-2	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2H-3	0.00	0.00	0.43	0.72	0.85	0.83	0.42	0.00	0.31	0.59	0.56	0.59
	2J	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2KA	0.00	0.00	0.55	0.79	0.97	1.01	0.50	0.00	0.35	0.65	0.63	0.63
	2KB	0.00	0.00	0.53	0.79	0.83	0.91	0.49	0.00	0.34	0.67	0.63	0.64
	2KC	0.00	0.00	0.53	0.79	0.83	0.91	0.49	0.00	0.34	0.67	0.63	0.64
Average for RVCA		0.00	0.00	0.41	0.54	0.60	0.64	0.33	0.00	0.25	0.47	0.42	0.49
ACA	3AA	0.00	0.47	0.68	0.14	0.20	0.19	0.00	0.00	0.26	0.47	0.32	0.45
	3AB	0.00	0.39	0.57	0.30	0.48	0.27	0.00	0.00	0.24	0.47	0.15	0.37
	3AC	0.00	0.37	0.62	0.00	0.00	0.07	0.00	0.00	0.20	0.50	0.20	0.16
	3BA	0.00	0.37	0.62	0.00	0.00	0.07	0.00	0.00	0.20	0.50	0.20	0.16
	3BB	0.00	0.39	0.57	0.30	0.48	0.27	0.00	0.00	0.24	0.47	0.15	0.37
	3BC	0.00	0.47	0.68	0.14	0.20	0.19	0.00	0.00	0.26	0.47	0.32	0.45
	3BD	0.00	0.37	0.62	0.00	0.00	0.07	0.00	0.00	0.20	0.50	0.20	0.16
	3CB	0.00	0.37	0.62	0.00	0.00	0.07	0.00	0.00	0.20	0.50	0.20	0.16
	3DA	0.00	0.47	0.68	0.14	0.20	0.19	0.00	0.00	0.26	0.47	0.32	0.45
	3DB	0.00	0.47	0.68	0.14	0.20	0.19	0.00	0.00	0.26	0.47	0.32	0.45
	3EA	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3EB	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3EC	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3ED	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3FA	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3FB	0.00	0.49	0.81	0.60	0.63	0.34	0.00	0.00	0.28	0.54	0.27	0.24
	3G	0.00	0.49	0.83	0.67	0.68	0.39	0.00	0.00	0.26	0.53	0.45	0.30
	3HA	0.00	0.49	0.83	0.67	0.68	0.39	0.00	0.00	0.26	0.53	0.45	0.30

Table 3.4.1 Unit Irrigation Water Requirement by Sub-basin in 2030 (3/4)

(unit: $m^3/s/1,000$ ha)

Catchment Area	Sub-basin Code	Unit Irrigation Water Requirement under 70% Irrigation Efficiency & 160% Cropping Intensity											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ACA	3HB	0.00	0.49	0.83	0.67	0.68	0.39	0.00	0.00	0.26	0.53	0.45	0.30
	3HC	0.00	0.51	0.90	0.68	0.58	0.33	0.00	0.00	0.27	0.53	0.48	0.35
	3HD1	0.00	0.52	0.97	0.66	0.02	0.07	0.00	0.00	0.29	0.55	0.58	0.60
	3HD2	0.00	0.52	0.97	0.66	0.02	0.07	0.00	0.00	0.29	0.55	0.58	0.60
	3J	0.00	0.46	0.61	0.38	0.43	0.32	0.00	0.00	0.27	0.54	0.44	0.39
	3K	0.00	0.54	0.98	0.54	0.22	0.19	0.00	0.00	0.24	0.50	0.51	0.43
	3LA	0.00	0.49	0.83	0.67	0.68	0.39	0.00	0.00	0.26	0.53	0.45	0.30
	3LB	0.00	0.49	0.83	0.67	0.68	0.39	0.00	0.00	0.26	0.53	0.45	0.30
	3MA-1	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.53	0.47	0.50
	3MA-2	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.53	0.47	0.50
	3MB	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.53	0.47	0.50
	3MC	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.50	0.51	0.43
	3MD1	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.50	0.51	0.43
	3MD2	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.50	0.51	0.43
	3N	0.00	0.49	0.88	0.71	0.65	0.39	0.00	0.00	0.26	0.50	0.51	0.43
Average for ACA		0.00	0.47	0.79	0.48	0.45	0.28	0.00	0.00	0.26	0.51	0.37	0.36
TCA	4AA	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4AB	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4AC	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4AD	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4BA	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4BB	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4BC	0.00	0.49	0.73	0.29	0.29	0.25	0.00	0.00	0.26	0.45	0.22	0.38
	4BD	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	4BE	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4BF	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4BG	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4CA	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4CB	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4CC	0.00	0.50	0.67	0.13	0.36	0.22	0.00	0.00	0.24	0.44	0.23	0.36
	4DA	0.00	0.49	0.73	0.29	0.29	0.25	0.00	0.00	0.26	0.45	0.22	0.38
	4DB	0.00	0.49	0.73	0.29	0.29	0.25	0.00	0.00	0.26	0.45	0.22	0.38
	4DC	0.00	0.49	0.73	0.29	0.29	0.25	0.00	0.00	0.26	0.45	0.22	0.38
	4DD	0.00	0.40	0.62	0.23	0.49	0.21	0.00	0.00	0.24	0.40	0.14	0.26
	4DE	0.00	0.40	0.62	0.23	0.49	0.21	0.00	0.00	0.24	0.40	0.14	0.26
	4EA	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4EB	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4EC	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4ED	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4FA	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4FB	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4GA	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4GB	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4GC	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4GD	0.00	0.46	0.89	0.83	0.89	0.39	0.00	0.00	0.28	0.56	0.42	0.43
	4GE	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4GF	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4GG	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4HA	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4HB	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4HC	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	4JA	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	4JB	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	4KA	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	4KB	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
Average for TCA		0.00	0.48	0.80	0.54	0.61	0.32	0.00	0.00	0.27	0.51	0.33	0.40
ENNCA	5AA	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	5AB	0.00	0.41	0.59	0.21	0.00	0.15	0.00	0.00	0.21	0.43	0.21	0.27
	5AC	0.00	0.43	0.83	0.55	0.56	0.26	0.00	0.00	0.24	0.46	0.39	0.43
	5AD	0.00	0.43	0.83	0.55	0.56	0.26	0.00	0.00	0.24	0.46	0.39	0.43
	5BA	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26
	5BB	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26
	5BC-1	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26

Table 3.4.1 Unit Irrigation Water Requirement by Sub-basin in 2030 (4/4)

(unit: m^3/s/1,000 ha)

Catchment Area	Sub-basin Code	Unit Irrigation Water Requirement under 70% Irrigation Efficiency & 160% Cropping Intensity											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ENNCA	5BC-2	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26
	5BD	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26
	5BE	0.00	0.28	0.44	0.43	0.68	0.29	0.00	0.00	0.25	0.31	0.18	0.26
	5CA	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5CB	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5CC	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5DA	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5DB	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5DC	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5DD	0.00	0.50	0.89	0.83	0.86	0.39	0.00	0.00	0.29	0.54	0.44	0.50
	5EA	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5EB	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5EC	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5ED	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5FA	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5FB	0.00	0.61	1.14	0.97	1.32	0.60	0.00	0.00	0.39	0.72	0.51	0.56
	5GA	0.00	0.54	0.98	0.74	0.84	0.43	0.00	0.00	0.29	0.52	0.48	0.54
	5GB	0.00	0.54	0.98	0.74	0.84	0.43	0.00	0.00	0.29	0.52	0.48	0.54
	5H	0.00	0.55	1.07	0.73	0.91	0.49	0.00	0.00	0.32	0.49	0.51	0.59
	5J	0.00	0.55	1.07	0.73	0.91	0.49	0.00	0.00	0.32	0.49	0.51	0.59
Average for ENNCA		0.00	0.47	0.84	0.69	0.84	0.40	0.00	0.00	0.30	0.51	0.39	0.45
Overall Average		0.15	0.38	0.57	0.44	0.45	0.35	0.11	0.00	0.23	0.44	0.36	0.40

Source: JICA Study Team based on Water Requirements for Irrigation in Kenya

Table 3.4.2 Potential Agricultural Area and Cropping Area by County and Catchment Area

1) Potential Agricultural Area and Cropping Area by County

Province	County	Area (km^2)	Potential Agricultural Area (1,000 ha)				Cropping Area in 2011	
			High Potential	Medium Potential	Low Potential	Total	Area (1000 ha)	Ratio to Potential A
Western	Bungoma	2,935	253	0	0	253	134	52.9%
	Busia	1,546	154	0	0	154	107	69.3%
	Kakamega	2,707	244	0	0	244	86	35.2%
	Vihiga	889	81	0	0	81	27	32.8%
Nyanza	Homa Bay	3,081	305	3	0	308	124	40.4%
	Migori	2,612	258	2	0	260	76	29.1%
	Kisii	1,326	130	0	0	130	56	43.1%
	Nyamira	906	150	0	0	150	94	62.7%
	Kisumu	2,080	195	13	0	208	76	36.6%
	Siaya	2,485	231	16	0	247	103	41.8%
Rift Valley	Baringo	10,905	166	84	751	1,001	40	4.0%
	Kericho	2,171	167	0	0	167	51	30.7%
	Bomet	2,808	213	0	0	213	60	28.4%
	Elgeyo Marakwet	3,031	104	0	92	196	10	5.4%
	Kajiado	21,716	100	0	1,760	1,860	56	3.0%
	Laikipia	9,467	130	0	768	898	46	5.1%
	Nakuru	7,322	291	39	231	561	118	21.0%
	Nandi	2,899	234	0	0	234	78	33.3%
	Narok	18,099	908	0	704	1,612	100	6.2%
	Samburu	20,972	140	0	1,612	1,752	1	0.0%
	Trans Nzoia	2,429	208	0	0	208	103	49.3%
	Turkana	67,446	12	0	5,937	5,949	4	0.1%
	Uasin Gishu	3,361	327	0	0	327	87	26.6%
	West Pokot	9,034	103	0	365	468	25	5.4%
Central	Kiambu	3,158	235	3	15	253	90	35.7%
	Kirinyaga	1,479	98	5	24	127	47	36.9%
	Muranga	1,980	151	2	9	162	68	41.9%
	Nyandarua	3,262	265	0	5	270	74	27.4%
	Nyeri	3,363	160	0	12	172	40	23.5%
Nairobi	Nairobi	702	16	0	38	54	1	2.4%
Eastern	Embu	2,833	66	186	0	252	87	34.4%
	Isiolo	25,225	3	0	2,522	2,525	1	0.1%
	Kitui	30,597	67	1,137	1,078	2,282	329	14.4%
	Machakos	6,270	55	339	200	594	294	49.5%
	Makueni	8,060	70	432	254	756	281	37.1%
	Marsabit	70,287	4	0	7,023	7,027	2	0.0%
	Meru	6,945	174	68	227	469	213	45.3%
	Tharaka-Nithi	2,653	67	27	88	182	132	72.3%
Coast	Kilifi	12,544	104	247	851	1,202	159	13.3%
	Kwale	7,954	126	162	502	790	125	15.8%
	Lamu	5,853	7	320	251	578	44	7.6%
	Mombasa	161	16	0	0	16	4	23.3%
	Taita Taveta	16,978	42	10	590	642	28	4.4%
	Tana River	38,473	73	58	3,393	3,524	15	0.4%
North Eastern	Garissa	44,015			4,393	4,393	3	0.1%
	Mandera	25,196			2,515	2,515	3	0.1%
	Wajir	55,998			5,590	5,590	3	0.1%
Total		576,213	6,903	3,153	41,800	51,856	3,706	7.1%

2) Potential Agricultural Area and Cropping Area by Catchment Area

Catchment Area	Area (km^2)	Potential Agricultural Area (1,000 ha)				Cropping Area in 2011	
		High Potential	Medium Potential	Low Potential	Total	Area (1000 ha)	Ratio to Potential A
Lake Victoria North	18,374	1,924	21	33	1,978	777	39.3%
Lake Victoria South	31,734	1,865	19	417	2,301	554	24.1%
Rift Valley	130,452	1,246	117	9,752	11,115	304	2.7%
Athi	58,639	558	1,096	3,429	5,083	877	17.2%
Tana	126,026	847	1,867	8,311	11,025	1,001	9.1%
Ewaso Ng'iro North	210,226	463	33	19,858	20,354	194	1.0%
Total	576,213	6,903	3,153	41,800	51,856	3,706	7.1%

Source: JICA Study Team, based on data from MOA.

Table 3.4.3 New Irrigation Area Distribution by Sub-basin for 1.2 Million ha

(Unit: ha)

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area	Sub-basin	Irrigation Area
1AA	2,464	1GA	858	2AA	447	3AA	1,571	4AA	5,704	5AA	1,646
1AB	633	1GB	2,427	2AB	1,260	3AB	3,269	4AB	6,230	5AB	622
1AC	250	1GC	2,090	2BA	730	3AC	2,243	4AC	4,191	5AC	1,537
1AD	4,041	1GD	8,518	2BB	840	3BA	8,832	4AD	4,316	5AD	729
1AE	3,789	1GE	2,857	2BC	2,069	3BB	4,722	4BA	3,938	5BA	1,319
1AF	4,357	1GF	4,199	2BD	2,404	3BC	9,346	4BB	7,331	5BB	4,005
1AG	3,595	1GG	1,364	2CA	456	3BD	6,286	4BC	13,117	5BC-1	3,363
1AH	12,156	1HA1	4,982	2CB	3,341	3CB	7,759	4BD	4,573	5BC-2	3,000
1BA	1,015	1HA2	4,983	2CC	4,763	3DA	2,719	4BE	7,900	5BD	931
1BB	1,524	1HB1	5,713	2D	4,724	3DB	1,553	4BF	2,981	5BE	8,106
1BC	1,130	1HB2	5,714	2EA	516	3EA	1,628	4BG	3,275	5CA	1,570
1BD	1,374	1HC	7,673	2EB	901	3EB	2,423	4CA	7,130	5CB	173
1BE	2,021	1HD	7,328	2EC	1,057	3EC	2,779	4CB	4,764	5CC	229
1BG	1,909	1HE	7,044	2ED	505	3ED	2,433	4CC	9,220	5DA	11,487
1BH	1,271	1HF	9,666	2EE	718	3FA	26,488	4DA	40,768	5DB	1,700
1CA	1,060	1HG	3,833	2EF	460	3FB	17,119	4DB	26,609	5DC	1,672
1CB	1,025	1JA	4,786	2EG1	505	3G	28,871	4DC	4,228	5DD	323
1CC	986	1JB	2,601	2EG2	1,509	3HA	5,639	4DD	3,768	5EA	1,749
1CD	829	1JC	815	2EH	711	3HB	9,340	4DE	1,977	5EB	1,830
1CE	570	1JD	657	2EJ	1,807	3HC	2,149	4EA	7,859	5EC	2,301
1DA	1,430	1JE	5,393	2EK	744	3HD1	399	4EB	9,073	5ED	30,229
1DB	1,437	1JF	8,652	2FA	699	3HD2	245	4EC	5,078	5FA	49,513
1DC	946	1JG1	1,455	2FB	182	3J	18,526	4ED	8,531	5FB	581
1DD	941	1JG2	1,455	2FC	1,832	3K	2,643	4FA	21,101	5GA	8,079
1EA	1,279	1KA	4,874	2GA	410	3LA	25,291	4FB	26,380	5GB	1,639
1EB	1,225	1KB	44,799	2GB	1,198	3LB	479	4GA	8,034	5H	3,274
1EC	804	1KC	21,637	2GC	1,027	3MA-1	15,888	4GB	14,943	5J	1,059
1ED	418	1LA1	4,922	2GD	1,361	3MA-2	15,000	4GC	5,980		
1EE	4,766	1LA2	609	2H-1	6,000	3MB	893	4GD	20,684		
1EF	6,881	1LA3	769	2H-2	6,010	3MC	519	4GE	20,979		
1EG	5,527	1LB1	3,584	2H-3	6,019	3MD1	742	4GF	33,727		
1FA	347	1LB2	725	2J	3,569	3MD2	65	4GG	13,300		
1FB	620			2KA	1,430	3N	5,770	4HA	3,151		
1FC	452			2KB	977			4HB	19,565		
1FD	782			2KC	2,311			4HC	14,797		
1FE	1,811							4JA	27,927		
1FF	922							4JB	10,619		
1FG	14,197							4KA	23,444		
								4KB	25,256		
Total	90,786	Total	186,978	Total	63,493	Total	233,628	Total	482,450	Total	142,665
Whole Country: 1,200,000 ha											

Source: JICA Study Team

Table 3.4.4 Irrigation Water Demand for 1.2 Million ha by Sub-basin in 2030 (1/4)

(Unit: MCM)

Catchment Area	Sub-basin	Irrigation Area (ha)	Irrigation Water Demand in 2030 under 60% Irrigation Efficiency and 160% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LVNCA	1AA	2,464	3.2	2.8	1.9	0.3	0.0	0.0	1.1	0.0	1.3	1.4	1.2	2.1	15
	1AB	633	0.8	0.7	0.5	0.1	0.0	0.0	0.3	0.0	0.3	0.4	0.3	0.5	4
	1AC	250	0.3	0.3	0.2	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.2	2
	1AD	4,041	5.2	4.6	3.1	0.6	0.0	0.0	1.8	0.0	2.2	2.3	2.0	3.4	25
	1AE	3,789	4.9	4.3	2.9	0.5	0.0	0.0	1.7	0.0	2.1	2.2	1.9	3.2	24
	1AF	4,357	5.6	4.9	3.3	0.6	0.0	0.0	1.9	0.0	2.4	2.5	2.2	3.7	27
	1AG	3,595	4.6	4.1	2.7	0.5	0.0	0.0	1.6	0.0	2.0	2.0	1.8	3.0	22
	1AH	12,156	15.7	13.8	9.3	1.7	0.0	0.0	5.4	0.0	6.6	6.9	6.1	10.2	76
	1BA	1,015	1.6	1.5	1.1	1.3	0.3	0.5	0.0	0.0	0.4	0.7	1.2	1.4	10
	1BB	1,524	2.4	2.3	1.7	1.9	0.4	0.7	0.0	0.0	0.7	1.0	1.8	2.1	15
	1BC	1,130	1.4	1.6	1.1	0.7	0.0	0.3	0.0	0.0	0.1	0.4	0.9	1.3	8
	1BD	1,374	2.2	2.1	1.5	1.7	0.4	0.7	0.0	0.0	0.6	0.9	1.7	1.9	14
	1BE	2,021	3.2	3.1	2.3	2.5	0.5	1.0	0.0	0.0	0.9	1.4	2.4	2.7	20
	1BG	1,909	3.0	2.9	2.1	2.4	0.5	0.9	0.0	0.0	0.8	1.3	2.3	2.6	19
	1BH	1,271	2.0	1.9	1.4	1.6	0.3	0.6	0.0	0.0	0.6	0.9	1.5	1.7	13
	1CA	1,060	1.6	1.6	1.3	1.1	0.8	0.6	0.0	0.0	0.3	1.2	1.3	1.5	11
	1CB	1,025	1.6	1.6	1.2	1.1	0.8	0.6	0.0	0.0	0.3	1.2	1.2	1.4	11
	1CC	986	1.2	1.5	1.2	0.3	0.7	0.1	0.1	0.0	0.6	1.1	1.1	1.3	9
	1CD	829	1.3	1.3	1.0	0.9	0.6	0.5	0.0	0.0	0.3	0.9	1.0	1.1	9
	1CE	570	0.9	0.9	0.7	0.6	0.4	0.3	0.0	0.0	0.2	0.6	0.7	0.8	6
	1DA	1,430	2.2	2.2	1.7	1.5	1.1	0.8	0.0	0.0	0.5	1.6	1.7	2.0	15
	1DB	1,437	2.3	2.2	1.6	1.8	0.4	0.7	0.0	0.0	0.6	1.0	1.7	2.0	14
	1DC	946	1.2	1.1	0.7	0.1	0.0	0.0	0.4	0.0	0.5	0.5	0.5	0.8	6
	1DD	941	1.2	1.1	0.7	0.1	0.0	0.0	0.4	0.0	0.5	0.5	0.5	0.8	6
	1EA	1,279	1.7	1.8	1.3	0.8	0.0	0.0	0.0	0.0	0.1	0.7	1.1	1.4	9
	1EB	1,225	1.7	1.7	1.2	0.8	0.0	0.0	0.0	0.0	0.1	0.7	1.1	1.3	9
	1EC	804	1.1	1.1	0.8	0.5	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.9	6
	1ED	418	0.5	0.5	0.3	0.1	0.0	0.0	0.2	0.0	0.2	0.2	0.2	0.4	3
	1EE	4,766	6.1	5.4	3.6	0.7	0.0	0.0	2.1	0.0	2.6	2.7	2.4	4.0	30
	1EF	6,881	9.3	10.0	5.8	7.3	2.9	10.0	6.9	0.0	4.4	8.3	7.6	7.9	80
	1EG	5,527	7.5	8.1	4.7	5.9	2.3	8.0	5.6	0.0	3.5	6.7	6.1	6.4	65
	1FA	347	0.4	0.5	0.4	0.1	0.2	0.0	0.0	0.0	0.2	0.4	0.4	0.5	3
	1FB	620	0.8	0.9	0.6	0.4	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.7	4
	1FC	452	0.6	0.6	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.5	3
	1FD	782	1.1	1.1	0.8	0.5	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.8	5
	1FE	1,811	2.4	2.6	1.8	1.1	0.0	0.0	0.0	0.0	0.2	1.0	1.6	2.0	13
	1FF	922	1.5	1.4	0.9	0.8	0.9	1.6	1.0	0.0	0.7	1.4	1.2	1.2	12
	1FG	14,197	19.3	20.7	12.0	15.0	5.9	20.6	14.3	0.0	9.0	17.1	15.6	16.3	166
Total for LVNCA		90,786	125	122	81	59	20	49	46	0	47	75	78	97	799
LVSCA	1GA	858	1.2	1.3	1.0	0.6	0.4	0.0	0.0	0.0	0.0	0.7	0.8	1.2	7
	1GB	2,427	2.6	2.9	2.0	0.0	0.0	0.7	0.6	0.0	0.9	1.8	2.0	2.6	16
	1GC	2,090	2.3	2.5	1.7	0.0	0.0	0.6	0.5	0.0	0.8	1.6	1.7	2.2	14
	1GD	8,518	14.7	14.3	9.9	6.0	8.8	11.0	7.9	0.0	6.5	11.4	11.0	10.8	112
	1GE	2,857	4.9	4.8	3.3	2.0	3.0	3.7	2.7	0.0	2.2	3.8	3.7	3.6	38
	1GF	4,199	7.2	7.1	4.9	3.0	4.3	5.4	3.9	0.0	3.2	5.6	5.4	5.3	55
	1GG	1,364	1.5	1.6	1.1	0.0	0.0	0.4	0.3	0.0	0.5	1.0	1.1	1.4	9
	1HA1	4,982	6.8	7.3	4.2	5.3	2.1	7.2	5.0	0.0	3.2	6.0	5.5	5.7	58
	1HA2	4,983	6.8	7.3	4.2	5.3	2.1	7.2	5.0	0.0	3.2	6.0	5.5	5.7	58
	1HB1	5,713	7.8	8.3	4.8	6.1	2.4	8.3	5.7	0.0	3.6	6.9	6.3	6.6	67
	1HB2	5,714	7.8	8.3	4.8	6.1	2.4	8.3	5.8	0.0	3.6	6.9	6.3	6.6	67
	1HC	7,673	10.4	11.2	6.5	8.1	3.2	11.1	7.7	0.0	4.9	9.3	8.4	8.8	90
	1HD	7,328	10.0	10.7	6.2	7.8	3.0	10.6	7.4	0.0	4.6	8.8	8.0	8.4	86
	1HE	7,044	9.6	10.3	6.0	7.5	2.9	10.2	7.1	0.0	4.5	8.5	7.7	8.1	82
	1HF	9,666	13.1	14.1	8.2	10.2	4.0	14.0	9.7	0.0	6.1	11.7	10.6	11.1	113
	1HG	3,833	5.2	5.6	3.2	4.1	1.6	5.6	3.9	0.0	2.4	4.6	4.2	4.4	45
	1JA	4,786	5.5	4.9	3.9	2.9	4.2	5.9	3.2	0.0	3.0	6.1	5.5	5.1	50
	1JB	2,601	3.0	2.7	2.1	1.6	2.3	3.2	1.8	0.0	1.6	3.3	3.0	2.8	27
	1JC	815	0.9	0.8	0.7	0.5	0.7	1.0	0.6	0.0	0.5	1.0	0.9	0.9	9
	1JD	657	0.8	0.7	0.5	0.4	0.6	0.8	0.4	0.0	0.4	0.8	0.7	0.7	7
	1JE	5,393	6.2	5.5	4.4	3.3	4.7	6.6	3.7	0.0	3.4	6.8	6.1	5.8	56
	1JF	8,652	9.9	8.8	7.0	5.3	7.5	10.6	5.9	0.0	5.5	11.0	9.9	9.2	91

Table 3.4.4 Irrigation Water Demand for 1.2 Million ha by Sub-basin in 2030 (2/4)

(Unit: MCM)

Catchment Area	Sub-basin	Irrigation Area (ha)	Irrigation Water Demand in 2030 under 60% Irrigation Efficiency and 160% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
LVSCA	1JG1	1,455	1.7	1.5	1.2	0.9	1.3	1.8	1.0	0.0	0.9	1.8	1.7	1.6	15
	1JG2	1,455	1.7	1.5	1.2	0.9	1.3	1.8	1.0	0.0	0.9	1.8	1.7	1.6	15
	1KA	4,874	7.6	7.3	3.9	1.8	2.6	7.8	5.3	0.0	3.8	6.3	5.2	5.8	57
	1KB	44,799	69.7	67.1	36.2	16.6	24.3	72.1	48.3	0.0	34.9	57.7	47.8	53.3	528
	1KC	21,637	33.7	32.4	17.5	8.0	11.7	34.8	23.3	0.0	16.9	27.9	23.1	25.8	255
	1LA1	4,922	5.7	5.0	4.0	3.0	4.3	6.1	3.3	0.0	3.1	6.2	5.6	5.3	52
	1LA2	609	0.7	0.6	0.5	0.4	0.5	0.7	0.4	0.0	0.4	0.8	0.7	0.7	6
	1LA3	769	0.9	0.8	0.6	0.5	0.7	0.9	0.5	0.0	0.5	1.0	0.9	0.8	8
	1LB1	3,584	4.1	3.7	2.9	2.2	3.1	4.4	2.4	0.0	2.3	4.5	4.1	3.8	38
	1LB2	725	0.8	0.7	0.6	0.4	0.6	0.9	0.5	0.0	0.5	0.9	0.8	0.8	8
Total for LVSCA		186,978	268	265	161	122	112	268	177	0	131	236	209	219	2,169
RVCA	2AA	447	0.0	0.0	0.7	1.1	1.3	1.4	0.7	0.0	0.5	0.9	0.8	0.9	8
	2AB	1,260	0.0	0.0	2.1	3.0	3.7	3.9	1.9	0.0	1.3	2.5	2.4	2.4	23
	2BA	730	0.0	0.0	1.0	1.6	1.9	1.8	0.9	0.0	0.7	1.3	1.2	1.3	12
	2BB	840	0.0	0.0	1.1	1.8	2.2	2.1	1.1	0.0	0.8	1.5	1.4	1.5	13
	2BC	2,069	0.0	0.0	2.7	4.5	5.3	5.2	2.6	0.0	1.9	3.7	3.5	3.7	33
	2BD	2,404	0.0	0.0	4.0	5.7	7.1	7.4	3.7	0.0	2.6	4.7	4.5	4.6	44
	2CA	456	0.0	0.0	0.8	1.1	1.3	1.4	0.7	0.0	0.5	0.9	0.9	0.9	8
	2CB	3,341	0.0	0.0	4.4	7.3	8.6	8.4	4.2	0.0	3.1	6.0	5.7	6.0	53
	2CC	4,763	0.0	0.0	6.2	10.4	12.3	11.9	6.0	0.0	4.4	8.5	8.1	8.5	76
	2D	4,724	0.0	0.0	6.2	10.3	12.2	11.8	6.0	0.0	4.4	8.4	8.0	8.4	76
	2EA	516	0.0	0.0	0.5	0.5	0.4	0.6	0.3	0.0	0.3	0.5	0.3	0.6	4
	2EB	901	0.0	0.0	0.9	0.8	0.8	1.0	0.5	0.0	0.5	0.8	0.6	1.0	7
	2EC	1,057	0.0	0.0	1.0	1.0	0.9	1.2	0.6	0.0	0.6	1.0	0.7	1.1	8
	2ED	505	0.0	0.0	0.5	0.5	0.4	0.6	0.3	0.0	0.3	0.5	0.3	0.5	4
	2EE	718	0.0	0.0	1.0	1.5	1.6	1.6	0.7	0.0	0.6	1.1	1.1	1.2	10
	2EF	460	0.0	0.0	0.4	0.4	0.4	0.5	0.3	0.0	0.2	0.4	0.3	0.5	4
	2EG1	505	0.0	0.0	0.5	0.5	0.4	0.6	0.3	0.0	0.3	0.5	0.3	0.5	4
	2EG2	1,509	0.0	0.0	1.5	1.4	1.3	1.7	0.9	0.0	0.8	1.4	1.0	1.6	12
	2EH	711	0.0	0.0	0.7	0.7	0.6	0.8	0.4	0.0	0.4	0.7	0.5	0.8	5
	2EJ	1,807	0.0	0.0	1.8	1.7	1.5	2.0	1.0	0.0	0.9	1.7	1.2	2.0	14
	2EK	744	0.0	0.0	0.7	0.7	0.6	0.8	0.4	0.0	0.4	0.7	0.5	0.8	6
	2FA	699	0.0	0.0	0.7	0.6	0.6	0.8	0.4	0.0	0.4	0.6	0.5	0.8	5
	2FB	182	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.0	0.1	0.2	0.1	0.2	1
	2FC	1,832	0.0	0.0	1.8	1.7	1.5	2.1	1.0	0.0	1.0	1.7	1.2	2.0	14
	2GA	410	0.0	0.0	0.4	0.4	0.5	0.5	0.4	0.0	0.3	0.5	0.4	0.5	4
	2GB	1,198	0.0	0.0	1.2	1.1	1.0	1.4	0.7	0.0	0.6	1.1	0.8	1.3	9
	2GC	1,027	0.0	0.0	1.0	1.1	1.2	1.3	0.9	0.0	0.6	1.2	1.0	1.2	10
	2GD	1,361	0.0	0.0	1.4	1.5	1.5	1.7	1.2	0.0	0.8	1.6	1.4	1.6	13
	2H-1	6,000	0.0	0.0	7.8	13.1	15.4	15.0	7.6	0.0	5.5	10.7	10.2	10.7	96
	2H-2	6,010	0.0	0.0	7.9	13.1	15.5	15.0	7.6	0.0	5.6	10.7	10.2	10.7	96
	2H-3	6,019	0.0	0.0	7.9	13.1	15.5	15.0	7.6	0.0	5.6	10.7	10.2	10.7	96
	2J	3,569	0.0	0.0	5.9	8.5	10.5	10.9	5.4	0.0	3.8	7.0	6.7	6.8	66
	2KA	1,430	0.0	0.0	2.4	3.4	4.2	4.4	2.2	0.0	1.5	2.8	2.7	2.7	26
	2KB	977	0.0	0.0	1.6	2.3	2.4	2.7	1.5	0.0	1.0	2.0	1.9	1.9	17
	2KC	2,311	0.0	0.0	3.7	5.5	5.8	6.4	3.5	0.0	2.4	4.7	4.4	4.5	41
Total for RVCA		63,492	0	0	83	124	142	146	75	0	55	104	96	106	932
ACA	3AA	1,571	0.0	2.2	3.2	0.7	0.9	0.9	0.0	0.0	1.2	2.2	1.5	2.1	15
	3AB	3,269	0.0	3.8	5.7	3.0	4.7	2.7	0.0	0.0	2.4	4.6	1.5	3.7	32
	3AC	2,243	0.0	2.5	4.2	0.0	0.0	0.5	0.0	0.0	1.3	3.4	1.3	1.1	14
	3BA	8,832	0.0	9.9	16.6	0.0	0.0	1.8	0.0	0.0	5.2	13.2	5.2	4.2	56
	3BB	4,722	0.0	5.5	8.2	4.3	6.8	3.9	0.0	0.0	3.4	6.7	2.1	5.3	46
	3BC	9,346	0.0	13.2	19.3	3.9	5.5	5.3	0.0	0.0	7.4	13.2	8.9	12.8	90
	3BD	6,286	0.0	7.0	11.8	0.0	0.0	1.3	0.0	0.0	3.7	9.4	3.7	3.0	40
	3CB	7,759	0.0	8.7	14.6	0.0	0.0	1.6	0.0	0.0	4.6	11.6	4.6	3.7	49
	3DA	2,719	0.0	3.8	5.6	1.1	1.6	1.5	0.0	0.0	2.2	3.9	2.6	3.7	26
	3DB	1,553	0.0	2.2	3.2	0.7	0.9	0.9	0.0	0.0	1.2	2.2	1.5	2.1	15
	3EA	1,628	0.0	2.4	4.0	3.0	3.1	1.7	0.0	0.0	1.4	2.7	1.3	1.2	21
	3EB	2,423	0.0	3.6	5.9	4.4	4.6	2.5	0.0	0.0	2.1	4.0	1.9	1.8	31
	3EC	2,779	0.0	4.1	6.8	5.1	5.3	2.8	0.0	0.0	2.4	4.6	2.2	2.0	35
	3ED	2,433	0.0	3.6	6.0	4.4	4.6	2.5	0.0	0.0	2.1	4.0	2.0	1.8	31

Table 3.4.4 Irrigation Water Demand for 1.2 Million ha by Sub-basin in 2030 (3/4)

(Unit: MCM)

Catchment Area	Sub-basin	Irrigation Area (ha)	Irrigation Water Demand in 2030 under 60% Irrigation Efficiency and 160% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ACA	3FA	26,488	0.0	39.2	64.9	48.2	50.2	27.0	0.0	0.0	22.6	43.5	21.3	19.2	336
	3FB	17,119	0.0	25.3	41.9	31.2	32.5	17.5	0.0	0.0	14.6	28.1	13.8	12.4	217
	3G	28,871	0.0	43.0	72.1	58.3	59.5	33.6	0.0	0.0	23.0	46.6	39.3	26.3	402
	3HA	5,639	0.0	8.4	14.1	11.4	11.6	6.6	0.0	0.0	4.5	9.1	7.7	5.1	78
	3HB	9,340	0.0	13.9	23.3	18.9	19.3	10.9	0.0	0.0	7.5	15.1	12.7	8.5	130
	3HC	2,149	0.0	3.3	5.8	4.4	3.8	2.1	0.0	0.0	1.8	3.4	3.1	2.3	30
	3HD1	399	0.0	0.6	1.2	0.8	0.0	0.1	0.0	0.0	0.3	0.7	0.7	0.7	5
	3HD2	245	0.0	0.4	0.7	0.5	0.0	0.1	0.0	0.0	0.2	0.4	0.4	0.4	3
	3J	18,526	0.0	25.7	34.2	21.1	24.2	18.0	0.0	0.0	14.9	30.0	24.5	21.7	214
	3K	2,643	0.0	4.3	7.8	4.3	1.8	1.5	0.0	0.0	2.0	4.0	4.1	3.5	33
	3LA	25,291	0.0	37.7	63.1	51.1	52.1	29.5	0.0	0.0	20.2	40.8	34.4	23.1	352
	3LB	479	0.0	0.7	1.2	1.0	1.0	0.6	0.0	0.0	0.4	0.8	0.7	0.4	7
	3MA-1	15,888	0.0	23.4	42.4	34.0	31.4	18.5	0.0	0.0	12.6	25.6	22.4	24.3	235
	3MA-2	15,000	0.0	22.1	40.1	32.1	29.6	17.5	0.0	0.0	11.9	24.2	21.2	22.9	221
	3MB	893	0.0	1.3	2.4	1.9	1.8	1.0	0.0	0.0	0.7	1.4	1.3	1.4	13
	3MC	519	0.0	0.8	1.4	1.1	1.0	0.6	0.0	0.0	0.4	0.8	0.8	0.7	8
	3MD1	742	0.0	1.1	2.0	1.6	1.5	0.9	0.0	0.0	0.6	1.1	1.1	1.0	11
	3MD2	65	0.0	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	1
	3N	5,770	0.0	8.5	15.4	12.3	11.4	6.7	0.0	0.0	4.6	8.6	8.9	7.6	84
Total for ACA		233,628	0	337	557	370	376	226	0	0	186	375	262	233	2,922
TCA	4AA	5,704	0.0	7.0	10.2	3.6	0.0	2.5	0.0	0.0	3.7	7.4	3.7	4.6	43
	4AB	6,230	0.0	7.6	11.2	3.9	0.0	2.7	0.0	0.0	4.0	8.1	4.0	5.0	47
	4AC	4,191	0.0	5.1	7.5	2.6	0.0	1.8	0.0	0.0	2.7	5.5	2.7	3.4	31
	4AD	4,316	0.0	5.3	7.7	2.7	0.0	1.9	0.0	0.0	2.8	5.6	2.8	3.5	32
	4BA	3,938	0.0	4.8	7.1	2.5	0.0	1.7	0.0	0.0	2.5	5.1	2.5	3.2	29
	4BB	7,331	0.0	9.0	13.1	4.6	0.0	3.2	0.0	0.0	4.7	9.5	4.7	5.9	55
	4BC	13,117	0.0	19.3	28.9	11.7	11.7	10.0	0.0	0.0	10.4	17.9	8.7	15.1	134
	4BD	4,573	0.0	5.6	8.2	2.9	0.0	2.0	0.0	0.0	2.9	5.9	2.9	3.7	34
	4BE	7,900	0.0	11.8	15.9	3.2	8.7	5.2	0.0	0.0	5.7	10.4	5.5	8.5	75
	4BF	2,981	0.0	4.5	6.0	1.2	3.3	2.0	0.0	0.0	2.2	3.9	2.1	3.2	28
	4BG	3,275	0.0	4.9	6.6	1.3	3.6	2.2	0.0	0.0	2.4	4.3	2.3	3.5	31
	4CA	7,130	0.0	10.7	14.4	2.9	7.9	4.7	0.0	0.0	5.2	9.4	5.0	7.7	68
	4CB	4,764	0.0	7.1	9.6	1.9	5.3	3.1	0.0	0.0	3.5	6.3	3.3	5.1	45
	4CC	9,220	0.0	13.8	18.6	3.7	10.2	6.1	0.0	0.0	6.7	12.2	6.4	9.9	88
	4DA	40,768	0.0	60.1	90.0	36.3	36.3	31.2	0.0	0.0	32.3	55.6	26.9	46.9	415
	4DB	26,609	0.0	39.2	58.7	23.7	23.7	20.4	0.0	0.0	21.1	36.3	17.6	30.6	271
	4DC	4,228	0.0	6.2	9.3	3.8	3.8	3.2	0.0	0.0	3.3	5.8	2.8	4.9	43
	4DD	3,768	0.0	4.6	7.1	2.7	5.6	2.4	0.0	0.0	2.8	4.6	1.7	3.0	34
	4DE	1,977	0.0	2.4	3.7	1.4	2.9	1.3	0.0	0.0	1.5	2.4	0.9	1.5	18
	4EA	7,859	0.0	10.9	21.1	19.6	21.1	9.2	0.0	0.0	6.6	13.3	9.9	10.3	122
	4EB	9,073	0.0	12.6	24.4	22.7	24.4	10.7	0.0	0.0	7.6	15.4	11.5	11.9	141
	4EC	5,078	0.0	7.0	13.7	12.7	13.7	6.0	0.0	0.0	4.3	8.6	6.4	6.7	79
	4ED	8,531	0.0	11.8	23.0	21.3	23.0	10.0	0.0	0.0	7.1	14.5	10.8	11.2	133
	4FA	21,101	0.0	29.3	56.8	52.8	56.8	24.8	0.0	0.0	17.7	35.8	26.7	27.7	328
	4FB	26,380	0.0	36.6	71.0	65.9	71.0	31.0	0.0	0.0	22.1	44.7	33.4	34.6	410
	4GA	8,034	0.0	11.1	21.6	20.1	21.6	9.4	0.0	0.0	6.7	13.6	10.2	10.5	125
	4GB	14,943	0.0	20.7	40.2	37.4	40.2	17.6	0.0	0.0	12.5	25.3	18.9	19.6	232
	4GC	5,980	0.0	8.3	16.1	15.0	16.1	7.0	0.0	0.0	5.0	10.1	7.6	7.8	93
	4GD	20,684	0.0	28.7	55.6	51.7	55.6	24.3	0.0	0.0	17.3	35.1	26.2	27.1	322
	4GE	20,979	0.0	31.9	56.6	52.4	54.4	25.0	0.0	0.0	18.6	34.2	27.7	31.8	333
	4GF	33,727	0.0	51.3	91.1	84.3	87.5	40.1	0.0	0.0	29.9	55.0	44.5	51.1	535
	4GG	13,300	0.0	20.2	35.9	33.3	34.5	15.8	0.0	0.0	11.8	21.7	17.6	20.2	211
	4HA	3,151	0.0	4.8	8.5	7.9	8.2	3.7	0.0	0.0	2.8	5.1	4.2	4.8	50
	4HB	19,565	0.0	29.8	52.8	48.9	50.7	23.3	0.0	0.0	17.4	31.9	25.8	29.7	310
	4HC	14,797	0.0	22.5	40.0	37.0	38.4	17.6	0.0	0.0	13.1	24.1	19.5	22.4	235
	4JA	27,927	0.0	51.2	95.9	81.8	111.3	50.3	0.0	0.0	32.8	60.6	43.2	47.0	574
	4JB	10,619	0.0	19.5	36.5	31.1	42.3	19.1	0.0	0.0	12.5	23.1	16.4	17.9	218
	4KA	23,444	0.0	43.0	80.5	68.7	93.5	42.2	0.0	0.0	27.6	50.9	36.3	39.5	482
	4KB	25,256	0.0	46.3	86.8	74.0	100.7	45.5	0.0	0.0	29.7	54.8	39.1	42.5	519
Total for TCA		482,450	0	737	1279	968	1103	548	0	0	429	805	550	652	7,072

Table 3.4.4 Irrigation Water Demand for 1.2 Million ha by Sub-basin in 2030 (4/4)

(Unit: MCM)

Catchment Area	Sub-basin	Irrigation Area (ha)	Irrigation Water Demand in 2030 under 60% Irrigation Efficiency and 160% Cropping Intensity												
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
ENNCA	5AA	1,646	0.0	2.0	2.9	1.0	0.0	0.7	0.0	0.0	1.1	2.1	1.1	1.3	12
	5AB	622	0.0	0.8	1.1	0.4	0.0	0.3	0.0	0.0	0.4	0.8	0.4	0.5	5
	5AC	1,537	0.0	2.0	3.9	2.6	2.6	1.2	0.0	0.0	1.1	2.1	1.8	2.0	19
	5AD	729	0.0	0.9	1.8	1.2	1.2	0.6	0.0	0.0	0.5	1.0	0.9	0.9	9
	5BA	1,319	0.0	1.1	1.8	1.7	2.7	1.2	0.0	0.0	1.0	1.2	0.7	1.0	12
	5BB	4,005	0.0	3.4	5.3	5.2	8.2	3.6	0.0	0.0	3.0	3.7	2.2	3.1	38
	5BC-1	3,363	0.0	2.8	4.5	4.4	6.9	3.0	0.0	0.0	2.5	3.1	1.8	2.6	32
	5BC-2	3,000	0.0	2.5	4.0	3.9	6.1	2.7	0.0	0.0	2.2	2.8	1.6	2.3	28
	5BD	931	0.0	0.8	1.2	1.2	1.9	0.8	0.0	0.0	0.7	0.9	0.5	0.7	9
	5BE	8,106	0.0	6.8	10.8	10.6	16.6	7.2	0.0	0.0	6.0	7.6	4.4	6.3	76
	5CA	1,570	0.0	2.4	4.2	3.9	4.1	1.9	0.0	0.0	1.4	2.6	2.1	2.4	25
	5CB	173	0.0	0.3	0.5	0.4	0.4	0.2	0.0	0.0	0.2	0.3	0.2	0.3	3
	5CC	229	0.0	0.3	0.6	0.6	0.6	0.3	0.0	0.0	0.2	0.4	0.3	0.3	4
	5DA	11,487	0.0	17.5	31.0	28.7	29.8	13.7	0.0	0.0	10.2	18.7	15.2	17.4	182
	5DB	1,700	0.0	2.6	4.6	4.2	4.4	2.0	0.0	0.0	1.5	2.8	2.2	2.6	27
	5DC	1,672	0.0	2.5	4.5	4.2	4.3	2.0	0.0	0.0	1.5	2.7	2.2	2.5	27
	5DD	323	0.0	0.5	0.9	0.8	0.8	0.4	0.0	0.0	0.3	0.5	0.4	0.5	5
	5EA	1,749	0.0	3.2	6.0	5.1	7.0	3.1	0.0	0.0	2.1	3.8	2.7	2.9	36
	5EB	1,830	0.0	3.4	6.3	5.4	7.3	3.3	0.0	0.0	2.2	4.0	2.8	3.1	38
	5EC	2,301	0.0	4.2	7.9	6.7	9.2	4.1	0.0	0.0	2.7	5.0	3.6	3.9	47
	5ED	30,229	0.0	55.4	103.9	88.6	120.5	54.4	0.0	0.0	35.5	65.6	46.8	50.9	622
	5FA	49,513	0.0	90.7	170.1	145.1	197.4	89.1	0.0	0.0	58.2	107.5	76.6	83.4	1,018
	5FB	581	0.0	1.1	2.0	1.7	2.3	1.0	0.0	0.0	0.7	1.3	0.9	1.0	12
	5GA	8,079	0.0	13.1	23.9	18.0	20.6	10.6	0.0	0.0	7.1	12.6	11.8	13.2	131
	5GB	1,639	0.0	2.7	4.9	3.7	4.2	2.2	0.0	0.0	1.4	2.6	2.4	2.7	27
	5H	3,274	0.0	5.4	10.5	7.2	9.0	4.9	0.0	0.0	3.2	4.8	5.0	5.8	56
	5J	1,059	0.0	1.7	3.4	2.3	2.9	1.6	0.0	0.0	1.0	1.6	1.6	1.9	18
Total for ENNCA		142,665	0	233	429	364	478	219	0	0	150	266	195	219	2,552
Grand Total		1,200,000	394	1,695	2,591	2,008	2,231	1,455	297	0	998	1,862	1,390	1,526	16,446

Source: JICA Study Team

Table 4.2.1 Large Scale Irrigation Projects Selected (1/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*[1]	Water Source Facilities*[2]		Present Status*[3] (Oct. 2012)	Estimated Cost*[4] (KSh mil.)	Executing Agency
						Type	Name of Dam			
LVNCA										
1.	Kibolo Irrigation	Kakamega	1CE	11,500	New	Dam	Kibolo	Proposed	6,435	LBDA
2.	Lower Nzoia Irrigation	Busia & Siaya	1EF	10,470	New	Weir/M-dam	Nzoia 42A	D/D done	6,334	NIB
3.	Lower Sio Irrigation	Busia	1AH	6,600	New	Weir	-	D/D done	5,566	NIB
4.	Moi's Bridge Irrigation	Bungoma	1BE	19,800	New	Multi-dam	Moi's Bridge	Proposed	13,585	LBDA
5.	Upper Nzoia Irrigation	Bungoma	1BG	24,000	New	Multi-dam	Nzoia 34B	Proposed	13,728	NIB
6.	Yala Swamp Drainage & Irrigation	Siaya	1FG	4,600	New	Weir	-	F/S done	2,317	LBDA
	Weir Irrigation under construction			1,400	Reh+Ext	Weir	-	On-going	560	
Total				78,370					48,525	
LVSCA										
1.	Ahero and West Kano Irrigation	Kisumu	1HD	1,800	Reh+Ext	Weir	-	F/S done	871	NIB
2.	Amala Irrigation	Bomet	1LB1	5,000	New	Multi-dam	Amala	Proposed	2,860	LBDA
3.	Ilooiterre Irrigation	Narok	1KC	3,000	New	Multi-dam	Ilooiterre	Proposed	1,716	LBDA
4.	Kano Plain Irrigation	Nyamira/Kisumu	1JG1	15,000	New	Multi-dam	Magwagwa	D/D on-going	14,300	LBDA
5.	Lower Kuja Irrigation (Stage-1)	Migori	1KB	7,800	New	Weir	-	D/D done	6,578	NIB
6.	Lower Kuja Irrigation (Stage-2)	Migori	1KB	32,700	New	Multi-dam	Katieno	Proposed	17,160	NIB
7.	Nandi Forest Irrigation	Nyando/Kisumu	1HA2	7,272	New	Multi-dam	Nandi Forest	F/S done	15,730	LBDA
8.	Nyando Irrigation	Kericho	1GD	3,000	New	Multi-dam	Nyando	Proposed	1,716	LBDA
Total				75,572					60,931	
RVCA										
1.	Arror Irrigation	Elgeyo Marakwet	2CC	10,850	New+Ext	Multi-dam	Arror	F/S done	7,865	KVDA
2.	Embobut Irrigation	Elgeyo Marakwet	2BB	2,000	Ext	Dam	Embobut	Proposed	1,001	KVDA
3.	Kimwarer Irrigation	Baringo	2CB	2,000	New	Multi-dam	Kimwarer	Proposed	1,144	KVDA
4.	Lower Ewaso Ng'iro Irrigation	Kajiado	2KB	15,000	New	Multi-dam	Oletukat	F/S on-going	8,580	NIB/ENSDA
5.	Norera Irrigation	Narok	2KA	2,000	New	Dam	Upper Narok	F/S on-going	1,144	ENSDA
6.	Oldekesi Irrigation	Narok	3KA	2,000	New	Weir	-	Proposed	1,373	ENSDA
7.	Perkera Irrigation Extension	Baringo	2EE	3,000	Reh+Ext	Weir/Dam	Perkera (E)	F/S on-going	2,217	NIB
8.	Todonyang-Omo Irrigation	Turkana	2AB	35,000	New	Multi-dam	Gibe 3 in Ethiopia	Proposed	24,310	KVDA
9.	Turkwel Irrigation	West Pokot	2BD	5,000	New	Dam (E)	Turkwel (E)	F/S done	3,575	KVDA
	Weir Irrigation under construction			2,000	Reh+Ext	Weir	-	On-going	800	KVDA
Total				78,850					52,009	

Table 4.2.1 Large Scale Irrigation Projects Selected (2/2)

No	Name of Project	County	Sub-basin Code	Irrigation Area (ha)	Project Type*1	Water Source Facilities*2		Present Status*3 (Oct. 2012)	Estimated Cost*4 (KSh mil.)	Executing Agency
						Type	Name of Dam			
ACA										
1.	Kanzalu Irrigation Extension	Makueni	3DA	15,000	Ext	Multi-dam	Munyu	Proposed	6,050	NIB
2.	Kibwezi Irrigation Extension	Makueni	3FA	17,000	New+Ext	Multi-dam	Thwake	Proposed	6,800	NIB/TARDA
3.	Mt. Kilimanjaro Irrigation	Kajiado	3G	1,500	Reh+Ext	Spring	-	Proposed	484	ENSDA
4.	Taita Taveta Irrigation	Taita Taveta	3J	3,780	Reh+Ext	Weir	-	F/S on-going	1,815	TARDA
	Total			37,280					15,149	
TCA										
1.	High Grand Falls Irrigation	Garissa/Tana River	4EB	106,000	New	Multi-dam	High Grand Falls	F/S done	242,000	TARDA
2.	Hola Irrigation Expansion	Tana River	4GF	800	Reh+Ext	Pump	-	On-going	402	NIB
3.	Hola Irrigation Greater Extension	Tana River	4GF	4,161	Reh+Ext	Weir	-	F/S on-going	3,146	NIB
4.	Kora Irrigation	Tana River	4GB	25,000	New	Dam	Kora	Proposed	12,870	TARDA
	Total			135,961					258,418	
ENNCA										
1.	Kieni Irrigation	Nyeri	5BC	4,202	New	Weir	-	F/S on-going	2,200	NIB
2.	Kihoto Irrigation	Laikipia	5BC	18,000	New	Multi-dam	Kihoto	Proposed	7,700	ENNDA
3.	Kom (Wajir) Irrigation	Isiolo/Samburu	5DA	4,000	New	Multi-dam	Archer's Post	F/S on-going	2,000	ENNDA
	Total			26,202					11,900	
	Grand Total			432,235					446,932	

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

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

Table 4.2.2 Possible Surface Water Irrigation Area by Sub-basin in 2030

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)
1AA	709	1GA	812	2AA	0	3AA	1,272	4AA	1,004	5AA	154
1AB	695	1GB	2,512	2AB	35,310	3AB	1,523	4AB	1,032	5AB	55
1AC	267	1GC	246	2BA	2,044	3AC	382	4AC	697	5AC	160
1AD	648	1GD	3,607	2BB	7,756	3BA	1,890	4AD	1,557	5AD	393
1AE	448	1GE	1,010	2BC	9,854	3BB	729	4BA	738	5BA	206
1AF	1,139	1GF	730	2BD	782	3BC	1,438	4BB	1,698	5BB	663
1AG	955	1GG	147	2CA	112	3BD	966	4BC	3,271	5BC-1	18,576
1AH	843	1HA1	8,072	2CB	3,034	3CB	2,194	4BD	1,703	5BC-2	477
1BA	119	1HA2	873	2CC	14,422	3DA	15,442	4BE	1,593	5BD	93
1BB	1,760	1HB1	800	2D	866	3DB	217	4BF	455	5BE	1,474
1BC	1,734	1HB2	792	2EA	90	3EA	275	4BG	548	5CA	154
1BD	1,446	1HC	396	2EB	155	3EB	291	4CA	1,081	5CB	0
1BE	21,186	1HD	1,328	2EC	175	3EC	275	4CB	731	5CC	0
1BG	25,171	1HE	1,012	2ED	349	3ED	237	4CC	3,431	5DA	5,804
1BH	644	1HF	1,650	2EE	187	3FA	20,213	4DA	10,175	5DB	201
1CA	666	1HG	625	2EF	206	3FB	1,944	4DB	6,651	5DC	717
1CB	527	1JA	2,680	2EG1	86	3G	7,009	4DC	1,880	5DD	3,632
1CC	982	1JB	25	2EG2	405	3HA	1,120	4DD	700	5EA	86
1CD	1,154	1JC	1,074	2EH	136	3HB	1,663	4DE	350	5EB	143
1CE	11,845	1JD	1,262	2EJ	274	3HC	1,420	4EA	1,974	5EC	268
1DA	8,627	1JE	2,107	2EK	124	3HD1	523	4EB	1,556	5ED	0
1DB	2,660	1JF	2,053	2FA	110	3HD2	614	4EC	943	5FA	0
1DC	2,814	1JG1	15,630	2FB	31	3J	7,478	4ED	2,443	5FB	29
1DD	3,050	1JG2	576	2FC	307	3K	436	4FA	3,966	5GA	0
1EA	2,985	1KA	2,418	2GA	58	3LA	4,706	4FB	110,885	5GB	811
1EB	5,324	1KB	41,860	2GB	114	3LB	528	4GA	1,263	5H	0
1EC	1,804	1KC	5,546	2GC	94	3MA-1	2,191	4GB	25,720	5J	0
1ED	99	1LA1	1,590	2GD	220	3MA-2	3,130	4GC	685		
1EE	23,346	1LA2	264	2H-1	900	3MB	115	4GD	2,120		
1EF	5,027	1LA3	3,416	2H-2	533	3MC	79	4GE	1,580		
1EG	3,776	1LB1	7,956	2H-3	0	3MD1	43	4GF	3,542		
1FA	426	1LB2	1,898	2J	0	3MD2	9	4GG	1,578		
1FB	1,182			2KA	2,128	3N	1,893	4HA	189		
1FC	628			2KB	15,571			4HB	829		
1FD	1,127			2KC	342			4HC	631		
1FE	5,106							4JA	369		
1FF	2							4JB	143		
1FG	22,600							4KA	316		
								4KB	359		
Total	163,521	Total	114,967	Total	96,772	Total	82,248	Total	200,387	Total	34,097
Whole Country: 691,992 ha											

Note: Above figures include existing irrigation area, and irrigation area having water source outside the water balance study basin, i.e. Todanyand-Omo irrigation (35,000 ha in 2AB) to be supplied from a dam in Ethiopia, and irrigation area to be supplied from water source outside the Athi river basin (1,500 ha in 3G and 3,780 ha in 3J)

Source: JICA Study Team

Table 4.2.3 Possible Groundwater Irrigation Area by Sub-basin in 2030

LVNCA		LVSCA		RVCA		ACA		TCA		ENNCA	
Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)	Sub-basin	Possible Irrigation Area (ha)
1AA	88	1GA	38	2AA	39	3AA	0	4AA	0	5AA	184
1AB	0	1GB	195	2AB	0	3AB	0	4AB	0	5AB	73
1AC	55	1GC	42	2BA	0	3AC	0	4AC	0	5AC	123
1AD	105	1GD	310	2BB	0	3BA	0	4AD	0	5AD	12
1AE	207	1GE	371	2BC	0	3BB	0	4BA	0	5BA	74
1AF	184	1GF	579	2BD	304	3BC	0	4BB	0	5BB	23
1AG	253	1GG	92	2CA	0	3BD	0	4BC	0	5BC-1	382
1AH	324	1HA1	0	2CB	11	3CB	0	4BD	0	5BC-2	16
1BA	224	1HA2	684	2CC	723	3DA	0	4BE	0	5BD	1
1BB	308	1HB1	0	2D	353	3DB	336	4BF	0	5BE	234
1BC	306	1HB2	6	2EA	0	3EA	13	4BG	0	5CA	85
1BD	0	1HC	74	2EB	0	3EB	14	4CA	0	5CB	3
1BE	38	1HD	0	2EC	0	3EC	10	4CB	0	5CC	0
1BG	0	1HE	52	2ED	0	3ED	11	4CC	0	5DA	1,168
1BH	0	1HF	0	2EE	4	3FA	1,565	4DA	0	5DB	119
1CA	56	1HG	0	2EF	0	3FB	457	4DB	0	5DC	109
1CB	0	1JA	376	2EG1	0	3G	232	4DC	0	5DD	50
1CC	82	1JB	156	2EG2	0	3HA	62	4DD	0	5EA	524
1CD	0	1JC	0	2EH	125	3HB	387	4DE	0	5EB	1,287
1CE	0	1JD	0	2EJ	0	3HC	383	4EA	0	5EC	1,355
1DA	0	1JE	643	2EK	0	3HD1	591	4EB	0	5ED	4,775
1DB	0	1JF	7	2FA	0	3HD2	28	4EC	0	5FA	1,959
1DC	0	1JG1	0	2FB	0	3J	179	4ED	0	5FB	131
1DD	0	1JG2	69	2FC	0	3KA	0	4FA	1,044	5GA	492
1EA	0	1KA	0	2GA	0	3KB	0	4FB	3,756	5GB	0
1EB	0	1KB	654	2GB	0	3LA	0	4GA	1,070	5H	70
1EC	0	1KC	1,034	2GC	158	3LB	0	4GB	721	5J	1,081
1ED	0	1LA1	115	2GD	0	3MA-1	0	4GC	413		
1EE	0	1LA2	0	2H-1	52	3MA-2	0	4GD	1,635		
1EF	345	1LA3	201	2H-2	0	3MB	0	4GE	2,608		
1EG	0	1LB1	54	2H-3	0	3MC	0	4GF	3,196		
1FA	159	1LB2	1,113	2J	0	3MD1	0	4GG	2,999		
1FB	29			2KA	114	3MD2	0	4HA	1,150		
1FC	0			2KB	16	3N	349	4HB	890		
1FD	79			2KC	193			4HC	157		
1FE	0							4JA	165		
1FF	0							4JB	145		
1FG	725							4KA	158		
								4KB	245		
Total	3,568	Total	6,867	Total	2,091	Total	4,618	Total	20,108	Total	14,331
Whole Country: 51,583 ha											

Source: JICA Study Team

Table 4.2.4 Possible Irrigation Area by Catchment Area in 2030

(Unit: ha)

Category	Existing Irrigation Area in 2010	New Irrigation Area in 2030						Total Irrigation Area in 2030
		Surface Water Irrigation			Ground water Irrigation	Water Harvesting Irrigation*2	Total New Irrigation Area	
		Weir*1	Dam	Total				
LVNCA								
Large Scale Irrigation	363	12,600	65,770	78,370	0	0	78,370	78,733
Small Scale Irrigation	1,327	41,638	0	41,638	1,784	3,700	47,122	48,449
Private Irrigation	186	41,637	0	41,637	1,784	0	43,421	43,607
Total	1,876	95,875	65,770	161,645	3,568	3,700	168,913	170,789
LVSCA								
Large Scale Irrigation	1,800	1,800	73,772	75,572	0	0	75,572	77,372
Small Scale Irrigation	10,225	14,477	0	14,477	3,434	4,590	22,501	32,726
Private Irrigation	1,193	11,700	0	11,700	3,433	0	15,133	16,326
Total	13,218	27,977	73,772	101,749	6,867	4,590	113,206	126,424
RVCA*3								
Large Scale Irrigation	774	7,000	71,850	78,850	0	0	78,850	79,624
Small Scale Irrigation	5,791	5,335	0	5,335	1,046	2,890	9,271	15,062
Private Irrigation	3,022	3,000	0	3,000	1,045	0	4,045	7,067
Total	9,587	15,335	71,850	87,185	2,091	2,890	92,166	101,753
ACA*4								
Large Scale Irrigation	0	5,280	32,000	37,280	0	0	37,280	37,280
Small Scale Irrigation	13,524	35	0	35	2,309	4,140	6,484	20,008
Private Irrigation	31,374	35	0	35	2,309	0	2,344	33,718
Total	44,898	5,350	32,000	37,350	4,618	4,140	46,108	91,006
TCA								
Large Scale Irrigation	11,200	4,961	131,000	135,961	0	0	135,961	147,161
Small Scale Irrigation	14,823	0	0	0	10,054	5,730	15,784	30,607
Private Irrigation	38,402	0	0	0	10,054	0	10,054	48,456
Total	64,425	4,961	131,000	135,961	20,108	5,730	161,799	226,224
ENNCA								
Large Scale Irrigation	0	4,202	22,000	26,202	0	0	26,202	26,202
Small Scale Irrigation	6,233	0	0	0	7,166	950	8,116	14,349
Private Irrigation	1,663	0	0	0	7,165	0	7,165	8,828
Total	7,896	4,202	22,000	26,202	14,331	950	41,483	49,379
TOTAL								
Large Scale Irrigation	14,137	35,843	396,392	432,235	0	0	432,235	446,372
Small Scale Irrigation	51,923	61,485	0	61,485	25,793	22,000	109,278	161,201
Private Irrigation	75,840	56,372	0	56,372	25,790	0	82,162	158,002
Grand Total	141,900	153,700	396,392	550,092	51,583	22,000	623,675	765,575

Note: *1 = including weir irrigation, pump irrigation and spring irrigation.
*2 = by small dam and water pan
*3 = including the Todonyang-Omo irrigation project (35,000 ha) to be supplied water by a dam in Ethiopia.
*4 = including existing irrigation areas (11,339 ha) and proposed irrigation areas (5,280 ha) to be supplied water from the outside of the Athi river basin.

Source: JICA Study Team

Table 4.2.5 Irrigation Water Demand by Catchment Area in 2030

(Unit: MCM/year)

Category	Existing Irrigation Demand in 2010	New Irrigation Water Demand in 2030						Total Irrigation Water Demand in 2030
		Surface Water Irrigation			Ground water Irrigation	Water Harvesting Irrigation*2	Total New Irrigation Demand	
		Weir*1	Dam	Total				
LVNCA								
Large Scale Irrigation	4	133	535	668	0	0	668	672
Small Scale Irrigation	13	308	0	308	14	30	352	365
Private Irrigation	1	308	0	308	13	0	321	322
Total	18	749	535	1,284	27	30	1,341	1,359
LVSCA								
Large Scale Irrigation	22	25	732	757	0	0	757	779
Small Scale Irrigation	121	83	0	83	26	37	146	267
Private Irrigation	12	75	0	75	25	0	100	112
Total	155	183	732	915	51	37	1,003	1,158
RVCA*3								
Large Scale Irrigation	12	49	1,101	1,150	0	0	1,150	1,162
Small Scale Irrigation	90	38	0	38	8	23	69	159
Private Irrigation	41	23	0	23	8	0	31	72
Total	143	110	1,101	1,211	16	23	1,250	1,393
ACA*4								
Large Scale Irrigation	0	40	311	351	0	0	351	351
Small Scale Irrigation	164	0	0	0	18	33	51	215
Private Irrigation	334	0	0	0	17	0	17	351
Total	498	40	311	351	35	33	419	917
TCA								
Large Scale Irrigation	130	37	1,767	1,804	0	0	1,804	1,934
Small Scale Irrigation	173	0	0	0	76	46	122	295
Private Irrigation	393	0	0	0	75	0	75	468
Total	696	37	1,767	1,804	151	46	2,001	2,697
ENNCA								
Large Scale Irrigation	0	31	302	333	0	0	333	333
Small Scale Irrigation	74	0	0	0	54	7	61	135
Private Irrigation	18	0	0	0	53	0	53	71
Total	92	31	302	333	107	7	447	539
TOTAL								
Large Scale Irrigation	168	315	4,748	5,063	0	0	5,063	5,231
Small Scale Irrigation	635	429	0	429	196	176	801	1,436
Private Irrigation	799	406	0	406	191	0	597	1,396
Total	1,602	1,150	4,748	5,898	387	176	6,461	8,063

Note: *1 = including weir irrigation, pump irrigation and spring irrigation.
*2 = by small dam and water pan
*3 = including the Todonyang-Omo irrigation project (560 MCM/year) to be supplied water by a dam in Ethiopia.
*4 = including existing irrigation areas (114 MCM/year) and proposed irrigation areas (40 MCM/year) to be supplied water from the outside of the Athi Catchment Area.

Source: JICA Study Team

Table 4.2.6 Water Demand for Surface Water Irrigation by Sub-basin in 2030 (1/4)

(unit: m^3/s)

Catchment Area	Sub-basin Code	Irrigation Water Demand under 70% Irrigation Efficiency											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	1AA	0.53	0.47	0.32	0.06	0.00	0.00	0.18	0.00	0.23	0.24	0.21	0.35
	1AB	0.46	0.41	0.27	0.05	0.00	0.00	0.16	0.00	0.20	0.20	0.18	0.30
	1AC	0.26	0.23	0.15	0.03	0.00	0.00	0.09	0.00	0.11	0.11	0.10	0.17
	1AD	0.48	0.42	0.29	0.05	0.00	0.00	0.17	0.00	0.20	0.21	0.19	0.32
	1AE	0.30	0.27	0.18	0.03	0.00	0.00	0.11	0.00	0.13	0.13	0.12	0.20
	1AF	0.77	0.68	0.46	0.08	0.00	0.00	0.27	0.00	0.33	0.34	0.30	0.51
	1AG	0.67	0.59	0.40	0.07	0.00	0.00	0.23	0.00	0.28	0.29	0.26	0.44
	1AH	0.75	0.65	0.44	0.08	0.00	0.00	0.26	0.00	0.31	0.33	0.29	0.49
	1BA	0.04	0.04	0.03	0.03	0.01	0.01	0.00	0.00	0.01	0.02	0.03	0.04
	1BB	1.59	1.53	1.13	1.25	0.26	0.48	0.00	0.00	0.45	0.69	1.22	1.37
	1BC	1.74	1.96	1.29	0.91	0.00	0.37	0.00	0.00	0.07	0.53	1.12	1.55
	1BD	0.75	0.72	0.53	0.59	0.12	0.23	0.00	0.00	0.21	0.33	0.58	0.65
	1BE	0.72	0.69	0.51	0.57	0.12	0.22	0.00	0.00	0.20	0.31	0.55	0.62
	1BG	0.61	0.59	0.43	0.48	0.10	0.19	0.00	0.00	0.17	0.27	0.47	0.53
	1BH	0.57	0.55	0.41	0.45	0.10	0.17	0.00	0.00	0.16	0.25	0.44	0.49
	1CA	0.49	0.49	0.38	0.34	0.24	0.18	0.00	0.00	0.10	0.36	0.39	0.44
	1CB	0.30	0.30	0.24	0.21	0.15	0.11	0.00	0.00	0.06	0.22	0.24	0.27
	1CC	0.59	0.70	0.55	0.16	0.32	0.04	0.05	0.00	0.29	0.53	0.54	0.62
	1CD	0.58	0.59	0.46	0.41	0.29	0.21	0.00	0.00	0.12	0.43	0.46	0.53
	1CE	0.17	0.18	0.14	0.12	0.09	0.06	0.00	0.00	0.04	0.13	0.14	0.16
	1DA	4.34	4.38	3.41	3.05	2.15	1.60	0.00	0.00	0.92	3.21	3.47	3.94
	1DB	1.82	1.75	1.29	1.44	0.30	0.56	0.00	0.00	0.51	0.79	1.40	1.57
	1DC	1.20	1.05	0.71	0.13	0.00	0.00	0.41	0.00	0.51	0.53	0.47	0.78
	1DD	1.30	1.14	0.77	0.14	0.00	0.00	0.45	0.00	0.55	0.57	0.51	0.85
	1EA	2.11	2.21	1.57	0.98	0.00	0.00	0.00	0.00	0.17	0.85	1.36	1.68
	1EB	5.45	5.72	4.05	2.54	0.00	0.00	0.00	0.00	0.43	2.20	3.53	4.35
	1EC	1.75	1.84	1.30	0.82	0.00	0.00	0.00	0.00	0.14	0.71	1.13	1.40
	1ED	0.06	0.05	0.04	0.01	0.00	0.00	0.02	0.00	0.03	0.03	0.02	0.04
	1EE	5.49	4.82	3.26	0.60	0.00	0.00	1.90	0.00	2.31	2.42	2.15	3.58
	1EF	3.41	3.66	2.12	2.66	1.04	3.64	2.53	0.00	1.59	3.03	2.76	2.88
	1EG	2.21	2.38	1.38	1.73	0.68	2.36	1.64	0.00	1.03	1.97	1.79	1.87
	1FA	0.30	0.36	0.28	0.08	0.16	0.02	0.02	0.00	0.15	0.27	0.28	0.32
	1FB	0.79	0.83	0.59	0.37	0.00	0.00	0.00	0.00	0.06	0.32	0.51	0.63
	1FC	0.57	0.60	0.42	0.26	0.00	0.00	0.00	0.00	0.05	0.23	0.37	0.45
	1FD	0.50	0.53	0.38	0.23	0.00	0.00	0.00	0.00	0.04	0.20	0.33	0.40
	1FE	2.28	2.40	1.70	1.06	0.00	0.00	0.00	0.00	0.18	0.92	1.48	1.82
	1FF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1FG	10.15	10.91	6.33	7.92	3.11	10.84	7.52	0.00	4.73	9.03	8.21	8.59
Total for LVNCA		56.14	56.67	38.20	30.02	9.25	21.30	16.00	0.00	17.06	33.21	37.59	45.22
LVSCA	1GA	0.61	0.67	0.52	0.28	0.20	0.02	0.00	0.00	0.00	0.34	0.40	0.58
	1GB	1.00	1.11	0.77	0.00	0.00	0.25	0.23	0.00	0.35	0.68	0.76	0.97
	1GC	0.09	0.10	0.07	0.00	0.00	0.02	0.02	0.00	0.03	0.06	0.07	0.09
	1GD	0.09	0.09	0.06	0.04	0.05	0.07	0.05	0.00	0.04	0.07	0.07	0.07
	1GE	2.25	2.19	1.51	0.92	1.35	1.68	1.21	0.00	1.00	1.75	1.69	1.65
	1GF	0.10	0.10	0.07	0.04	0.06	0.08	0.05	0.00	0.05	0.08	0.08	0.07
	1GG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1HA1	0.15	0.16	0.09	0.12	0.05	0.16	0.11	0.00	0.07	0.13	0.12	0.13
	1HA2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1HB1	0.07	0.08	0.04	0.06	0.02	0.08	0.05	0.00	0.03	0.06	0.06	0.06
	1HB2	0.15	0.16	0.09	0.12	0.05	0.16	0.11	0.00	0.07	0.13	0.12	0.13
	1HC	2.79	3.00	1.74	2.18	0.85	2.98	2.07	0.00	1.30	2.48	2.26	2.36
	1HD	0.92	0.98	0.57	0.72	0.28	0.98	0.68	0.00	0.43	0.81	0.74	0.78
	1HE	0.55	0.59	0.34	0.43	0.17	0.58	0.40	0.00	0.25	0.49	0.44	0.46
	1HF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1HG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1JA	1.18	1.04	0.83	0.62	0.89	1.26	0.69	0.00	0.65	1.29	1.17	1.09
	1JB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1JC	0.55	0.49	0.39	0.29	0.42	0.59	0.32	0.00	0.30	0.60	0.54	0.51
	1JD	0.59	0.52	0.41	0.31	0.45	0.63	0.35	0.00	0.32	0.65	0.58	0.55
	1JE	0.91	0.81	0.64	0.49	0.69	0.98	0.54	0.00	0.50	1.01	0.91	0.85
	1JF	0.88	0.78	0.62	0.47	0.67	0.94	0.52	0.00	0.49	0.97	0.87	0.82
	1JG1	0.57	0.50	0.40	0.30	0.43	0.60	0.33	0.00	0.31	0.62	0.56	0.53

Table 4.2.6 Water Demand for Surface Water Irrigation by Sub-basin in 2030 (2/4)

(unit: m^3/s)

Catchment Area	Sub-basin Code	Irrigation Water Demand under 70% Irrigation Efficiency											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVSCA	1KA	0.37	0.36	0.32	0.30	0.43	1.29	0.43	0.00	0.09	0.31	0.26	0.29
	1KB	0.10	0.09	0.08	0.08	0.11	0.33	0.11	0.00	0.02	0.08	0.07	0.07
	1KC	0.39	0.38	0.34	0.31	0.46	1.36	0.45	0.00	0.10	0.33	0.27	0.30
	1LA1	0.21	0.19	0.25	0.37	0.53	0.75	0.21	0.00	0.06	0.23	0.21	0.19
	1LA2	0.03	0.03	0.04	0.05	0.08	0.11	0.03	0.00	0.01	0.03	0.03	0.03
	1LA3	0.39	0.35	0.46	0.69	0.98	1.39	0.38	0.00	0.11	0.43	0.39	0.36
	1LB1	0.34	0.30	0.39	0.60	0.85	1.20	0.33	0.00	0.09	0.37	0.33	0.31
	1LB2	0.29	0.26	0.34	0.51	0.73	1.04	0.29	0.00	0.08	0.32	0.29	0.27
Total for LVSCA		15.78	15.52	11.53	10.39	10.97	19.74	10.10	0.00	6.88	14.58	13.48	13.71
RVCA	2AA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2BA	0.00	0.00	0.53	1.78	2.10	2.04	0.52	0.00	0.11	0.44	0.41	0.44
	2BB	0.00	0.00	0.84	5.59	6.60	6.41	0.81	0.00	0.00	0.00	0.00	0.00
	2BC	0.00	0.00	0.52	3.50	4.13	4.01	0.51	0.00	0.00	0.00	0.00	0.00
	2BD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2CA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2CB	0.00	0.00	0.22	0.75	0.88	0.85	0.22	0.00	0.05	0.18	0.17	0.18
	2CC	0.00	0.00	0.34	1.13	1.34	1.30	0.33	0.00	0.07	0.28	0.26	0.28
	2D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2EA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2EB	0.00	0.00	0.04	0.08	0.07	0.09	0.02	0.00	0.01	0.02	0.02	0.03
	2EC	0.00	0.00	0.01	0.03	0.02	0.03	0.01	0.00	0.00	0.01	0.01	0.01
	2ED	0.00	0.00	0.06	0.11	0.10	0.13	0.03	0.00	0.01	0.03	0.02	0.04
	2EE	0.00	0.00	0.04	0.13	0.14	0.14	0.03	0.00	0.01	0.03	0.03	0.03
	2EF	0.00	0.00	0.05	0.09	0.08	0.11	0.03	0.00	0.01	0.03	0.02	0.03
	2EG1	0.00	0.00	0.01	0.02	0.02	0.02	0.01	0.00	0.00	0.01	0.00	0.01
	2EG2	0.00	0.00	0.13	0.25	0.23	0.30	0.08	0.00	0.02	0.08	0.05	0.09
	2EH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2EJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2EK	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2FA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2FB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2FC	0.00	0.00	0.01	0.03	0.03	0.03	0.01	0.00	0.00	0.01	0.01	0.01
	2GA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2GB	0.00	0.00	0.02	0.03	0.03	0.04	0.01	0.00	0.00	0.01	0.01	0.01
	2GC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2GD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2H-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2H-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2H-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2KA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2KB	0.00	0.00	0.08	0.45	0.47	0.52	0.07	0.00	0.00	0.00	0.00	0.00
	2KC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total for RVCA		0.00	0.00	2.91	13.96	16.23	16.05	2.68	0.00	0.29	1.12	1.01	1.15
ACA	3AA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3BA	0.00	0.17	1.17	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	3BB	0.00	0.01	0.07	0.04	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	3BC	0.00	0.07	0.43	0.09	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00
	3BD	0.00	0.04	0.26	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	3CB	0.00	0.23	1.53	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	3DA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3DB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3EA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3EB	0.00	0.02	0.10	0.07	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	3EC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3ED	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3FA	0.00	0.02	0.16	0.12	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	3FB	0.00	0.07	0.43	0.32	0.33	0.05	0.00	0.00	0.00	0.00	0.00	0.00
	3G	0.00	0.00	0.03	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.2.6 Water Demand for Surface Water Irrigation by Sub-basin in 2030 (3/4)

(unit: m^3/s)

Catchment Area	Sub-basin Code	Irrigation Water Demand under 70% Irrigation Efficiency											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ACA	3HB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3HC	0.00	0.25	1.75	1.33	1.13	0.16	0.00	0.00	0.00	0.00	0.00	0.00
	3HD1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3HD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3K	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3LA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3LB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MA-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MA-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MD1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3MD2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3N	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total for ACA		0.00	1.02	6.86	2.74	2.64	0.46	0.00	0.00	0.00	0.00	0.00	0.00
TCA	4AA	0.00	0.12	0.34	0.12	0.00	0.04	0.00	0.00	0.02	0.07	0.04	0.05
	4AB	0.00	0.21	0.60	0.21	0.00	0.07	0.00	0.00	0.03	0.13	0.06	0.08
	4AC	0.00	0.56	1.65	0.58	0.00	0.20	0.00	0.00	0.09	0.36	0.18	0.22
	4AD	0.00	0.21	0.60	0.21	0.00	0.07	0.00	0.00	0.03	0.13	0.06	0.08
	4BA	0.00	0.04	0.13	0.04	0.00	0.02	0.00	0.00	0.01	0.03	0.01	0.02
	4BB	0.00	0.31	0.91	0.32	0.00	0.11	0.00	0.00	0.05	0.20	0.10	0.12
	4BC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4BD	0.00	0.96	2.81	0.99	0.00	0.35	0.00	0.00	0.15	0.61	0.30	0.38
	4BE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4BF	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4BG	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4CA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4CB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4DA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4DB	0.00	1.38	4.13	1.67	1.67	0.72	0.00	0.00	0.22	0.77	0.37	0.65
	4DC	0.00	1.02	3.04	1.23	1.23	0.53	0.00	0.00	0.16	0.56	0.27	0.48
	4DD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4DE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4EA	0.00	0.25	1.97	1.83	1.97	0.21	0.00	0.00	0.00	0.00	0.00	0.00
	4EB	0.00	0.04	0.35	0.32	0.35	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	4EC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4ED	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4FA	0.00	0.05	0.38	0.36	0.38	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	4FB	0.00	0.40	3.08	2.87	3.08	0.34	0.00	0.00	0.00	0.00	0.00	0.00
	4GA	0.00	0.39	3.06	2.84	3.06	0.33	0.00	0.00	0.00	0.00	0.00	0.00
	4GB	0.00	0.40	3.11	2.89	3.11	0.34	0.00	0.00	0.00	0.00	0.00	0.00
	4GC	0.00	0.13	1.03	0.96	1.03	0.11	0.00	0.00	0.00	0.00	0.00	0.00
	4GD	0.00	0.54	4.17	3.88	4.17	0.46	0.00	0.00	0.00	0.00	0.00	0.00
	4GE	0.00	0.88	6.23	5.77	5.98	0.69	0.00	0.00	0.00	0.00	0.00	0.00
	4GF	0.00	1.13	8.01	7.42	7.70	0.88	0.00	0.00	0.00	0.00	0.00	0.00
	4GG	0.00	0.39	2.73	2.53	2.63	0.30	0.00	0.00	0.00	0.00	0.00	0.00
	4HA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4HB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4HC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4JA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4JB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4KA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4KB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total for TCA		0.00	9.41	48.34	37.03	36.36	5.85	0.00	0.00	0.77	2.87	1.40	2.07
ENNCA	5AA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5AB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5AD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5BA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5BB	0.00	0.02	0.11	0.10	0.16	0.02	0.00	0.00	0.00	0.00	0.00	0.00

Table 4.2.6 Water Demand for Surface Water Irrigation by Sub-basin in 2030 (4/4)

(unit: m^3/s)

Catchment Area	Sub-basin Code	Irrigation Water Demand under 70% Irrigation Efficiency											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ENNCA	5BC-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5BD	0.00	0.01	0.05	0.05	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	5BE	0.00	0.04	0.24	0.24	0.37	0.04	0.00	0.00	0.00	0.00	0.00	0.00
	5CA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5CB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5CC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5DA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5DB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5DC	0.00	0.09	0.64	0.59	0.61	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	5DD	0.00	0.46	3.24	3.00	3.12	0.36	0.00	0.00	0.00	0.00	0.00	0.00
	5EA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5EB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5EC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5ED	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5FA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5FB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5GA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5GB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5H	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5J	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total for ENNCA		0.00	0.66	4.58	4.28	4.80	0.54	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total		71.92	83.28	112.42	98.43	80.24	63.94	28.78	0.00	25.00	51.77	53.48	62.15

Source: JICA Study Team

Table 5.2.1 Project Cost for Irrigation Development (1/2)

Catchment Area/ Irrigation Type	Irrigation Project	Irrigation Area (ha)	Direct Construction Cost (Irrigation)	Project Cost* (KSh million)			
				Cost for Irrigation System**	Multipurpose Dam Cost Allocation***		Total Project Cost
					Name of Dam	Cost Allocation	
LVNCA							
Large Scale Irrigation	Kibolo Irrigation	11,500	6,435	8,317	Kibolo	3,188	11,505
	Lower Nzoia Irrigation	10,470	6,334	8,186	Nzoia 42A	8,047	16,233
	Lower Sio Irrigation	6,600	5,566	7,194			7,194
	Moi's Bridge Irrigation	19,800	13,585	17,558	Moi's Bridge	4,603	22,161
	Upper Nzoia Irrgation	24,000	13,728	17,742	Nzoia 34B	3,640	21,382
	Yala Swamp Irrigation	4,600	2,317	2,995			2,995
	Projects under construction	1,400	560	724			724
	Sub-total	78,370	48,525	62,716		19,478	82,194
Small Scale Irrigation		47,122	23,561	30,451			30,451
Private Irrigation		43,421	65,132	84,178			84,178
Total		168,913	137,218	177,345		19,478	196,823
LVSCA							
Large Scale Irrigation	Ahero and West Kano Irrigation	1,800	871	1,126			1,126
	Amala Irrigation	5,000	2,860	3,696	Amala	19,852	23,548
	Ilooiterre Irrigation	3,000	1,716	2,218	Ilooiterre	1,031	3,249
	Kano Plain Irrigation	15,000	14,300	18,482	Magwagwa	6,112	24,594
	Lower Kuja Irrigation (Stage-1)	7,800	6,578	8,502			8,502
	Lower Kuja Irrigation (Stage-2)	32,700	17,160	22,178	Katieno	5,933	28,111
	Nandi Forest Irrigation	7,272	15,730	20,449	Nandi Forest	5,285	25,734
	Nyando Irrigation	3,000	1,716	2,218	Nyando	11,175	13,393
	Sub-total	75,572	60,931	78,869		49,388	128,257
Small Scale Irrigation		22,501	11,251	14,540			14,540
Private Irrigation		15,133	22,700	29,338			29,338
Total		113,206	94,881	122,747		49,388	172,135
RVCA							
Large Scale Irrigation	Arror Irrigation	10,850	7,865	10,165	Arror	5,498	15,663
	Embobut Irrigation	2,000	1,001	1,294	Embobut	2,617	3,911
	Kimwarer Irrigation	2,000	1,144	1,479	Kimwarer	10,834	12,313
	Lower Ewaso Ng'iro Irrigation	15,000	8,580	11,089	Oletukat	18,804	29,893
	Norera Irrigation	2,000	1,144	1,479	Upper Narok	4,987	6,466
	Oldekesi Irrigation	2,000	1,373	1,775			1,775
	Perkera Irrigation Extention	3,000	2,217	2,865			2,865
	Todonyang-Omo Irrigation	35,000	24,310	31,419			31,419
	Turkwel Irrigation	5,000	3,575	4,620			4,620
	Projects under construction	2,000	800	1,034			1,034
	Sub-total	78,850	52,009	67,219		42,740	109,959
Small Scale Irrigation		9,271	4,636	5,991			5,991
Private Irrigation		4,045	6,068	7,842			7,842
Total		92,166	62,712	81,052		42,740	123,792

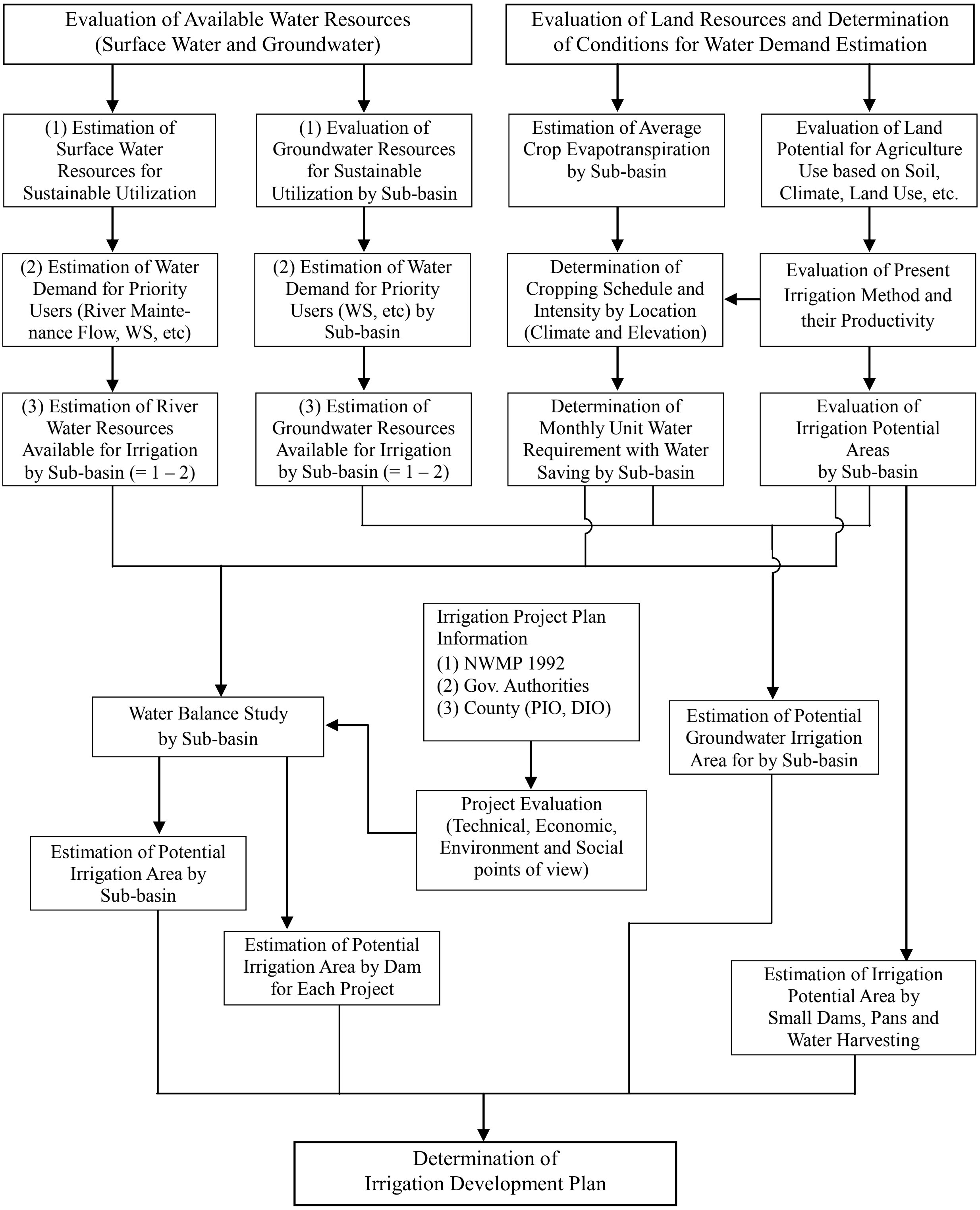
Table 5.2.1 Summary of Project Cost for Irrigation Development by 2030 (2/2)

Catchment Area/ Irrigation Type	Irrigation Project	Irrigation Area (ha)	Direct Construction Cost (Irrigation)	Project Cost* (KSh million)			
				Cost for Irrigation System**	Multipurpose Dam Cost Allocation***		Total Project Cost
					Name	Cost Allocation	
ACA							
Large Scale Irrigation	Kanzalu Irrigation Exteision	15,000	6,050	7,819	Munyu	8,584	16,403
	Kibwezi Irrigation Extention	17,000	6,800	8,789	Thwake	5,813	14,602
	Mt. Kilimanjaro Irrigation	1,500	484	626			626
	Taita Taveta Irrigation	3,780	1,815	2,346			2,346
	Sub-total	37,280	15,149	19,580		14,397	33,977
Small Scale Irrigation		6,484	3,242	4,190			4,190
Private Irrigation		2,344	3,516	4,544			4,544
Total		46,108	21,907	28,314		14,397	42,711
TCA							
Large Scale Irrigation	High Grand Falls Irrigation	106,000	242,000	290,400			290,400
	Hola Irrigation Expansion	800	402	520			520
	Hola Irrigation Greater Extention	4,161	3,146	4,066			4,066
	Kora Irrigation	25,000	12,870	16,634	Kora	13,255	29,889
	Sub-total	135,961	258,418	311,620		13,255	324,875
Small Scale Irrigation		15,784	7,892	10,200			10,200
Private Irrigation		10,054	15,081	19,491			19,491
Total		161,799	281,391	341,311		13,255	354,566
ENNCA							
Large Scale Irrigation	Kieni Irrigation	4,202	2,200	2,843			2,843
	Kihoto Irrigation	18,000	7,700	9,952	Kihoto	14,192	24,144
	Kom (Wajir) Irrigation	4,000	2,000	2,585	Archers' Post	16,733	19,318
	Sub-total	26,202	11,900	15,380		30,925	46,305
Small Scale Irrigation		8,116	4,058	5,245			5,245
Private Irrigation		7,165	10,748	13,890			13,890
Total		41,483	26,706	34,515		30,925	65,440
TOTAL							
Large Scale Irrigation		432,235	446,932	555,384		170,183	725,567
Small Scale Irrigation		109,278	54,639	70,617		0	70,617
Private Irrigation		82,162	123,243	159,283		0	159,283
Grand Total		623,675	624,814	785,284		170,183	955,467

Note: *: Project cost includes direct construction cost, physical contingency, engineering services and indirect costs.
**: Project cost for irrigation system includes irrigation canal and headworks (dam, wer, pmuping station, tubewell)
***: Refer to Sectoral Report (G)

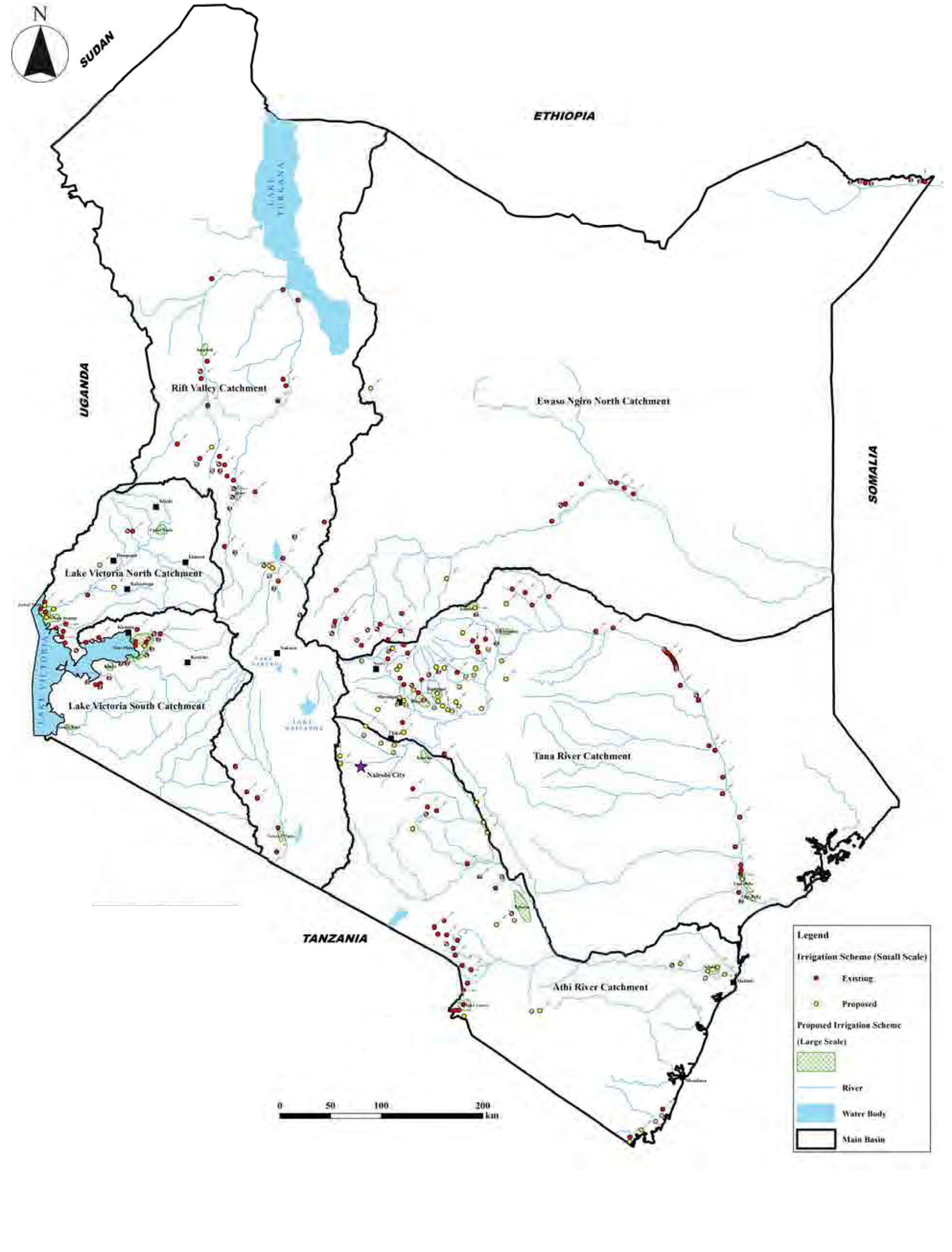
Source: JICA Study Team

Figures



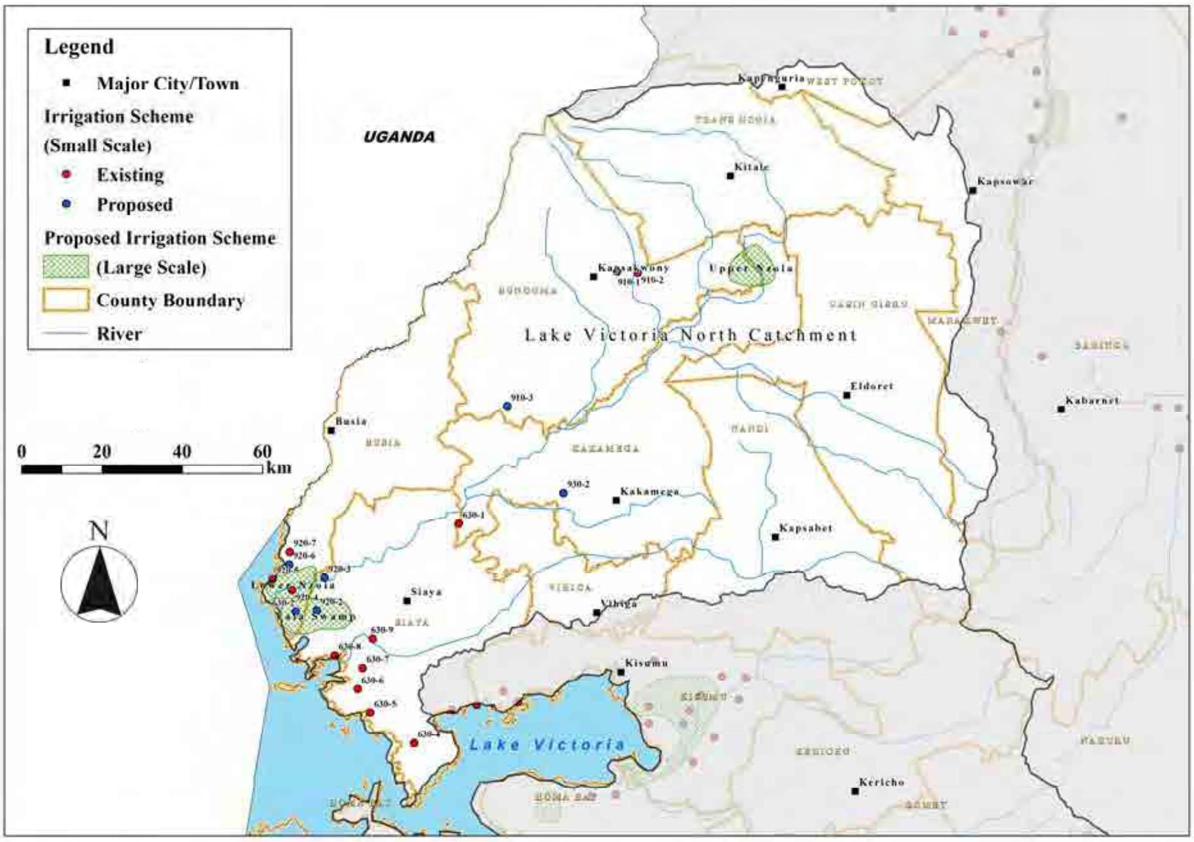
Source: JICA Study Team

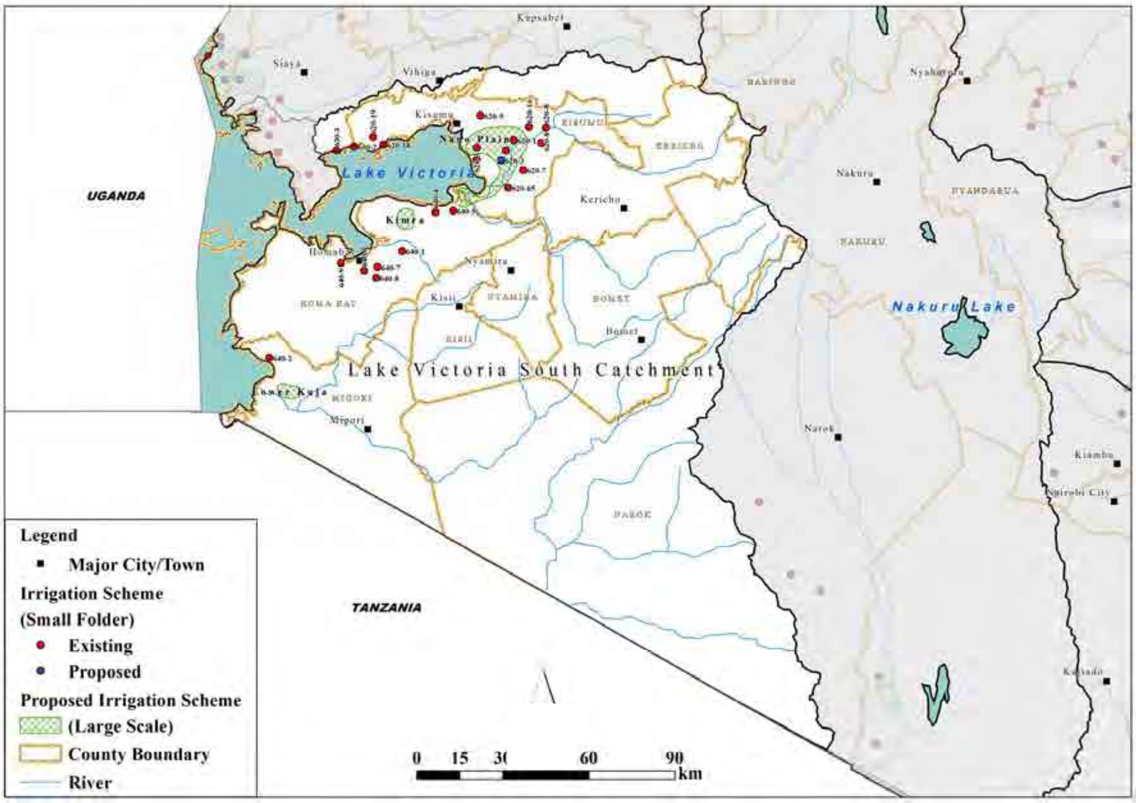
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.2.1 Study Flow of Irrigation Development Plan Formulation**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: NWMP (1992)

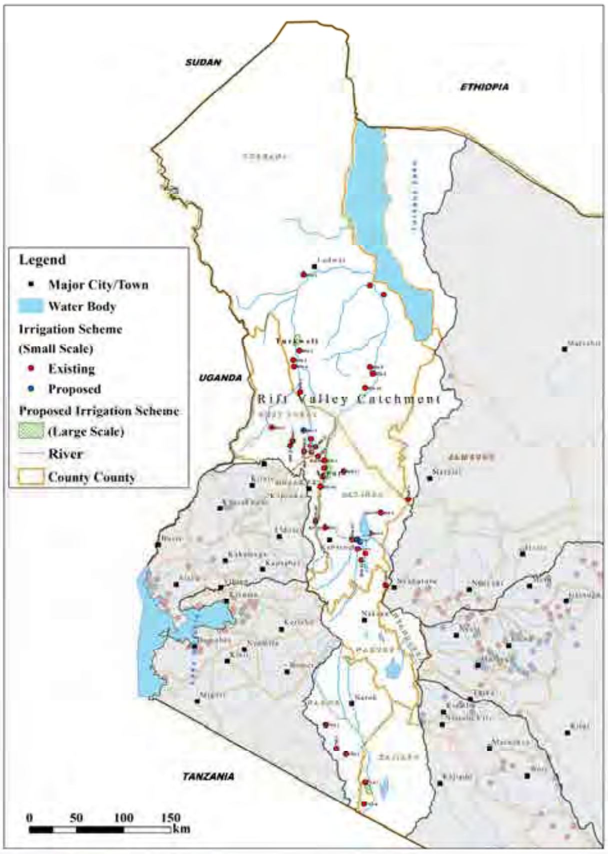
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.1 Existing and Proposed Irrigation Schemes for Whole Country in NWMP (1992)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

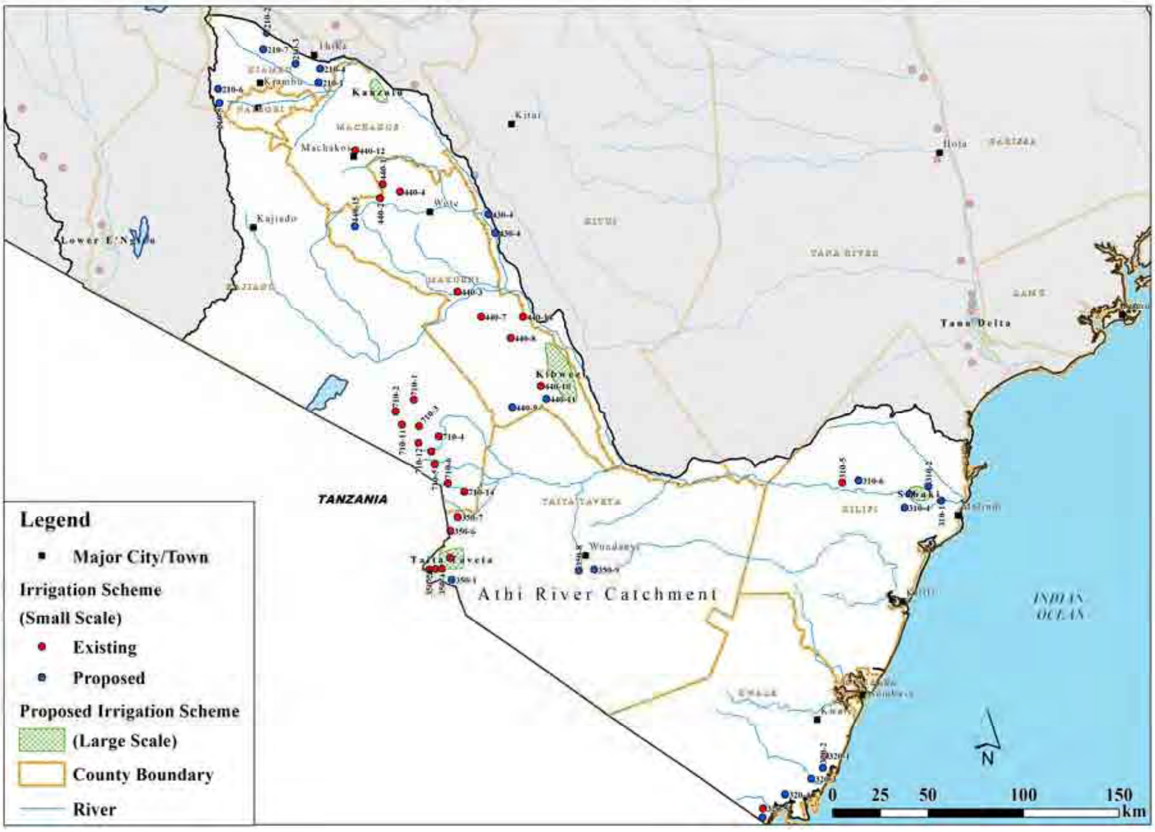




Source: NWMP (1992)

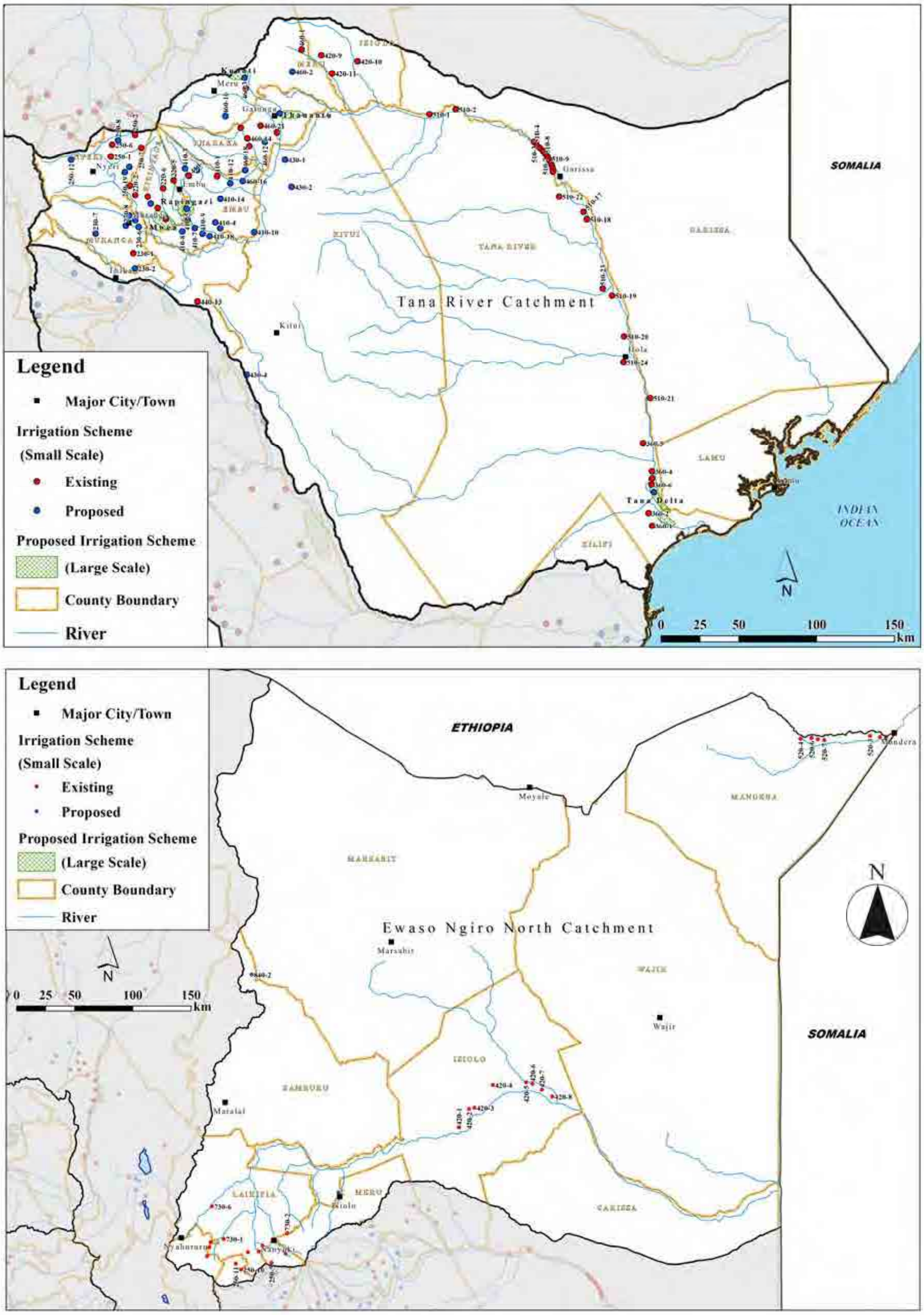
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.2** Existing and Proposed Irrigation Schemes for LVNCA and LVSCA in NWMP (1992)
JAPAN INTERNATIONAL COOPERATION AGENCY	





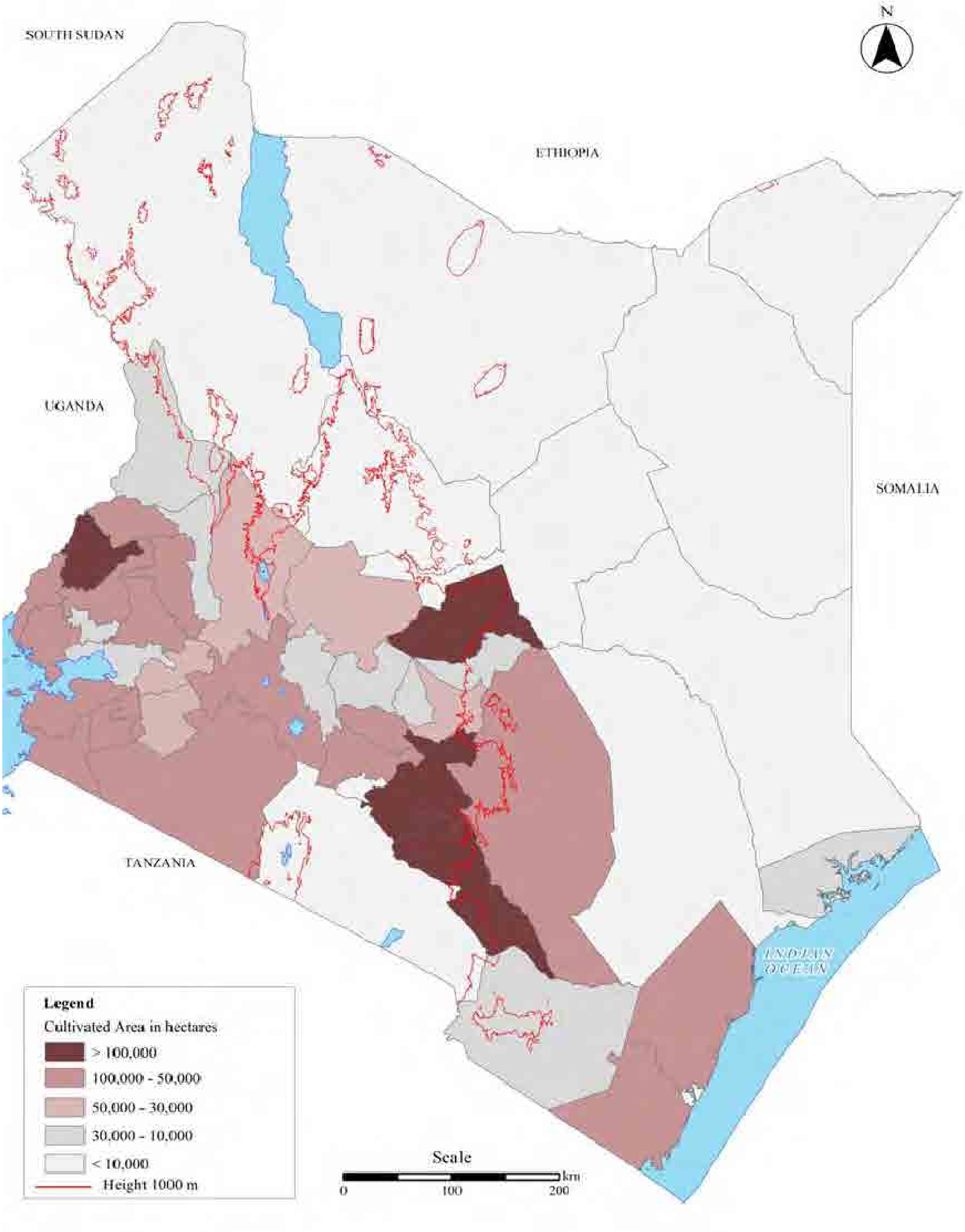
Source: NWMP (1992)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.3 Existing and Proposed Irrigation Schemes for RVCA and ACA in NWMP (1992)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



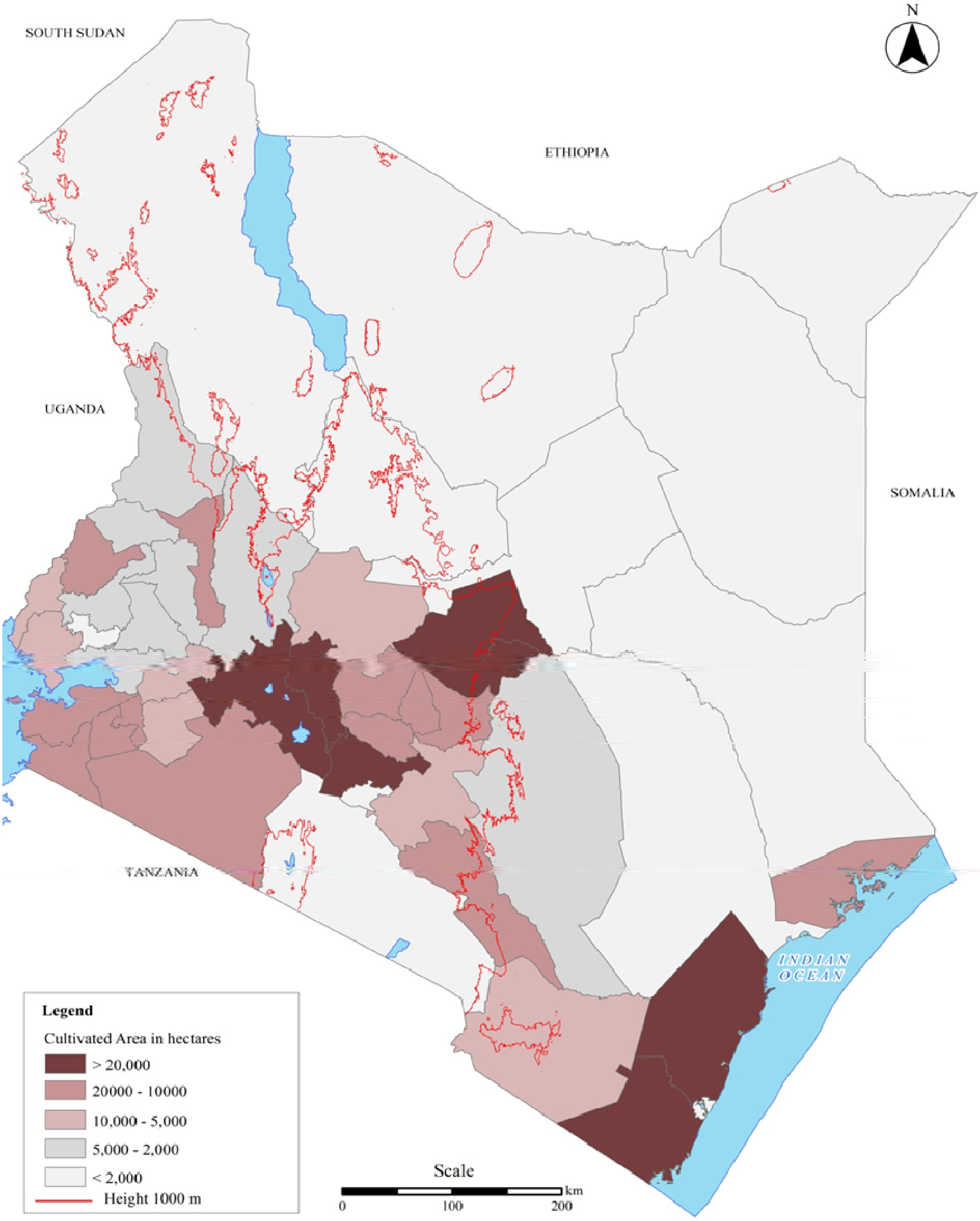
Source: NWMP (1992)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.3.4** **Existing and Proposed Irrigation Schemes for TCA and ENNCA in NWMP (1992)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



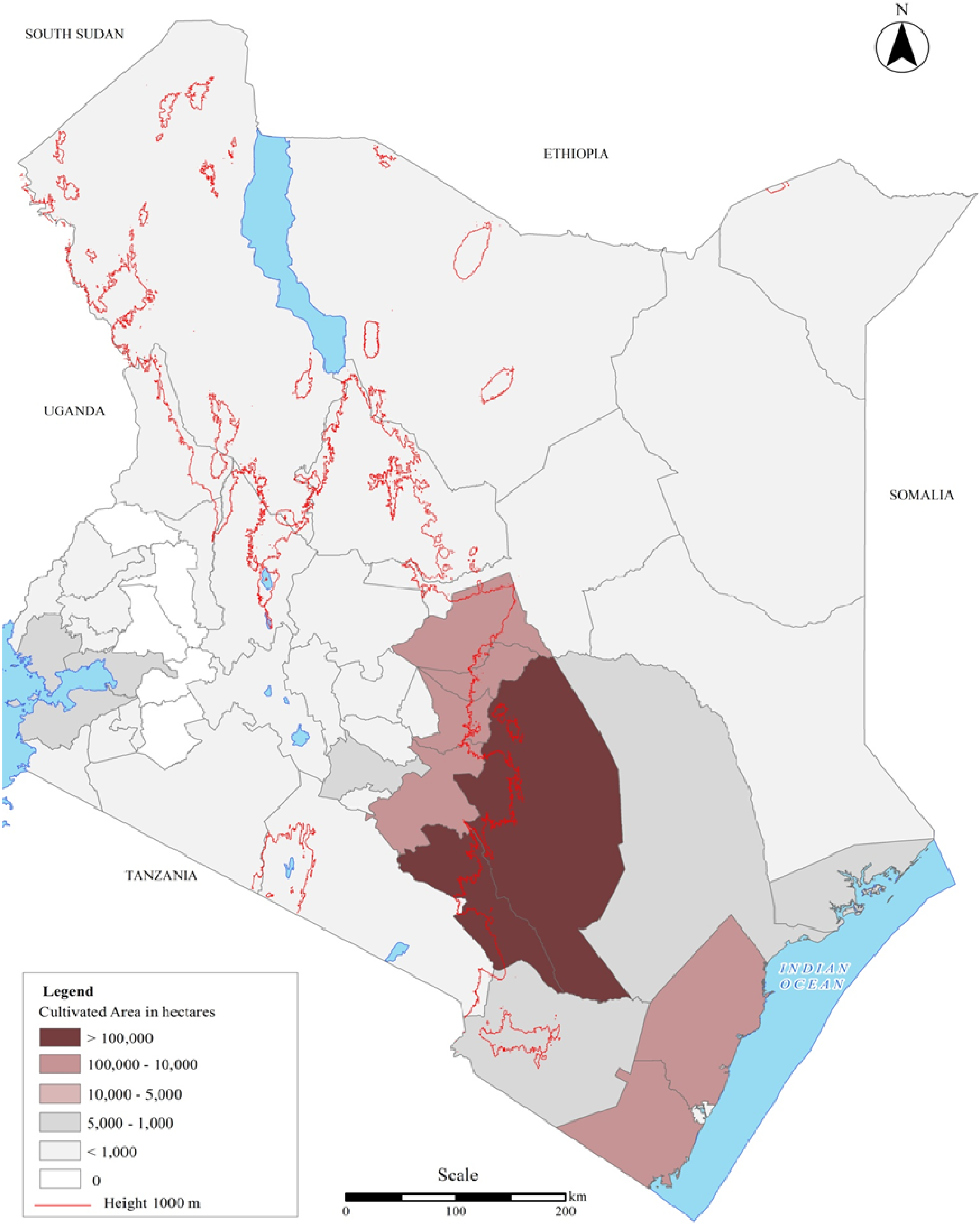
Source: JICA Study Team 2012 based on data from Economic Review of Agriculture 2012, MOA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.1 Cropping Area of Maize by County in 2011**
JAPAN INTERNATIONAL COOPERATION AGENCY	



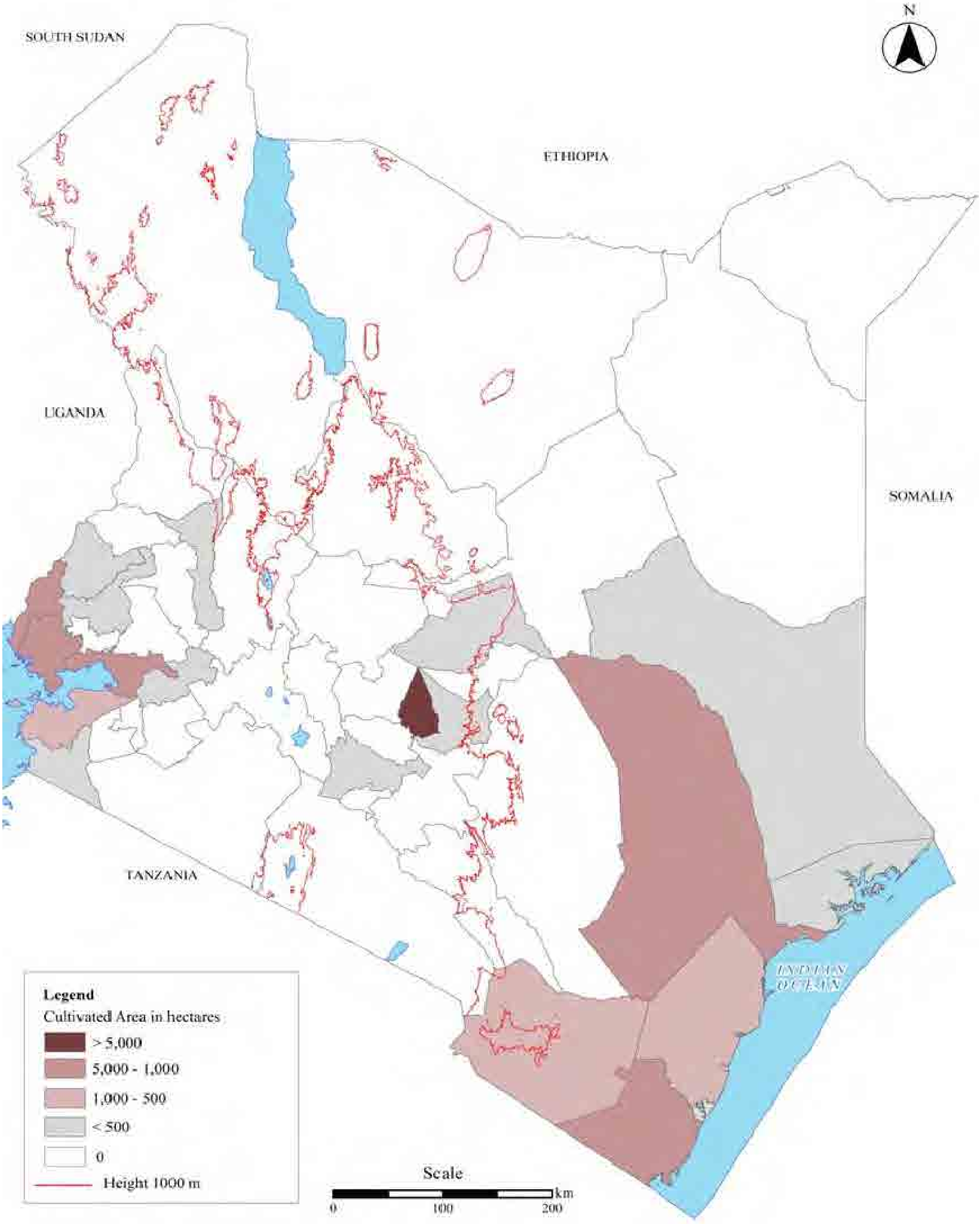
Source: JICA Study Team 2012 based on data from Economic Review of Agriculture 2012, MOA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.2 Cropping Area of Horticultural Crops by County in 2011**
JAPAN INTERNATIONAL COOPERATION AGENCY	



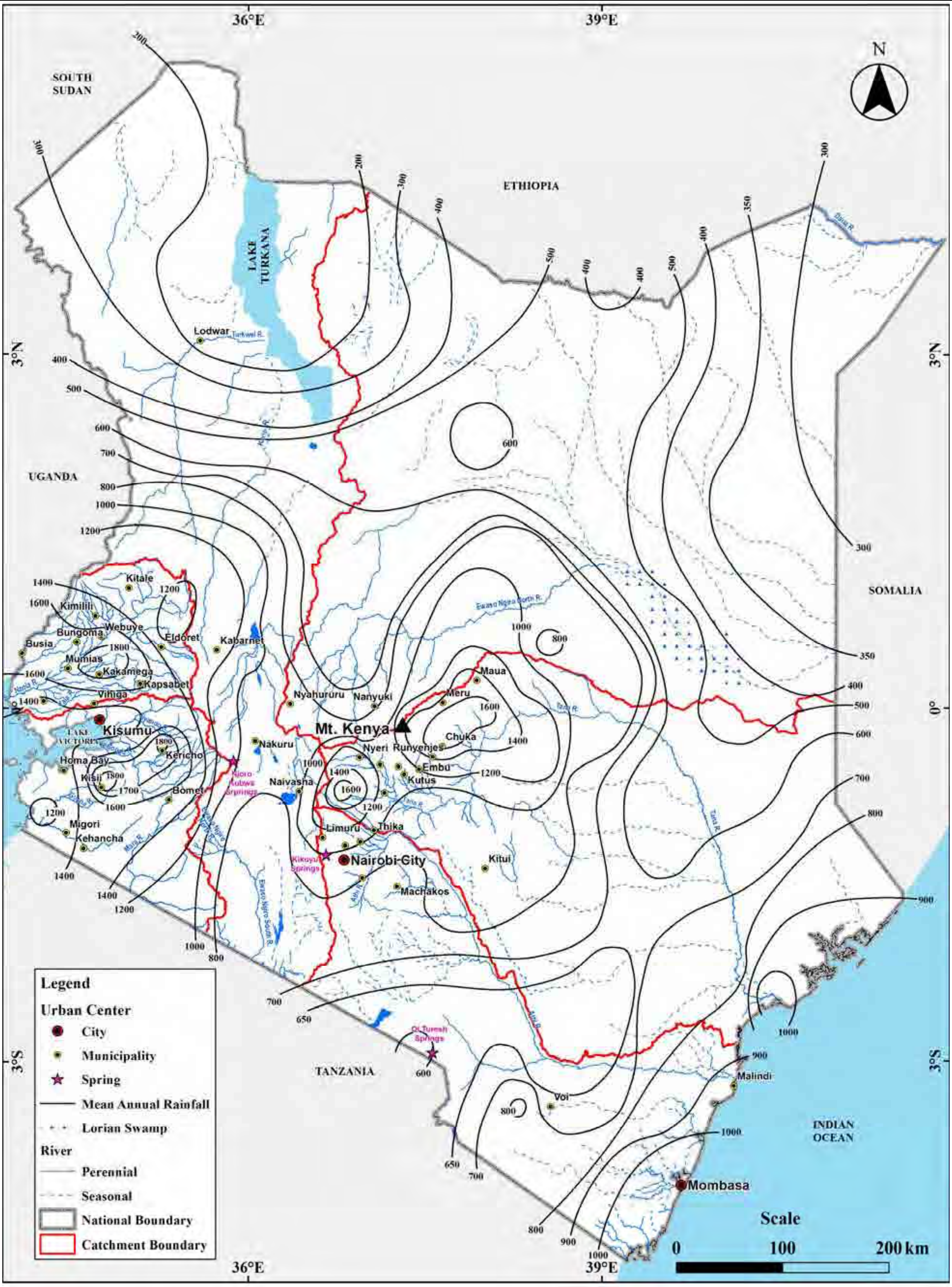
Source: Economic Review of Agriculture 2012, MOA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.3 Cropping Area of Beans by County in 2011**
JAPAN INTERNATIONAL COOPERATION AGENCY	



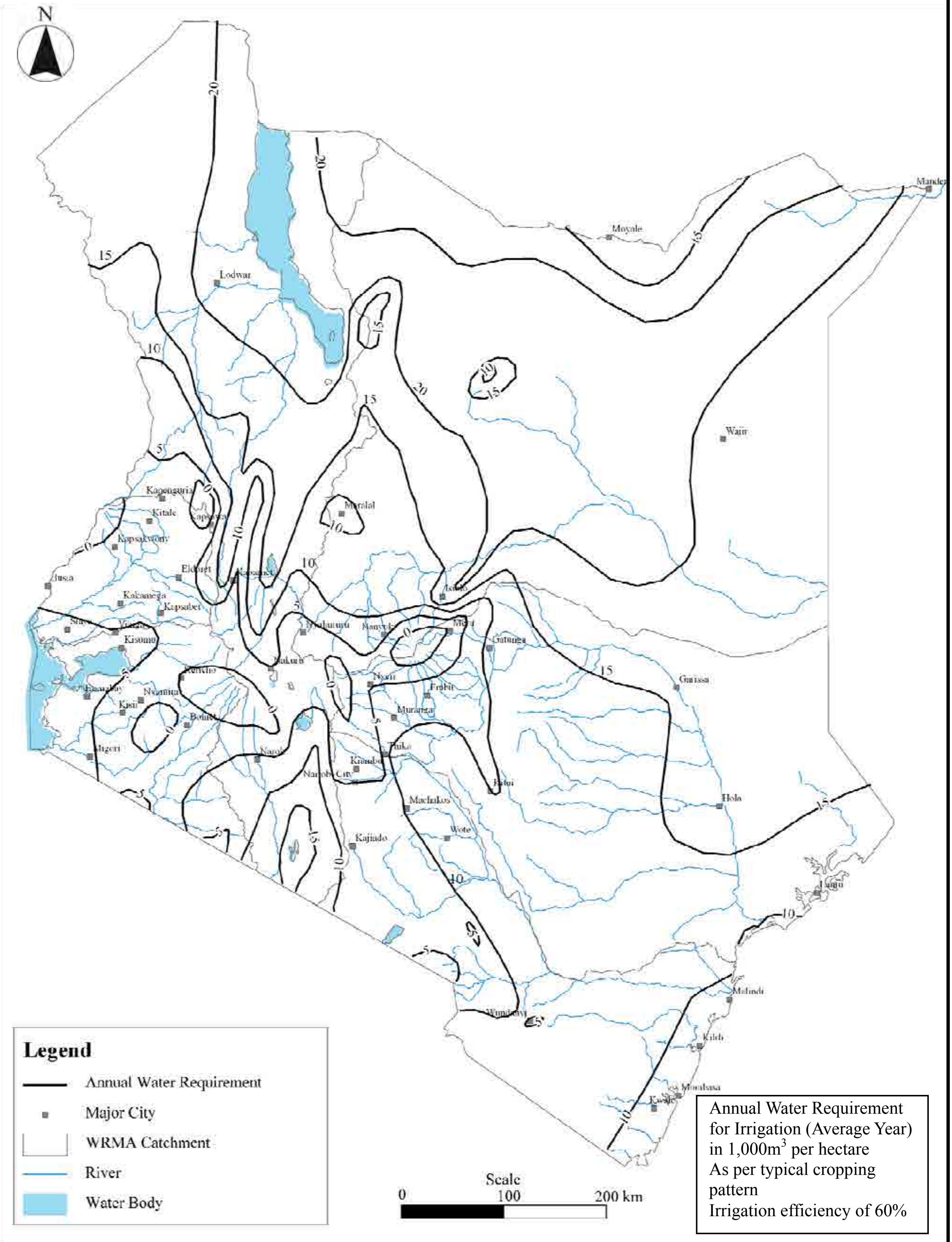
Source: JICA Study Team 2012 based on data from Economic Review of Agriculture 2012, MOA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.4 Cropping Area of Rice by County in 2011**
JAPAN INTERNATIONAL COOPERATION AGENCY	



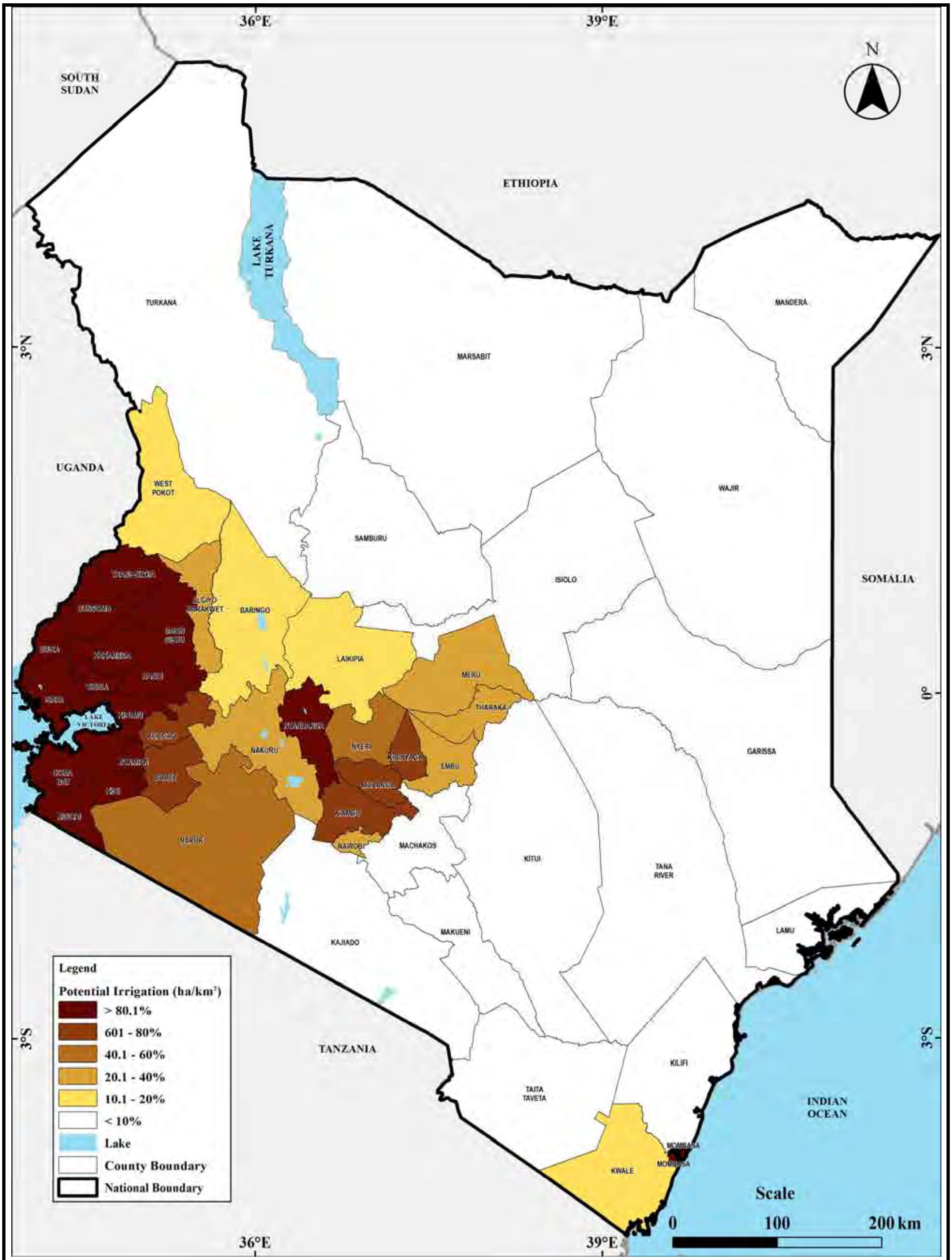
Source: JICA Study Team based on data from WRMA

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.2.1 Isohyetal Map of Mean Annual Rainfall for 1981 to 2010**
JAPAN INTERNATIONAL COOPERATION AGENCY	



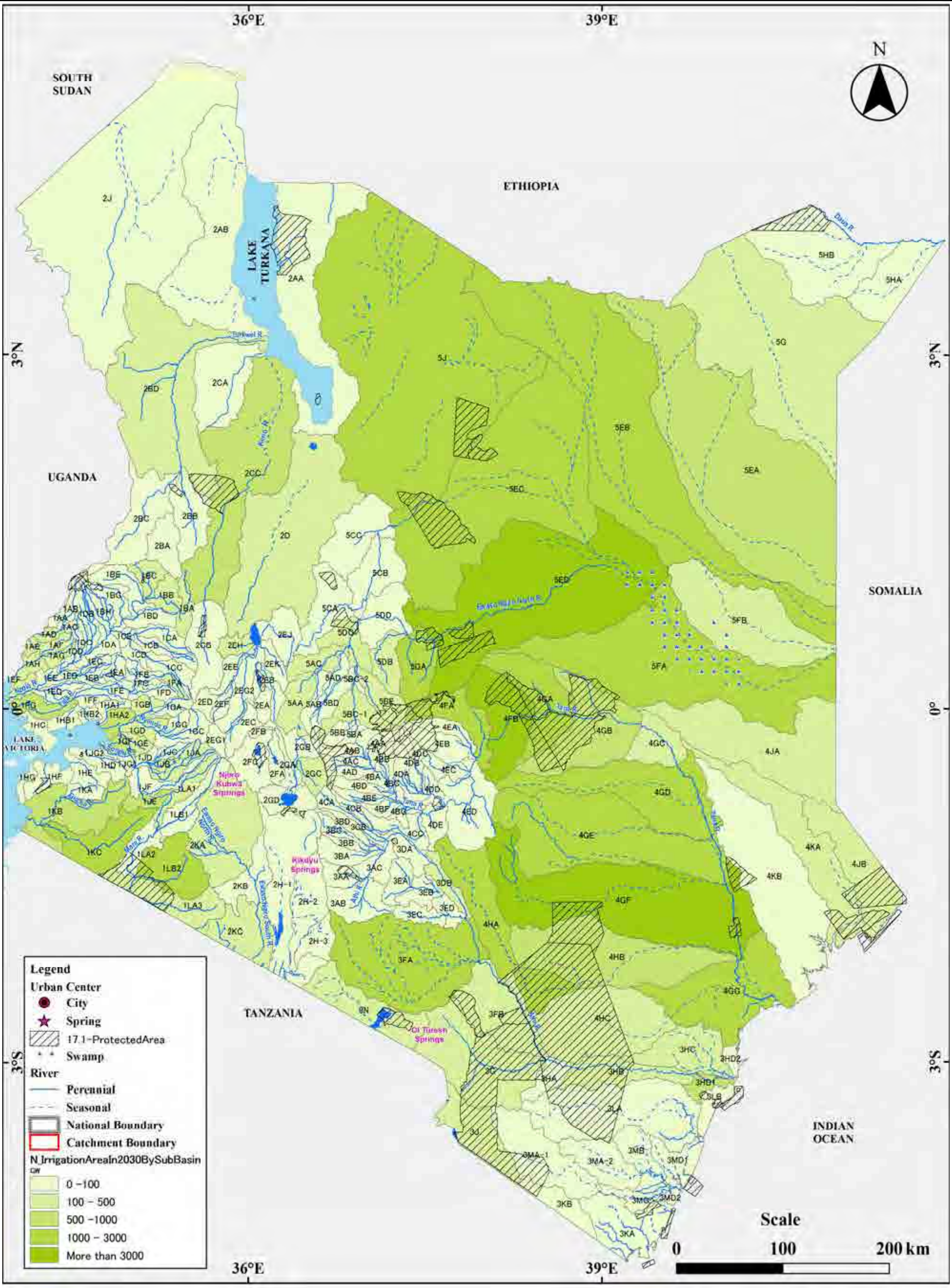
Source: Water Requirements for Irrigation in Kenya, Ministry of Water Development, Sep. 1985

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.3.1 Iso-annual Irrigation Water Requirement**
JAPAN INTERNATIONAL COOPERATION AGENCY	



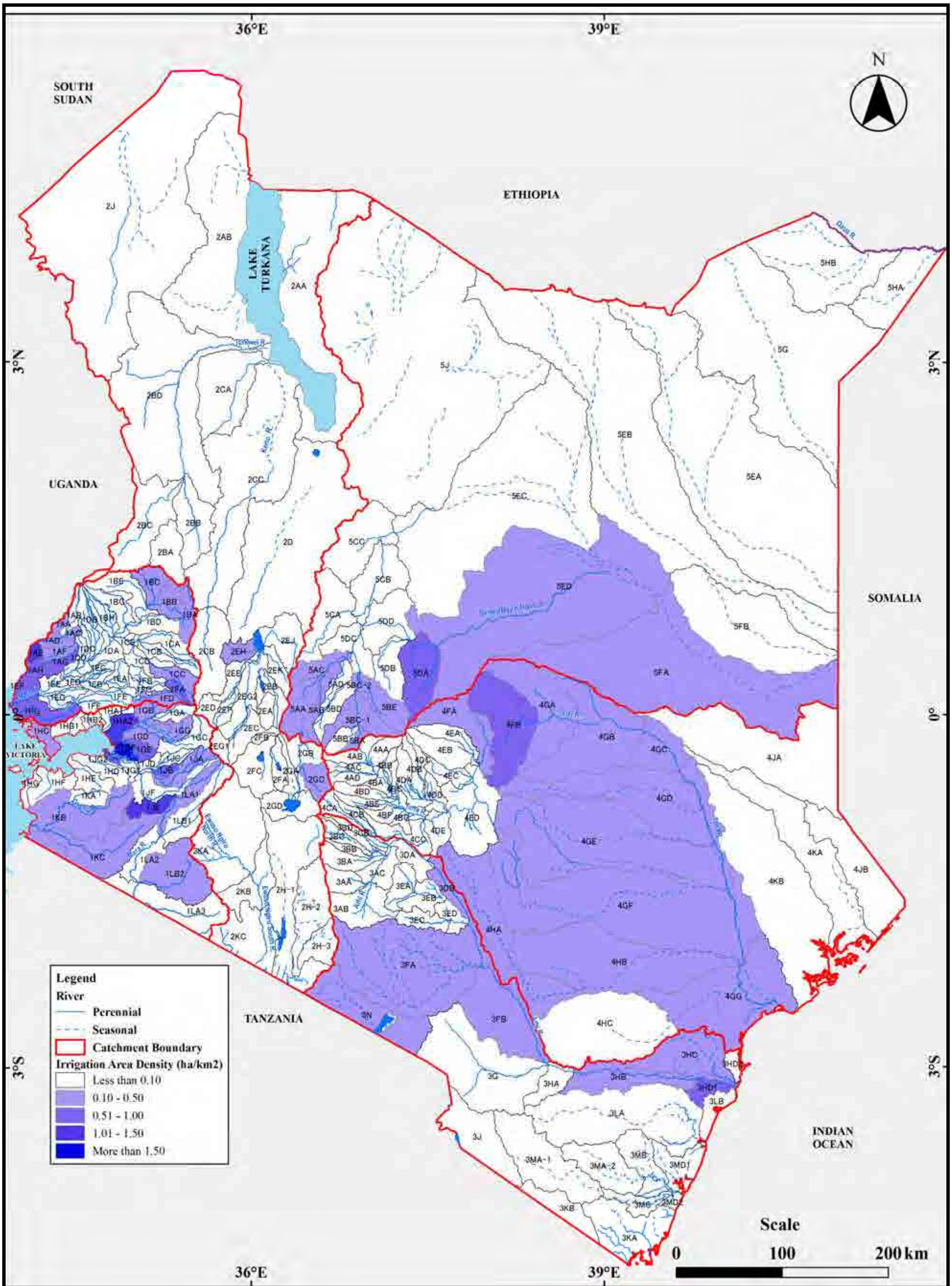
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.4.1** **Density of Potential Agricultural Area by County**
JAPAN INTERNATIONAL COOPERATION AGENCY	



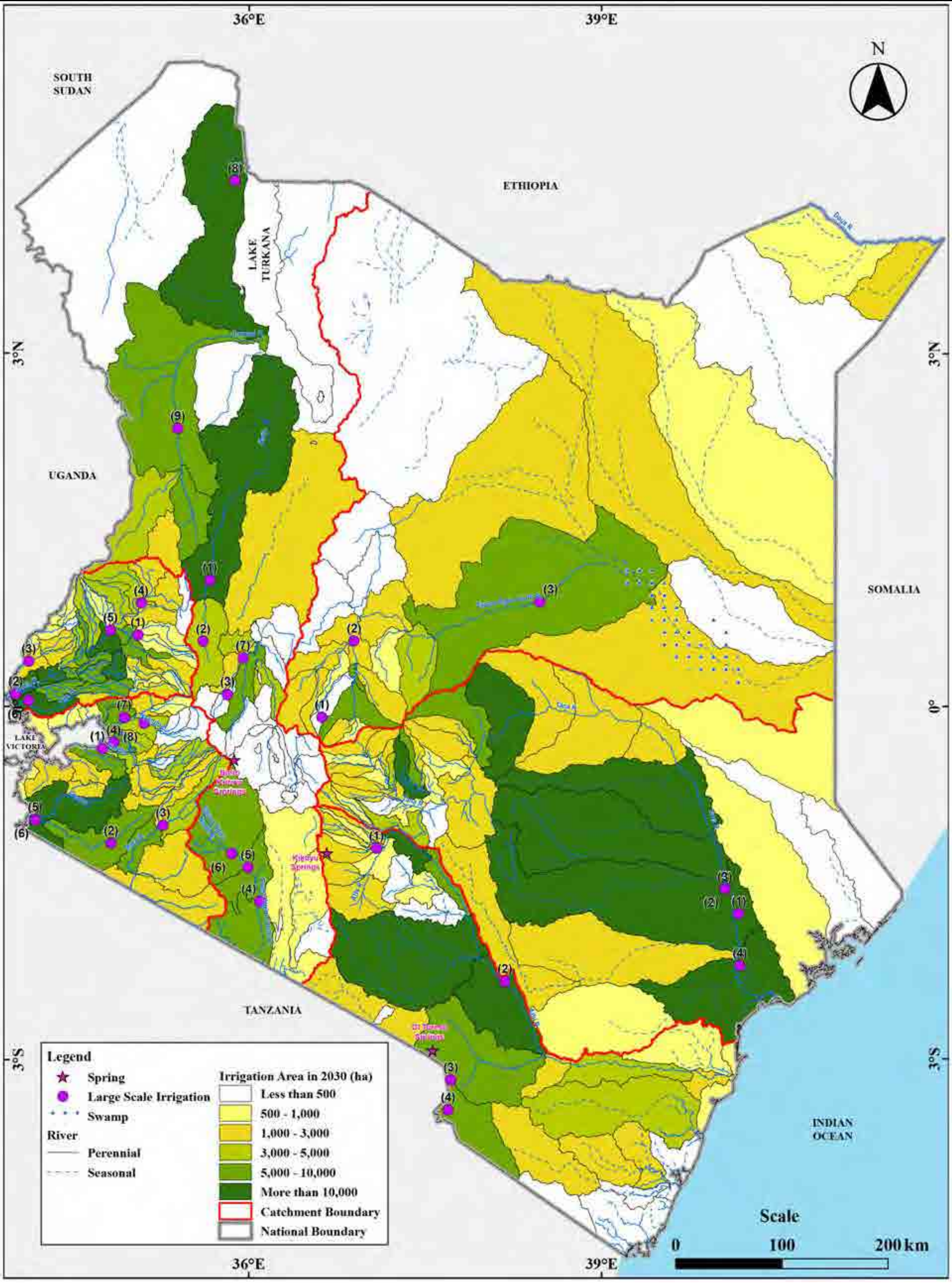
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.2.1** Possible Irrigation Area by Surface Water and by Sub-basin in 2030
JAPAN INTERNATIONAL COOPERATION AGENCY	



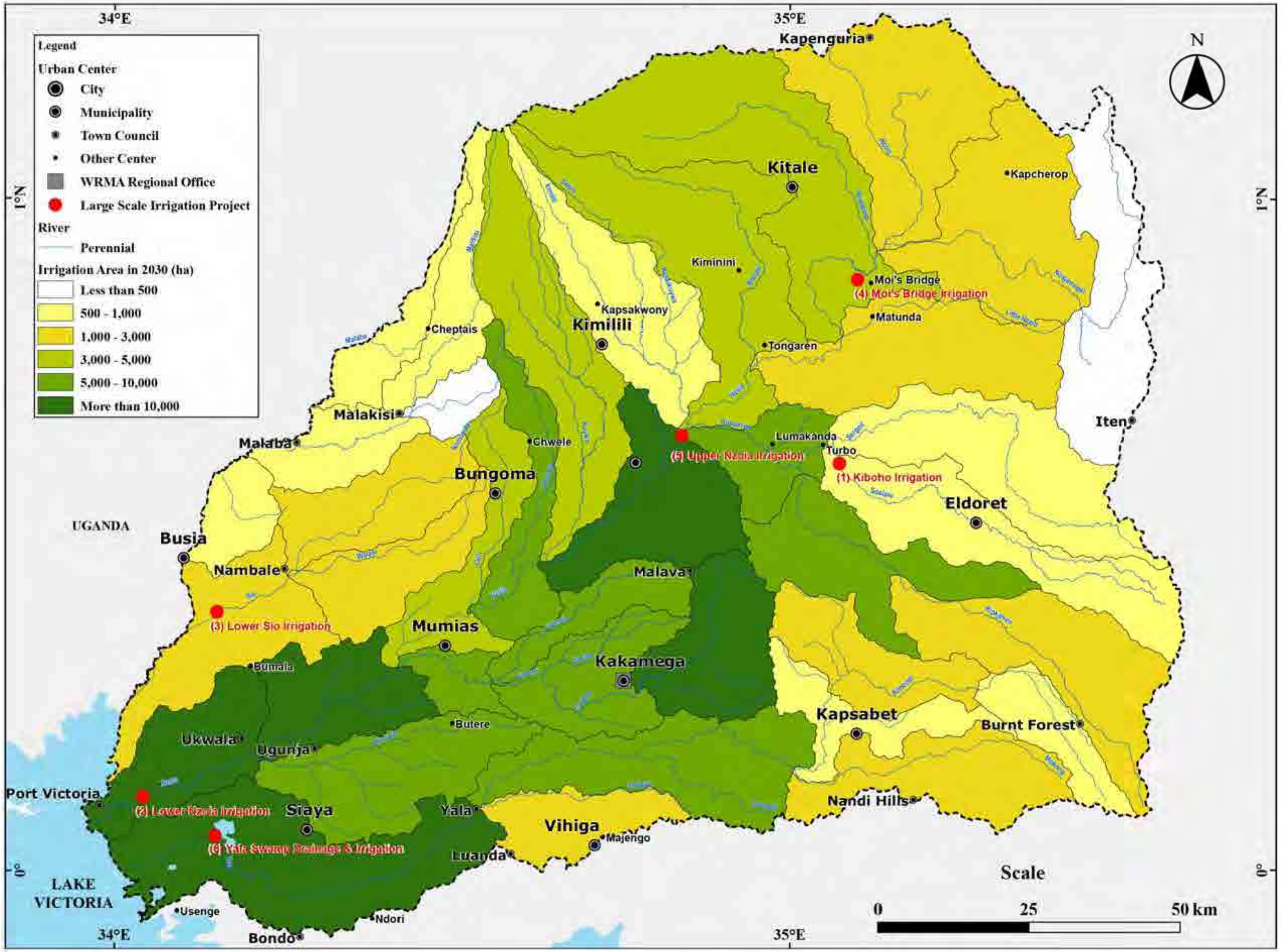
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.2.2 Possible Irrigation Area by Groundwater and by Sub-basin in 2030**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 4.2.3 Irrigation Development Area in 2030 in Kenya
JAPAN INTERNATIONAL COOPERATION AGENCY	

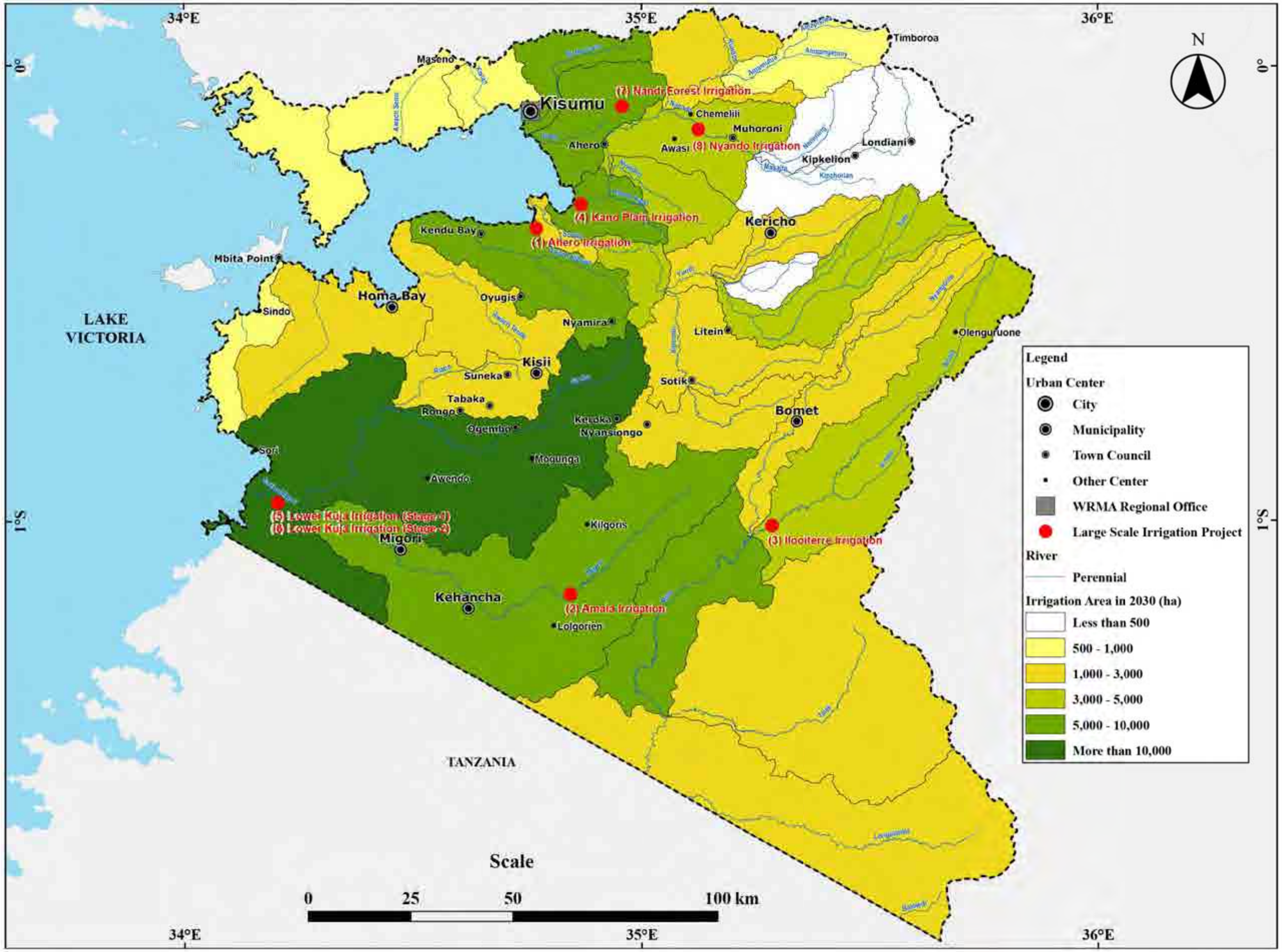


Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.1
Irrigation Development Area in 2030
(LVNCA)

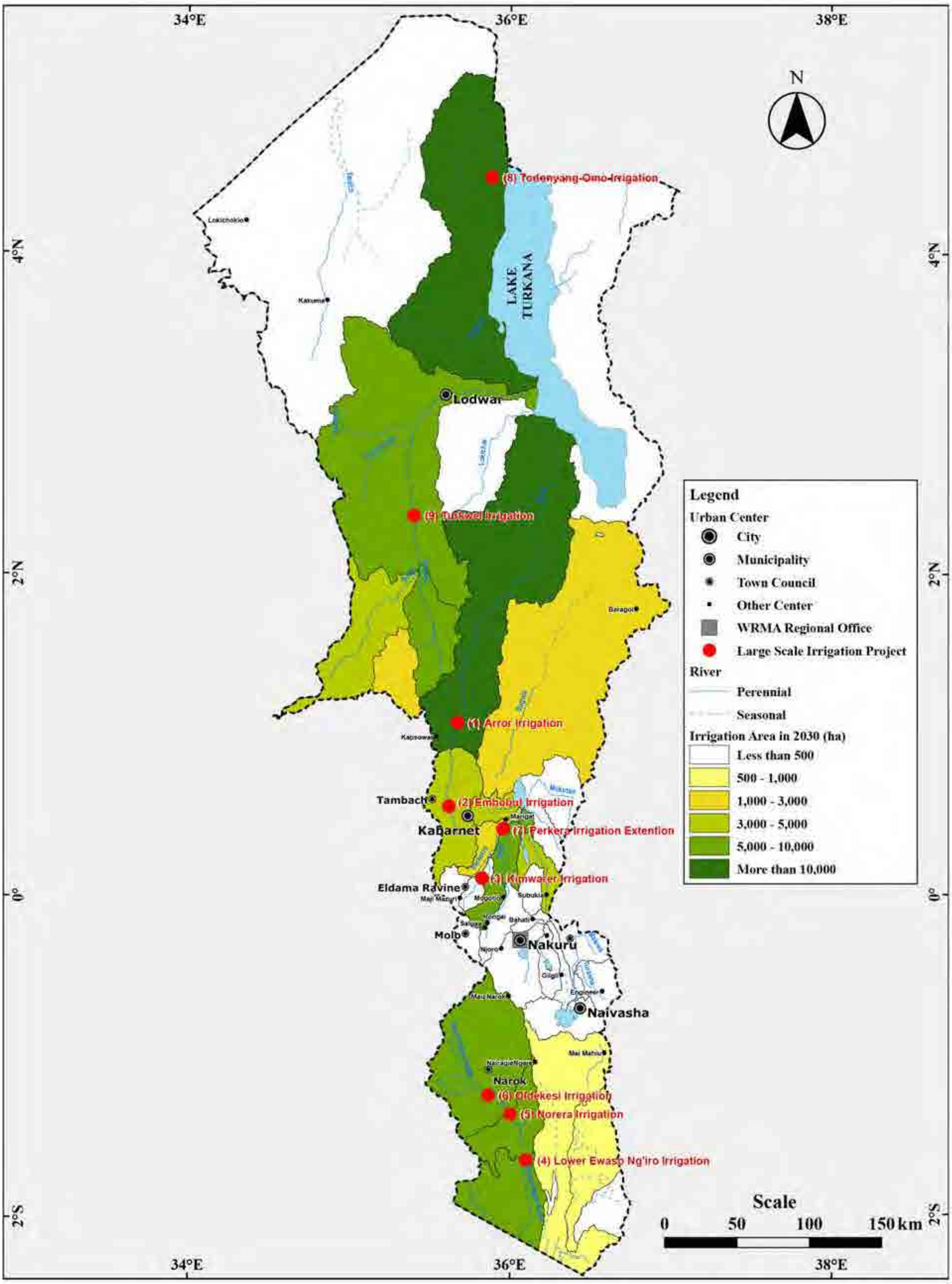


Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

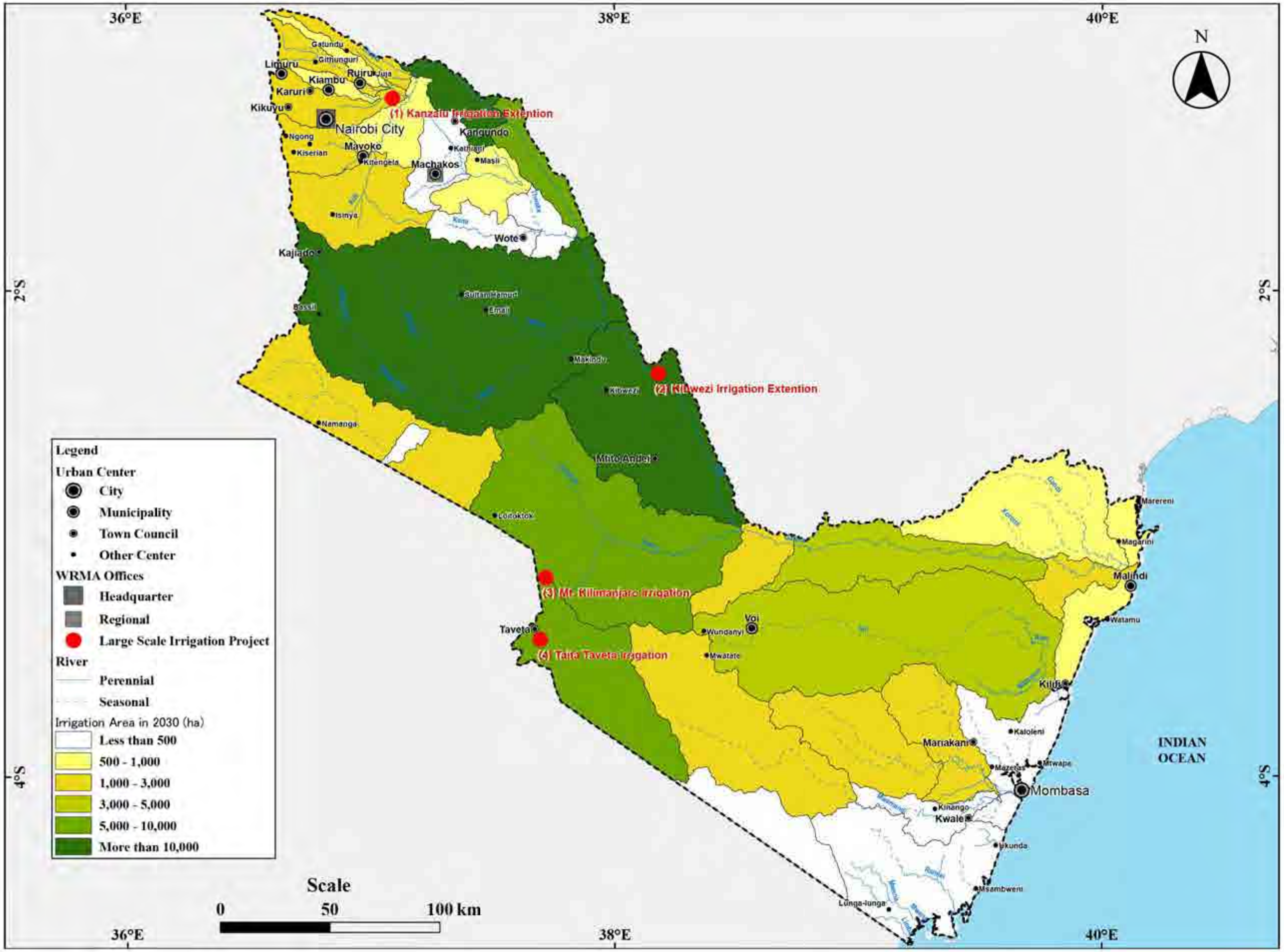
Figure 4.3.2
Irrigation Development Area in 2030
(LVSCA)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.3.3** **Irrigation Development Area in 2030 (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

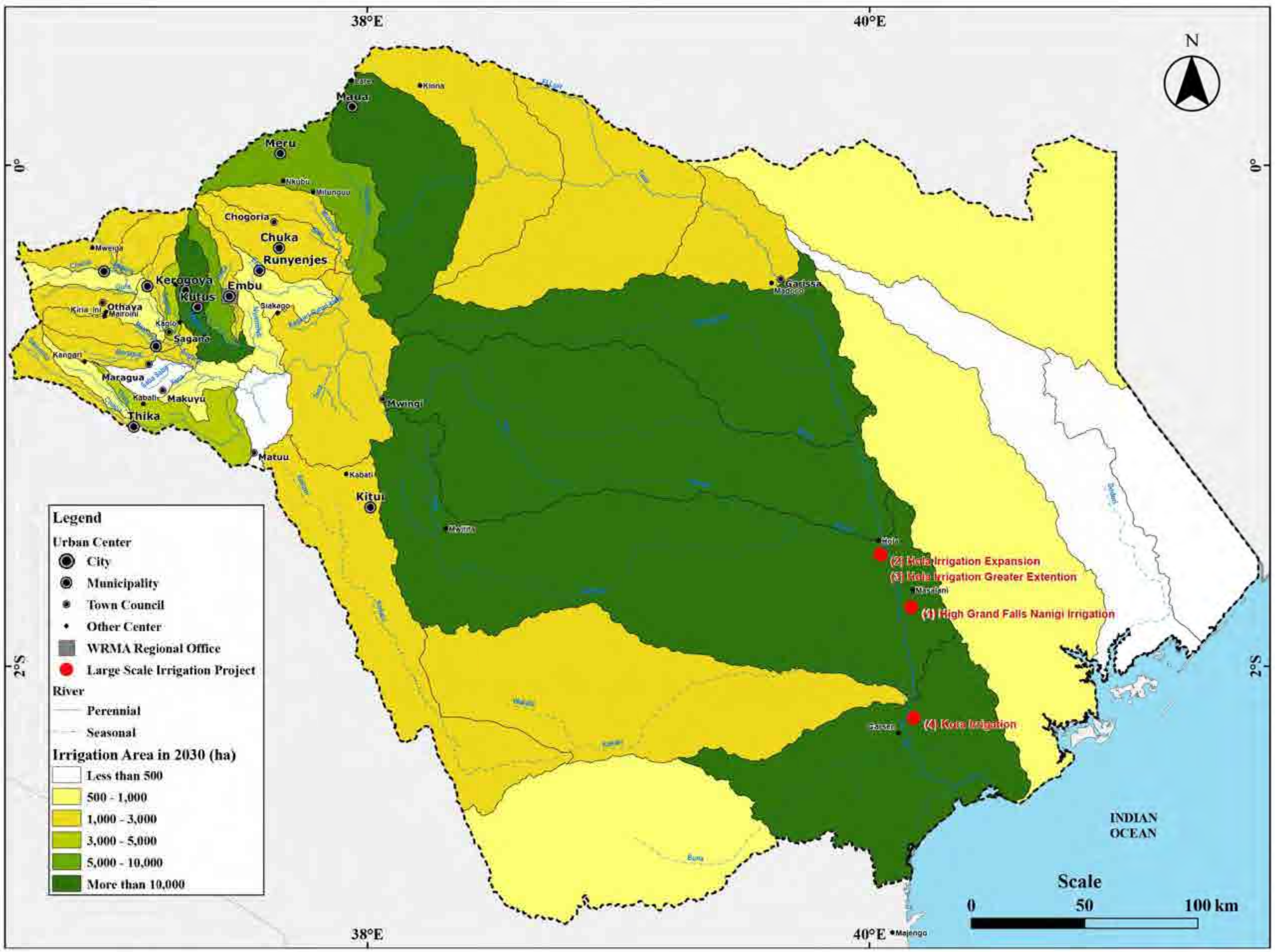
Source: JICA Study Team



THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.4
Irrigation Development Area in 2030 (ACA)

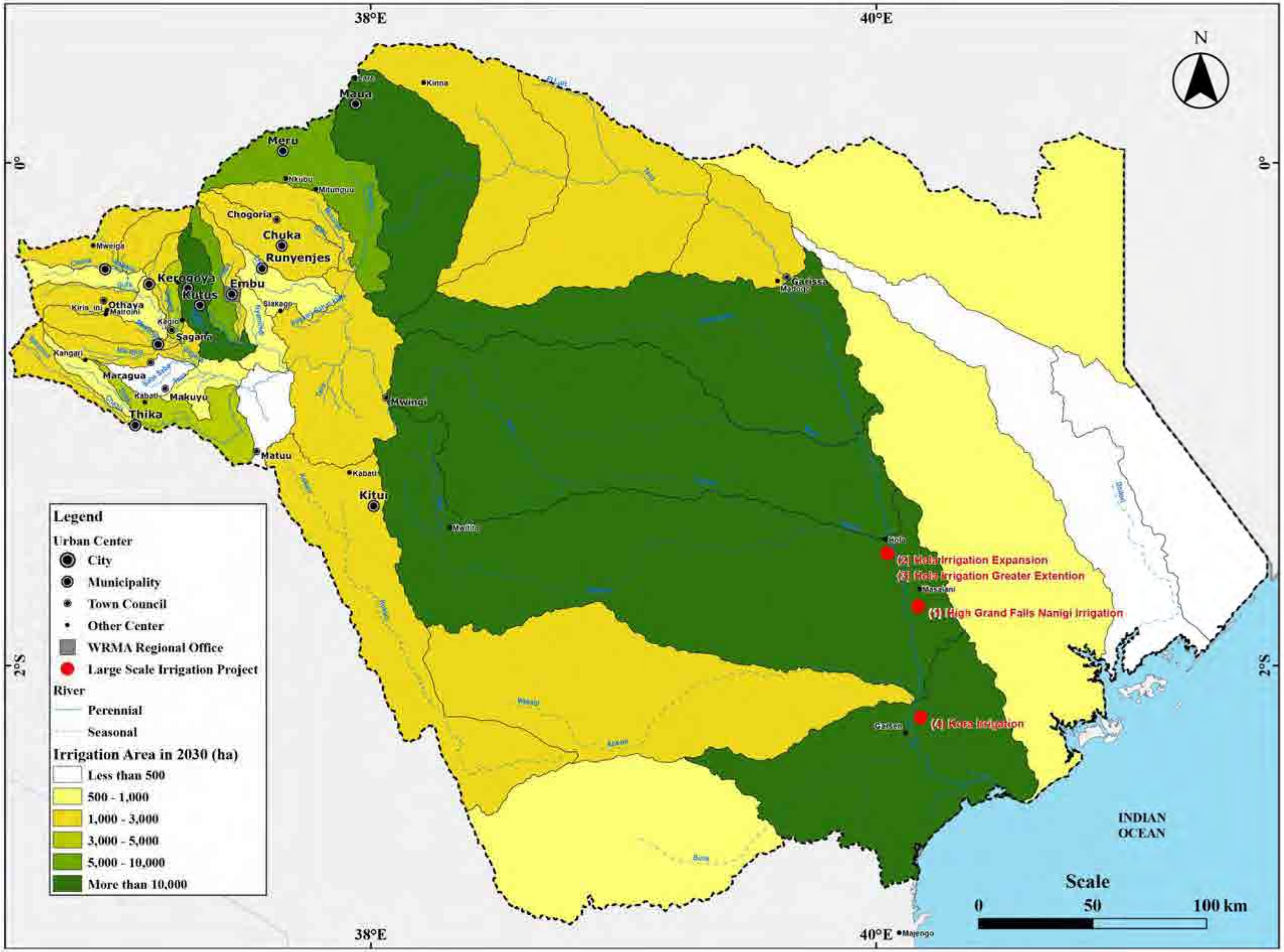


Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.5
Irrigation Development Area in 2030 (TCA)



Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.6
Irrigation Development Area in 2030
(ENNCA)

LNNCA

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

Note:
- 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 7.3.1 Implementation Schedule of Irrigation Development (LVNCA)

LVSCA

No	Name of Project	County	Irrigation Area (ha)	Multi-purpose Dam	Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
A. Large Scale Irrigation Project (New)																						
1	Kano Plain Irrigation	Nyamira/ Kericho	15,000	Magwa gwa			P			Dam												
2a	Lower Kuja Irrigation (Stage-1)	Migori	7,800	-																		
2b	Lower Kuja Irrigation (Stage-2)	Migori	32,700	Katieno					P					Dam								
3	Ahero and West Kano Irrigation	Kisumu	1,800	-				P														
4	Nandi Forest Irrigation	Nyando, Kisumu	7,272	Nandi Forest						P	Dam											
5	Nyando Irrigation	Kericho	3,000	Nyando (Koru)								P		Dam								
6	Amala Irrigation	Bomet	5,000	Amala											P						Dam	
7	Ilooiterre Irrigation	Narok	3,000	Illoiterre														Dam P				
	Total		75,572		7,800					16,800					50,972							
B. Small Scale Irrigation Project (New)																						
1	Weir Irrigation		14,477		2,895					4,343					7,239							
2	Dam Irrigation		0		0					0					0							
3	Small Dam/Pond/Water Pan Irrigation		4,590		918					1,377					2,295							
4	Groundwater Irrigation		3,434		687					1,030					1,717							
	Total for B		22,501		4,500					6,750					11,251							
C. Private Irrigation Project (New)																						
1	Weir Irrigation		11,700		2,340					3,510					5,850							
2	Groundwater Irrigation		3,433		687					1,030					1,716							
	Total for C		15,133		3,027					4,540					7,566							
	Total for LVSCA		113,206		15,327					28,090					69,789							

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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.2
Implementation Schedule of Irrigation Development (LVSCA)

RVCA

No	Name of Project	County	Irrigation Area (ha)	Multi-purpose Dam	Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
A. Large Scale Irrigation Project (New)																						
1	Perkera Irrigation Extention	Baringo	3,000	-		P																
2	Turkwel Irrigation	West Pokot	5,000	Turkwel	Dam (Existing)		P															
3	Arror Irrigation	Elgeyo Marakwet	10,850	Arror				P			Dam											
4	Norera Irrigation	Narok	2,000	Upper Narok					P			Dam										
5	Lower Ewaso Ng'iro Irrigation	Kajiado	15,000	Oldorko/ Oletukat							P				Dam							
6	Todonyang-Omo Irrigation	Turkana	35,000	Gibe 3 Ethiopia					Dam (in Ethiopia)			P										
7	Kimwarer Irrigation	Baringo	2,000	Kimwarer											P				Dam			
8	Oldekesi Irrigation	Narok	2,000	-												P						
9	Embobut Irrigation	Elgeyo Marakwet	2,000	Embobut													P		Dam			
	On-going Weir Irrigation		2,000																			
	Total		78,850		2,000					17,850					59,000							
B. Small Scale Irrigation Project (New)																						
1	Weir Irrigation		5,335		1,067					1,601					2,667							
2	Dam Irrigation		0		0					0					0							
3	Small Dam/Pond/Water Pan Irrigation		2,890		578					867					1,445							
4	Groundwater Irrigation		1,046		209					314					523							
	Total for B		9,271		1,854					2,782					4,635							
C. Private Irrigation Project (New)																						
1	Weir Irrigation		3,000		600					900					1,500							
2	Groundwater Irrigation		1,045		209					314					522							
	Total for C		4,045		809					1,214					2,022							
	Total for RVCA		92,166		4,663					21,846					65,657							

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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.3 Implementation Schedule of Irrigation Development (RVCA)

ACA

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	**Figure 7.3.4 Implementation Schedule of Irrigation Development (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

TCA

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	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

Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.5
Implementation Schedule of Irrigation Development (TCA)

ENNCA

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

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 7.3.6
Implementation Schedule of Irrigation Development (ENNCA)

Sectoral Report (F) Hydropower

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

FINAL REPORT
VOLUME – V SECTORAL REPORT (2/3)

F: HYDROPOWER

Abbreviation

Table of Contents

Page

List of Tables

Page

List of Figures

Page

List of Abbreviations and Acronyms

B/C	:	Benefit and Cost
CDA	:	Coast Development Authority
EIRR	:	Economic Internal Rate of Return
ENN	:	Ewaso Ng'iro North
ENNDA	:	Ewaso Ng'iro North Development Authority
ENSDA	:	Ewaso Ng'iro South Development Authority
ERC	:	Energy Regulatory Commission
F/S	:	feasibility study
FSL	:	Full Supply Level
HGF	:	High Grand Falls
IPP	:	Independent Power Producer
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KETRACO	:	Kenya Electricity Transmission Company
KP	:	Kenya Power Limited
KP	:	Kenya Power
KPLC	:	Kenya Power and Lighting Company
KTDA	:	Kenya Tea Development Authority
KTPC	:	Kenya Tea Power Company
KVDA	:	Kerio Valley Development Authority
LBDA	:	Lake Basin Development Authority
LCPDP	:	Least Cost Power Development Plan
LENS	:	Lower Ewaso Ng'iro South
LVN	:	Lake Victoria North
LVS	:	Lake Victoria South
MMBTU	:	Million British Thermal Unit
MOE	:	Ministry of Energy
MORDA	:	Ministry of Regional Development Authority
NIB	:	National Irrigation Board
NPV	:	Net Present Value
NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
O&M	:	Operation and Maintenance
PF	:	plant factor
REA	:	Rural Electrification Authority
RV	:	Rift Valley
TARDA	:	Tana and Athi River Development Authority

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

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

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

This sectoral report provides information on the hydropower development plan in the National Water Master Plan (NWMP) 2030. Contents of this sectoral report include: (i) Overview of the current situation of hydropower development in the country; (ii) Hydropower development plans to be taken up to 2030; (iii) Aggregate cost estimate for development; (iv) Economic evaluation of the proposed development plans; and (v) Implementation programme for the development plans.

Figure 1.1.1 shows the study flow of the Hydropower Development Plan.

CHAPTER 2 CURRENT SITUATION OF HYDROPOWER DEVELOPMENT

2.1 Relevant Policies and Strategies

(1) National Energy Policy (Third Draft) May 2012

A new National Energy Policy (Third Draft) was published in May 2012 (hereinafter "the Draft Energy Policy") for public hearing. In the Draft Energy Policy, the following items were recognised as challenges to hydropower development:

- Hydropower is vulnerable to variations in hydrology and climate.
- The economic risk in hydropower projects is relatively higher than other modes of electricity generation as hydropower is capital intensive and wholly dependent on hydrology.
- Relocation and resettlement of affected persons is a major challenge.
- Long lead time for construction, between seven and ten years, as compared to other modes of electricity generation.
- Conflicting and competing land and water users among various sectors.

To cope with the above challenges, the Draft Energy Policy declared the following measures as policies:

- The Government of Kenya shall set up a hydro risk mitigation fund to cater for risks such as prolonged droughts.
- To cope with competing water requirements between hydropower generation and other users, the government will establish an inter-ministerial committee comprising relevant stakeholders to ensure coordination at policy, regulatory, and operational levels.
- The government shall implement hydropower projects as multi-purpose projects.

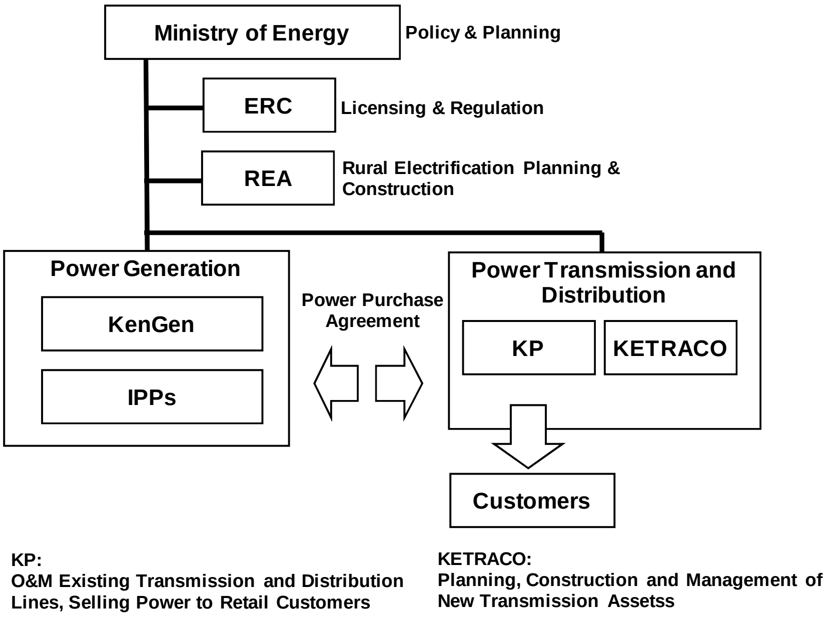
The above challenges and policies can be summarised and incorporated into the NWMP 2030 as follows:

- As countermeasures for climate change, it is recommended to maintain the ratio of hydropower generation in the energy mixture in an appropriate level; and
- From the point of effective use of limited water resources among conflicting and competing users, future hydropower projects should be developed as a multipurpose type of development.

According to the result of water balance study, more impending demand and supply balance problems are expected in the future. Additional coordination with other water users and more efficient water use will be required. Under such situations, it will be very important to promote water resources development and use of water for hydropower generation by multipurpose dam development schemes.

2.2 Relevant Organisations

The relevant organisations for hydropower development are shown below together with other power sector organisations. The Ministry of Energy (MOE) acts as a policy maker while the Energy Regulatory Commission (ERC) regulates the entire energy sector, including the power sector. Under the control of the MOE and the ERC, power supply to customers is carried out by power generation companies (Kenya Electricity Generating Company Limited (KenGen) and independent power producers (IPPs)), and power transmission and distribution companies (Kenya Power Limited (KP) and Kenya Electricity Transmission Co. Ltd. (KETRACO)) through power purchase agreements. The Rural Electrification Authority (REA) acts as an agency responsible for accelerating rural electrification in order to promote sustainable socioeconomic development.



Source: JICA Study Team based on information from the Ministry of Energy (As of November 2012)

Institutional Structure of the Power Sector

In addition to the above organisations, there are other organisations that are involved in hydropower development such as the Ministry of Regional Development Authorities (MORDA), which promotes multipurpose dam development. MORDA’s mandate is to contribute to wealth creation in Kenyan economy through regional development by its six regional development authorities, namely, Tana and Athi Rivers Development Authority (TARDA), Kerio Valley Development Authority (KVDA), Lake Basin Development Authority (LBDA), Ewaso Ng’iro North Development Authority (ENNDA), Ewaso Ng’iro South Development Authority (ENSDA), and Coast Development Authority (CDA).

2.3 Current Situation of Hydropower Development

2.3.1 Overview

(1) Power Generation System

Figure 2.3.1 shows the location of existing hydropower stations in operation as of June 30, 2011. KenGen is the largest electric power generation company in Kenya, producing about 80% of electricity consumed in the country. KenGen owns 14 hydropower stations, three thermal plants, two geothermal plants, a wind farm comprising two wind turbines and two off-grid stations, namely, Garissa and Lamu. KenGen generates and sells electricity to authorised distributor, Kenya Power

Limited (KP). The following table shows the comparison of energy mixture of the country for 1991 and 2011.

Comparison of Energy Mixture in 1991 and 2011

Energy Source	As of January 1991		As of June 2011			
	Installed Capacity (MW)	Share	Installed Capacity (MW)			Share
			KenGen	IPP	Total	
Hydropower	495	70.2%	763	0.3	763.3	49.8%
Thermal	165	23.4%	259	281.6	540.6	35.3%
Geothermal	45	6.4%	150	48	198	12.9%
Wind			5.3		5.3	0.3%
Cogeneration				26	26	1.7%
Total	705	100.0%	1,177.30	355.90	1,533.20	100.0%

Source: NWMP (1992), KP Annual Report 2010/2011

In the 1990s, hydropower generation dominated at about 70% of the total installed capacity, and at 80% of the total power generation. As of June 2011, the share of hydropower has decreased to less than 50%; however, it is still the largest share among other energy sources in Kenya. The installed capacity more than doubled in twenty years by increasing the ratio of geothermal power four times, thermal power three times, and hydropower 1.5 times.

Currently, the total power generation in the country amounts to 6456 GWh (average from 2005 to 2010)[1]. Hydropower generates 3039 GWh or 47% of the total power generation. Of the 3039 GWh, 2313 GWh (76%) is generated by five power stations located in the Tana River. The two power stations of Turkwel and Sondu/Miriu, which are located in the western part of the country, produce a total 622 GWh (21%) of power, while the rest are produced by small hydropower stations generating a total of 104 GWh (3%).

1) Large Hydropower Stations

As shown in Figure 2.3.1, there are five large hydropower stations, namely, Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere, having a total installed capacity of 563.2 MW. Other major hydropower stations include the Turkwel Power Station in the northwestern part of the country with 106 MW installed capacity, and the Sondu/Miriu Power Station with 60 MW installed capacity. With the installation of these two power stations outside Tana, the risk of power output decreases during severe drought periods in the Tana River system.

The table below gives the details of existing large hydropower stations in the country.

[1] KP Annual Report and Financial Statements 2010/2011

Existing Large Hydropower Stations

Station	Location	No. of Units	Rating per Unit (MW)	Installed Capacity (MW)	Year Installed	Age (Years)	Remaining Economic Lives (Years)
Kindaruma	Tana River	2	20	40	1968	41	9
Kamburu 1 and 2	Tana River	2	31.4	62.8	1974	35	15
Kamburu 3	Tana River	1	31.4	31.4	1976	33	17
Gitaru	Tana River	2	72.5	145	1978	31	19
Gitaru Unit 3	Tana River	1	80	80	1999	10	40
Masinga	Tana River	2	20	40	1981	28	22
Kiambere	Tana River	2	84	164	1988	21	29
Turkwel	Turkwel River	2	53	106	1991	18	32
Sondu	Sondu River	2	30	60	2008	1	49
Total		16		729.2			

Source: LCPDP 2011-2031

In addition to the above table, the Sangoro Hydropower Station with an installed capacity of 21 MW was constructed in the Sondu River. The station generates power by utilising the tailwater of the Sondu/Miriu Hydropower Station.

As shown in the table above, most of the hydropower stations in the country are already 20 to 40 years of age. To make full use of these power stations, it is necessary to rehabilitate and upgrade its power generating facilities, such as civil structures, and hydromechanical and electrical equipment.

2) Small Hydropower Stations

In Kenya, a small hydropower station is defined as a plant having an installed capacity below 10 MW. Several small hydroelectric power plants in Kenya were commissioned between 1925 and 1958. The table below gives a list of the existing small hydropower stations operating in the country.

Existing Small Hydropower Stations

Plant		Year	Installed by	No. of Units	Rating per Unit (MW)	Total Installed Capacity (MW)
Ndula		1925	KPLC	2	2.000	2.000
MESCO		1933	KPLC	1	0.380	0.350
Selby Falls (Sosiani)		1952	KPLC	2	2.000	0.400
Sagana Falls		1955	KPLC	3	0.500	1.500
Gogo Falls		1958	Mining Co.	2	1.000	2.000
Tana 1 and 2		1952	KPC	2	2.000	4.000
Tana 3		1952	KPC	1	2.400	2.400
Tana 4		1954	KPC	1	2.000	4.000
Tana 5		1955	KPC	1	2.400	2.400
Tana 6		1956	KPC	1	2.000	2.000
Wanjii 1 and 2		1952	KPC	2	2.700	5.400
Wanjii 3 and 4		1952	KPC	2	1.000	2.000
James Finlay (K) Ltd	1	1934		2	0.150	0.300
	2	1934		2	0.200	0.400
	3	1980		2	0.060	0.120
	4	1984		1	0.320	0.320
	5	1999		2	0.536	1.072
Brooke Bond	1					0.090
	2					0.120
	3					0.180
	4					0.240
Savani		1927	Eastern Produce			0.095
Diguna		1997	Missionary			0.400
Tenwek			Missionary	1		0.320
Mujwa			Missionary	1		0.068
Community MHPs		2002				0.017
Total						31.822

Note: KPLC: Kenya Power and Lighting Company, KPC: Kenya Power Company
Source: LCPDP 2011-2031

In addition to the above list, the Kenya Tea Development Authority (KTDA) has a mini-hydropower station at its tea factory in Imenti, Meru District. The tea factory in Imenti has recently concluded a power purchase agreement with KP to sell generated power to the national grid.

To accelerate the development of small hydropower, the REA has set a feed-in-tariff system for renewable energy sources, as shown in the following table.

Feed-In-Tariff System of the REA

Renewable Energy	Plant Capacity (kW)	Tariff (US$0.01/kWh)	
		Firm	Non-firm
Wind	0.5 – 100	12.0	-
Biomass	40	8.0	6.0
Small Hydro	<1	12.0	10.0
	1 – 5	10.0	8.0
	5 – 10	8.0	6.0
Geothermal	70	8.5	-
Biogas	0.50 – 40	-	8.0
Solar	0.50 – 10	20.0	10.0

Source: REA

(3) Power Transmission Network

The existing transmission network consists of 220 kV and 132 kV high-voltage transmission lines, while the distribution network consists of 33 kV and 11 kV medium-voltage lines, as well as 66 kV sub-transmission lines around Nairobi. Figure 2.3.2 shows the existing transmission line network of 220 kV and 130 kV lines, together with proposed 500 kV, 400 kV, 220 kV, and 132 kV lines.

2.3.2 Lake Victoria North Catchment Area

(1) Existing Hydropower Stations

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

(2) Multipurpose Dam Development Project by the MORDA

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

(3) Other Multipurpose Dam Development Projects

There are three multipurpose dam development projects which have hydropower components. These are the Hemsted Bridge Dam, the Nzoia Dam (34B), and the Nzoia Dam (42A). All three schemes were planned in the Nzoia River.

The Hemsted Bridge Dam was planned for water supply, irrigation, and hydropower development. Its hydropower component has an installed capacity of 60 MW. However, this power generation scheme is planned as an inter-basin transfer from the Lake Victoria North Catchment Area to the Rift Valley Catchment Area via a 53.4 km tunnel. In case such diversion scheme matches with the water balance calculation of this study, the Hemsted Bridge Dam would be considered.

The Nzoia Dam (34B) was planned in the upper reach of the Nzoia River before it joins with the Kipkaren River. The dam was planned for water supply, flood control, irrigation, and hydropower development. According to the F/S report by the National Water and Conservation and Pipeline Corporation (NWCPC) in December 2010, its hydropower component has an installed capacity of 16 MW.

The Nzoia Dam (42A) was planned at the lower reach of the Nzoia River near Ugunja Town. The dam was planned for flood control and hydropower development. According to the study report by the

National Irrigation Board (NIB) in January 2011, its hydropower component has an installed capacity of 25 MW.

2.3.3 Lake Victoria South Catchment Area

(1) Existing Hydropower Station

There are three existing hydropower stations in the Lake Victoria South Catchment Area, namely, Gogo Falls, Sondu/Miriu and Sangoro power stations.

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

The Sondu/Miriu and Sangoro power stations are located in the downstream reach of the Sondu River. The Sondu/Miriu Power Station is a run-of-river type hydropower scheme with an installed capacity of 60 MW. The Sangoro Power Station uses the tailwater of Sondu/Miriu Power Station and its remaining head between the power station and the Sondu River to generate an additional 21 MW.

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

(2) Multipurpose Dam Development Project by the MORDA

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

2.3.4 Rift Valley Catchment Area

(1) Existing Hydropower Station

There is only one existing hydropower station in the Rift Valley Catchment Area, namely the Turkwel Hydropower Station. This hydropower station is located in the upstream reach of the Turkwel River with an installed capacity of 106 MW.

(2) Multipurpose Dam Development Project by the KVDA

There is a proposed multipurpose dam project called the Arror Dam, which is located in the Arror River, a tributary of the Kerio River in its upstream reach. The dam was designed for hydropower and irrigation. According to information from the KVDA, the hydropower component of the Arror Dam would have an installed capacity of 80 MW.

There is another multipurpose dam project called the Embobut Dam, which is located in the Embobut River, a tributary of the Turkwel River in the upstream reach. The dam was designed for hydropower and irrigation. According to information from the KVDA, the hydropower component of the Embobut Dam would have an installed capacity of 45 MW.

Another multipurpose dam project called the Kimwarer Dam is located in the most upstream reach of the Kerio River. The dam was designed for hydropower and irrigation. According to the information from the KVDA, the hydropower component of the Kimwarer Dam would have an installed capacity of 20 MW.

(3) Multipurpose Dam Development Project by the ENSDA

There are three multipurpose dam development projects which have hydropower components. These dams are the Oletukat, Leshota and Oldorko dams with cascade development along the Ewaso Ng'iro South River. These three projects are under the Lower Ewaso Ng'iro South River Multipurpose Dam Project. According to information from the ENSDA, its F/S is ongoing, having started in June 2012 for a period of 18 months. Although the figures are still preliminary, the project would have a total installed capacity of 180 MW. Out of the 180 MW, 36 MW would be produced by the Oletukat Dam, 54 MW by the Leshota Dam, and 90 MW by the Oldorko Dam.

2.3.5 Athi Catchment Area

(1) Existing Hydropower Station

There is no existing hydropower station in the Athi Catchment Area.

(2) Multipurpose Dam Development Project by the TARDA

There are two multipurpose dam projects proposed by the TARDA, namely, the Munyu and Thwake dams. The Munyu Dam was designed for hydropower and irrigation. According to information from the TARDA, the hydropower component of the Munyu Dam would have an installed capacity of 40 MW.

The Thwake Dam was designed for water supply, irrigation and hydropower development. According to information from the TARDA, the hydropower component of the Thwake Dam would have an installed capacity of 20 MW.

2.3.6 Tana Catchment Area

(1) Existing Hydropower Station

There are five major power stations in the Tana Catchment Area in the upstream reach of the Tana River, namely, the Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere. The total installed capacity of these five power stations is 563.2 MW, which is 37% of the total installed capacity in the country as of June 2011. In terms of power generation, these five power stations accounts for 39% of the total power generation in the country[2].

There are also small hydropower stations further in the upstream area of these five major power stations, namely, the Ndula, Tana, Wanji, Mesco and Sagana power stations.

(2) Multipurpose Dam Development Project by the TARDA

There is one multipurpose dam development project proposed by the TARDA, namely, the High Grand Falls Dam. According to the F/S report prepared by the 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 would have an installed capacity of 500 MW in Stage 1 (2018-2027) and an additional 200 MW (2028-) in Stage 2 of the project.

2.3.7 Ewaso Ng'iro North Catchment Area

(1) Existing Hydropower Station

There is no existing hydropower station in the Ewaso Ng'iro North Catchment Area.

(2) Multipurpose Dam Development Project

There is no development plan in the catchment area.

2.4 Ongoing Projects and Existing Plans

The ongoing projects and existing plans in the hydropower sector are explained below.

(1) Ongoing Project

According to the Least Cost Power Development Plan (LCPDP) 2011-2031, the ongoing hydropower project is the upgrading of the Kindaruma Hydropower Station to increase its capacity with an additional 32 MW. The upgrading works are on-going and will be completed by 2014.

(2) Existing Plans

1) Updated Least Cost Power Development Plan (Study Period: 2011-2031)

KenGen and other power sector related organisations prepare the LCPDP every year in March to indicate the power development plan for the next 20 years. The latest LCPDP was prepared in March 2011 for the period from 2011 to 2031.

As mentioned in Section 2.1, by referring to the National Energy Policy (Third Draft), the government directs to decrease the dependency on hydropower generation to keep the ratio of hydropower generation at appropriate levels in the energy mixture as countermeasures against

[2] KP Annual Report and Financial Statements 2010/2011

future climate change. In the LCPDP 2011-2031, it was planned that the current ratio of installed hydropower capacity against the total installed capacity will decrease from the current level of around 50% to around 5% toward 2031, as shown in Figure 2.4.1.

The LCPDP 2011-2031 shows the following hydropower projects as scheduled to be put into the national grid.

Candidate Projects in the LCPDP 2011-2031

No.	Project Name	Installed Capacity (MW)	Commissioning Year
1	Import of Hydropower	200	2014
2	Kindaruma Upgrade	32	2014
3	Small Hydropower	25	2015
4	Mutonga and Low Grand Falls	200	2018
Total		457	

Source: LCPDP 2011-2031

Of the above projects, according to the TARDA, the Mutonga and Low Grand Falls projects will be replaced with the High Grand Falls Project, which has a total installed capacity of 700 MW (500 MW for Stage 1 to be commissioned in 2018, and additional 200 MW for Stage 2 to be commissioned in 2028). The High Grand Falls Project is one of the flagship projects in Kenya Vision 2030.

2) Other Hydropower Projects by KenGen

According to information from KenGen, KenGen has the following extension projects other than the above listed projects:

a) Raising of Full Supply Level (FSL) of the Masinga Dam

Extension is planned to raise the FSL of the Masinga Dam by 1.5 m. Through this extension, the reservoir is able to have additional storage of 188 million m^3 with additional power generation of 81 GWh per year. The extension project is in the design stage.

b) Extension of the Gogo Falls Dam

KenGen intends to extend the installed capacity of the Gogo Falls Dam to 60 MW at maximum from its current 2 MW. However, detailed examination and final decision has not yet been made.

3) Multipurpose Development Projects under the MORDA

The MORDA also considers the hydropower scheme as a part of the multipurpose development. Currently, there are five multipurpose dam development schemes being studied under the MORDA. Though the figures are not yet final, the interim results of the hydropower generation components are as shown in the following table.

Multipurpose Dam Development Schemes under the MORDA

Name of Development Scheme	Preliminary Size of Hydropower Generation	Source of Information
High Grand Falls	Stage 1: 500 MW Stage 2: +200 MW	F/S Report, February 2011
Nandi Forest	50 MW	F/S Report, November 2010
Arror	80 MW	KVDA
Magwagwa	115 MW	Investment Plan for Magwagwa Multipurpose Project, July 2011
Mwache	No hydropower scheme considered.	MORDA

Source: MORDA

4) Small Hydropower Development by the MOE

From January to June 2006, the MOE assessed the countrywide small hydropower potential using existing studies and data. The assessment result showed that there are about 600 MW of unexploited small hydropower potential. However, due to limited hydrological data and accurate topographic survey results, the assessment result recommends further feasibility studies on 15 sites for refinement of the existing studies. The sites include Gachoronina, Zaina, Thiba, Gicheru, Mpenja, Gitwiki, Ndurumo, Timbiri Falls, Reuben and Rokonget 1 and 2 combination, Legon, Jeamich Falls, Yala Falls, Ndano Falls, Webuye, and Embobut.

5) Small Hydropower Development by the KTDA

The KTDA's subsidiary company, the Kenya Tea Power Company (KTPC), is responsible for the development of small hydropower stations to feed electricity to their factories as well as selling electricity to the grid. The KTPC has 12 regional companies which manage their own power stations at their regions. The KTPC has identified 14 small hydropower potential sites for further development with a total installed capacity of about 28 MW. The sites include South Mara, Mutonga, Iraru, Thuci, Nyamindi, Kiringa, Maragwa, Chania, Itare, Kipsonoi 1, Kipsonoi 2, Gucha, Gura, and North Mathioya.

2.5 Operations and Maintenance Issues

Sedimentation in the reservoir will be a major operation and maintenance issue for hydropower generation related to water resources. In the upper Tana River, the sediment inflow into the reservoirs is becoming serious due to catchment degradation. Catchment degradation results from the encroachment of forest lands by people seeking for water resources and forest resources for socio-cultural benefits. Accelerated sedimentation in the reservoir will shorten the lifespan of reservoirs, which currently supply about 40% of the total electricity supply in the country. Careful monitoring of the reservoir sedimentation and preventive measures should be considered accordingly.

2.6 Challenges and Key Issues

Based on the review of the NWMP (1992) and the current situation of the hydropower sector, the challenges and key issues of the hydropower sector have been identified as follows:

(1) Low Rate of Development Against the Target

Of the seven proposed projects in the NWMP (1992), only three projects were implemented and operated, namely, the extension of the existing Gitaru Power Station (80 MW), the Sondu/Miriu Hydropower Project (60 MW), and the Sangoro Hydropower Project (21 MW). The total additional capacity is 161 MW. The achievement ratio against the proposed 525.1 MW in the NWMP (1992) is 31%.

(2) High Dependency on Hydropower

As compared in the 1990s, the share of hydropower has decreased for both installed capacity and generation output; however, the hydropower still kept the highest share among other energy sources as of 2011. In the case of severe drought especially in the Tana River, a significant drawdown of power output occurs which badly affects the power supply of the whole country. A proper mixture of energy sources is necessary to stabilize the power supply in any occasion.

(3) Aging of Existing Power Stations

The power stations in the Tana River have existed for 20 to 40 years from their construction. Considering the current high dependency on hydropower generation, it will be necessary to keep the present power generation capacity as much as possible through rehabilitation and upgrading of the existing power stations.

(4) Promotion of Multipurpose Dam Projects with Hydropower Components

Although studies on the five multipurpose dam development projects are in-progress, it is not clearly decided when the projects can be realised as well as which institution/organisation would finance and coordinate the projects. So far there is no significant progress on the multipurpose dam development projects in Kenya. The main challenge for development will be the coordination among many beneficiaries, sponsors, government, and other stakeholders in order to maximize the benefits of the multipurpose dam and to minimize any adverse affects. In Kenya, it seems that communications among ministries and agencies are not well-coordinated. Therefore, strong coordination between agencies will be required to realise the development of such multipurpose dams.

CHAPTER 3 HYDROPOWER DEVELOPMENT PLAN

3.1 General

A hydropower development plan was formulated considering the current conditions of hydropower development, as described in Chapter 2, namely, energy policy, related organisations, development situations by catchment, existing plans, challenges and key issues. From the viewpoint of catchment management, the hydropower development plan was formulated for the six catchment areas of the WRMA, the same way other development plans were formulated.

3.2 Overall Concept and Framework for Planning

As a result of the review works of existing documents related to the power sector, the following documents are regarded as key documents which describe the policy and planning directions of the power sector in the country, including hydropower development:

i) National Energy Policy (Draft), May 2012

ii) Updated Least Cost Power Development Plan (LCPDP) (Study Period: 2011-2031), March 2011

By referring to the above documents, a hydropower development plan was formulated based on the following framework:

i) Formulate a plan by taking up plans in the LCPDP, which is a key document for power development planning in the country.

ii) Take up plans for hydropower components of multipurpose dam development schemes to promote the efficient use of water among other water sources such as water supply and irrigation.

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

3.3 Hydropower Development Plan for the Lake Victoria North Catchment Area (LVNCA)

3.3.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following two strategies were applied for the development of the LVNCA:

i) Apply development plans based on the LCPDP.

ii) Apply hydropower components of multipurpose dam development schemes.

The above strategies will be applied to the LVNCA as follows:

i) LCPDP projects: There is no plan proposed in the LCPDP.

ii) There are three multipurpose dam schemes with hydropower components, namely, the Nandi Forest Dam, the Nzoia (34B) Dam, and the Nzoia (42B) Dam. These three dams will be taken up as proposed plans.

3.3.2 Proposed Hydropower Plan

Based on the development strategy in Subsection 3.3.1, the following hydropower development plans will be taken up in the NWMP 2030.

(1) Nandi Forest Multipurpose Dam

As one of the proposed multipurpose dam projects by the MORDA, the Nandi Forest Dam was taken as a candidate project in the NWMP 2030. The MORDA has already conducted an F/S, which was completed in October 2010. According to the F/S report by the MORDA, the Nandi Forest Dam is planned to be constructed in the middle reach of the Yala River and would have an installed capacity of 50 MW.

(2) Nzoia (34B) Multipurpose Dam

The Nzoia (34B) Multipurpose Dam was taken as a candidate project in the NWMP 2030. The Nzoia (34B) Multipurpose Dam is planned in the upstream reach of the Nzoia River. The NWCPC completed its F/S in March 2010. According to the F/S report, the Nzoia (34B) Multipurpose Dam is scheduled to have an installed capacity of 16 MW.

(3) Nzoia (42A) Multipurpose Dam

The Nzoia (42A) Multipurpose Dam is planned to be constructed in the downstream reach of the Nzoia River near Ugunjua. According to a study report in January 2011 prepared by the NIB, the Nzoia (42A) Multipurpose Dam is scheduled to have an installed capacity of 25 MW.

The following table shows the summary of development schemes in the LVNCA.

Hydropower Development Schemes in the LVNCA

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

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

The locations of the proposed hydropower projects are as shown in Figure 3.3.1.

3.4 Hydropower Development Plan for the Lake Victoria South Catchment Area (LVSCA)

3.4.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following three strategies were applied for the development of the LVSCA:

i) Apply development plans based on the LCPDP.

ii) Apply hydropower components of multipurpose dam development schemes.

The above strategies will be applied to the LVSCA as follows:

i) LCPDP projects: There is no plan proposed in the LCPDP.
ii) Multipurpose dam development schemes: There is one multipurpose dam scheme with hydropower component, namely the Magwagwa Dam. This dam will be taken up as a proposed plan.

3.4.2 Proposed Hydropower Plan

Based on the development strategy in Subsection 3.4.1, the following hydropower development plans will be taken up for NWMP 2030.

(1) Magwagwa Multipurpose Dam

As one of the proposed multipurpose dam projects by the MORDA, the Magwagwa Dam was taken as a candidate project in the NWMP 2030. The MORDA has conducted a preliminary design and investment plan for this project, which was completed in July 2011. According to the investment plan by the MORDA, the Magwagwa Dam is planned in the middle reach of the Sondu River, which would have an installed capacity of 115 MW.

Hydropower Development Schemes in the LVSCA

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

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

The locations of the proposed hydropower projects are as shown in Figure 3.3.1.

(2) Other Projects

KenGen intends to expand the Gogo Falls Dam from the current installed capacity of 2 MW to 60 MW at maximum. Since a concrete plan for expansion has not yet been decided as of November 2012, this plan was not taken up in the NWMP 2030 at the moment. Furthermore, the NIB is also interested in the redevelopment of the Gogo Falls Dam in order to expand irrigation areas downstream. In this regard, the coordination between KenGen as power generator and NIB as irrigation developer should be promptly required. Once detailed development plans have been agreed to and prepared, the scheme should be taken up as a NWMP 2030 candidate project.

3.5 Hydropower Development Plan for the Rift Valley Catchment Area (RVCA)

3.5.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following three strategies are applied for the development of the RVCA:

i) Apply development plans based on the LCPDP.
ii) Apply hydropower components of multipurpose dam development schemes.

The above strategies will be applied to the RVCA as follows:

i) LCPDP projects: There is no plan proposed in the LCPDP.

ii) Multipurpose dam development schemes: There are six multipurpose dam schemes with hydropower components, namely, the Arror, Oletukat, Leshota, Oldorko, Kimwarer, and Embobut dams. These dams will be taken up as proposed plans.

3.5.2 Proposed Hydropower Plan

Based on the development strategy in Subsection 3.5.1, the following hydropower development plans will be taken up in the NWMP 2030.

(1) Arror Multipurpose Dam

As one of the proposed multipurpose dam projects by the MORDA, the Arror Dam was taken as a candidate project in the NWMP 2030. The Arror Dam is to be constructed in the Arror River, a tributary of the Kerio River in the upstream reach. According to information provided by the KVDA in November 2012, a pre-F/S of the Arror Dam has been completed. The Arror Dam is planned to have an installed capacity of 80 MW.

(2) Lower Ewaso Ng'iro South Multipurpose Dam (Oletukat, Leshota, and Oldorko)

The ENSDA has three development plans, namely, the i) Oletukat, ii) Leshota, and iii) Oldorko hydropower projects, which are located in the upstream reach of the Ewaso Ng'iro South River. These projects combined are called the "Lower Ewaso Ng'iro South Multipurpose Dam," which is under cascade scheme for development. For these three projects, there is an ongoing F/S, which started in June 2012 with a schedule of 18 months.

(3) Kimwarer Multipurpose Dam

The Kimwarer Multipurpose Dam is planned at the most upstream part of the Kerio River. According to information from the KVDA in November 2012, a pre-F/S of the Kimwarer Dam has been completed. The Kimwarer Dam is planned to have an installed capacity of 20 MW.

(4) Embobut Multipurpose Dam

The Embobut Multipurpose Dam is planned at the most upstream part of the Kerio River. According to information from the KVDA in November 2012, a pre-F/S of the Embobut Dam has been completed. The Embobut Dam is planned to have an installed capacity of 45 MW.

Hydropower Development Schemes in the RVCA

No.	Name of Scheme	Installed Capacity (MW)	Purpose	Source of Information
1	Arror Multipurpose Dam	80	Water Supply, Irrigation, Hydropower	KVDA
2	Oletukat Multipurpose Dam	36	Water Supply, Hydropower	ENSDA
3	Leshota Multipurpose Dam	54	Water Supply, Hydropower	ENSDA
4	Oldorko Multipurpose Dam	90	Water Supply, Irrigation, Hydropower	ENSDA
5	Kimwarer Multipurpose Dam	20	Water Supply, Irrigation, Hydropower	KVDA
6	Embobut Multipurpose Dam	45	Water Supply, Irrigation, Hydropower	KVDA
	Total	325		

Source: JICA Study Team based on information from MORDA, KVDA and ENSDA

The locations of the proposed hydropower projects are as shown in Figure 3.3.1.

3.6 Hydropower Development Plan for the Athi Catchment Area (ACA)

3.6.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following three strategies are applied for the development of the ACA:

i) Apply development plans based on the LCPDP.
ii) Apply hydropower components of multipurpose dam development schemes.

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

i) LCPDP projects: There is no project proposed in the LCPDP.
ii) Multipurpose dam development schemes: There are two multipurpose dam schemes proposed, namely, the Thwake and Munyu dams.

3.6.2 Proposed Hydropower Plan

Based on the development strategy in Subsection 3.6.1, the following hydropower development plans will be taken up in the NWMP 2030.

(1) Munyu Multipurpose Dam

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

(2) Thwake Multipurpose Dam

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

Hydropower Development Schemes in the ACA

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

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

The locations of the proposed hydropower projects are as shown in Figure 3.3.1.

3.7 Hydropower Development Plan for Tana Catchment Area (TCA)

3.7.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following three strategies are applied for the development of the TCA:

i) Apply development plans based on the LCPDP.
ii) Apply hydropower components of multipurpose dam development schemes.

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

i) LCPDP projects: There are two projects proposed in the LCPDP, namely, the upgrading of the Kindaruma Hydropower Station, the Mutonga Hydropower Project and the Low Grand Falls Hydropower Project. The upgrading of the Kindaruma Hydropower Station is under construction and is expected to be completed by 2014. With the upgrade, Kindaruma Hydropower Station will have an additional 32 MW installed capacity to its existing 40 MW. The Mutonga (60 MW) and Low Grand Falls (140 MW) Hydropower Projects have been scheduled; however, according to the TARDA, both 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 by the MOE, and will be reflected in the next update of the LCPDP.
ii) Multipurpose dam development schemes: As mentioned above, there is one multipurpose dam scheme proposed, namely the High Grand Falls Dam.

In addition to the above, KenGen has a plan to develop the Karura Hydropower Project, which would utilise the remnant head between Kindaruma and Kiambere. The installed capacity would be 90 MW.

3.7.2 Proposed Hydropower Plan

Based on the development strategy in Subsection 3.7.1, the following hydropower development plans will be taken up in the NWMP 2030.

(1) High Grand Falls Multipurpose Dam

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

(2) Karura Hydropower Project

KenGen is executing an F/S of the Karura Hydropower Project as of January 2013. The Karura Hydropower Project is planned to utilise the remnant head between the Kindaruma Hydropower Station and the Kiambere Reservoir. The hydropower project is expected to have an installed capacity of 90 MW. According to KenGen, the F/S is expected to be completed by January 2013, and is expected to be commissioned in 2018. The F/S report for the Karura Hydropower Project is on-going as of January 2013.

Hydropower Development Schemes in 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	Karura Hydropower	90	Hydropower	KenGen
	Total	790		

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

The locations of the proposed hydropower projects are as shown in Figure 3.3.1.

3.8 Hydropower Development Plan for Ewaso Ng'iro North Catchment Area (ENNCA)

3.8.1 Development Strategy

Following the overall concept and framework for planning as mentioned in Section 3.2, the following three strategies are applied for the development of the ENNCA:

i) Apply development plans based on the LCPDP.
ii) Apply hydropower components of multipurpose dam development schemes.

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

i) LCPDP projects: There is no plan proposed in the LCPDP.
ii) Multipurpose dam development schemes: There is no multipurpose dam scheme with hydropower component.

Considering the above strategies and situation of the catchment area, there is no hydropower development plan proposed for the ENNCA.

3.8.2 Proposed Hydropower Plan

There is no hydropower development plan proposed for the ENNCA.

CHAPTER 4 COST ESTIMATE

4.1 Basic Conditions for Cost Estimate

Cost estimates were made for the 14 proposed hydropower schemes mentioned in Chapter 3.

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

The basic conditions for the project cost estimate are as follows:

a) Project costs are updated to the current price level as of November 1, 2012;

b) Exchange rate applied is US$1.0 = KSh85.24 as of November 1, 2012;

c) Physical contingency is assumed to be 15% of the direct construction cost;

d) Cost of engineering services (detailed design and construction supervision) is assumed to be 10% of the direct construction cost; and

e) Land acquisition cost is assumed at KSh100,000 per ha, if evidence is unavailable.

4.2 Cost Estimates for Proposed Plans

Required costs were estimated for (i) construction costs and (ii) operations and maintenance costs.

4.2.1 Construction Cost

(1) Cost Estimate of Multipurpose Projects

For the construction of multipurpose dam projects, it is necessary to share dam construction cost by related subsectors such as irrigation, water supply, hydropower, etc. To decide the ratio of cost sharing by the subsectors, the results of the water balance calculation were referred to. Based on the allocated water volume to relevant sector, cost allocation was considered.

For hydropower development schemes, the construction cost for hydropower components such as headrace tunnel, penstock and power station were estimated in addition to allocated dam construction cost.

In case any estimated costs are available through related studies, such as pre-F/S, F/S or preliminary design, such figures will be applied for cost estimation.

(2) Cost Estimate of Hydropower Development Schemes

For hydropower development schemes, related study reports by developers or donors were referred to for cost estimatation.

4.2.2 Operation and Maintenance Costs

The annual operations and maintenance (O&M) costs for completed project facilities were assumed as a fixed rate of percentage to the project costs, namely 0.5% per annum of the allocated dam construction cost and hydropower component construction cost. Estimated costs for the proposed hydropower projects are as shown in Table 4.2.1.

CHAPTER 5 ECONOMIC EVALUATION

5.1 Evaluation Method and Basic Conditions

The economic viability of selected projects is evaluated based on the estimated economic cost and hydropower benefit. The criteria for economic decision making are based on the following:

a) Economic internal rate of return (EIRR)
b) Net present value (NPV)
c) Benefit and cost ratio (B/C ratio)

The following assumptions were made for the economic analysis:

a) Price Level:

Investment costs and O&M costs were estimated at the current price level in November 1, 2012. All prices are expressed in US$ currency. The foreign exchange rates were set at Ksh 85.24 to US$1.00, JP¥79.98 to US$1.00, and KSh110.48 to €1.00.

b) Economic Value:

The prices of internationally tradable goods and services will be valued on the basis of the international border prices, which are often expressed in the World Bank's "Commodity Prices and Price Forecast". The price of non-traded goods and services will be converted from their financial value to economic value 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.

c) 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.

d) Economic Life of the Projects:

The economic life of the projects was set at 50 years for hydropower projects, as is normally applied for hydropower projects and also applied in the planning documents such as the LCPDP in Kenya.

e) Multipurpose Dams:

The construction costs and annual O&M costs of multipurpose dams were allocated on the basis of the existing F/S, the role of leading subsectors for project implementation, and water storage volume.

Twelve selected hydropower projects were preliminarily evaluated for the analysis of economic viability, while the overall economic evaluation was carried out for each catchment at the master plan level. The Oletukat, Leshota, and Oldorko projects were integrated into one hydropower project called the "Lower Ewaso Ng'iro South (LENS) River Multipurpose Dam Scheme", since these projects were located along the same river. The F/S of the LENS scheme has been undertaken since June 2012. The economic evaluation on the High Grand Falls (HGF) project is based on the results of its F/S in 2011. This report does not perform additional analysis.

5.2 Economic Benefits

There are two types of benefits identified for the selected hydropower projects as follows:

(1) Capacity Benefit

If the selected hydropower projects were not constructed, alternative thermal power plant would be built in order to meet the increased energy demand. The economic benefit of hydropower projects is considered as an avoided cost of constructing an alternative thermal power plant for the firm or peak power output. This is called capacity benefit (kW-value), or opportunity cost of constructing alternative thermal benefits. This capacity benefit includes the investment cost and fixed O&M costs of thermal power plants as an alternative.

In this study, three types of generation plants were selected for candidate alternative thermal power stations, namely, gas-fired generation unit, coal-fired steam generation unit, and medium speed diesel generation unit. General information on capital cost, construction period, and project life for the three types of generation in Kenya were provided in the Updated Least Cost Power Development Plan 2011-2031 as of March 2011. Such information are shown in the following table. The capital costs of generation plants were adjusted to the current price level in November 2012.

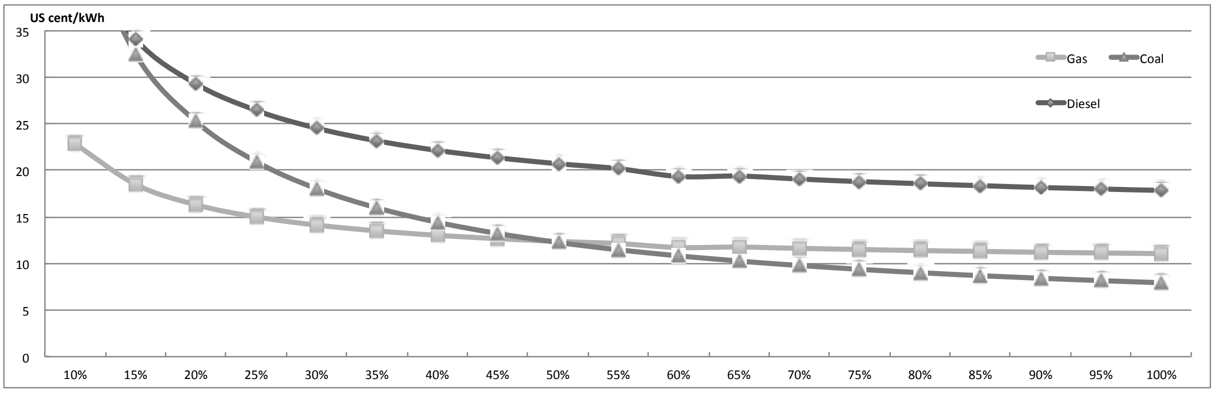
General Features of Alternative Thermal Plants in Kenya

Item	Unit	Gas-fired	Coal-fired Steam	Medium Speed Diesel
Capital Cost*[a]	US$/kW	790	2,216	1,436
Construction Period*[b]	Years	2	4	2
Project Life*[b]	Years	20	25	20
Heat Rate*[b]	KJ/kWh	9,504	9,914	9,336
Fuel Price*[c]	US$	10.83/MMBTU	94.5/ton	106.48/BBL
Unit Cost of Fuel	US$/kWh	0.0684	0.0354	0.1336
Annual Fixed O&M		3% of capital cost	5% of capital cost	5.5% of capital cost

Source: *[a] LCPDP 2011, the data adjusted from 2011 price to November 2012 price.
*[b] LCPDP 2011
*[c] *Commodity Prices and Price Forecast*, September, 2012, the World Bank

Fuel prices are an important factor in calculating the average generation cost of thermal plants. The fuel price forecast by the World Bank in the "Commodity Prices and Price Forecast, dated September 10, 2012" is the latest available data and reflects a border price (international prices) for fuels, which were used in this study. The average international fuel prices between 2012 and 2025 were applied in this study, because the project will be operational in the long-term.

The following figure shows the levelised generation costs of alternative thermal plants throughout the project life by plant factor (PF), based on the above assumptions. When PF is lower than 50%, gas-fired generation unit is the cheapest because of the cheapest capital cost (US$790/kW). When PF is higher than 50%, coal-fired steam plant is the cheapest, mainly due to its low fuel unit cost (US$0.0354/kWh). From these results, the proposed hydropower projects with PF lower than 50% and installed capacity lower than 100 MW can be compared with gas-fired turbine unit as the cheapest alternative thermal generation unit, since both types of generation can be used for peak power. On the other hand, the proposed hydropower projects with higher PF and installed capacity of more than 100MW can be compared with coal-fired steam, since both types can be used for base power alternatives (Magwagwa and LENS).



Source: JICA Study Team

Generation Cost and Plant Factor of Alternative Thermal Plants

Adjustments for alternative power generation plants are needed to reflect the different features in capacity value when compared with hydropower projects, namely, transmission loss, forced outage, planned outage, and station use. This adjustment is required because additional thermal capacity is necessary for providing an incremental peak load in a system. Generally speaking, hydropower is located far from the prospective consumers compared to thermal plants. But at the preliminary stage, it is difficult to estimate the difference. Therefore, the transmission loss is set at the same rate of 2.00% for both hydropower and thermal plants. The following table shows the efficiency in percent which is used for calculation of adjustment factors. These percentages are typical values which can be applied to relevant energy sources. Using these percentages, the kW adjustment factors to hydropower were calculated as 1.21 for gas-fired generation unit and 1.30 for coal-fired steam generation unit. The kWh adjustment factors to hydropower for gas-fired turbine and coal-fired steam were calculated as 1.03 and 1.07, respectively.

Assumption for Calculating Adjustment Factors

	Hydropower	Alternative (Gas)	Alternative (Coal)
Station Use	0.30%	2.80%	7.00%
Forced Outage	0.50%	8.00%	10.00%
Planned Outage	3.15%	11.00%	12.00%
Transmission Loss	2.00%	2.00%	2.00%

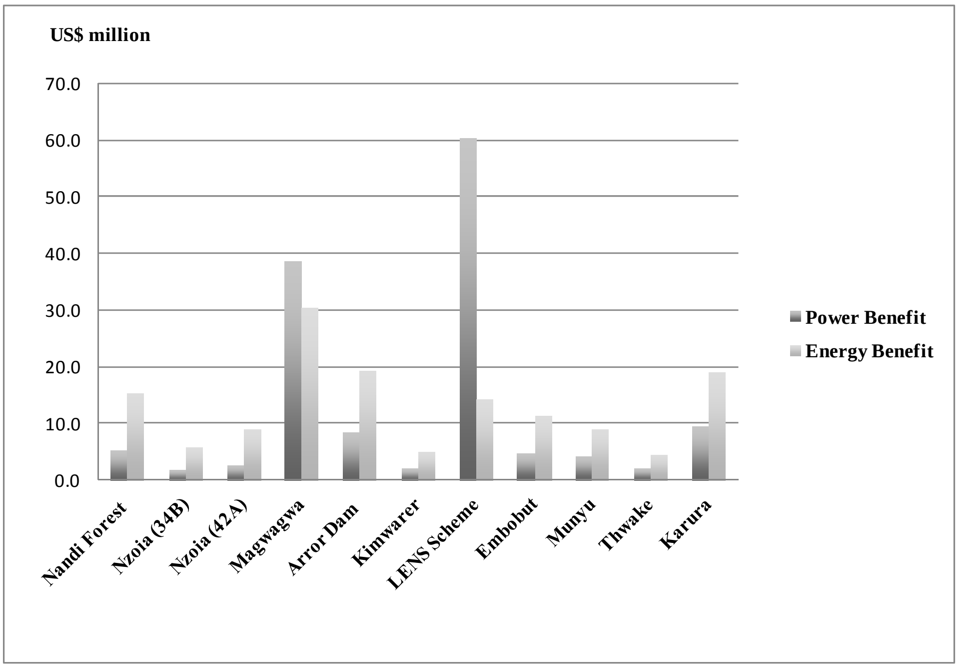
Source: JICA Study Team

Accordingly, the kW values or the annualised fixed costs of alternative power stations were calculated as US$103.3 per kW for gas-fired plant, and US$334.2 per kW for coal-fired steam plant. Using the above assumptions, the power benefit was calculated by multiplying the kW value and installed capacity of alternative thermal plants.

(2) Energy Benefit

The avoided costs of alternative thermal power plant also include fuel costs and variable O&M, which are commonly regarded as energy benefits (kWh-value). Using the above assumptions on the kWh adjustment factors and unit costs of fuel, the energy values were calculated at US$0.101 for gas-fired generation unit and US$0.043 for coal-fired unit. The energy benefit was estimated by multiplying the energy value and the annual energy generation.

The following figure shows the power benefit and energy benefit of proposed hydropower projects. A high power benefit was found in the LENS scheme; however, the referred construction costs should be reviewed as they seem to be too low. Magwagwa has a higher level of energy benefit due to its relatively high annual power generation.



Source: JICA Study Team

Summary of Power Benefits and Energy Benefits of Selected Hydropower Projects

5.3 Economic Cost

(1) Investment Cost

For economic evaluation, the economic investment cost was converted to their equivalent economic value to remove transfer payments such as taxes and subsidies. The investment cost of the Nandi Forest, Nzoia (34B), Nzoia (42A), Arror, Magwagwa, and High Grand Falls were based on the existing F/S and detailed design, while that of other hydropower projects were derived from dam costs of past experiences in Kenya. The cost of multipurpose dam construction was included as described in Section 6.1. Land acquisition cost was calculated from the estimated reservoir area. The physical contingency was included in the investment cost, which was set at 15% of the direct construction cost. The total investment costs for the selected hydropower projects are summarised in Table 5.3.1 and the economic and financial investment costs by each catchment are provided in Table 5.3.2. The total economic investment cost for the proposed hydropower projects was estimated at US$3,185 million.

The implementation period of hydropower projects was set to four years, except for the High Grand Falls and Magwagwa projects, which would take five years to complete their construction.

(2) Annual O&M Cost

The annual O&M costs for this study were set at 0.5% of the initial construction cost for hydropower facilities and 0.5% of the initial construction cost for water source facilities (dam). The O&M cost was further converted to economic value.

5.4 Results of Economic Evaluation

The results of economic evaluation for the selected 12 hydropower projects are summarised in Table 5.4.1. Of the 12 selected hydropower projects, ten hydropower projects exceeded 10% of its EIRR and thus were considered economically viable. The Nandi Forest Dam and the Karura hydropower projects, however, had lower EIRR and B/C ratio, mainly due to their high unit construction costs. Further review is needed for the two projects in the future.

The overall economic evaluation was performed for each catchment and is summarised in Table 5.3.2. All catchments seem to be economically viable for implementing hydropower projects. The high EIRR of the ACA was mainly due to the low level of unit construction cost (US$1,545/kW), however, the level of the unit construction cost should be reviewed by further studies. Although the unit construction cost was relatively high in the LVSCA, the energy and power benefits of this catchment were high; therefore significantly increased its economic benefits. The overall economic impact on the national economy was estimated at US$3,278 million at the present value (as of November 2012).

CHAPTER 6 IMPLEMENTATION PROGRAMME

6.1 General

For the implementation of the proposed 14 hydropower schemes, the implementation programme was prepared, taking into account the priorities and maturity of the plan, etc. The implementation programme was prepared for a period of 18 years from 2013 to 2030 by dividing the term in three, namely, the short term (five years from 2013 to 2017), the medium term (five years from 2018 to 2022), the and long term (eight years from 2023 to 2030).

The individual projects will have EIAs which will address all issues including land acquisition and compensation.

6.2 Criteria for Prioritisation for Implementation

For the formulation of the implementation programme for the proposed 14 projects, the following criteria were used for the prioritisation of projects.

a) For projects in which its commissioning years are clearly mentioned in the national plan or its reports were prepared by implementing agencies, the commissioning years are referred to when formulating the implementation programme.
b) For multipurpose dam projects, priority is decided by referring to the Implementation Programme for Water Resources Development.
c) For projects with related studies that are still premature and needs further confirmation, such projects should be given low priority considering the required additional study period.
d) Projects with low economic viability should be given low priority considering the required period for review and reconsideration of such projects.
e) The implementation programme should be formulated considering the scheduled commissioning year and required period for study, design, procurement and construction.

6.3 Implementation Programmes of Proposed Plans

Based on the criteria mentioned in the previous section, the implementation programme was formulated as shown in Figure 6.3.1.

6.4 Recommendations for Further Surveys and Studies for NWMP2030

In the course of formulation of the hydropower development plan, several assumptions had to be introduced due to lack or insufficiency of the required data and information. For the further study, the following actions are recommended.

(1) Update of National Level Power Development Plan

The proposed hydropower development plan of NWMP 2030 was formulated according to the policy directions of Draft National Energy Policy announced in May 2012, that is, i) to maintain a ratio of hydropower generation in the energy mixture in an appropriate level and ii) to develop hydropower as multipurpose type development from the viewpoint of effective use of limited water resources. However, there is no national target figure for hydropower development toward the future. Also, National Power Development Plan was prepared in 1987 and updated in 1991, but no updating has been made since then.

In this study, the hydropower development target was set based on the existing development plans of which total installed capacity (1,381 MW) is almost near the potential (1,449 MW) stated in the Least Cost Power Development Plan 2011-2031. It is recommended to update the National Power Development Plan including confirmation of hydropower development potential to make the national target of future hydropower development clear.

(2) Further Study on Hydropower Component of Multipurpose Dam Development Plans

The proposed 13 hydropower development plans except Karura Hydropower Development Project are of hydropower component of multipurpose dam development. Among them, Nandi Forest, Magwagwa and High Grand Falls multipurpose dam projects have the detailed study documents. Other plans, especially the plans of which main purposes are irrigation or water supply, have no sufficient information and data for hydropower development planning such as water use rules and storage usable for hydropower. Under such conditions, the proposed hydropower development plans as the components of the multipurpose dam plans had to be formulated roughly. It is recommended to further study the proposed plans with sufficient information and data.

Tables

Table 4.2.1 Cost Estimate for Proposed Hydropower Projects

Catchment Area	No.	Name of Plan	Installed Capacity	Estimated Cost				Purpose
				Dam Allocation Cost (US$ million)	Hydropower Component cost (US$ million)	Total Project Cost (US$ million)	Annual O&M Cost (US$ million)	
LVNCA	1	Nzoia (34B) Multipurpose Dam Development Plan	16 MW	4.7	6.4	11.1	0.06	Water Supply, Irrigation, Flood Control, Hydropower
	2	Nzoia (42A) Multipurpose Dam Development Plan	25 MW	10.5	29.6	40.1	0.20	Flood Control, Hydropower
	3	Nandi Forest Multipurpose Dam Development Plan	50 MW	62.0	197.0	259.0	1.30	Water Supply, Irrigation, Hydropower
		Sub-total	91 MW	77.2	233.0	310.2	1.56	
LVSCA	4	Magwagwa Multipurpose Dam Development Plan	115 MW	167.4	372.9	540.3	2.70	Water Supply, Irrigation, Hydropower
		Sub-total	115 MW	167.4	372.9	540.3	2.70	
RVCA	5	Embobut Multipurpose Dam Development Plan	45 MW	7.7	15.4	23.1	0.12	Water Supply, Irrigation, Hydropower
	6	Arror Multipurpose Dam Development Plan	80 MW	64.5	53.8	118.3	0.59	Water Supply, Irrigation, Hydropower
	7	Kimwarer Multipurpose Dam Development Plan	20 MW	16.1	40.2	56.3	0.28	Water Supply, Irrigation, Hydropower
	8	Oletukat Multipurpose Dam Development Plan	36 MW	220.6	114.9	335.5	1.68	Water Supply, Hydropower
	9	Leshota Multipurpose Dam Development Plan	54 MW	79.0	23.2	102.2	0.51	Water Supply, Hydropower
	10	Oldorko Multipurpose Dam Development Plan	90 MW	26.0	8.7	34.7	0.17	Water Supply, Irrigation, Hydropower
		Sub-total	325 MW	413.9	256.2	670.1	3.35	
ACA	11	Munyu Multipurpose Dam Development Plan	40 MW	25.2	31.5	56.7	0.28	Irrigation, Hydropower
	12	Thwake Multipurpose Dam Development Plan	20 MW	10.5	26.2	36.7	0.18	Water Supply, Irrigation, Hydropower
		Sub-total	60 MW	35.7	57.7	93.4	0.46	
TCA	13	High Grand Falls Multipurpose Dam Development Plan	Stage 1: 500 MW Stage 2: +200 MW	1,168.6	292.0	1,460.6	7.30	Water Supply, Irrigation, Hydropower
	14	Karura Hydropower Development Project	90 MW		333.0	333.0	1.67	Hydropower
		Sub-total	790 MW	1,168.6	333.0	333.0	8.97	
		Total	1,381 MW	1,862.8	1,252.8	1,947.0	17.04	

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

Table 5.3.1 Summary of Investment Cost for Selected Hydropower Projects

(Unit: US$ million)

Catchment Area	No.	Project Name	Installed Capacity (MW)	Unit Construction Cost (US$/kW)	Total Financial Cost	Total Economic Cost
LVN	1	Nandi Forest	50	5,180	259	249
	2	Nzoia (34B)	16	692	11	11
	3	Nzoia (42A)	25	1,605	40	39
LVS	4	Magwagwa	115	4,698	540	519
RV	5	Arror	80	1,481	118	114
	6	Kimwarer	20	2,805	56	54
	7	Lower Ewaso Ng’iro South (LENS) Scheme	180	2,626	472	425
	8	Embobut	45	504	23	22
Athi	9	Munyu	40	1,405	56	54
	10	Twake	20	1,825	37	35
Tana	11	High Grand Falls *	500	2,892	1,446	1,345
	12	Karura	90	3,700	333	320

Note: *The cost of High Grand Falls project was derived from the F/S in 2011

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

Table 5.3.2 Summary of Economic Evaluation for Hydropower Projects by Catchment

(Unit: US$ million)

Catchment Area	Annual Power Generation (GWh)	Estimated Economic Cost	Estimated Financial Cost	Unit Construction Cost (US$/kW)	Net Present Value (10%)		B/C	EIRR
					Cost	Benefit		
LVN	294	293	310	3,409	242	265	1.10	10.9%
LVS	700	519	540	4,698	408	423	1.04	10.3%
RV	681	639	671	2,064	527	846	1.61	15.2%
Athi	131	89	94	1,562	73	132	1.80	16.8%
Tana	1,400	1,666	1,794	3,040	1,419	1,614	1.14	11.8%
Total	3,206	3,205	3,409	2,559	2,668	3,278	1.23	12.2%

Source: JICA Study Team

Table 5.4.1 Summary of Economic Evaluation for Selected Hydropower Projects

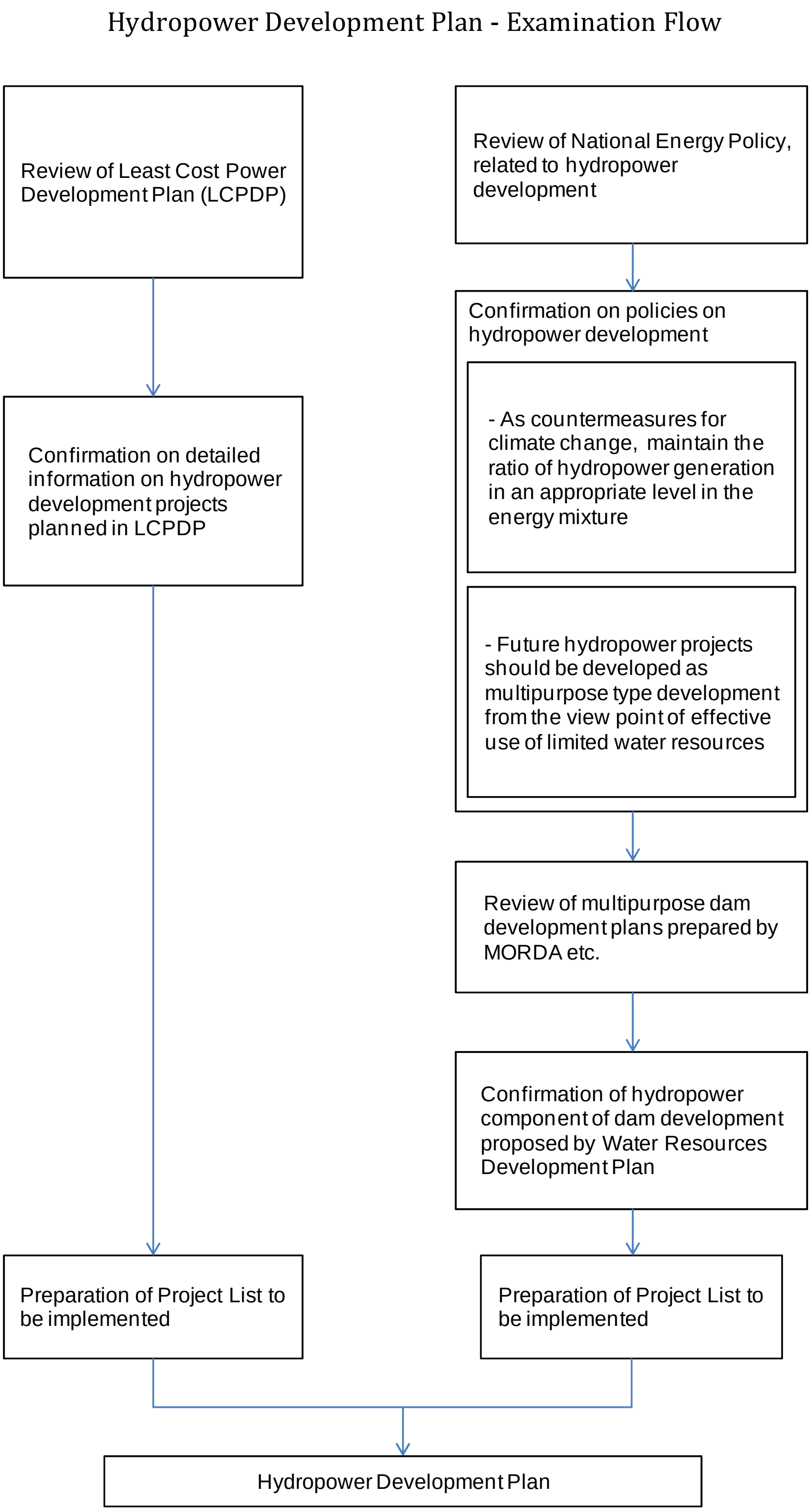
(Unit: US$ million)

Catchment Area	Project No.	Project Name	Net Present Value (10%)		B/C	EIRR
			Cost	Benefit		
LVN	1	Nandi Forest	205	138	0.67	6.7%
	2	Nzoia (34B)	9	50	5.64	39.3%
	3	Nzoia (42A)	32	77	2.43	21.4%
LVS	4	Magwagwa	408	423	1.04	10.3%
RV	5	Arror	94	186	1.98	18.2%
	6	Kimwarer	44	48	1.09	10.8%
	7	Lower Ewaso Ng’iro South (LENS) Scheme	351	504	1.43	13.8%
	8	Embobut	18	108	6.00	40.9%
Athi	9	Munyu	44	88	1.98	18.1%
	10	Twake	29	44	1.52	14.6%
Tana	11	High Grand Falls *	1,154	1,423	1.23	13.3%
	12	Karura	264	190	0.72	7.2%

Note: *The results of economic evaluation in High Grand Falls were derived from the F/S in 2011

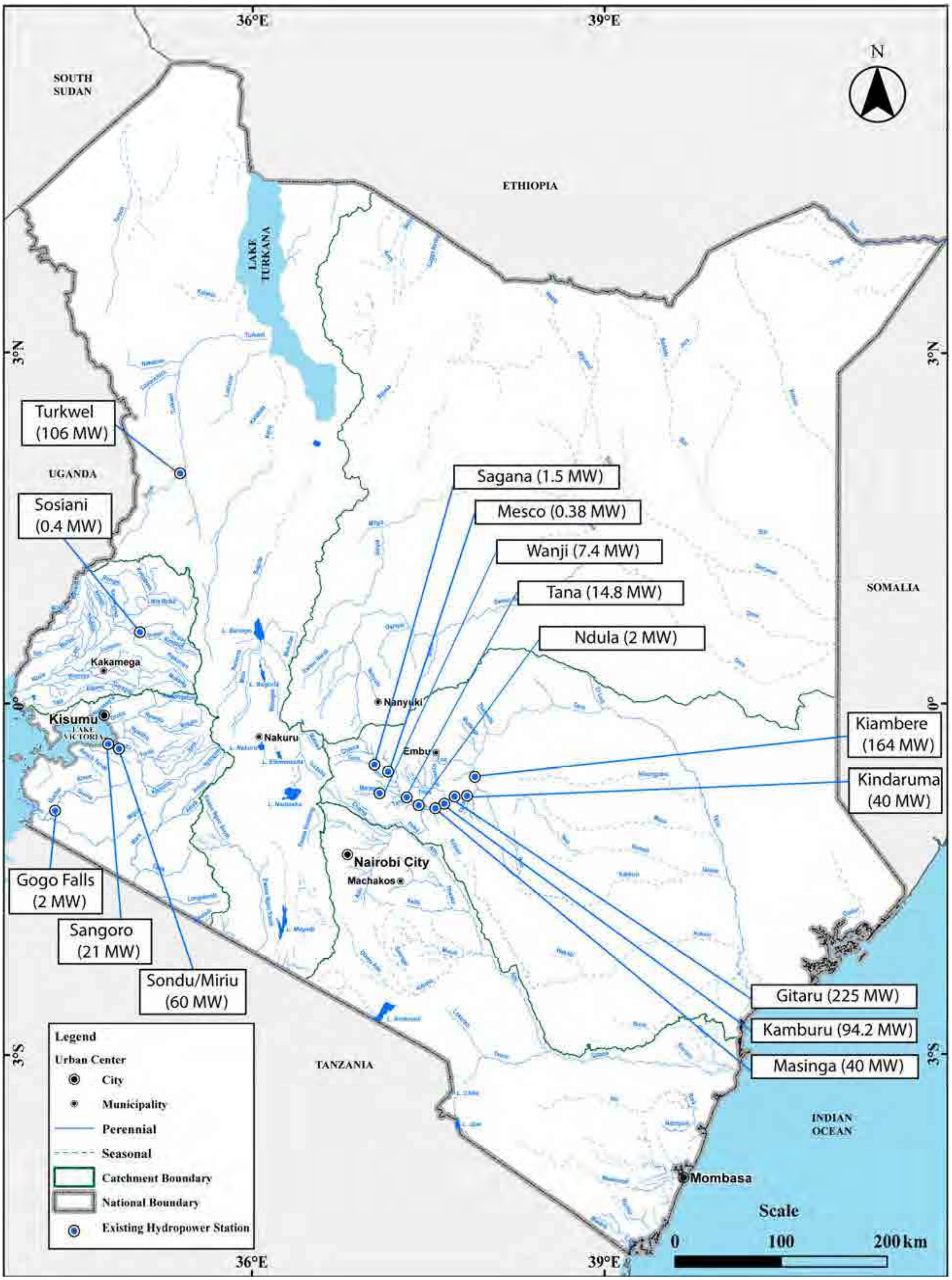
Source: JICA Study Team

Figures



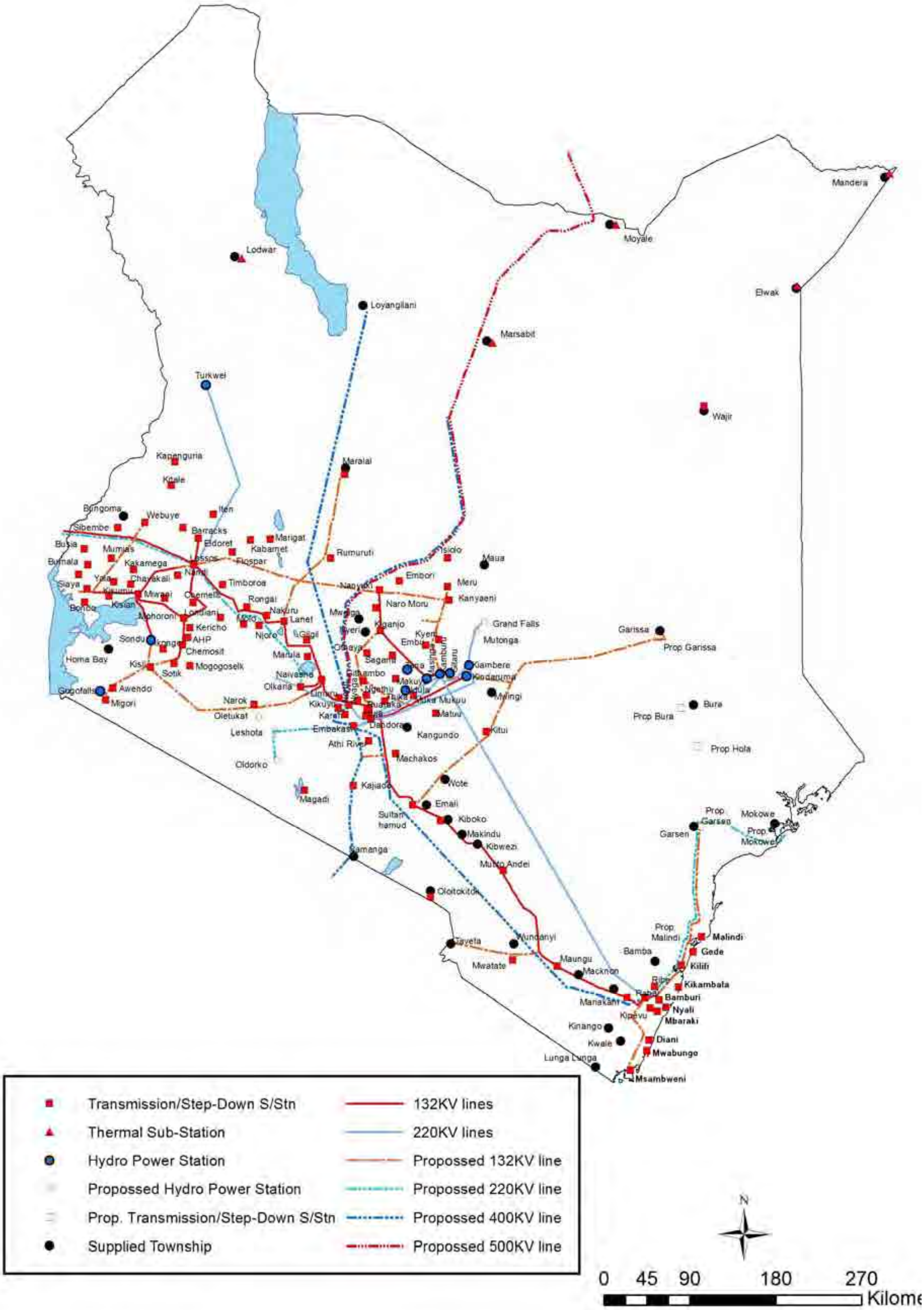
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.1.1 Study Flow for Hydropower Development Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	



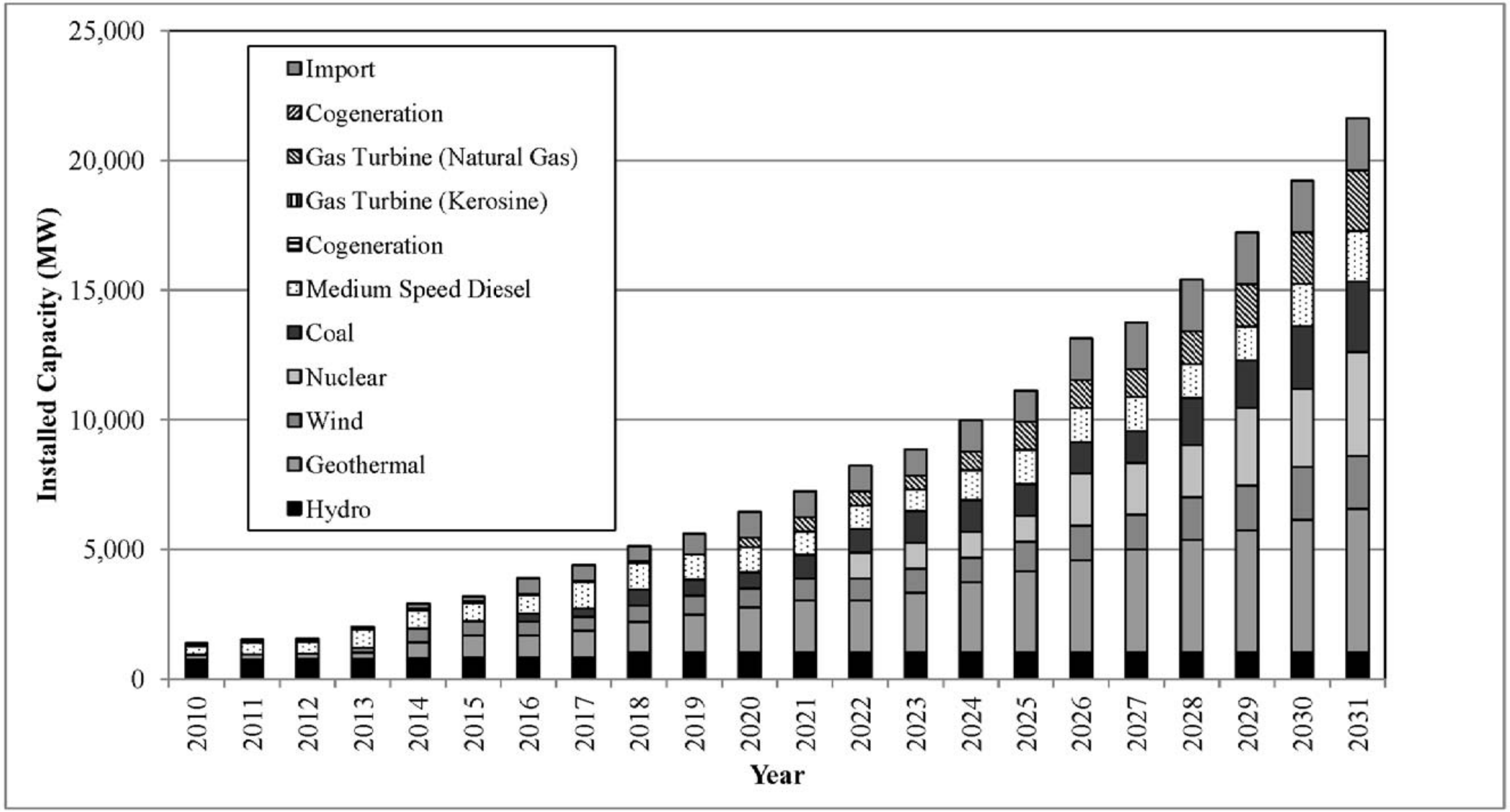
Source: LCPDP 2011-2031

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.1 Locations of Existing Hydropower Stations**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: KETRACO Annual Report (As of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.2 Transmission Network of Kenya**
JAPAN INTERNATIONAL COOPERATION AGENCY	

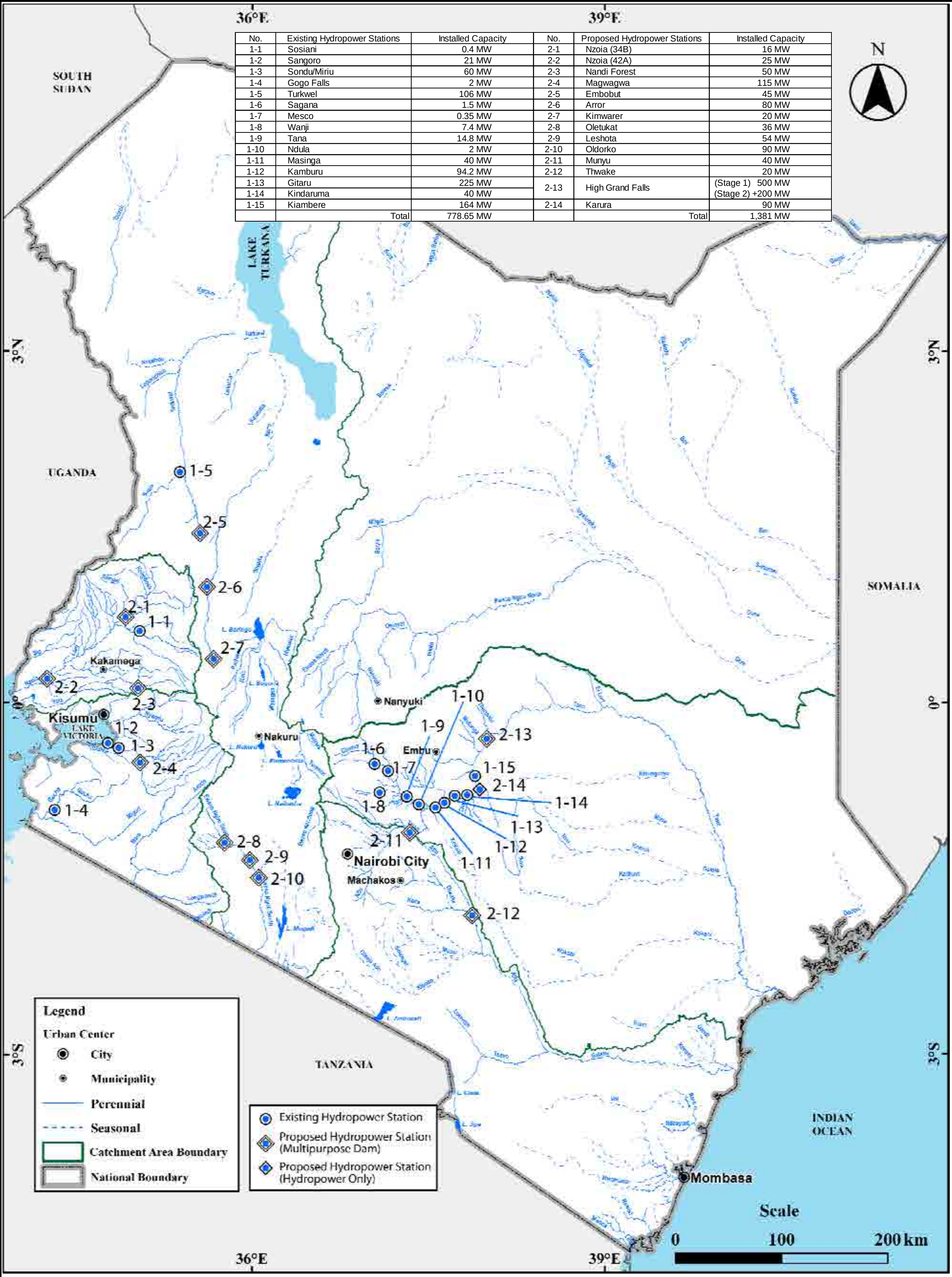


Source: LCPDP 2011-2031

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.4.1 Power Development Plan by Type of Energy



No.	Existing Hydropower Stations	Installed Capacity	No.	Proposed Hydropower Stations	Installed Capacity
1-1	Sosiani	0.4 MW	2-1	Nzoia (34B)	16 MW
1-2	Sangoro	21 MW	2-2	Nzoia (42A)	25 MW
1-3	Sondu/Miriu	60 MW	2-3	Nandi Forest	50 MW
1-4	Gogo Falls	2 MW	2-4	Magwagwa	115 MW
1-5	Turkwel	106 MW	2-5	Embobut	45 MW
1-6	Sagana	1.5 MW	2-6	Arror	80 MW
1-7	Mesco	0.35 MW	2-7	Kimwarer	20 MW
1-8	Wanji	7.4 MW	2-8	Oletukat	36 MW
1-9	Tana	14.8 MW	2-9	Leshota	54 MW
1-10	Ndula	2 MW	2-10	Oldorko	90 MW
1-11	Masinga	40 MW	2-11	Munyu	40 MW
1-12	Kamburu	94.2 MW	2-12	Thwake	20 MW
1-13	Gitaru	225 MW	2-13	High Grand Falls	(Stage 1) 500 MW
1-14	Kindaruma	40 MW			(Stage 2) +200 MW
1-15	Kiambere	164 MW	2-14	Karura	90 MW
	Total	778.65 MW		Total	1,381 MW

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.3.1 Locations of Proposed Hydropower Projects**
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No	Name of Project	Purpose	Installed Capacity (MW)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
LVN	1	Nandi Forest Dam	W, I, P	50	D/D done		P																
	2	Nzoia (34B) Dam	W, I, P, F	16	Flagship D/D ongoing					P													
	3	Nzoia (42A) Dam	W, P, F	25	Flagship D/D ongoing							P											
LVS	4	Magwagwa Dam	W, I, P, F	115	D/D done																		
RV	5	Arror Dam	W, I, P, F	80	D/D done		P																
	6	Oletukat Dam	W, P	36	D/D ongoing				P														
	7	Leshota Dam	W, P	54	D/D ongoing					P													
	8	Oldorko Dam	W, I, P	90	D/D ongoing						P												
	9	Kimwarer Dam	W, I, P	20	F/S done										P								
	10	Embobut Dam	W, I, P	45	Pre-F/S done										P								
Athi	11	Thwake Dam	W, I, P	20	Flagship D/D done		P																
	12	Munyu Dam	I, P	40	Flagship F/S done										P								
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																

(grey)	F/S and/or D/D
P	Procurement
(black)	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 6.3.1
Implementation Schedule for Hydropower Projects

Sectoral Report (G)
Water Resources Development

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

FINAL REPORT
VOLUME – V SECTORAL REPORT (2/3)

G: WATER RESOURCES DEVELOPMENT

Abbreviation

Table of Contents

List of Tables

Page

<u>**List of Figures**</u>

Page

List of Abbreviations and Acronyms

ACA	:	Athi Catchment Area
AfDB	:	African Development Bank
AMREF	:	African Medical and Research Foundation
ASAL	:	Arid and Semi-arid Land
AWSB	:	Athi Water Services Board
B/C	:	Benefit and Cost
CA	:	catchment area
CBO	:	Community Based Organization
CDA	:	Coast Development Authority
CMS	:	Catchment Management Strategy
CWSB	:	Coast Water Services Board
D/D	:	Detailed Design
EC	:	European Commission
EIRR	:	Economic Internal Rate of Return
ENN	:	Ewaso Ng'iro North
ENNCA	:	Ewaso Ng'iro North Catchment Area
ENNDA	:	Ewaso Ng’iro North Development Authority
ENSDA	:	Ewaso Ng’iro South Development Authority
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product
GOK	:	Government of Kenya
HGF	:	High Grand Falls
ICRAF	:	International Centre for Research in Agroforestry
IFAD	:	International Fund for Agricultural Development
IWRM	:	Integrated Water Resources Management
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KFS	:	Kenya Forest Service
KVDA	:	Kerio Valley Development Authority
LBDA	:	Lake Basin Development Authority
LVN	:	Lake Victoria North
LVNCA	:	Lake Victoria North Catchment Area
LVNWSB	:	Lake Victoria North Water Services Board
LVS	:	Lake Victoria South
LVSCA	:	Lake Victoria South Catchment Area
LVSWSB	:	Lake Victoria South Water Services Board
MOA	:	Ministry of Agriculture
MORDA	:	Ministry of Regional Development Authority
MOSSP	:	Ministry of State for Special Programmes
MWI	:	Ministry of Water and Irrigation
NCCRS	:	National Climate Change Response Strategy
NGO	:	Non-Governmental Organization
NIB	:	National Irrigation Board
NPV	:	Net Present Value

NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
NWRMS	:	National Water Resources Management Strategy
NWSB	:	Northern Water Services Board
O&M	:	Operation and Maintenance
P/D	:	Preliminary Design
RDA	:	Regional Development Authority
RV	:	Rift Valley
RVCA	:	Rift Valley Catchment Area
RVWSB	:	Rift Valley Water Services Board
SAPROF	:	Special Assistance for Project Formation
TARDA	:	Tana and Athi River Development Authority
TCA	:	Tana Catchment Area
TWSB	:	Tana Water Services Board
UNICEF	:	United Nations Children's Fund
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WSB	:	Water Service Board
WSTF	:	Water Services Trust Fund

Abbreviations of Measures

Length

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

Area

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

Volume

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

Weight

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

Time

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

Money

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

Energy

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

Others

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

NOTE

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

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

3. Information to be updated

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

   (1) Information on the proposed development projects

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

   (2) Information on the water demand

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

4. Exchange rate for cost estimate

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

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

CHAPTER 1 INTRODUCTION

1.1 Scope of the Report

Water resource is practically a fundamental element in every phase of social and economic life. Good and well balanced planning for water resources development in Kenya takes an important role in view of the limited availability and geographical maldistribution of water sources.

The integrated water resources development plan was formulated for the previous National Water Master Plan (NWMP) (1992) towards the year 2010 by basin. As the readily available water sources appeared to have already been committed for major water demands, the integrated approach to development was introduced to meet the requirement of all the sectors. This approach aimed to avoid competition among water demands and conflict in water use as well as to optimise the use of limited water resources. The major water use sectors were as follows: 1) domestic and industrial water supply, 2) rural and livestock water supply, 3) irrigation water supply, 4) wildlife and fishery, and 5) hydropower development. The development plan was established with high priority on domestic and industrial water supply.

Two decades had passed since the preparation of the NWMP (1992), and situations surrounding water use and demand have been changed in Kenya. Kenya Vision 2030 was prepared in 2007 and presented the country's new development blueprint toward the year 2030. Global climate change has become a great challenge in Kenya, and the Government of Kenya (GOK) prepared the National Climate Change Response Strategy (NCCRS) to deal with the challenge. The aforementioned situations had required the renewal of the NWMP (1992).

The study of the NWMP 2030 (this study) was conducted aiming at the renewal of the NWMP (1992). The planning horizon of the NWMP 2030 is set to year 2030. This Sectoral Report (G) "Water Resources Development" covers, as part of the NWMP 2030, the formulated water resources development plan.

Figure 1.1.1 illustrates the flow of the study to formulate the water resources development plan.

The outputs of the NWMP 2030 are water resources allocation plans in this sub-sector. Each proposed development plan such as dam and water transfer facility plan serves as basic data for the allocation study. Therefore, realisation of the water resources development plan proposed in this study needs more detailed investigations and further studies including alternative studies to seek for an optimum development plan.

1.2 Outline of the Water Resources Development Plans in NWMP (1992)

This section describes an outline of the water resources development plans and priority projects formulated and proposed in the NWMP (1992), which serves as basic information for its renewal.

1.2.1 Development Policies and Plans in NWMP (1992)

The water resources development policies adopted and development plans formulated in the NWMP (1992) for major water use sectors are summarised below.

a) Domestic and Industrial Water Supply: The NWMP (1992) assumed the provision of safe and reliable water to all the population in 2010, taking into account the government's policy. In total, 158 urban areas were selected for the urban water supply systems planning. The selected urban areas were i) the towns nominated as urban centres, and ii) the towns that would have a population of more than 5,000 in year 2000. The estimated total urban water demand was 1.91 MCM/day and industrial water demand was 0.49 MCM/day in 2010. Among the various water sources, surface water has been predominantly utilised as the main source for urban water supply, because of easy accessibility and generally cheaper abstraction cost. Several urban areas have to rely on water from the storage reservoirs and water transfer.

b) Rural and Livestock Water Supply: In view of the vastness of the study area and varying types of water sources envisaged, the NWMP (1992) did not formulate definite water supply plans specific to each rural area, but attempted to evaluate the potential water sources available in each area and to estimate the conceptual costs of the developments. The rural and livestock water demand was estimated at 1.78 MCM/day in total for 2010, comprising 1.16 MCM/day of rural water demand and 0.62 MCM/day of livestock water demand. The water source allocation plan showed the sources of surface water, groundwater (borehole and shallow well), water harvesting (roof catchment, small dam, sub-surface dam, sand dam, and rock catchment), and the existing pipelines. In addition, the NWMP (1992) recommended watering points (boreholes or shallow wells with windmill pump) in nomadic pasturage areas in arid lands to promote nomadic production activities.

c) Irrigation Water Supply: The development strategies of the NWMP (1992) are as follows: i) small-scale irrigation schemes are given top priority, ii) irrigation areas adjoining densely-populated district or location are given high priority, and iii) areas where only irrigation follows watering method for agriculture are given high priority. About 140 small-scale irrigation schemes with a total area of about 7,000 ha were proposed in the NWMP (1992) in line with the government policy. Small-scale schemes are implemented by farmers themselves with the assistance from the government agencies concerned. The 18 large-scale irrigation schemes were also proposed, with total irrigation area of 111,355 ha. Among these 18 irrigation schemes, seven schemes were planned to have irrigation water supplied by the dams. The annual average irrigation water demand was estimated at 134.9 m^3/s (11.66 MCM/day) in year 2010, varying from 93.4 m^3/s in January to 184.3 m^3/s in October. The sources of irrigation water are surface water (including water from dams and through water transfer facility) and groundwater.

d) Wildlife and Fishery: The major water source for wildlife and fishery is river water. The other sources are groundwater and water from water harvesting. The NWMP (1992) was planned to keep a minimum river maintenance flow during the dry season in the upstream stretches, and to consider the impact of the plan on wildlife living downstream. The NWMP (1992) assumed that the future water demand for wildlife is not significantly different from the present level (at the NWMP (1992) formulation time) of 21,000 m^3/day. The total water use for fish farming was estimated at about 78,000 m^3/day (28.6 MCM/year) in 2010. However, the perennial river flow during the wet season has been utilised for inland fishery. Present and future water uses for inland fishery might not have negative effect on the water balance to the downstream users during the dry period.

e) Hydropower Development: The existing and ongoing hydropower facility has installed capacity of 601.5 MW, and the remaining hydropower potential nationwide is estimated to be 1,422 MW, when the NWMP (1992) was formulated. Incorporated in the NWMP (1992) are the selected five hydropower schemes (Sondu/Miriu, Low Grand Falls, Oldorko, Mutonga and Gitaru No.3) and the Magwagwa project as the proposed schemes. The five schemes were recommended by the updated national power development plan (1991). The Magwagwa project was attested to be technically and economically feasible in the feasibility study (1991).

1.2.2 Proposed Priority Projects in NWMP (1992)

In the formulation of the water resources development plan of the NWMP (1992), various water source structures/facilities such as dams, bulk water transfer structures, groundwater facilities, and water harvesting facilities were examined. The following priority projects of the water source structures/facilities were proposed in the NWMP (1992) to be implemented by 2010:

(1) Dams

In total, there were 28 priority dams selected in the NWMP (1992) for water supply, irrigation, and/or hydropower purposes. These dams were proposed for implementation towards 2010 as shown in Table 1.2.1 and are tabulated below:

Priority Dams Proposed in NWMP (1992)

Purposes		Dam (No.)	Name of Dam
Single purpose dam	Water supply	19	Moiben and Mukulusi (LVNCA); Londiani, Kibos, Itare, and Bunyunyu (LVSCA); Chemususu, Kirandich, Malewa, and Upper Narok (RVCA); Upper Athi, Ruaka, Ruiru-A, Kikuyu, Rare, Mwachi, and Pemba (ACA); Rumuruti and Nyahururu (ENNCA)
	Irrigation	2	Yatta (ACA), Thiba (TCA)
	Hydropower	2	Mutonga and Low Grand Falls (TCA)
Multipurpose dam	Water supply and irrigation	2	Ndarugu (ACA), Chania-B (TCA)
	Water supply, irrigation and hydropower	1	Oldorko (RVCA)
	Irrigation and hydropower	2	Sondu/Miriu and Magwagwa (LVSCA)
Total		28	

Note: ( ) = Catchment area
Source: NWMP (1992)

The dam (or large dam) was defined in the NWMP (1992) as a dam with height of 15 m or more. A small dam, as discussed in the following paragraphs, is defined as a dam having a height of less than 15 m.

Out of the 28 dams, 22 dams are relevant to urban water supply schemes. These 22 dams will supply water of about 1.8 MCM/day in total. There is no flood control dam included in the dam schemes. Also, there is no rehabilitation work of the existing dams proposed in the NWMP (1992).

In addition to the 28 selected dam schemes, the NWMP (1992) listed 57 dam schemes worthy of further consideration as alternatives to the selected schemes, and/or schemes to be added in the development plan when new demands arise or if the economic viability is justified in further studies. These future development dam schemes are listed in Table 2.3.1 (2/3) and (3/3).

(2) Bulk Water Transfer

It was conceived in the NWMP (1992) that water transfer was necessary. This will be done first from another sub-basin on the same river basin (intra-basin water transfer scheme) and second, from another river basin (inter-basin water transfer scheme), in case none of the potential dam site is in the sub-basin and additional storage is not available.

In total, 24 intra-basin water transfer schemes and 16 inter-basin water transfer schemes were identified in the NWMP (1992) for domestic and industrial water supply and/or irrigation purposes as listed in Table 1.2.2 and as summarised below by catchment area.

Bulk Water Transfer Schemes Proposed in NWMP (1992)

Catchment Area	Intra-basin Bulk Water Transfer	Inter-basin Bulk Water Transfer
LVNCA	Sio River, Moiben Dam, Mukulusi Dam (3 schemes)	Moiben Dam, Edzawa Dam (2 schemes)
LVSCA	Londiani Dam, Kibos Dam, Bunyunyu Dam (3 schemes)	Itare Dam (1 scheme)
RVCA	Chemususu Dam, Malewa Dam, Upper Narok Dam (3 schemes)	Malewa Dam, Kirandich Dam, Oloibortoto River (3 schemes)
ACA	Upper Athi Dam, Kikuyu Dam, Kiambaa Dam, Ruiru A Dam, Ndarugu Dam, Munyu Dam, 4 schemes of Athi River, Pemba Dam, Mwachi Dam, Rare Dam (13 schemes)	Kiserian Dam, Second Mzima, Sabaki Extension (3 schemes)
TCA	-	Chania B Dam, 2 schemes of Komu transfer, Thika Dam system, Masinga Dam, Tana River (6 schemes)
ENNCA	Nyahururu Dam, Rumuruti Dam (2 schemes)	Ewaso Ng'iro River (1 scheme)
Total	(24 schemes)	(16 schemes)

Source: NWMP (1992)

(3) Groundwater

Groundwater instead of surface water or a combination of both was utilised in formulating the NWMP (1992) in case the surface water could not meet the water development requirement. The proposed groundwater abstraction (borehole and shallow well) in the NWMP (1992) was estimated at 74,600 m^3/day for urban water supply, 591,700 m^3/day for rural and livestock water supply, and some amounts for irrigation water supply (no specific supply value is available) and wildlife/ fishery use (no value is available).

There is no artificial groundwater recharge scheme proposed in the NWMP (1992).

According to the domestic and industrial water supply study in the NWMP (1992), 22 urban centres had to utilise groundwater as a major water source with a total supply demand of 74,600 m^3/day in 2010. The 22 urban centres are as follows: Msambweni, Isiolo, Garbatula, North Horr, Korr, Kargi, Marsabit, Sololo, Moyale, Mudo Gashe, Ijara, Kotile, Elwak, Wajir, Buna, Bute, Nyabikaye, Wamba, Barogoi, Lodwar, Nyahururu, and Rumuruti.

The water source allocation plan of the NWMP (1992) for rural and livestock water supply showed the allocated amount of 0.59 MCM/day for groundwater (borehole and shallow well) as shown below.

Water Source for Rural and Livestock Water Supply in NWMP (1992)

(Unit: thousand m^3/day)

Water Source	Rural	Livestock	Total
Surface water	696	248	944
Borehole	145	134	279
Shallow well	162	151	313
Roof catchment	44	0	44
Small dam	35	14	49
Subsurface dam	2	4	6
Sand dam	2	4	6
Rock catchment	2	0	2
Existing pipeline	72	3	75
Total	1,160	558	1,718

Source: NWMP (1992)

(4) Water Harvesting

There are some cases in the NWMP (1992) that stated the unavailability of surface water sources and groundwater could not meet the water development requirement due to water quality constraint. In those cases, maximum affordable development of roof catchment and subsurface dams is considered instead of groundwater but this is particularly suited in peri-urban and rural areas.

The proposed water harvesting (roof catchment, small dam/water pan, sub-surface dam, sand dam, and rock catchment) in the NWMP (1992) estimated a volume of 107,200 m^3/day for rural and livestock water supply, some amounts for urban water supply (no specific supply value is available), and wildlife/ fishery use (no value is available).

1.3 Basic Conditions Considered in the Water Resources Development Plans of NWMP 2030

1.3.1 Major Water Use Sub-sectors Considered in the NWMP 2030

The major water use sub-sectors considered in the NWMP 2030 are decided on the basis of the current major water users and their future trends, as well as the sub-sectors applied in the NWMP (1992). These sub-sectors are categorised as domestic, industrial, irrigation, livestock, wildlife, inland fishery, and hydropower.

The domestic water demand was projected to increase due to increase in population from 39 million in 2010 to 68 million in 2030. The industrial water demand was projected to increase following the increase in GDP toward 2030. The irrigation water demand was projected to increase aiming at the maximum expansion of irrigation area using the available water and promotion of water saving irrigation method.

The aforementioned increase in future water demands necessitates the integrated water resources development approach in formulating the development plans for the NWMP 2030 in order to use the limited water resources efficiently.

The future water demands are discussed in Chapter 3 of this report and summarised in Chapter 6 of the Main Report Part A. The details of the estimates are described in the Sectoral Report (C) for domestic, industrial, livestock, wildlife, and fishery water uses, and in the Sectoral Report (E) for irrigation water use.

1.3.2 Available Water Sources and Relevant Structures Applied for the NWMP 2030

The increase in future water demands requires a planning strategy on water resources development. It is envisioned that every possible development measure will be considered in order to balance the water demand with water supply, although water resources development shall, in principle, proceed from less expensive sources to expensive ones.

Available water sources and relevant water resources development structures considered for the NWMP 2030 were decided on the basis of the sources and structures used at present and those applied for the NWMP (1992) as follows:

Water Sources and Relevant Structures

Water Sources	Relevant Water Resources Development Structures
Rainwater	Water harvesting structure (roof catchment, rock catchment)
Surface water - Perennial rivers, Lakes, and Springs - Seasonal rivers	 Intakes, dams, water transfer structure, water harvesting structure (small dams/ water pans, subsurface/sand dams) Water harvesting structure (small dams/water pans, subsurface/sand dams)
Groundwater	Boreholes, shallow wells

Source: JICA Study Team based on the NWMP (1992)

The surface water in rivers has been predominantly utilised among the water sources in Kenya, and it will be used as the cheap development alternative in formulating the water resources development plans for the NWMP 2030. The storage dams and water transfer facilities will also be used for the plans to augment the available surface water.

Lake water will not be considered and used in the plan formulation due to the current unsustainable and heavy utilisation of lake water resulting in certain environmental issues such as lowering of the lake water level and pollution. The future spring sources utilisation is considered in principle as a continuation of the present use, because most water sources have already been utilised.

Water harvesting, which has been practiced for many years in ASAL, is the process in which rainfall and runoff from small catchment areas are redirected and collected in storage tanks and reservoirs for consumption, mainly during the dry months. Commonly used measures for water harvesting are considered in formulating the water resources development plans. These are roof catchment, rock catchment, small dams/water pans, and sub-surface/sand dams. The small dam is defined as the dam with a height of less than 15 m, since this definition has been applied in the NWMP (1992).

Groundwater is one of the major water sources and important especially in ASAL where less surface water is available.

1.3.3 Transboundary Waters

There are 18 international drainage basins in Kenya related to transboundary waters. The transboundary waters are estimated to be around 57% of the average renewable surface water resources under the 2030 climate condition as detailed in the Sectoral Report (B).

The NWMP 2030 includes the water resources development plans prepared for the international drainage basins of transboundary water in order to achieve the targets of Kenya Vision 2030. The development of the transboundary water resources should be undertaken with treaties and agreements with related countries in line with the Transboundary Water Policy, which is currently being formulated by MWI.

CHAPTER 2 CURRENT SITUATION OF WATER RESOURCES DEVELOPMENT

2.1 Relevant Policies and Strategies

There are certain policies, strategies, and master plans currently effective in the water resources development sub-sector, namely:

a) As to the national policies, i) Sessional Paper No.1 of 1999 on the National Policy on Water Resources Management and Development prepared by the Ministry of Water Resources, ii) the National Water Storage Policy (2009) prepared by MWI, and iii) the National Water Harvesting and Storage Management Policy (2010) prepared by MWI. The first one, the "National Policy on Water Resources Management and Development" is the basic policy framework of the nation, outlining the policy direction on water resources management and development. (The Water Act 2002 is the legal framework to support this national policy.) Since both the national policy and Water Act 2002 do not comprehensively address issues on water harvesting and storage, the National Water Storage Policy was prepared. The National Water Harvesting and Storage Management Policy seems to be the revised version of the National Water Storage Policy.

b) Two strategies, namely, i) National Water Resources Management Strategy (NWRMS) 2010-2016 prepared by MWI in 2012, and ii) Catchment Management Strategies (CMSs) prepared by WRMA in 2008, were formulated conforming to the Water Act 2002.

c) Kenya Vision 2030 is the long-term national planning strategy for multi-sectoral developments. The vision is based on three pillars: economic, social, and political. Under the vision, the Environment, Water, and Sanitation Sector Plan was prepared to identify the programmes and projects to be implemented in 2008-2012 in order to address various challenges facing the sector.

These policies, strategies, and Kenya Vision 2030 are outlined and discussed further in the following sections.

2.1.1 National Policies

The Sessional Paper No.1 of 1999 on the National Policy on Water Resources Management and Development (1999) was prepared by the Ministry of Water Resources in 1999. The policy states four specific policy objectives, namely: i) to preserve, conserve, and protect available water resources and allocate it in a sustainable, rational, and economical way; ii) to supply water of good quality and in sufficient quantities; iii) to establish an efficient and effective institutional framework to achieve a systematic development and management of the water sector; and iv) to develop a sound and sustainable financing system. The policy then intended to revise the Water Act.

The National Water Storage Policy (2009) prepared by MWI aims to facilitate a better and efficient water harvesting and storage infrastructure development contributing to the achievement of the national average of 16 m^3 water storage per capita from the current 5.3 m^3. The policy describes its policy statements in terms of institutional framework as follows:

a) The government, through its ministry in charge of water resources development and management, will be responsible for policy formulation, development coordination, and regulation of activities of the various stakeholders involved;

b) The government, through its various statutory boards, regional development authorities, and the National Water Conservation and Pipeline Corporation, will be encouraged to support water storage infrastructure development and management; and

c) The government will encourage and support commercial entities, individuals, cooperative societies, NGOs, and community-based organisations (CBOs) to develop, operate, and maintain water storage infrastructure and facilities, upon registration and approval of the project by relevant authorities as stipulated in the Water Act 2002.

The National Water Harvesting and Storage Management Policy (2010) prepared by MWI describes the policy components including the following items for water resources development:

a) Commissioning of a nationwide study to develop comprehensive water harvesting and storage, and a flood control master plan;

b) Development of water harvesting and storage capacities up to 4.5 billion m^3 over the next ten years by realising at least 340 million m^3 of additional storage annually, through the construction of large, medium, and small dams in addition to water pans, rock, roadside and roof catchments systems, and other runoff channels or lagas;

c) Development of elaborate underground water recharge systems based on harvesting of at least 15% of the surface runoff in farms and along the road networks;

d) Design and implementation of appropriate policies and programmes to promote and enforce innovative water harvesting systems based on roof, rock, tree trunks, and roadside catchments, land surface runoff, and other flush flood runoff throughout the country including major towns and ASAL areas; and

e) Inclusion of afforestation activities in all constructions of dams and flood control structures with the view of controlling soil erosion.

The abovementioned national policies depict the general and overall ideas on the development policies for water resources covering the policy statements and components. These policies are therefore reflected in the NWMP 2030.

2.1.2 MWI's and WRMA's Strategies

In relation to the water resources development, the Water Act 2002 states that:

a) A national water resources management strategy shall be formulated by MWI, in accordance with which the water resources of Kenya shall be managed, protected, used, developed, conserved, and controlled (Section 11).

b) A catchment management strategy shall be formulated by WRMA for the management, use, development, conservation, protection, and control of water resources within each catchment area (Section 15).

The National Water Resources Management Strategy (NWRMS) 2010-2016, which was prepared by MWI in April 2012, provides eight strategies, i.e.: i) to improve water resources assessment and develop systems for information dissemination; ii) to strengthen the roles of gender and stakeholder participation in water resources management; iii) to promote the functioning of integrated approaches to water resources and catchment management and livelihood enhancement; iv) to create mechanisms for coordination of measures that will enhance the availability and access of water resources of suitable quality and quantity where and when it is needed; v) to strengthen the systems that will promote the sharing of data and information on water use and demand; vi) to create mechanisms for private sector financing so as to improve opportunities for sustainable financing in water resources sub-sector; vii) to develop proactive mechanisms for implementing disaster management strategies, namely: floods, droughts, landslides, and pollution; and viii) to promote the implementation of transboundary water resources use.

The NWRMS also enumerates, among others, the following strategic actions relating in particular to water resources development to realise the above strategies:

a) To operationalise the criteria developed for reserve water determination to ensure availability of water for basic human needs and the environment.
b) To implement flagship projects to enhance availability of good quality water. The flagship projects are as follows: i) development of a multipurpose dam with capacity of 1.2 BCM along River Nzoia; ii) construction of 22 medium-sized dams with a total capacity of 2 BCM to supply water for domestic, livestock, and irrigation; iii) establishment of 600 regular gauging stations; and iv) mapping of Turkana Aquifer. In addition, projects and programmes will be developed for the implementation of the National Water Harvesting and Storage Management Strategy, National Water Quality Management Strategy, and National Water Storage Policy.
c) To build capacity to promote the implementation of flagship projects in order to enhance availability of good quality water.
d) To implement the water harvesting and storage management policy and to develop a policy for groundwater storage and use as a stable source of water resources.

The catchment management strategies (CMSs) were prepared in 2008 by WRMA for each of the six catchment areas. The CMSs describe the characteristics of the areas and strategies of the water resources development as enumerated in Table 2.1.1 and as summarised as follows:

a) Effective use of water harvesting measures is a common target among all CMSs. The measures include roof catchment with tanks, small dams/water pans, farm ponds, sub-surface/sand dams, check dams, rock catchment, etc.
b) The terms of reservoirs, multipurpose dams, or large dams are used in all CMSs to be developed for surface water storage.
c) Artificial groundwater recharge is also a common target activity among all CMSs for groundwater storage development.
d) The CMS for ENNCA noted in particular a concern that creating reservoirs to provide water for nomadic populations and their livestock was not always desirable because this might lead to concentration of people and livestock, generation of over-grazing, ecological degradation, etc.

The abovementioned strategies in the CMSs are applied for the formulation of the NWMP 2030.

2.1.3 Kenya Vision 2030

Kenya Vision 2030 (2008-2030) is the country's long-term national planning strategy. It represents a development blueprint of the country, which aims at transforming Kenya into "a newly- industrialising, middle-income country providing a high quality life to all its citizens in a clean and secure environment" by year 2030.

The goals of Kenya Vision 2030 for 2012 in the water and sanitation sector are: i) to attain 90% access to safe and reliable water for urban areas and 70% for rural areas; ii) to reduce the levels of unaccounted-for-water to below 30%; iii) to achieve 70% and 65% access to safe sanitation for urban and rural households; iv) to increase water storage per capita to 16 m^3 from the current 8 m^3; v) to increase regular monitoring of water resources from the current 30%-40% to 70%; vi) to finalise the implementation of the two water catchment management strategies in Tana and Lake Victoria North and to complete the preparation of the remaining four strategies; and vii) to ensure that 90% of the rivers have reserve flow at all times.

To ensure the achievement of the 2012 goals mentioned above, the following four flagship projects have been identified in the Kenya Vision 2030 documents:

a) To improve water resource information and management by rehabilitating 600 stations of the hydro-meteorological network and undertaking ground water hydro-geological mapping in Turkana and Marsabit.
b) To increase water storage and harvesting by developing two multipurpose dams with storage capacity of 2.4 billion m^3 along Nzoia and Nyando rivers and constructing 22 medium-sized multipurpose dams with a total capacity of 2 billion m^3.
c) To increase the national coverage of water supply and sanitation by rehabilitating and expanding the Mzima pipeline; rehabilitating and expanding urban water supply and sanitation in the satellite towns around Nairobi, Mombasa, Kisumu, Nakuru, and Kisii, 15 medium-sized towns and resort cities; and exploring possibilities of transborder sources of water.
d) To develop irrigation and drainage by constructing the Tana Delta project; rehabilitating and expanding the schemes in Bura, Hola, Kano Plains, Nzoia, Perkera, Kerio Valley, Mwea, Taita Taveta, Ewaso Ng'iro North, and Ngurumani; and expanding the drainage areas in the western and central provinces.

According to the First Medium Term Plan (2008–2012) of Sector Plan for Environment, Water and Sanitation in Kenya Vision 2030, the following projects are identified as flagship projects for 2008-2012 in terms of water resources development:

<u>Flagship projects</u>

a) To develop the High Grand Falls Multipurpose Reservoir with a storage of 5.4 billion m^3 and a 54 km inter-basin water transfer canal in Rahole Area;
b) To develop the two multipurpose dams with a total storage capacity of 2.4 billion m^3 along the Nzoia and Nyando rivers;
c) To construct the 24 medium-sized multipurpose dams with a total capacity of 2 billion m^3 in order to supply water for domestic, livestock, and irrigation uses in ASAL areas, i.e.: Bunyunyu, Munyu, Londiani, Itare, Upper Narok, Chemesusu, Kiserian, Yatta, Kitui,

Mwingi, Thwake, Rare, Thiba, Umaa, Rumuruti, Badasa, Archers' Post, Awasi, Kora, Ndarugu, Mwachi, Ruiru A, Siyoi, and Nyahururu;

d) To expand the Mzima pipeline to meet the current demand of the coastal towns; and

e) To drill 140 boreholes and construct 160 small dams/pans in ASAL areas for domestic water supply.

The above stated flagship projects are taken into consideration in formulating the NWMP 2030. It is noted that there was no information obtained from the government on Kitui and Mwingi dams listed in Item c) above as flagship projects.

2.2 Relevant Organisations

Relevant organisations for the water resources development sub-sector are mainly MWI, WRMA, water resource users associations (WRUAs), NWCPC, WSBs, NIB, MORDA, RDAs, KenGen, and the Ministry of Agriculture (MOA) as of November 2012.

MWI has the mandate for water affairs in the country. According to the Water Act 2002, MWI is responsible for policy formulation, sector coordination, and monitoring/evaluation.

Under MWI, several organisations are responsible for water resources development including WRMA, WRUAs, NWCPC, WSBs, and NIB. WRMA is responsible for planning, regulation, and management of water resources. WRUAs are local bodies for water users to participate in the water resource management, and WSBs are regional bodies responsible for regulation and planning of water and sewerage services. NWCPC is responsible in the construction of dams and boreholes, and NIB has a role in the development of irrigation infrastructures.

Apart from MWI, MORDA is mandated to formulate regional development policies, and RDAs are in charge in the promotion of integrated development. KenGen is a state-owned company responsible to produce electricity that will be consumed in the country. MOA is mandated to promote production of food and advanced agro-based industry.

The abovementioned relevant organisations are tabulated below by structures and illustrated in Figure 2.2.1.

Relevant Organisations by Structures

Structures	Relevant Organisations
Large-scale dam	MWI, WRMA, NWCPC, WSBs, NIB, MORDA, RDAs, KenGen
Water transfer	MWI, WRMA, NWCPC, WSBs
Small dam	MWI, WRMA, WRUAs, NWCPC, WSBs, MOA, NGOs, Communities
Water pan/rock catchment/sub-surface dam/sand dam	MWI, WRMA, WRUAs, NWCPC, WSBs, MOA, NGOs, Communities, Individuals
Boreholes	MWI, WRMA, WRUAs, NWCPC, WSBs, NGOs, Communities, Individuals

Source: JICA Study Team based on the information from MWI, WRMA, NWCPC, WSBs, NIB, MORDA, RDAs, and KenGen

The following sections are outlines on the functions and activities of the organisations as of November 2012:

(1) MWI

The Ministerial Strategic Plan 2009-2012 prepared by MWI in May 2009 states that the Department of Irrigation, Drainage, and Water Storage of MWI is responsible for the development of irrigation, drainage, water harvesting, and storage infrastructure. But few data and information are available in MWI including the department on current situations of the existing water resources infrastructures and development plans/studies. Although the National Water Storage Policy (March 2009) mentioned that the government will develop a master plan for water storage in all drought prone areas in Kenya, such plan has not been available.

(2) WRMA and WRUAs

The Water Act 2002 empowers WRMA to manage and control water storage and transfer, according to the WRMA Strategic Plan 2009-2012. Although some data/information on the boreholes and water pans can be collected from WRMA, these are not compiled and maintained properly. The basic data on the existing and proposed dams and transfer structures are not available in WRMA.

It is noted that WRUAs have planned and implemented water harvesting facilities with the support of WRMA.

(3) NWCPC

The Water Act 2002, Section 22 mentions that NWCPC, on behalf of the minister, is required to develop works and manage assets for the purposes of a state scheme for the provision of bulk water supplies for use by licensees and water service providers. In fact, NWCPC has the main role for the development of the water resources infrastructures.

According to the NWCPC Strategic Plan 2010-2015, the NWCPC’s core functions are as follows: i) to plan, develop, and manage state schemes and other water infrastructure in Kenya and beyond, including large and medium dams, small dams and pans, flood control structures, boreholes, dykes, groundwater recharge facilities, canals, and water supplies, ii) to develop and enter into agreements with WSBs for the development and management of state schemes, iii) to develop a mechanism to access funding from Water Services Trust Fund (WSTF) and any other financial institutions, and iv) to develop a collaborative mechanism with WRMA for the development and management of water resources.

As stated above, NWCPC is the main player for the development of water resources structures including dams, water transfers, water harvesting (small dam/water pan, sand dam, sub-surface dam, rock catchment), and boreholes. Four large dams are under construction by NWCPC and seven dams are planned to be constructed according to the NWCPC Strategic Plan. The small dams/water pans, boreholes, and artificial groundwater recharge have been and are being implemented by NWCPC.

(4) WSBs and NIB

Tanathi WSB has a plan to construct Yatta Dam while NIB is going to construct Thiba Dam. WSBs also plan and implement water transfer facilities, water harvesting, and boreholes.

(5) MORDA and RDAs

MORDA facilitates and coordinates with the RDAs in the execution of participatory, integrated basin-based development programmes through policy guidance and capacity building for sustainable utilisation of natural resources. The RDAs like TARDA implement the multi-purpose dams. MORDA is planning/designing or has completed designs for several multi-purpose dams such as Magwagwa, Mwachi, Nandi Forest, Arror, High Grand Falls, and Lake Chala dams.

(6) KenGen

KenGen has implemented several dam and hydropower development projects since the 1950s. KenGen has done some feasibility studies for dam and hydropower projects such as Mutonga and Low Grand Falls dams.

(7) Others

MOA studies, designs, and implements the water harvesting structures such as small dams/water pans and sub-surface dams.

In addition to the above, private players construct boreholes, and NGOs implement water harvesting structures and boreholes.

(8) Less Coordination among the Organisations

NWCPC and MORDA are the main players in planning, design, and implementation of large dams. NIB and WSBs are also playing some roles in dam construction. In addition, NWCPC has the role of borehole construction and water harvesting. Other organisations and individuals are also involved in borehole construction and water harvesting.

It seems there is a lack of coordination among concerned organisations in pursuing water resources development. For example, separate studies have been made by NWCPC and MORDA at the same dam site (not the same dam axes) for the Mwachi Dam in ACA.

During the data/information collection from government organisations and interviews with concerned officials, there was no specific government organisation, department, division, or unit responsible in planning the basic water resources development as well as coordinating with other agencies in planning and implementing water resources development as the lead organisation.

2.3 Current Situation of Water Resources Development

2.3.1 Overview

(1) Current Situation on Dams

On the basis of the data collected from MWI, WRMA, NWCPC, WSBs, NIB, MORDA, RDAs, KenGen and so forth, as well as the list included in the NWMP (1992), there are 26 existing and operational dams for water resources development in Kenya as of November 2012, as follows:

Existing Dams

Catchment Area	Number of Dams	Name of Dams	Total Storage Volume (MCM)
LVNCA	5	Moiben, Twin Rivers, Ellegirini, Kipkarren, Lessos	24
LVSCA	2	Gogo Falls, Sondu/Miriu	1
RVCA	5	Turkwel, Chemeron, Kirandich, Turasha, Aram	1,653
ACA	7	Ruiru, Bathi, Mulima, Manooni, Muoni, Kikoneni, Maruba	10
TCA	7	Sasumua, Thika, Masinga, Kamburu, Gitaru, Kindaruma, Kiambere	2,218
ENNCA	0	-	0
Total	26		3,906

Source: JICA Study Team based on the NWMP (1992) and information from MWI, WRMA, NWCPC, WSBs, NIB, MORDA, RDAs, and KenGen

Locations of the existing dams listed above are shown in Figures 4.4.1, 4.5.1, 4.6.1, 4.7.1, 4.8.1 and 4.9.1 for the respective catchment areas.

As of November 2012, the following ongoing dam schemes whose constructions are in progress or whose detailed designs or feasibility studies are completed or being carried out, are shown below.

Ongoing Dam Schemes

Catchment Area	Dams under Construction	Detailed Designs are Completed	Detailed Designs are Ongoing	Preliminary Designs or Feasibility Studies are Done or Ongoing
LVNCA	-	Nandi Forest	Siyoi, Nzoia (34B site), Nzoia (42A site)	-
LVSCA	-	Magwagwa, Bunyunyu	-	Itare, Nyando
RVCA	Chemususu	Arror	Oletukat, Leshota, Oldorko	-
ACA	Kiserian	Ruaka (Kiambaa), Thwake	Rare, Lake Chala	Ruiru-A (Ruiru 2), Ndarugu, Mwachi, Munyu, Stony Athi, Kamiti 1
TCA	Umaa	Thiba, High Grand Falls, Yatta	-	Maragua 4, Karimenu 2, Thika 3A
ENNCA	Badasa	-	-	Isiolo
Total No.	4	9	8	12

Source: JICA Study Team based on the NWMP (1992) and information from MWI, WRMA, NWCPC, WSBs, NIB, MORDA, RDAs, and KenGen

In addition to the abovementioned ongoing dam schemes, many dam schemes had been completed or are at a certain stage of study including pre-feasibility studies, namely: i) Hemsted Bridge Dam in LVNCA; ii) Londiani, Kibos, Timbilil, Katieno, and Ilooiterre dams in LVSCA; iii) Kimwarer and Embobut dams in RVCA; and iv) Kiteta and Olkishunki dams in ACA.

Tables 1.2.1, 2.3.1, and 2.3.2 show the current status of the various dam schemes including the schemes listed in the NWMP (1992) such as existing, proposed, and recommended as future potential dams, as well as the schemes identified by the Kenyan government but not in the NWMP (1992). The general features of these dams are presented in Tables 2.3.4, 2.3.5, and 2.3.6.

It is noted that among the 28 priority dam schemes proposed to be implemented in the NWMP (1992), as of November 2012, only three dams were completed, one dam is under construction, and nine dams have their detailed design, feasibility study and/or any other studies carried out after the preparation of the NWMP (1992), as represented in Table 1.2.1. The slow progress in implementing the priority dam projects might be due to the following matters: a) unclear mandates and responsibilities and insufficient resources of the organisations concerned in terms of planning and implementation, b) insufficient technical database for planning and designing, c) unspecific implementation plans, d) insufficient coordination among the related organisations, and e) insufficient budget for implementation.

In addition, the following are some recent topics in the dam development sub-sector:

a) The Chemususu Dam, which is under construction, is situated within the Lembus Forest and will take about 95 ha of forest land. The Kenya Forest Services (KFS) charged for the access to dam site and quarry sites, as well as for the trees cut within the reservoir area and rocks excavated from the quarry. This will increase the project cost by KSh186.5 million.

b) Not only the new dam construction but also the rehabilitation works of the existing dams such as Sasumua Dam, Thika Dam, Maruba Dam, etc. have been implemented.

c) The High Grand Falls Dam in TCA and Magwagwa Dam in LVSCA will start their construction soon, according to an information obtained from MORDA in November 2012.

(2) Current Situation on Bulk Water Transfers

A total of ten intra-basin and five inter-basin bulk water transfer schemes are currently in operation as of November 2012 as follows:

Bulk Water Transfer Schemes Currently in Operation

Scheme	Name of Scheme	Transfer Volume
Intra-basin bulk water transfer schemes, ten schemes in total	Scheme for Moiben Dam (LVNCA) Kikuyu Spring, Ruiru Dam, Nol Turesh, Mzima springs, Marere boreholes, Tiwi boreholes, and Baricho shallow wells (ACA) Kiambere Dam to Mwingi and Masinga Dam to Kitui (TCA)	Total transfer volume of 74 MCM/year
Inter-basin bulk water transfer schemes, five schemes in total	Scheme for Moiben Dam (LVNCA) Scheme for Kirandich Dam (RVCA) Scheme for Maruba Dam (ACA) Schemes for Sasumua and Thika dams (TCA)	Total transfer volume of 185 MCM/year

Note: ( ) = Catchment area
Source: JICA Study Team based on the information from WRMA, NWCPC, WSBs, MORDA, and RDAs

As of November 2012, ongoing intra- and inter-basin bulk water transfer schemes whose constructions are in progress or whose detailed designs, feasibility studies, or other studies are completed or being carried out are enumerated below.

Ongoing Bulk Water Transfer Schemes

Scheme	Schemes under Construction	Detailed Designs are Completed or Ongoing	Preliminary Designs or Studies are Done or Ongoing
Intra-basin bulk water transfer schemes	Scheme for Chemususu Dam (RVCA)	Scheme for Bunyunyu Dam (LVSCA) Schemes for Ruaka (Kiambaa) Dam and Rare Dam (ACA)	Scheme for Londiani Dam (LVSCA) Schemes for Ruiru-A, Ndarugu, Munyu, and Mwachi dams (ACA)
Inter-basin bulk water transfer schemes	Oloibortoto River (RVCA) Scheme for Kiserian Dam (ACA) Scheme for Umaa Dam (TCA) Scheme for Badasa Dam (ENNCA)	Schemes for Siyoi, Nzoia 34B, and Nandi Forest Dam (LVNCA) Scheme for Magwagwa Dam (LVSCA)	Schemes for Itare and Nyando dams (LVSCA) Schemes for Second Mzima and Sabaki Extension (ACA) Scheme for Komu Transfer (TCA)

Note: ( ) = Catchment area
Source: JICA Study Team based on information from WRMA, NWCPC, WSBs, MORDA, and RDAs

Tables 1.2.2 and 2.3.3 show the current status of the various intra- and inter-basin bulk water transfer schemes including the schemes listed in the NWMP (1992) as proposed schemes, and the schemes identified by the Kenyan government but not in the NWMP (1992). The general features of these water transfer schemes are presented in Tables 2.3.7 and 2.3.8.

It is noted that among the 24 intra-basin water transfer schemes proposed to be implemented in the NWMP (1992), only the scheme of Moiben Dam was completed and the scheme of Chemususu Dam is under construction. Eight schemes of Londiani, Bunyunyu, Ruaka, Ruiru-A, Ndarugu, Munyu, Mwachi and Rare dams have their detailed designs, feasibility studies, or other studies completed or ongoing.

It is also noted that among the 16 inter-basin water transfer schemes proposed in the NWMP (1992), four schemes of Moiben, Kirandich, Thika and Masinga dams were completed, and two schemes of Oloibortoto River and Kiserian Dam are under construction. Four schemes of Itare Dam, Second Mzima, Sabaki Extension, and Komu Transfer have some completed studies or ongoing.

The abovementioned situations show a slow implementation progress similar to that of the dams. This slow progress might be due to the same reasons as those for the dams such as unclear mandates and insufficient resources of the organisations concerned, insufficient databases, unspecific implementation plans, insufficient coordination among the organisations, insufficient budget for implementation, and so forth.

(3) Current Situation of Water Harvesting

The water harvesting facility consists of roof catchment, small dam/water pan, subsurface/sand dam, and rock catchment. Based on the data and information collected from WRMA and NWCPC, the current situation of water harvesting revealed the following items:

1) <u>Roof Catchment</u>: No records are available in terms of the construction and maintenance of roof catchment. This may be resulting from the fact that construction and maintenance are made mainly by individuals and/or communities instead of the government agencies. There is a great potential for storage improvement through the promotion of roof catchment storage tanks. The CMS for LVSCA states, for example, that data on roof catchment coverage is scanty, but the World Agroforestry Centre (ICRAF: International Centre for Research in Agroforestry), SANA and World Vision have carried out successful campaigns in Nyando and Rachuonyo districts.

2) <u>Small Dam/Water Pan</u>: Inventory of dams and water pans in Kenya was prepared by the Ministry of Water Resources Management and Development in August 2003. The first draft gives the number and capacity of small dams and water pans constructed in the country as follows:

Number and Capacity of Constructed Small Dams/Water Pans by Catchment Area (2003)

Catchment Area	Number of Small Dams/ Water Pans	Total Original Capacity (m^3)	Total Existing Capacity (m^3)
LVNCA *1	270	19,539,340	8,132,000
LVSCA	544	11,443,205	5,307,015
RVCA *2	660	19,143,903	11,776,557
ACA *3	1,326	27,167,980	11,598,423
TCA *4	622	76,101,865	26,935,676
ENNCA *5	615	19,353,945	10,335,670
Total	4,037	172,750,238	74,085,341

Notes: *1=Subtracting from the Ministry list three large scale dams of Lessos, Ellegirini and Kipkarren dams.
*2=Subtracting from the Ministry list one large scale dam of Chemeron Dam.
*3=Subtracting from the Ministry list two large scale dams of Bathi and Mulima dams, and 65 subsurface dams.
*4=Subtracting from the Ministry list two large scale dams of Thika and Upper Kajito dams, 13 sand dams and four rock catchments.
*5=Subtracting from the Ministry list four subsurface dams.
Source: JICA Study Team based on the data from the Ministry of Water Resources Management and Development (2003)

The above table shows that the total number of small dams/water pans was 4,037 in 2003, and the total existing capacity was 74 million m^3. Needed data/information in updating the above table are not available. However, it can be said from the table that sedimentation into the small dams/water pans is one of the issues that needs to be addressed.

The 2003 inventory shows that almost all the listed small dams/water pans are for domestic and livestock water supply purposes. There are some small dams/water pans for irrigation water supply purpose in ACA and TCA with the total storage volumes of 2.4 MCM and 10.3 MCM, respectively.

The summary of collected records for small dams and water pans constructed or rehabilitated by NWCPC is shown below by catchment area.

Total Storage Capacity of Small Dams and Water Pans Executed by NWCPC

(Unit: 1,000 m^3)

Catchment Area	2005-2006		2006-2007		2007-2008	
	Constructed	Rehabilitated	Constructed	Rehabilitated	Constructed	Rehabilitated
LVNCA	55	183	0	0	0	0
LVSCA	178	527	15	170	40	35
RVCA	368	588	211	416	100	28
ACA	395	923	378	751	265	55
TCA	666	632	99	1,412	74	29
ENNCA	349	1,259	160	844	151	22
Total	2,011	4,112	863	3,593	630	169

Source: JICA Study Team based on data from NWCPC (2011)

As seen in the above table, NWCPC constructed and rehabilitated small dams and water pans with the annual development/rehabilitation capacity of 6.1 MCM/year to 0.8 MCM/year.

WRMA has some information on the existing small dams/water pans which are owned by the government, local authorities, communities, private firms, development partners, and so forth. The Rapid Assessment Dams is one of the records; however, this seems to cover only part of the constructed small dams/water pans after the NWMP (1992) was formulated.

3) Sub-surface/Sand Dam: Few data/information are available in WRMA and NWCPC for the constructed subsurface/sand dams. The NWCPC Second Quarter Report for July to

December 2010 described that there are three subsurface dam projects (Ikutha Dam in Kitui District, Chalbi Dam in Marsabit North District, and Mulingwa Dam in Machakos District) under implementation. No other recorded information on sub-surface/sand dam is available as of November 2012.

4) Rock Catchment: Only few data/information on rock catchments are available. The only collected WRMA record shows the construction in 1993 of 12 rock catchment facilities located in ENNCA, with total capacity of 1,015 m^3.

The collected data and information on the water harvesting facilities are very few as represented in the above paragraphs. This shows that the general overview of the current situation of the water harvesting facilities is difficult.

(4) Current Situation on Groundwater Abstraction (Boreholes)

As of November 2012, the only available data on the situation of borehole development nationwide are the record managed by MWI covering the period from 1900 to 2011 and that in the WRMA Performance Report Issue One (July 2010) as shown in the following table:

Number of Drilled Boreholes by Catchment Area

Catchment Area	Number of Drilled Boreholes *1		Number of Drilled Boreholes *2
LVNCA	1,776	(41 MCM/year)	1,400
LVSCA	489	(36 MCM/year)	1,361
RVCA	2,094	(115 MCM/year)	1,574
ACA	5,351	(230 MCM/year)	14,739
TCA	1,587	(68 MCM/year)	2,000
ENNCA	1,147	(35 MCM/year)	1,500
Total	12,444	(525 MCM/year)	22,574

Note: Figures in parentheses are annual total abstraction volumes.
Source: *1 = JICA Study Team based on data from MWI
*2 = WRMA Performance Report 2010

It is hard to comment on the situation of borehole development in the country since the above two data sets show quite different values.

The following data show the recent situation of boreholes construction and operation, which were collected mainly from NWCPC and WRMA:

Annual Increment of Boreholes Constructed by NWCPC in the Whole Nation, by Fiscal Year

Fiscal Year	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Number	227	208	161	85	102	90	64
Yield (m^3/day)	26,637	24,604	21,624	14,146	13,500	11,597	8,208

Source: JICA Study Team based on the data from NWCPC (2012)

Borehole Yield Data Compiled by WRMA by Catchment Area

Catchment Area	Annual Average Yield Increment	Cumulative Yield at the end of 2010
LVNCA	920 m^3/day (average of 2005-2010)	-
RVCA	3,325 m^3/day (average of 1994-2010)	193,951 m^3/day
ACA	21,330 m^3/day (average of 2003-2010)	606,434 m^3/day
TCA	8,872 m^3/day (average of 1993-2004, including rehabilitated boreholes)	-
ENNCA	1,292 m^3/day (average of 1993-2008)	-

Note: Data for LVSCA are not available as of November 2012.
Source: JICA Study Team based on the data from WRMA

It is noted that the data of NWCPC in the above table are only those of boreholes constructed by NWCPC, while the data of WRMA are summed yields of boreholes constructed by NWCPC, individuals and communities, NGOs, etc. The NWCPC data suggests a decreased annual increment in number and yield of boreholes mainly due to financial constraints. The WRMA data shows the largest yields of boreholes in ACA to meet large water demands.

Data and information on shallow wells construction and operation are not available. According to WRMA, the number of constructed shallow wells is not so large because there is a small amount of available water and inferior water quality. In addition, no registration is required for shallow wells without pumps. It should be noted, however, that shallow well is one of the important water sources, particularly in the coast areas such as Lamu, Kilifi, and Mombasa.

(5) Current Organisations and Ongoing Projects/Plans

The organisations related to water resources development are discussed in Section 2.2, and the ongoing projects and existing plans for water resources development are represented in Section 2.4.

(6) Assistance by Development Partners

Various development partners (donors) are playing important roles in Kenya. According to MWI’s data list (November 2010), international institutions such as the World Bank, African Development Bank (AfDB), International Fund for Agricultural Development (IFAD), and UNICEF, and many foreign governments such as France, Germany, European Commission (EC), Italy, and Japan are assisting development activities in Kenya in the water and sanitation sector. The total amount for the ongoing programmes in this sector is equivalent to around KSh 89,133 million, and that for the pipeline programmes is equivalent to around KSh 21,542 million, as of November 2010.

In the water resources development sub-sector, the following ongoing programmes are listed in the MWI’s data list (November 2010):

Donor Activities in the Water Resources Development Sub-sector (MWI, 2010)

Donor	Programme Title	Purpose	Implementing Agency	Geographical Area	Scheduled Completion	Amount Allocated
France (AFD)	Nairobi Water and Sewerage Emergency Physical Investment Project	Rehabilitation of Sasumua Dam, and other structures	Athi Water Services Board	Nairobi	December 2010	Equivalent to KSh 3.0 billion
EC	AMREF Water and Sanitation Umbrella Programme	Shallow wells, giant wells, boreholes, subsurface dams, earth dams, roof catchments, and others	AMREF	Eastern (Kitui, Makueni), Rift V. (Kajiado), Coast (Kilifi, Malindi)	September 2011	Equivalent to KSh 269 million
EC	Safe Water Provision and Sustainable Water Management Options	Household rainwater harvesting, community surface rainwater harvesting, and other structures	LVIA	Eastern Province (Meru Region)	May 2010	Equivalent to KSh 47.5 million
EC	Improved Rural Drinking Water Supply for ASAL Mwingi District	Protection of 2 springs, construction of 29 subsurface dams, 6 shallow wells, 1 rock catchment, 20 school roof catchments, and others	German Agro Action	Eastern Province (Mwingi District)	November 2011	Equivalent to KSh 151 million
JICA	Revision of National Water Masterplan	Revision of the National Water Masterplan for 2030	MWI, WRMA	Countrywide	2012	Equivalent to KSh 355 million

Source: JICA Study Team based on the Matrix of Donor Activities in the Water and Sanitation Sector, MWI, November 2010

The sum of the allocated amounts for the above water resources development programmes is equivalent to approximately KSh 3.8 billion, which is merely 4% of the total amount of ongoing programmes. Other ongoing programmes are mainly in the sub-sectors of water supply, sanitation and sewerage, irrigation, watershed management, flood control, and water sector reform.

2.3.2 Lake Victoria North Catchment Area

LVNCA has a total catchment area of 18,374 km^2 and an annual average rainfall of 1,420 mm, the largest among the six WRMA catchment areas.

The main river basins in LVNCA are as follows:

Main River Basins (LVNCA)

Name of River	Sub-basins	Catchment Area (km^2)
Nzoia River	1B–1E	12,853
Yala River	1F	3,259

Source: JICA Study Team

The present water demand (2010) in LVNCA was estimated based on the population of 6.96 million and irrigation area of 1,876 ha as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (LVNCA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	169
Industrial	6
Irrigation	18
Livestock	26
Wildlife	0
Fisheries	9
Total	228

Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from the rivers are listed below.

Existing Water Resources Structures/Facilities (LVNCA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	Moiben Dam	Domestic water supply to Eldoret	Storage volume of 18 MCM
Dam	Twin Rivers Dam	Domestic water supply to Eldoret	-
Dam	Ellegirini Dam	Domestic water supply to Eldoret	Storage volume of 2 MCM
Dam	Kipkarren Dam	Domestic water supply to Eldoret	Storage volume of 3 MCM
Dam	Lessos Dam	Domestic water supply	Storage volume of 1 MCM
Intra-basin Water Transfer	From Moiben Dam	Domestic water supply to Eldoret/ Iten	5 MCM/year (15,000 m^3/day) in total
Inter-basin Water Transfer	From Moiben Dam	Domestic water supply to Tambach	
Small Dam/Water Pan	Total No. of 270	Domestic and livestock water supply	Total storage volume of 8.1 MCM, average volume per facility of 30,000 m^3
Borehole	Total No. of 1,776	Mainly for domestic water supply	Total abstraction volume of 41 MCM/year

Note: See Table 2.3.5 for details of dams and Table 2.3.7 for details of water transfers.
See Sub-section 2.3.1 (3) for small dams/water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, NWCPC and LVNWSB

The total storage volume of the existing water resources structures/facilities in LVNCA is approximately 32 MCM, which is equivalent to the sum of dams and small dams/water pans volumes listed in the above table. The five existing dams are for domestic water supply purposes. There is no dam under construction. The only completed detailed design was that of Nandi Forest Dam (domestic and irrigation water supply and hydropower). The dams under planning and/or design in LVNCA are Siyoi Dam (domestic water supply), Nzoia Dam at 34B site (domestic and irrigation water supply, flood control, and hydropower), and Nzoia Dam at 42A site (domestic and irrigation water supply, flood control, and hydropower).

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

2.3.3 Lake Victoria South Catchment Area

LVSCA has a total catchment area of 31,734 km^2 and an annual average rainfall of 1,280 mm, which is the second largest among the six WRMA catchment areas.

The main river basins in LVSCA are as follows:

Main River Basins (LVSCA)

Name of River	Sub-basins	Catchment Area (km^2)
Nyando River	1G	3,604
Sondu River	1J	3,474
Kuja River	1K	6,843
Amala River	1L	9,107

Source: JICA Study Team

The present water demand (2010) in LVSCA was estimated based on the population of 7.37 million and an irrigation area of 13,218 ha, as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (LVSCA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	165
Industrial	10
Irrigation	155
Livestock	43
Wildlife	3
Fisheries	9
Total	385

Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from rivers are listed below.

Existing Water Resources Structures/Facilities (LVSCA)

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

Note: See Table 2.3.5 for details of dams.
See Sub-section 2.3.1 (3) for small dams /water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, NWCPC, and KenGen

The total storage volume of the existing water resources structures/facilities in LVSCA is approximately 6 MCM, which is equivalent to the sum of dams and small dams/water pans volumes listed in the above table. The two existing dams are for hydropower generation purposes. There is no dam under construction. The detailed designs of Bunyunyu Dam (domestic water supply and hydropower) and Magwagwa Dam (domestic and irrigation water supply, hydropower, and flood control) are completed. The dams under planning and/or design in LVSCA are Itare Dam (domestic water supply) and Nyando Dam (domestic and irrigation water supply, hydropower, and flood control).

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

2.3.4 Rift Valley Catchment Area

RVCA has a total catchment area of 130,452 km^2 and an annual average rainfall of 510 mm, which is similar to that of ENNCA and the smallest among the six WRMA catchment areas. The annual rainfall differs spatially within the catchment area, ranging from around 200 mm near Turkana Lake to 1,000 mm near the Kenya's Five Water Towers.

The main river basins in RVCA are as follows:

Main River Basins (RVCA)

Name of River	Sub-basins	Catchment Area (km^2)
Turkwel River	2BA–2BD	19,821
Kerio River	2CB–2CC	13,928
Perkerra River	2ED–2EF	1,400
Malewa River	2GB–2GC	1,676
Ewaso Ng'iro South River	2KA–2KC	8,792

Source: JICA Study Team

The present water demand (2010) in RVCA was estimated based on the population of 4.86 million and irrigation area of 9,587 ha, as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (RVCA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	129
Industrial	10
Irrigation	143
Livestock	70
Wildlife	1
Fisheries	4
Total	357

Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from the rivers are listed below.

Existing Water Resources Structures/Facilities (RVCA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	Turkwel Dam	Hydropower (106 MW), irrigation	Storage volume of 1,650 MCM
Dam	Chemeron Dam	Domestic and irrigation water supply	Reservoir is almost filled with sand.
Dam	Kirandich Dam	Domestic water supply	Storage volume of 3 MCM
Dam	Turasha Dam	Domestic water supply to Nakuru	-
Dam	Aram Dam	Domestic water supply	-
Inter-basin Water Transfer	From Kirandich Dam	Domestic water supply to Kabarnet	1 MCM/year (2,496 m^3/day)
Small Dam/Water Pan	Total No. of 660	Domestic and livestock water supply	Total storage volume of 11.8 MCM, average volume per facility of 18,000 m^3
Borehole	Total No. of 2,094	Mainly for domestic water supply	Total abstraction volume of 115 MCM/year

Note: See Table 2.3.5 for details of dams and Table 2.3.7 for details of water transfers.
See Sub-section 2.3.1 (3) for small dams/water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, NWCPC, and RVWSB

The total storage volume of the existing water resources structures/facilities in RVCA is approximately 1,665 MCM, which is equivalent to the sum of dams and small dams/water pans volumes listed in the above table. There are five existing dams. The Turkwel Dam is a 155 m high dam constructed for hydropower generation (106 MW) and irrigation water supply purposes. Meanwhile, the Chemeron Dam was constructed for domestic and irrigation water supply purposes; however, its reservoir is almost filled with sand. The other three existing dams are all for domestic water supply purposes.

The Chemususu Dam is under construction for domestic water supply purposes (storage volume of 10 MCM). The Oloibortoto River Water Transfer Work is also under construction. The detailed design of the Arror Dam (domestic and irrigation water supply, hydropower and flood control) is completed. The structures under planning and/or design in the catchment area are Oletukat, Leshota, and Oldorko dams for the Lower Ewaso Ng'iro South River Multipurpose Dam Development Project (domestic and irrigation water supply, and hydropower).

There are 660 small dams/water pans with total storage volume of about 12 MCM. There are 2,094 boreholes in the catchment area, which is approximately 17% of the national total of 12,444 boreholes (MWI).

2.3.5 Athi Catchment Area

ACA has a total catchment area of 58,639 km^2 and an annual average rainfall of 810 mm, which is between a rather rich rainfall of around 1,300-1,400 mm in LVNCA and LVSCA and less rainfall of around 500 mm in RVCA and ENNCA. The annual rainfall differs spatially within the catchment area, ranging from around 500 mm in the southern part near the border with Tanzania to 1,200 mm in the western mountainous area.

The main river basins in ACA are as follows:

Main River Basins (ACA)

Name of River	Sub-basins	Catchment Area (km^2)
Athi River	3A–3H	38,143
Gashi River	3LA	7,625
Mwachi River	3MA2, 3MB	3,875
Cha Shimba River	3MA1, 3MC	4,760

Source: JICA Study Team

The present water demand (2010) in ACA was estimated based on the population of 9.79 million and irrigation area of 44,898 ha, as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (ACA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	519
Industrial	93
Irrigation	*498
Livestock	25
Wildlife	3
Fisheries	7
Total	1,145

Note: *= Including water demand of 114 MCM/year supplied by water resources of Tanzania.
Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from the rivers are listed below.

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	Total No. of 1,326	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	Total No. of 5,351	Mainly for domestic water supply	Total abstraction volume of 230 MCM/year

Note: See Tables 2.3.5 and 2.3.6 for details of dams and Tables 2.3.7 and 2.3.8 for details of water transfers.
See Sub-section 2.3.1 (3) for small dams/water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, NWCPC, AWSB, Tanathi WSB, and CWSB

The total storage volume of the existing water resources structures/facilities in ACA is approximately 22 MCM, which is equivalent to the sum of the dams and small dams/water pans volumes listed in the above table. The seven existing dams are all for domestic water supply purposes.

The Kiserian Dam is under construction for domestic water supply purposes to Kajiado (storage volume of 1 MCM). The designs of Thwake Dam (domestic and irrigation water supply and hydropower) and Ruaka Dam (domestic water supply) are completed. The dams under planning and/or design in the catchment area are 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 are the Second Mzima and Sabaki extension schemes.

There are 1,326 small dams/water pans with total storage volume of 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 of 12,444 boreholes (MWI). These boreholes supply around 44% of the domestic demand in ACA. Both small dams/water pans and boreholes have been exploited to satisfy the large water demands in the catchment area.

2.3.6 Tana Catchment Area

TCA has a total catchment area of 126,026 km^2 and an annual average rainfall of 840 mm, which is between a rather rich rainfall of around 1,300-1,400 mm in LVNCA and LVSCA and less rainfall of around 500 mm in RVCA and ENNCA. The annual rainfall differs spatially within the catchment area, ranging from around 500 mm in the middle reach area of the Tana River to 1,400 mm in the western mountainous area.

The main river basin in TCA is the Tana River basin as follows:

Main River Basin (TCA)

Name of River	Sub-basins	Catchment Area (km^2)
Tana River	4A–4H	95,884

Source: JICA Study Team

The present water demand (2010) in TCA was estimated based on a population of 5.73 million and irrigation area of 64,425 ha, as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (TCA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	146
Industrial	5
Irrigation	696
Livestock	34
Wildlife	1
Fisheries	9
Total	891

Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from the rivers are listed below.

Existing Water Resources Structures/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 (1,390 m^3/day)
Intra-basin Water Transfer	From Masinga Dam	Domestic water supply to Kitui	3 MCM/year (7,296 m^3/day)
Inter-basin Water Transfer	From Sasumua Dam	Domestic water supply to Nairobi	21 MCM/year (56,200 m^3/day)
Inter-basin Water Transfer	From Thika Dam	Domestic water supply to Nairobi	161 MCM/year (440,700 m^3/day)
Small Dam/Water Pan	Total No. of 622	Mainly for domestic and livestock water supply and partly for irrigation	Total storage volume of 26.9 MCM, average volume per facility of 43,000 m^3
Borehole	Total No. of 1,587	Mainly for domestic water supply	Total abstraction volume of 68 MCM/year

Note: See Table 2.3.5 for details of dams and Tables 2.3.7 and 2.3.8 for details of water transfers.
See Sub-section 2.3.1 (3) for small dams/water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, NWCPC, AWSB, Tanathi WSB, and CWSB

The total storage volume of the existing water resources structures/facilities in TCA is approximately 2,245 MCM, which is equivalent to the sum of the dams and small dams/water pans volumes listed in the above table. There are seven existing large-scale dams, among which the Sasumua and Thika dams are for domestic water supply to 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 for domestic water supply purposes (storage volume of 1 MCM). The detailed designs of the Thiba Dam (irrigation water supply), High Grand Falls Dam (hydropower, domestic and irrigation water supply, and flood control), and Yatta Dam (domestic water supply) are completed. The water resources structures 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 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 demand in TCA.

2.3.7 Ewaso Ng'iro North Catchment Area

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 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 part to 1,400 mm in the southwestern part near the Kenya's Five Water Towers.

The main river basins in ENNCA are as follows:

Main River Basins (ENNCA)

Name of River	Sub-basins	Catchment Area (km^2)
Ewaso Ng'iro North River	5A–5D, 5EC, 5ED, 5FA	81,750
Bogal River	5EB	26,049
Bor River	5EA	26,938

Source: JICA Study Team

The present water demand (2010) in ENNCA was estimated based on a population of 3.82 million and irrigation area of 7,896 ha, as presented in Table 3.3.2 of this report, Chapter 6 of the Main Report Part A, and summarised below.

Present Water Demand (2010) (ENNCA)

Sub-sector	Present Water Demand (2010) (MCM/year)
Domestic	58
Industrial	1
Irrigation	92
Livestock	57
Wildlife	0
Fisheries	4
Total	212

Source: JICA Study Team

To satisfy the above stated present water demands, the existing water resources structures/facilities except the direct intake facilities from the rivers are listed below.

Existing Water Resources Structures/Facilities (ENNCA)

Existing Structures/ Facilities	Name of Structures/ Facilities	Purposes	Notes
Dam	-	-	-
Small Dam/Water Pan	Total No. of 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. of 1,147	Mainly for domestic water supply	Total abstraction volume of 35 MCM/year

Note: See Sub-section 2.3.1 (3) for small dams/water pans, and Sub-sections 2.3.1 (4) and 3.3.1 (3) for boreholes.
Source: JICA Study Team based on the NWMP (1992) and data from MWI, WRMA, and NWCPC

The total storage volume of the existing water resources structures/facilities in ENNCA is approximately 10 MCM, which is the total of the volumes of the small dams/water pans mentioned in the above table. There is no existing dam. The Badasa Dam is under construction for domestic water supply purposes (storage volume of 4 MCM). The feasibility study for the Isiolo Dam is ongoing (domestic water supply).

There are 615 small dams/water pans with total storage volume of 10.3 MCM. There are 1,147 boreholes in the catchment area, which is approximately 9% of the national total of 12,444 boreholes (MWI). These boreholes supply around 60% of the domestic water demand in ENNCA.

2.4 Ongoing Projects and Existing Plans

2.4.1 Ongoing Projects

(1) Dams

The table below is a summary of dams being constructed or whose detailed designs are completed or ongoing as of November 2012.

Dam Projects under Construction, or with Completed or Ongoing Detailed Designs

Current Status	Name of Dam and Expected Year of Completion
Dams under construction by NWCPC: 4 dams	Chemususu Dam (RVCA), to be completed in 2013 Kiserian Dam (ACA), to be completed in 2013 Umaa Dam (TCA), to be completed in 2013 Badasa Dam (ENNCA), to be completed in 2013
Detailed designs are completed by NWCPC: 4 dams	Bunyunyu Dam (LVSCA) Ruaka Dam (ACA) Thwake Dam (ACA) Yatta Dam (TCA)
Detailed designs are completed by NIB: 1 dam	Thiba Dam (TCA)
Detailed designs are completed by MORDA: 4 dams	Nandi Forest Dam (LVNCA) Magwagwa Dam (LVSCA) Arror Dam (RVCA) High Grand Falls Dam (TCA)
Detailed designs are ongoing by NWCPC: 3 dams	Siyoi Dam (LVNCA), to be completed in 2013 Nzoia Dam at No. 34B (LVNCA), to be completed in 2013 Rare Dam (ACA), to be completed in 2013
Detailed designs are ongoing by MOSSP/ MWI: 1 dam	Nzoia Dam at No. 42A (LVNCA), to be completed in 2013
Detailed designs are ongoing by MORDA: 4 dam	Oletukat Dam (RVCA), to be completed in 2013 Leshota Dam (RVCA), to be completed in 2013 Oldorko Dam (RVCA), to be completed in 2013 Lake Chala Dam (ACA)

Note: ( ) = Catchment area
See Tables 1.2.1, 2.3.1 and 2.3.2 for details.
Source: JICA Study Team based on the information from MWI, NWCPC, NIB, MORDA and RDAs

Dams with completed or ongoing preliminary designs, feasibility studies or other preliminary studies are listed in Sub-section 2.3.1.

These dams under the stages of construction, detailed designs, or studies seem to be well dispersed in the six catchment areas. While the ongoing four dams are for water supply purposes, some of the dams under study and/or design are multi-purpose.

(2) Bulk Water Transfer

The table below is a summary of intra-basin bulk water transfer schemes being constructed, or whose detailed designs are completed or ongoing as of November 2012.

Intra-basin Bulk Water Transfer Schemes under Construction, or with Completed or Ongoing Detailed Designs

Current Status	Name of Scheme
Scheme under construction by NWCPC: 1 scheme	Scheme for Chemususu Dam (RVCA)
Detailed design is completed or ongoing by NWCPC: 3 schemes	Scheme for Bunyunyu Dam (LVSCA) Scheme for Ruaka Dam (ACA) Scheme for Rare Dam (ACA)

Note: ( ) = Catchment area
See Table 1.2.2 for details.
Source: JICA Study Team based on the information from WRMA, NWCPC, WSBs, MORDA, and RDAs

The table below is a summary of inter-basin bulk water transfer schemes being constructed, or whose detailed designs are completed or ongoing as of November 2012.

Inter-basin Bulk Water Transfer Schemes under Construction, or with Completed or Ongoing Detailed Designs

Current Status	Name of Scheme
Schemes under construction by NWCPC: 4 schemes	Scheme of Oloibortoto River (RVCA) Scheme for Kiserian Dam (ACA) Scheme for Umaa Dam (TCA) Scheme for Badasa Dam (ENNCA)
Detailed designs are completed or ongoing by NWCPC: 2 schemes	Scheme for Siyoi Dam (LVNCA) Scheme for Nzoia Dam at No.34B (LVNCA)
Detailed designs are completed or ongoing by MORDA: 2 schemes	Scheme for Nandi Forest Dam (LVNCA) Scheme for Magwagwa Dam (LVSCA)

Note: ( ) = Catchment area
See Tables 1.2.2 and 2.3.3 for details.
Source: JICA Study Team based on the information from WRMA, NWCPC, WSBs, MORDA and RDAs

Water transfer schemes with completed or ongoing preliminary designs, feasibility studies or other preliminary studies are listed in Sub-section 2.3.1.

(3) Water Harvesting

According to an information obtained from NWCPC in May 2012, NWCPC constructed 59 new small dams/water pans nationwide (total storage capacity of 853,735 m^3) and desilted 29 existing dams/pans (total storage capacity of 489,322 m^3) in 2009/2010. Furthermore, it constructed 58 new small dams/water pans (total storage capacity of 1,215,310 m^3) and desilted 18 existing dams/pans (total storage capacity of 471,535 m^3) in 2010/2011.

(4) Groundwater (Boreholes)

According to the information obtained from NWCPC in June 2012, NWCPC drilled 90 boreholes nationwide (total yield of 11,597 m^3/day) in 2010/2011 as well as 64 boreholes (total yield of 8,208 m^3/day) in 2011/2012 for domestic water supply purposes.

2.4.2 Existing Development Plans

(1) Strategic Plans

The NWCPC Strategic Plan 2010-2015 enumerates the implementation plans for the proposed water resources development as follows:

a) Studies and detailed designs of 12 dams including Nzoia, Siyoi, Bunyunyu, Koru, Thua, Wiyumiririe, Mwache, Isiolo, Ndarugu, Itare, Yame (Maralal), and Rare;
b) Construction of 11 dams including Umaa, Kiserian, Badasa, Chemususu, Nzoia, Siyoi, Bunyunyu, Wyumireria, Mwache, Isiolo, and Thua;
c) Design of 505 small dams/water pans;
d) Desilting of existing small dams/water pans and construction of new ones, with a total number of 505;
e) Design for the rehabilitation and augmentation of 15 medium and large dams;
f) Rehabilitation and augmentation of 17 medium and large dams;
g) Design and construction of nine pilot artificial groundwater recharge schemes with monitoring; and
h) Drilling and equipping of 507 boreholes.

The MORDA Strategic Plan 2008-2012 proposes studies and designs for the following multi-purpose dam projects: i) High Grand Falls Multipurpose Reservoir, ii) Munyu Multipurpose and Kibwezi Irrigation, iii) Lower Ewaso Ng'iro Multipurpose Development Project, iv) Sand River Multipurpose Dam Project, v) Olkejuado Dryland Multipurpose Project, vi) Magwagwa Multipurpose Dam, vii) Nandi Forest Multipurpose Dam, viii) Webuye-Teremi Multipurpose Dam, ix) Wajir Integrated Development Programme, x) Lake Chala Integrated Water Resource Project, xi) Mwache Dam Multipurpose Development Project, and xii) Arror Integrated Multipurpose Project.

(2) Water Resources Management Study

The Ewaso Ng'iro North River Catchment Conservation and Water Resource Management Study was carried out in 2001-2002, financed through a grant from AfDB. The study emphasised the formulation of integrated water resources development programmes towards 2025 with an aim to bring about an even distribution of water in the region for all water users. The development programmes included:

a) Domestic and irrigation water supply schemes, and
b) Catchment conservation programme.

As sources of water, surface water, boreholes, shallow wells, subsurface dams, and water pans are expected.

2.5 Operation and Maintenance Issues

Current issues on the O&M of water resources structures are enumerated below, which were obtained mainly from the interviews with government officials concerned.

(1) Dam and Reservoir

Operation and maintenance efforts to sustain water demand for irrigation, domestic, and electricity generation have not kept pace with the need to improve the services. The rehabilitation needed to overcome construction deficiencies and neglected maintenance overwhelms the national budget. At the same time, water user groups contribute minimally to financing and maintenance.

Data for O&M of reservoirs are also not up to date, which reflects a lack of effective monitoring of the dams/reservoirs.

The Physiographical Baseline Survey for the Upper Tana Catchment Area (2011) by WRMA has disclosed the survey results on the change in the capacity by sedimentation of reservoirs located in the Upper Tana, as shown in the following:

Survey on the Change in Reservoir Capacity (Upper TCA)

Reservoir	Catchment Area	2010 Reservoir Survey	Design Value (year)	% Difference	Annual Denudation Rate
Masinga	7,335 km^2	1,401.9 MCM	1,560.0 MCM (1981)	10%	0.7 mm/year
Kamburu	9,520 km^2	110.1 MCM	146.0 MCM (1974)	25%	-
Ndakaini (Thika)	71 km^2	71.5 MCM	70.0 MCM (1994)	0%	-

Note: The annual denudation rate was estimated by the JICA Study Team without considering the trap efficiency.
Source: JICA Study Team based on the Physiographical Baseline Survey for the Upper Tana Catchment Area, 2011

The estimated annual denudation rate of 0.7 mm/year for Masinga Reservoir seems to be high compared with the specific sediment of 120 to 350 m^3/km^2/year applied for the Upper Tana catchment in the NWMP (1992).

(2) Small Dam/Water Pan

Rapid siltation of small dams/pans is a challenge that frequently arises, particularly in arid and semi-arid areas. According to the latest information obtained from NWCPC in May 2012, about 30% (in number) of the small dams/water pans constructed/rehabilitated by NWCPC were desilted.

2.6 Challenges and Key Issues

The challenges and key issues identified in this study for the water resources development sub-sector are listed below.

(1) Low Development Rate against the Target

Among the 28 priority dam schemes proposed in the NWMP (1992), only three dams have been completed and another dam is under construction, as of November 2012. Out of the proposed 24 intra-basin and 16 inter-basin bulk water transfer schemes in the NWMP (1992), only one intra-basin and four inter-basin water transfer schemes have been completed. The slow progress in implementing the priority dam and water transfer projects might be caused by the following factors: a) insufficient coordination among related organisations, b) insufficient resources of the organisations in terms of planning and implementation, c) insufficient technical databases, d) unspecific implementation plans, and/or e) insufficient budget for implementation, and so forth.

(2) Climate Change Impact on Water Resources in the Future

As stated in the Sectoral Report (B), climate change will likely increase the frequency and duration of droughts particularly in the coastal areas of the country; therefore, strengthening the water resources management is essential. The National Climate Change Response Strategy (April 2010) states that adaptation measures that have been proposed in the water sector are as follows: i) construction of dams and water pans, ii) protection of water towers, river banks, and water bodies, iii) desilting of riverbeds and dams, iv) municipal water recycling facilities, and v) building capacity for water quality improvement and awareness campaign to promote water efficiency measures. The strategy highlights that interventions in the water sector will have to adapt an integrated approach to water resource management and utilisation.

Studies on water resources development were carried out based on the estimated hydrological datasets including the impact of climate change. With regard to the water resources development sub-sector, the conceivable measures to cope with the risks of droughts due to climate change are to increase water storage volumes by new storage construction, existing reservoir rehabilitation and water transfer, and to reallocate the existing reservoir water.

(3) Need of Inter-basin Transfer due to Maldistribution of Water Resources

The water resources are unevenly distributed both in space and time. In case none of the potential dam site is found in the sub-basin or no additional storage is available, the inter-basin bulk water transfer will be examined as an option to supplement water deficit.

It is noted that the water transfer structures will be applied when these are technically and economically feasible, and will not induce serious environmental issues.

(4) Water Demand Management

It is important to consider managing the demand of water to ensure sustainability of water resources as emphasised in the NWRMS 2007-2009. The principal measures for water demand management may include water pricing and charges, reduction of unaccounted for water, recycling of water, more efficient irrigation technologies, public awareness, etc.

(5) Introduction of Flood Control Concept to Dam Planning

Flood control dams or multi-purpose dams with flood control purposes were not proposed in the NWMP (1992) from the economical viewpoint, as well as, due to the undetermined effects of flood regulation and difficulty in operation. However, dams with flood control purposes are essential, taking into consideration the concept of integrated water resources management (IWRM) and the current situation of the flood control sub-sector in Kenya, which has certain schemes of multi-purpose dam projects including flood control purposes.

CHAPTER 3 WATER RESOURCES AND WATER DEMANDS

3.1 General

Future water demands will heighten due to the increase in population and economic activities. Furthermore, available water resources will be affected by climate change. The water resources development plan in this study needs to be formulated in order to attain an appropriate allocation of the limited and climate-affected water resources to the heightened demands of various water users. This plan will also identify the water resources infrastructures required to be developed. The target year of the plan formulation is 2030.

This chapter presents the available future water resources considering climate change impacts and future water demand projections for 2030 and 2050, as well as the present water resources and water demands estimated for 2010. The present water resources and demands for 2010 were discussed to understand the current situation. The water resources and demands for 2030 were also presented to evaluate the vulnerability of the water resources in order to develop concepts in the formulation of the water resources development plan. The water resources and demands for 2050 were discussed to evaluate the vulnerability of the water resources for further consideration in the future.

Details of the estimated water resources for 2010, 2030, and 2050 are given in Sectoral Report (B). Details of the present and projected future water demands are shown in Sectoral Report (C) for domestic, industrial, livestock, wildlife, and inland fisheries water, as well as in Sectoral Report (E) for irrigation water.

3.2 Water Resources Estimated Considering Impact of Climate Change

Annual renewable surface water and sustainable yield of groundwater resources were estimated for 2010 (present), 2030, and 2050 by catchment area as explained in the Main Report Part A and Sectoral Report (B), and summarised as follows:

Annual Renewable Surface Water and Sustainable Yield of Groundwater Resources

(Unit: MCM/year)

Catchment Area	2010			2030			2050		
	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total	Surface Water	Groundwater	Total
LVNCA	4,626	116	4,742	4,969	108	5,077	5,455	140	5,595
LVSCA	4,773	203	4,976	5,749	188	5,937	7,005	190	7,195
RVCA	2,457	102	2,559	3,045	102	3,147	3,794	109	3,903
ACA	1,198	305	1,503	1,334	300	1,634	1,711	332	2,043
TCA	5,858	675	6,533	7,261	567	7,828	7,383	508	7,891
ENNCA	1,725	526	2,251	2,536	475	3,011	1,361	449	1,810
Total	20,637	1,927	22,564	24,894	1,740	26,634	26,709	1,728	28,437

Note: Refer to the Main Report Part A and Sectoral Report (B) for details.
Source: JICA Study Team

Monthly mean values of the annual renewable surface water resources are shown by sub-basin in Table 3.2.1 for 2010 and Table 3.2.2 for 2030. The annual sustainable yield of groundwater resources are shown by sub-basin in Table 3.2.3 for 2010 and 2030.

The sustainable yield of groundwater was derived to be 10% of the groundwater recharge in the catchment areas excluding river courses and riparian areas with a width of 1 km. The areas of 1 km wide along the rivers are areas where groundwater abstraction will be restricted in order to maintain groundwater tables beside rivers. The impacts of climate change were incorporated into the above estimates for 2030 and 2050.

From the spatial aspect, it seems that the spatial distribution of renewable water resources will not change drastically in the future. The renewable water resources in the northern half and the eastern half of the country are expected to be similar to the present condition. On the other hand, the renewable water resources in the central mountainous area and the western side around the Lake Victoria are expected to increase.

From the temporal viewpoint, the southeastern part of ENNCA and the middle reach of TCA are anticipated to be drier in the long rain season between March and May. Other areas are expected to have more water resources. In the dry season, from June to August, almost the whole country will experience drier days. There will be more water resources during the rainy season.

The availability of water resources is expected to be more unevenly distributed in terms of spatial and temporal viewpoints in the future.

The water resources development plan was formulated based on the water resources estimates for 2030. Prior to the formulation of the plan, the estimated water resources for 2030 and 2050 were evaluated and explained in Section 3.4.

3.3 Water Demands

The estimated water demands of domestic, industrial, irrigation, livestock, wildlife and inland fisheries for 2010, 2030, and 2050 are presented and explained in the Main Report Part A and Sectoral Reports (C) and (E). The said water demands are summarised below.

Water Demands

(Unit: MCM/year)

Sub-sector	Year 2010	Year 2030	Year 2050
Domestic	1,186	2,561	3,657
Industrial	125	280	613
Irrigation	1,602	18,048	18,048
Livestock	255	497	710
Wildlife	8	8	8
Fisheries	42	74	105
Total	3,218	21,468	23,141

Note: Refer to Main Report Part A and Sectoral Reports (C) and (E) for details.
Source: JICA Study Team

Table 3.3.1 shows annual water demands by sub-sector and sub-basin for 2010, 2030 and 2050.

The estimated present water demands (2010) were applied as the present water use, since records of the actual water uses were insufficient to be utilised for evaluation. The present water demands were estimated based on the assumed unit water requirements for the respective sub-sectors.

It is noted that the abovementioned irrigation water demands for 2030 and 2050 were projected under the condition of the new irrigation development up to 1.2 million ha following the targets of Kenya Vision 2030.

The present water demands for 2010 were divided into surface water demands and groundwater demands by source by estimating the present groundwater demands and subtracting them from the total water demands, as shown below.

Present Surface Water and Groundwater Demands by Catchment Area in 2010

(Unit: MCM/year)

Catchment Area	Total Water Demands (2010)	Surface Water Demands (2010)	Groundwater Demands (2010)
LVNCA	228	187	41
LVSCA	385	349	36
RVCA	357	242	115
ACA	1,145	915	230
TCA	891	823	68
ENNCA	212	177	35
Total	3,218	2,693	525

Source: JICA Study Team

There is no available official statistical data for groundwater abstraction rate in Kenya. In this evaluation, the groundwater abstraction rate was directly estimated by the collected borehole database information from MWI. Out of the 12,444 borehole data in the database, 6,349 boreholes have the exact location data. First, the groundwater abstraction rate was estimated by using the 6,349 borehole data. Secondly, the estimated abstraction rate was adjusted by a rate proportional to the total abstraction rate of 12,444 borehole data. The total abstraction yield was estimated at 560 MCM/year. However, there are some boreholes which have been abandoned and are not being used at present. The present groundwater abstraction rate was further adjusted to 525 MCM/year using an assumed percentage derived from the actual abandonment. Table 3.3.2 shows volumes of the present (2010) water demands divided into the surface water and groundwater by sub-basin.

3.4 Evaluation of Water Resources

The estimated future water resources for 2030 and 2050 were evaluated on the basis of the WRMA catchment area to look at the impacts of climate change and the increase in future water demands. The evaluation was made in terms of surface and groundwater resources potential for development for 2010, 2030 and 2050, and preliminary water balance and deficit in 2010 and 2030 under the existing water resources development structures/facilities condition and for the present and future water demands.

3.4.1 Water Resources Potential for Development

(1) Definition of Water Resources Potential for Development

The water resources potentials for development in this study are defined as shown below.

Renewable Water Resources					
Renewable Surface Water Resources			Renewable Groundwater Resources		
Present Surface Water Use	Unavailable Surface Water	Surface Water Resources Potential for Development	Present Groundwater Use	Unavailable Groundwater	Groundwater Resources Potential for Development

Source: JICA Study Team

Renewable Water Resources and Water Resources Potential for Development

The renewable water resources are the total of renewable surface and groundwater resources. The above terms and definitions are explained as follows:

Terms and Definitions

Terms	Definitions
Renewable Water Resources	It is theoretically the maximum usable freshwater resources, which can be estimated by multiplying the difference of the annual precipitation and actual annual evapotranspiration by the area.
Present Water Use	The amount of water that is presently abstracted from river or wells. The water demand of 2010 is applied as present water use.
Unavailable Water	The amount of water that is not suitable for development such as reserve flow and groundwater, which is not sustainable for abstraction.
Water Resources Potential for Development	The amount of water that is estimated by subtracting the present water use and unavailable water from renewable water resources. The volume of surface water resources potential is made with an assumption that all resources are usable, if necessary water storages will be developed.

Source: JICA Study Team

(2) Renewable Water Resources

The present and future renewable water resources were estimated by catchment area for 2010, 2030, and 2050, as follows:

Annual Renewable Surface Water and Renewable Groundwater Recharge

(Unit: MCM/year)

Catch-ment Area	2010			2030			2050		
	Surface Water	Ground-water Recharge	Total	Surface Water	Ground-water Recharge	Total	Surface Water	Ground-water Recharge	Total
LVNCA	4,626	1,326	5,952	4,969	1,251	6,220	5,455	1,612	7,067
LVSCA	4,773	2,294	7,067	5,749	2,112	7,861	7,005	2,126	9,131
RVCA	2,457	1,126	3,583	3,045	1,126	4,171	3,794	1,209	5,003
ACA	1,198	3,345	4,543	1,334	3,303	4,637	1,711	3,649	5,360
TCA	5,858	7,719	13,577	7,261	6,520	13,781	7,383	5,840	13,223
ENNCA	1,725	5,660	7,385	2,536	5,095	7,631	1,361	4,851	6,212
Total	20,637	21,470	42,107	24,894	19,407	44,301	26,709	19,287	45,996

Note: Refer to the Main Report Part A and Sectoral Report (B) for details.
Source: JICA Study Team

The renewable groundwater recharge is regarded as the renewable groundwater resource. The differences between the renewable water resources for 2030 and 2010 and those for 2050 and 2010 are tabulated below, to assess the impact of climate change on the resources.

Differences of Renewable Water Resources

(Unit: MCM/year)

Catchment Area	Differences of Renewable Water Resources			
	2030-2010		2050-2010	
LVNCA	268	(4.5%)	1,115	(18.7%)
LVSCA	794	(11.2%)	2,064	(29.2%)
RVCA	588	(16.4%)	1,420	(39.6%)
ACA	94	(2.1%)	817	(18.0%)
TCA	204	(1.5%)	-354	(-2.6%)
ENNCA	246	(3.3%)	-1,173	(-15.9%)
Total	2,194	(5.2%)	3,889	(9.2%)

Note: Figures in parentheses are the percentages of the difference based on 2010 values.
Source: JICA Study Team

As shown in the above table, the renewable water resources in all catchment areas except in TCA and ENNCA have an increasing trend. The renewable water resources in TCA and ENNCA are expected to increase toward 2030, but will decrease toward 2050 due to increase in potential evapotranspiration. The contradicting trend is seen due to the sensitive balance between the increase of rainfall and increase of evapotranspiration.

(3) Present Water Use and Future Water Demands

The present water use and future water demands are presented in Section 3.3.

(4) Unavailable Water

Unavailable surface water includes the reserve, which consists of the surface water for ecological need and basic human needs. It was determined to be the 95% value of the naturalised daily flow duration curve with the probability of once in 10 years for each river under the present climate condition, in accordance with the WRMA Guidelines for Water Allocation, First Edition, 2010 and results of discussions with them. The estimated reserve at the most downstream of each catchment area is shown in the following table:

Estimated Reserve by Catchment Area

(Unit: MCM/year)

Catchment Area	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Reserve	1,284	807	3	114	1,252	0

Source: JICA Study Team

The above table shows zero value of the reserve for ENNCA. The zero is caused by seasonal rivers in downstream of the catchment area. In addition to the values in the above table, the estimated reserve values of 17 reference points are tabulated in Sub-section 4.3.2 (2) with explanation of the estimate. The reserves for the sub-basins to be incorporated into the water balance study are tabulated in Table 4.3.1.

Unavailable groundwater was estimated by subtracting the sustainable yield of groundwater resources from the renewable groundwater recharges.

(5) Surface Water Resources Potential for Development

The surface water resources potential for development is the maximum potential water resources which can be developed in a sustainable manner. The surface water resources potential for development was estimated by simply subtracting the water resources already developed and unavailable surface water from the renewable surface water resources, conforming to the aforementioned definition. No return flow on the various water uses was considered in the estimate considering nature of the water uses. The estimated surface water resources potential for development is summarised by catchment area as follows:

Surface Water Resources Potential for Development by Catchment Area

(Unit: MCM/year)

Catchment Area	2010	2030	2050
LVNCA	3,155	3,498	3,984
LVSCA	3,617	4,593	5,849
RVCA	2,212	2,800	3,549
ACA	169	305	682
TCA	3,783	5,186	5,308
ENNCA	1,548	2,359	1,184
Total	14,484	18,741	20,556

Source: JICA Study Team

Since the present surface water use and reserve are considered to be unchanged, the surface water resources potential for development will increase as the renewable surface water resources increase in general. LVNCA, LVSCA, RVCA, and TCA are projected to have increased surface water resources potential. Even under the condition of increased potential, the water storages are required in order to utilise the excessive flows of water during the rainy season. These water storages will be used during water scarce periods. Further, it must be reminded that the spatial distribution within the catchment area was not considered in this evaluation; therefore, water shortage might be observed locally and this requires more detailed discussions.

In ACA, the marginal potential for development was estimated for 2010 because the sum of the present surface water use and reserve are almost the same as the renewable surface water resources. Considering the expected large increase in future domestic water demands especially in Nairobi and Mombasa, the irrigation water demand, which is the largest user among the sub-sectors, should be adjusted so as to attain an appropriate balance with the water resources.

ENNCA shows increased surface water resources potential for development in 2030 and decreased results in 2050 due to the same trend of renewable surface water resources.

(6) Groundwater Resources Potential for Development

The groundwater resources potential for development was calculated by subtracting the present groundwater use and unavailable groundwater from the renewable groundwater recharges. The calculated groundwater resources potentials for development for 2010, 2030, and 2050 are summarised by catchment area below.

Groundwater Resources Potential for Development by Catchment Area

(Unit: MCM/year)

Catchment Area	Area	2010	2030	2050
LVNCA	18,374 km^2	75 (4.1)	67 (3.6)	99 (5.4)
LVSCA	31,734 km^2	167 (5.3)	152 (4.8)	154 (4.9)
RVCA	130,452 km^2	-13 (-)	-13 (-)	-6 (-)
ACA	58,639 km^2	75 (1.3)	70 (1.2)	102 (1.7)
TCA	126,026 km^2	607 (4.8)	499 (4.0)	440 (3.5)
ENNCA	210,226 km^2	491 (2.3)	440 (2.1)	414 (2.0)
Total	575,451 km^2	1,402 (2.4)	1,215 (2.1)	1,203 (2.1)

Note: The values in parentheses are the volumes per catchment area (1,000 m^3/year/km^2)
Source: JICA Study Team

Negative groundwater resources potential for development was estimated in RVCA both at present and in future, suggesting tight situation of balance between sustainable groundwater resources and groundwater use.

The present groundwater resources potential is approximately 10% of the present surface water resources potential, while 2030 groundwater resources potential is about 6% of 2030 surface water resources potential.

TCA and ENNCA have relatively high groundwater resources potential for development among 6 catchment areas.

(7) Summary of Water Resources Potential for Development

The total water resources potential for development is the sum of the surface water and groundwater resources potentials for development. Based on the estimates above, the table below is a summary of the water resources potential for development by catchment area.

Water Resources Potential for Development by Catchment Area

(Unit: MCM/year)

Catchment Area	2010	2030	2050
LVNCA	3,230	3,565	4,083
LVSCA	3,784	4,745	6,003
RVCA	2,199	2,787	3,543
ACA	244	375	784
TCA	4,390	5,685	5,748
ENNCA	2,039	2,799	1,598
Total	15,886	19,956	21,759

Source: JICA Study Team

The water resources potential for development is expected to increase in all the catchment areas except in ENNCA due to the effects of climate change. ACA has relatively small potential for development.

From the aspect of total resources volume, climate change is not expected to cause severe negative impacts. However, the availability of water resources is expected to be more unevenly distributed spatially and temporally in the future. Considering such situation, the preliminary water balance study was carried out to disclose influences of unevenly distributed water resources to the present and future water uses as described in the following sub-section.

3.4.2 Preliminary Water Balance Study

It is important to assess the magnitude of water resources shortage and to also identify the area where and the period when the water shortage occurs in order to develop the concepts in the formulation of the water resources development plans. If the water demand exceeds the supply capacity, it is required to develop new water sources and water supply facilities and/or adjust the amounts of water demands.

For the abovementioned assessment and identification, the preliminary water balance study was carried out for 2010 and 2030 under the existing water resources development structures/facilities condition. The surface water resources were applied in the preliminary water balance study, which are the predominant water sources covering more or less 80% of the total water demands.

The surface water balance (surplus/deficit) for 2010 and 2030 was calculated by sub-basin between surface water resources and surface water demands applying the existing water resources infrastructures. For the calculation in 2010, the present renewable surface water resources as summarised in Sub-section 3.4.1 (2) were applied as the water resources. For the calculation in 2030, the 2030 surface water resources potential for development as summarised in Sub-section 3.4.1 (5) was utilised.

Computation models for the surface water balance study constructed for each of the six catchment areas as well as the applied basic conditions including prioritisation of water allocation, reserve, etc. are explained in Section 4.3.

Results of the surface water balance study are shown in Table 3.4.1 and Figure 3.4.1 for 2010 and Table 3.4.2 and Figure 3.4.2 for 2030, representing the annual water deficits with the probability of once in 10 years for domestic and industrial uses and once in 5 years for irrigation use. A summary of the estimated annual water deficits for 2010 and 2030 is shown by catchment area below.

Estimated Annual Water Deficits by Catchment Area for 2010 and 2030

Catchment Area	2010			2030		
	Surface Water Resources (MCM/year)	Deficit Volume (MCM/year)	Percentage of Deficit/ Surface WR	Surface Water Resources (MCM/year)	Deficit Volume (MCM/year)	Percentage of Deficit/ Surface WR
LVNCA	4,626	27	0.6%	4,969	371	7.5%
LVSCA	4,773	150	3.1%	5,749	1,304	22.7%
RVCA	2,457	92	3.7%	3,045	867	28.5%
ACA	1,198	745	62.2%	1,334	4,153	311.3%
TCA	5,858	336	5.7%	7,261	5,822	80.2%
ENNCA	1,725	68	3.9%	2,536	2,442	96.3 %
Total	20,637	1,418	6.9%	24,894	14,959	60.1%

Source: JICA Study Team

The above table indicates increases in deficit volume in 2030 to 14,959 MCM/year and percentage of deficit/surface water resources in 2030 to 60.1% in the country.

Table 3.4.1 and Figure 3.4.1 show that the present surface water demand is not fully satisfied by the surface water in a number of sub-basins with existing facilities with probability of once in 10 years for domestic and industrial uses and once in 5 years for irrigation use, under the condition of the estimated water demand and reserve. Table 3.4.2 and Figure 3.4.2 indicate that the estimated 2030 water shortage is recognised to be more severe than the present condition because the 2030 water demands will increase greatly. The water balance between the surface water resources and surface water demands is assessed for 2010 and 2030 for the respective catchment areas, as follows:

a) LVNCA

In 2010, minor water deficit of 1 to 2 MCM/year/sub-basin is seen in the sub-basins upstream of Nzoia River, downstream of Sio River and in middle reach of Yala River, and almost all other sub-basins show deficit of less than 1 MCM/year/sub-basin due to abundant water resources and low water demands. But in 2030, the major part of the catchment area shows deficit of more than 1 MCM/year/sub-basin due to increase in mainly irrigation water demand and partly domestic water demand. The sub-basins located in lower reaches of Sio, Nzoia and Yala rivers show higher deficits of 38 to 69 MCM/year/sub-basin in 2030.

b) LVSCA

In 2010, the sub-basin downstream of Nyando River and that with Homabay have high water deficits of 20 and 35 MCM/year/sub-basin respectively, and the sub-basins located north of Lake Victoria and those east and west of Homabay have the deficits of around 10 MCM/year/sub-basin because of high water demands for urban domestic and irrigation uses. Almost all other sub-basins extending east of the catchment area show deficits of less than 1 MCM/year/sub-basin, because of relatively low water demands in 2010. In 2030 however, the major part of the catchment area shows water deficits of more than 1 MCM/year/sub-basin due to increase in domestic and irrigation water demand. The sub-basins in lower catchment of Nyando River and near Homabay have high deficits of 47 to 130 MCM/year/sub-basin, and those north of Lake Victoria have deficit of 53 to 93 MCM/year/sub-basin. The sub-basins in Gucha and Migori rivers also show high deficits of 56 to 286 MCM/year/sub-basin in 2030.

c) RVCA

In 2010, high water deficits of 10 to 18 MCM/year/sub-basin are observed in the sub-basin of Suguta River located south of Lake Turkana and those around and north of Lake Magadi due to limited water resources. The sub-basins located west of Lake Turkana, in Kerio River, near Nakuru and Naivasha, and downstream of Ewaso Ng'iro South River have deficits of 2 to 7 MCM/year/sub-basin due to also limited water resources. In 2030, increased deficits are observed in the abovementioned sub-basins because of demand increase. The sub-basin of Suguta River and those around and north of Lake Magadi show the deficits of 91 to 115 MCM/year/sub-basin. The sub-basins west of Lake Turkana, in Kerio River, and downstream of Ewaso Ng'iro South River have deficits of 11 to 34 MCM/year/sub-basin. The sub-basins near Nakuru and Naivasha show deficit of 74 MCM/year/sub-basin. The northwestern end of the catchment area shows the deficit of 71 MCM/year/sub-basin in 2030.

d) ACA

Almost all sub-basins of the catchment area face high water deficits larger than 5 MCM/year/sub-basin in 2010 and deficits larger than 10 MCM/year/sub-basin in 2030 because of large domestic and irrigation water demands against limited water resources. The water deficit observed in the sub-basin where Nairobi is situated shows an increase from 88 in 2010 to 426 MCM/year/sub-basin in 2030 due to large domestic water demands. The sub-basins in the middle reach of Athi River have the increased deficits from 70 in 2010 to 474 MCM/year/sub-basin in 2030 due to large irrigation water demand. The sub-basin of Mombasa shows the increase from 31 in 2010 to 152 MCM/year/sub-basin in 2030.

e) TCA

Almost all sub-basins of the catchment area show water deficits more than about 2 MCM/year/sub-basin in 2010 and deficits more than about 15 MCM/year/sub-basin in 2030 due to large irrigation and domestic water demands. The sub-basins located upstream of Tana River and in Thiba River show the increased deficits from a range of 24-49 MCM/year/sub-basin in 2010 to a range of 93-430 MCM/year/sub-basin in 2030 because of large domestic and irrigation water demands. The sub-basins in the middle reach of Tana River also show water deficit increase from 13-25 in 2010 to 50-273 MCM/year/sub-basin in 2030 due to large irrigation water demand. The sub-basins in the lower reach of Tana River show in 2030 high water deficit up to 482 MCM/year/sub-basin due to large irrigation water demand.

f) ENNCA

The major part of the catchment area shows water deficit of more than 1 MCM/year/sub-basin in 2010 and deficit of more than about 5 MCM/year/sub-basin in 2030 due to limited water resources. In 2010, high water deficit of 12 MCM/year/sub-basin is seen in the northeastern end of the catchment area. In 2030, the sub-basins in the middle reach of Ewaso Ng'iro North River show the water deficits up to 573 MCM/year/sub-basin.

3.4.3 Vulnerability of Future Water Resources

Vulnerability of the future water resources is summarised below on the basis of discussions on the estimated water resources mentioned in the preceding Section 3.2 and water resources potential for development and preliminary water balance study described in the respective Sub-sections 3.4.1 and 3.4.2.

(1) Renewable Water Resources and Comparison with Water Demands

The available water resources in 2030, which consist of surface water runoff and sustainable yield of groundwater resources, are estimated to be 26,634 MCM/year considering the climate change impact. On the other hand, the 2030 water demand is projected to increase to 21,468 MCM/year as mentioned in Section 3.3 following the target of Kenya Vision 2030. The ratio of the water demands and available water resources, which is known as a water stress ratio, reaches approximately 81%.

Generally, the water stress ratio of more than 40% indicates the severe water stress condition[1] in a basin. Therefore, the water stress ratio of 81% for the country implies to have the severe water stress by 2030. There is a need to develop new water sources and water supply facilities as well as the necessity to adjust the amounts of water demand.

(2) Water Resources Potential for Development and Climate Change Impact

The water resources potential for development is expected to increase toward 2030 and 2050 in all the catchment areas except in ENNCA due to the effects of climate change as estimated in Sub-section 3.4.1 (7). ACA has relatively small potential for development in 2030 and 2050. From the aspect of total resources volume, climate change is not expected to cause severe negative impacts.

However, the water resources are expected to be more unevenly distributed in terms of spatial and temporal viewpoints in the future due to climate change impacts. Especially, the impact will cause the northern part of RVCA and the northern part of ENNCA to have less water resources.

(3) Preliminary Water Balance Study and Estimated Deficits under Existing Water Resources Structures Condition

The volume of deficit in the country will increase overwhelmingly from 1,418 MCM/year in 2010 to 14,959 MCM/year in 2030 due to demand increase, as estimated by the preliminary water balance study under the existing water resources structures condition with probability of once in 10 years for domestic and industrial uses and once in 5 years for irrigation use. The surface water resources potential for development in 2030 is projected to increase by 29% from 2010 due to climate change impact. Meanwhile, the surface water demand of 20,363 MCM/year estimated for 2030 is 7.6 times as large as the present demand of 2,693 MCM/year. As a result, severe water shortage will be expected by 2030.

It is therefore clear that the vulnerability of water resources is high. The appropriate water allocation, development and management as well as water savings are required to mitigate the water shortage.

Especially, it is necessary to reduce the irrigation water demand which has the largest demand among the water users by examining the appropriate size of irrigation areas and adoption of water saving irrigation technique.

3.4.4 Water Demands Modified for 2030 and Water Resources to be Used

The water demands discussed in the preceding sections for 2030 were reviewed and modified by the water balance study to be within the available water resources through the application of reduced irrigation water requirements by reducing the irrigation areas and by introducing water saving irrigation methods. The water balance study incorporated the water storage, transfer, and abstraction facilities proposed in the water resources development plans stated in Chapter 4.

[1] OECD's definition

The table below is a summary of the modified water demands for 2030 for the respective catchment areas.

Water Demands Modified for 2030

Catchment Area	Water Demands for 2030 (MCM/year)						
	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
LVNCA	424	19	1,359	61	0	16	1,879
LVSCA	464	41	1,158	106	3	15	1,787
RVCA	264	23	*1,393	123	1	8	1,812
ACA	941	153	*917	59	3	12	2,085
TCA	343	42	2,697	69	1	16	3,168
ENNCA	125	2	539	79	0	7	752
Total	2,561	280	8,063	497	8	74	11,483

Notes: *= Including water demand of 560 MCM/year to be supplied by water resources of Ethiopia.
**=Including water demand of 154 MCM/year to be supplied by water resources of Tanzania.
Source: JICA Study Team

The total modified water demands of 11,483 MCM/year in 2030 are approximately 3.6 times of the present water demands of 3,218 MCM/year mainly due to increase in population and irrigation areas.

The water resources will be utilised in 2030 corresponding to the water demands mentioned above under the balanced condition between water resources and water demands as explained in Chapter 4.

CHAPTER 4 WATER RESOURCES DEVELOPMENT PLAN

4.1 General

This chapter presents the formulated water resources development plan by catchment area to meet the water demands projected for 2030 together with its concept, frameworks, and methodologies for planning.

The formulation of the water resources development plan was based on the water resources and water demands discussed in Chapter 3.

4.2 Overall Concept and Framework for Planning

Considering the current situation of the water resources development sub-sector, future water demands, and needs of the sub-sector as stated in the preceding Chapters 2 and 3, the following development target, water allocation policy, and overall planning concepts and frameworks were conceived in formulating the water resources development plan:

4.2.1 Development Target

The target of the water resources development plan is to meet all the water demands projections based on Kenya Vision 2030 for the target year of 2030 to its maximum including domestic, industrial, irrigation, livestock, wildlife and inland fisheries water demands, and hydropower use.

Water supply reliability to be targeted in the development planning is a probability of once in 10 years for domestic and industrial uses and once in 5 years for irrigation use. The reliability follows that set in the NWMP (1992) and discussion results with MWI and WRMA.

4.2.2 Water Allocation Policy

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

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

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

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

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

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

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

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

a) The reserve consisting of ecological need and basic human needs has the highest priority as stipulated in the WRMA Guidelines.

b) There have been no international obligations in terms of water allocation according to MWI, therefore, no obligation was considered in the study. The existing inter-basin transfers were incorporated in the study making it second priority considering importance of the existing commitment having been made. In addition to the existing inter-basin transfers, the existing water uses including domestic, industrial and irrigation water uses also have the second priority as these are also deemed to be the existing commitments.

c) The WRMA Guidelines state that after allocating the abovementioned reserve, international obligation, and inter-basin transfer, all other uses of water resources are authorised according to the criteria of equitable allocations, but domestic water has a higher priority than other uses. Therefore, the third priority was given to the newly planned domestic water supply. Newly planned industrial water supply also has the third priority, since the industrial water is generally supplied by the same system as that of the domestic water supply.

d) The fourth priority was given to the newly planned water supply for livestock, wildlife, and inland fisheries demands. These demands have rather small volume compared with the available water resources.

e) After allocating all the above needs, new irrigation water demand was allocated, because the amount of the irrigation water demand is considerably larger compared with the others.

f) Hydropower generation does not consume water and its water use follows the use of other demands in principle.

The following table summarises a priority of the water allocation discussed above:

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 water resources development plan includes the water resources of the transboundary water within the territory of Kenya, but excludes the transboundary water resources outside of Kenya, to use the water controllable within the country.

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

4.2.3 Planning Concepts and Frameworks for Water Resources Development

Water resources development plan requires overall planning concepts and frameworks, which were prepared considering the existing water resources structures, future water demands and available water resources, and so forth.

The overall planning concepts and frameworks to be adopted in this study are:

i) Develop the water resources to the maximum to meet the water demands;
ii) Use water resources effectively through multi-purpose development, inter-basin transfer, intra-basin transfer, water saving, reuse of water, etc.;
iii) Allocate the water resources based on the water allocation policy described in the preceding sub-section;
iv) Consider the climate change impacts in formulating the water resource development plan by applying the water resources estimates including effects of climate change; and
v) Formulate the hydropower development plan to include in multi-purpose dam development plans.

Details of the concepts and frameworks are as described below.

(1) Maximisation of Water Resources Development

To maximise the development of water resources, policies on the use of surface water and groundwater are set as follows:

a) By taking into account of the present water use and available water resources, for domestic and industrial water supply, surface water (including storage dams, water transfers and water harvesting measures) will be allocated first, which is generally the cheapest in development cost. The groundwater will be allocated only in the following conditions: when there is insufficient surface water, available surface water is located far from the demand sites, and/or amount of the water demand is not substantial. In the coastal area, desalination is also considered where the surface water and groundwater are not sufficiently available.

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

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

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

(2) Effective Use of Water Resources

To use the water resources effectively, various water resources development measures were conceived including dams, water transfers, water harvesting measures (small dams/water pans, sub-surface/sand dams, roof catchment, and rock catchment), and boreholes, as follows:

a) <u>Dams</u>: The dams are planned as necessary to supply relatively large demands such as domestic, industrial, and irrigation water demands. Dams play an important role to meet large water demands projected for 2030. The dams are as far as possible to be multi-purpose including flood control and hydropower generation functions to utilise the limited resources efficiently. A dam is defined to have a height of 15 m or more. The availability of river water varies in time and space and dams assist in storage of the water to ensure the availability during the time of scarcity. Rehabilitation of the existing dams is not considered in this study since few data on current situation of the existing dams including siltation are available.

b) <u>Water transfers</u>: The water transfers are planned for domestic, industrial, and irrigation water demands, and where both surface water and groundwater are not available within the sub-basin or basin. These water transfers should be technically and economically viable, and environmentally friendly. However, the implementation of inter-basin water transfer, in particular, may need a decision at the national level. The water transfer is to be considered after meeting the demand at the source.

c) <u>Water harvesting measures</u>: The water harvesting measures are planned mainly for rural domestic, irrigation, livestock, wildlife, and fisheries water demands. For rural domestic water supply, small dams, instead of water pans, are used in view of water quality. For irrigation, livestock, wildlife and fisheries demands, small dams/water pans are mainly adopted. The roof catchment, rock catchment and sub-surface/sand dams are recommended as supplementary measures to domestic water use except for drinking purposes.

d) <u>Boreholes</u>: Groundwater usage through boreholes is planned mainly for domestic, industrial, and small-scale irrigation water demands where surface water is not available.

Storage volumes of the dams are planned through the water balance studies to supplement the estimated water deficits. The abovementioned structures need to be planned to minimise the negative impacts to the natural and social environments induced by development. Furthermore, it is essential in the formulation of sustainable plans.

As the catchment degradation leads to siltation as well as reduction of water availability, the watershed conservation is essential. The communities need to be involved in the watershed conservation. Furthermore, water conservation including water saving and recycling of water use is also important for the management of the limited water resources.

(3) Water Allocation based on Allocation Policy

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

(4) Consideration of Climate Change Impact in the Development Plan

The climate change impacts on water resources were considered in the projection for 2030. Results of the projection showed the following facts: i) the spatial distribution will be almost unchanged compared with the present situation, but the northern part of both RVCA and ENNCA will be drier; and ii) as to the seasonal variation, more water resources will be expected during the rainy season and it will become drier during the long dry season (June to August) in most of the country. The projected 2030 water resources amounts and discharge patterns were applied in the water resources development plans to make them more realistic.

(5) Inclusion of Hydropower Development into Multi-purpose Scheme

The hydropower development plan will be formulated to include in multi-purpose dam development plans conforming to the planning concepts as explained in Section 7.6 of the Main Report Part A.

(6) Others

1) In addition to the above Items (1) to (5), it is noted that rainwater harvesting and groundwater with rich fluoride and salinity were not included in the water balance study; however, the following factors need to be considered:
    a) Rainwater harvesting such as roof catchment and rock catchment will be recommended in order to supplement the supply for domestic and livestock water demands, and to prepare for drought risks. Sub-surface/sand dams will be also recommended for domestic use, and
    b) Groundwater that is rich in fluoride and/or salinity showing the content level above the allowable ones (more than 0.3 mg/L and 500 mg/L, respectively) will be recommended for domestic purposes other than drinking.
2) The groundwater recharge areas are localised, hence no plans were developed for them in NWMP 2030. Further study will be required for flood storage for groundwater recharge as well as the recharge, considering local specific hydrological and hydrogeological conditions.
3) The water supply reliability of once in 10 years or once in 5 years mentioned in Sub-section 4.2.1 and to be discussed in the following sections means that the water supply plan for the domestic and industrial use is formulated to satisfy their water demands under the drought

condition with probability of once in 10 years, and water supply plan for irrigation use is provided to satisfy irrigation water demand under the drought condition with probability of once in 5 years.

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

5) The water resources are national, and planning, development and management of the water resources should be basin-wise. The projects will be implemented, while managing the challenges through EIA implementation. It is noted that involvement of county governments in the implementation of the water resources development projects has not been clear so far.

4.3 Water Balance Study

4.3.1 Methodology of Water Balance Study

The water balance study was carried out to assess the magnitude of water resources shortage for 2010 (present condition) and 2030 (future condition) by subtracting the water demands from the estimated water resources for the respective years. In addition, it aims to quantify the required water resources volumes to be newly developed for 2030 so as to incorporate it into the water resources development plan.

Adjustments on the future water demands are required since the demands, following Kenya Vision 2030, were beyond the water resources capacities under the maximum water resources development condition, or the demands were far less than the available water resources. Section 3.4 discusses about the adjustments made through the water balance study.

The water balance study was carried out for a period of 20-years from 1991 to 2010 for the present condition and from 2021 to 2040 for the future condition between the surface water and ground water resources estimates for 20 years and the projected water demands for 2010 and 2030 for each of the six WRMA catchment areas. The water balance study was conducted separately for surface water and groundwater, because there are some differences between their usage in terms of quantities, users and their locations, abstraction and storage facilities, etc. The procedure of the water balance study adopted in this study is as follows:

(1) Procedure of Surface Water Balance Study

The procedure of the water balance study between the surface water resources and demands are explained below.

a) Setting percentages of the water resources allocation, i.e., surface water and groundwater, to supply for each of domestic, industrial, and irrigation water demands considering the actual allocation rates, distributions of water demands, and economical usage of the water resources, to achieve an effective combination of the surface water and groundwater resources. The percentages are set in principle, as follows:

Percentages of Water Resources Allocation by Subsector

(Unit: %)

Water Resources	Domestic, Urban	Domestic, Rural, Large	Domestic, Rural, Small	Industrial	Irrigation
Surface Water	95	50	0	50	-
Groundwater	5	50	100	50	-
Total	100	100	100	100	-

Note: For irrigation, see Sectoral Report (E)
Source: JICA Study Team, based on current situation

b) Calculating the surface water demands by applying the above percentages to the total demands for domestic, industrial and irrigation uses.

c) The livestock, wildlife, and inland fisheries water demands are planned to be supplied by surface water only, because these demands are actually being supplied by the surface water source. Since the demands are small in amount representing about 2% of the surface water resources nationwide and are distributed widely apart from rivers, the demands are excluded from those of the surface water balance study. The livestock, wildlife, and inland fisheries water demands will be supplied from small dams and water pans.

d) Balancing the surface water resources and surface water demands for domestic, industrial, and irrigation water uses to assess the surface water deficits and identify the required water resources development infrastructures.

The surface water balance study was conducted by applying the surface water resources and demands to a computation model developed for each of the six catchment areas under the conditions described in the following sub-section.

(2) Procedure of Groundwater Balance Study

Water demands to be supplied by groundwater for domestic and industrial water were estimated following the percentages of the water resources allocation shown in Paragraph (1) as stated above. The demands for the domestic and industrial uses and available groundwater resources were compared for each sub-basin. The remaining groundwater resources after the comparison were allocated to the irrigation use for each sub-basin.

4.3.2 Computation Models and Conditions of Surface Water Balance Study

The surface water balance study was conducted by using the computation models under the conditions as explained below.

(1) Computation Model of Surface Water Balance Study

The computation model for the surface water balance study was developed for each of the six catchment areas. The model consists of sub-basins representing the surface water resources, water demand points where water demands are abstracted, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities.

There are 204 sub-basins in total as the minimum units for the water balance study as tabulated below.

Number of Sub-basins

Catchment Area	Area (km^2)	No. of Sub-basins
LVNCA	18,374	38
LVSCA	31,734	32
RVCA	130,452	35
ACA	58,639	33
TCA	126,026	39
ENNCA	210,226	27
Total	575,451	204

Source: JICA Study Team

Figures 4.3.1 to 4.3.6 show the sub-basin division maps for the respective catchment areas. The computation models of the surface water balance study for the respective catchment areas are illustrated in Figures 4.3.7–4.3.12.

(2) Conditions of the Surface Water Balance Study

1) Naturalised Surface Water

The naturalised surface water resources were used for the water balance study. The naturalised surface water is defined as the surface water under the natural condition without any water abstraction for use.

A set of the naturalised surface water resources for 20 years between 1991 and 2010, representing the year of 2010, was provided by the rainfall-runoff model constructed with parameters derived based on the observed river discharges plus estimated actual water use. Another set of the naturalised surface water resources for 20 years between 2021 and 2040, representing 2030, was also estimated by applying the future rainfall considering climate change impact to the rainfall-runoff model. The monthly mean naturalised surface water is shown by sub-basin in Table 3.2.1 for 2010 and Table 3.2.2 for 2030. Details of the rainfall-runoff model are explained in Sectoral Report (B).

2) Water Demands

The water demands to be used for the water balance study were estimated for 2010 and projected for 2030 for the water use sub-sectors including domestic, industrial, irrigation, livestock, wildlife and inland fisheries.

The present water demands for 2010 are presented in Sub-sections 2.3.2 to 2.3.7 for the respective catchment areas. A summary of the water demands for 2030 is shown in Section 3.4. Table 3.3.1 shows the estimated/projected annual water demands by sub-sector and by sub-basin for 2010, 2030 and 2050.

3) Priority of Water Allocation in the Water Balance Study

The prioritisation of water allocation conforms to the water allocation policy determined in Sub-section 4.2.2 as follows:

Prioritisation of Water Allocation for NWMP 2030

Priority	Water Use
1	Reserve consisting of ecological and basic human needs
2	Existing water uses for domestic, industrial, irrigation and hydropower, and existing inter-basin transfer water (International obligation to allocate water for releasing to neighbouring countries is not considered, because there is no international commitments so far as described in Sub-section 4.2.2.)
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

4) Reserve

The amount of the reserve, consisting of ecological and basic human needs, was determined as the 95% value of the naturalised present daily flow duration curve for each river under drought condition with probability of once in 10 years, in accordance with the WRMA Guidelines for Water Allocation (First Edition, 2010) and results of the discussions with WRMA. The discussions with WRMA include:

a) The probability of once in 10 years (equivalent to the second lowest value in 20 years data series) was applied as the basic requirement.
b) The estimated flow duration curves under the present climate condition (2010) were utilised instead of observed ones, because there were a lot of missing data in the records.
c) A base dry year to estimate the reserves in the catchment area was determined at the most downstream reference point of the catchment area.

According to the Water Resources Management Rules 2007, the basic human needs mean the quantity of water required for drinking, food preparation, washing of clothes, bathing, basic sanitation and are assumed to be equal to 25 L/p/d. The above estimate for the reserve was made based on the present climate condition in order to maintain the current situation. In general, no quantitative value was set as the reserve for seasonal rivers.

The reserves estimated for 17 reference points are listed in the table below, and the flow duration curves used for the estimate are shown in Figure 4.3.13.

Reserves Estimated for 17 Reference Points

Catchment Area	Reference Point	Name of River	Location of Reference Point	Reserve (m^3/s)
LVNCA	1DA02	Nzoia	Near Webuye Town	15.9
	1FG01	Yala	Near Bondo Town	6.7
LVSCA	1GD03	Nyando	Near Ahero Town	1.6
	1JG05	Sondu	Near Sondu Town	10.5
	1KB03	Gucha	Near Rongo Town	0.4
	1KC03	Migori	Near Migori Town	1.5
	1LA04	Mara	Upstream of Masai-Mara National Reserve	4.3
RVCA	2B21	Turkwel	Near Lodwar Town	0.0
	2C16	Kerio	Downstream of confluence with Arror River (Kolowa)	0.0
	2K06	Ewaso Ng'iro South	Near Narok Town	0.0
	2GB01	Malewa	Upstream of Naivasha	0.0
ACA	3DB01	Athi (middle)	Near Wamunyu Town	8.6

	3HA12	Athi (lower)	Downstream of confluence with Tsavo River (Epiya Chapeyu)	8.9
TCA	4CC03	Thika	Downstream of Thika Town	8.5
	4BE10	Tana (upper)	Tana Rukanga	13.5
	4G01	Tana (lower)	Garissa	53.5
ENNCA	5ED01	Ewaso Ng'iro North	Archers' Post	1.6

Source: JICA Study Team

Values of the reserves estimated by sub-basin for the water balance study are shown in Table 4.3.1.

In cases where the river discharge is less than the reserve in a sub-basin in the water balance study, the discharge is released downstream if there is no dam located upstream, or supplemented from dams if there are dams upstream.

5) Dams and Water Transfer Facilities

The existing dams and water transfer facilities were included in the model, as listed below.

Existing Dams in the Water Balance Study

Catchment Area	Name of Dams
LVNCA	Moiben, Twin Rivers, Ellegirini, Kipkarren, Lessos
LVSCA	Gogo Falls, Sondu/Miriu
RVCA	Turkwel, Chemeron, Kirandich, Turasha, Aram
ACA	Ruiru, Bathi, Mulima, Manooni, Muoni, Kikoneni, Maruba
TCA	Sasumua, Thika, Masinga, Kamburu, Gitaru, Kindaruma, Kiambere
ENNCA	-

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

Existing Intra- and Inter-basin Water Transfer Schemes in the Water Balance Study

Scheme	Name of Schemes
Intra-basin bulk water transfer schemes	Scheme for Moiben Dam (LVNCA) Kikuyu Springs, Ruiru Reservoir, Nol Turesh, Mzima Springs, Marere boreholes, Tiwi boreholes, and Baricho shallow wells (ACA) Kiambere Dam to Mwingi and Masinga Dam to Kitui (TCA)
Inter-basin bulk water transfer schemes	Scheme for Moiben Dam (LVNCA) Scheme for Kirandich Dam (RVCA) Scheme for Maruba Dam (ACA) Schemes for Sasumua andThika dams (TCA)

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

The candidate dams and water transfer facilities for future development are in principle i) those proposed by the NWMP (1992) as the priority or future development potential ones; and ii) those under design and/or study by the government including the Kenya Vision 2030 flagship projects. These dam candidates are shown in Tables 1.2.1, 2.3.1 and 2.3.2. The water transfer candidates are shown in Tables 1.2.2 and 2.3.3.

6) Time Interval

Monthly mean values of the water resources and demands were applied for the water balance study. The monthly mean values were applied for water balance studies of the NWMP (1992), and usually used in the studies for national water master plans of other countries.

7) Dam Operation

Operation methods of dams in the water balance study are those that supply water from the dams when the water deficit occurred in the downstream.

The flow regulation effect of the five existing large-scale dams in TCA, i.e.: Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere dams was included in the naturalised discharge of the Tana River.

8) River Channel Loss

The observed river discharge records indicated that the discharge volume in the downstream reaches is sometimes smaller than the volume in the upstream reaches. This phenomenon is regarded as a river channel loss and mainly occurs by percolation and/or evapotranspiration. The river channel loss is incorporated in the water balance study.

Such phenomenon is seen in RVCA, ACA, TCA, and ENNCA. An approximately 15% to 20% of the annual runoff is accounted as river channel loss.

9) Return Flow

The following return flow rates were used in the water balance study with considerations:

a) Return flow rate of 25% of the demand for urban domestic water supply considering expected future rate of wastewater treatment,
b) Return flow rate of 5% of the demand for paddy irrigation water supply considering the experience,
c) Return flow rate of 100% of the water use for hydropower generation, and
d) Return flow rate of 0% for other water uses.

4.4 Water Resources Development Plan for the Lake Victoria North Catchment Area

4.4.1 Development Strategy for LVNCA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.2 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in LVNCA are as follows:

Present and Future Water Demands (LVNCA)

(Unit: MCM/year)

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

Source: JICA Study Team

The projected 2030 water demands showed a great increase of about 8.2 times compared with the present demands due to considerable increase in population to 12.36 million and irrigation areas to 170,789 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in LVNCA:

Present Water Supply Reliability at Reference Points (LVNCA)

Reference Point	1DA02 (Nzoia River)	1FG01 (Yala River)
Present Water Supply Reliability	1/7	1/7

Note: The water supply reliability of 1/7 means that water demands are satisfied by water resources under the drought condition with probability of once in 7 years.
Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and new structures/facilities are required to be developed.

As the estimated available 2030 surface water of 4,969 MCM/year is far larger than the groundwater of 108 MCM/year in the catchment area, the development will focus on surface water.

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

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

b) The existing intra-basin water transfer facility from Moiben Dam to Eldoret/Iten will be included in the development plan to satisfy future domestic water demands in the area. The planned inter-basin water transfer from Nandi Forest Dam to LVSCA is also included in the plan, since the detailed design was completed by MORDA. The volume of water transferred from Nandi Forest Dam to LVSCA is included in the water demands mentioned in Sub-section 4.5.1 for LVSCA.

c) Dams are essential to be developed over the catchment area in order to satisfy the sharply increased and widely expanded future large water demands such as domestic, industrial and irrigation water demands in the catchment area. Candidates of dam development for maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992) and ii) dams under design and/or planning by the government including the Kenya Vision 2030 flagship projects.

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

e) Groundwater will be exploited for domestic, industrial and irrigation uses where surface water is not available or insufficient.

4.4.2 Conditions of Water Balance Study for LVNCA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study conformed to the policies of the water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for LVNCA. Prior to the surface water balance study, the amounts of the water demands to be supplied by groundwater were subtracted from the total water demands. Water demands of livestock, wildlife, and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the water balance study, because these demands are small in amount representing about 2% of the available water resources in the catchment area, and are 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 summarised as follows:

i) The model consists of 38 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities as illustrated in Figure 4.3.7;
ii) Monthly mean values of water resources and demands are applied;
iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and
iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

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

a) <u>Moi's Bridge Dam and Hemsted Bridge Dam</u>: Moi's Bridge Dam site (catchment area of 858 km^2) and Hemsted Bridge Dam site (catchment area of 3,825 km^2) are closely located on a tributary and main stream of the Nzoia River, respectively. Moi's Bridge Dam was selected to be studied in the water balance, since Moi's Bridge Dam site is located upstream of Hemsted Bridge Dam and it has larger storage efficiency than Hemsted Bridge Dam.
b) <u>Nandi Forest Dam and Kimondi Dam</u>: Nandi Forest Dam site (catchment area of 1,339 km^2) on Yala River and Kimondi Dam site (catchment area of 692 km^2) on Kimondi River are

closely located. Nandi Forest Dam was selected to be studied in the water balance, since its detailed design was completed by the government.

Operation of Nandi Forest Dam reservoir for the water balance study was set to have a constant discharge for hydropower generation throughout the year, meeting the prime purpose of the hydropower generation among others as stated in the final study report of MORDA.

4.4.3 Proposed Water Resources Development Plan for LVNCA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – Dams (LVNCA)

(Unit: MCM)

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

Note: D/D=Detailed design
Source: JICA Study Team

Table 4.4.1 presents the details of the proposed dams.

2) Water Transfers

Proposed Plan – Water Transfers (LVNCA)

(Unit: MCM/year)

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

Source: JICA Study Team

3) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (LVNCA)

(Unit: MCM)

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

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

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

The proposed volumes mentioned above for domestic use were estimated based on water deficits calculated after supplying available water from dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation sub-sector.

4) Boreholes

Proposed Plan – Boreholes (LVNCA)

(Unit: MCM/year)

Facilities	Volume for Domestic/Industrial	Volume for Irrigation	Total Volume	Remarks
Borehole	29	27	56	Total no. of boreholes = 560

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

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

Figure 4.4.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in LVNCA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (LVNCA)

(Unit: MCM/year)

Sub-sector	Water Demand (2030)	Water Resources Allocation (2030)	
		Surface Water	Groundwater
Domestic	424	363	61
Industrial	19	10	9
Irrigation	1,359	1,332	27
Livestock	61	61	0
Wildlife	0	0	0
Fisheries	16	16	0
Total	1,879	1,782	97

Source: JICA Study Team

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in LVNCA is summarised in Table 4.4.3 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 in LVNCA is summarised below as well as that for 2010:

Water Supply Reliability at Reference Point (LVNCA)

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

Source: JICA Study Team

The future water supply reliability at the reference point of Webuye in Nzoia River is estimated at 1/5, since water demand downstream of the reference point is irrigation use only. The future water supply reliability at the reference point of Bondo in Yala River is estimated at 1/10, since water demand downstream of the reference point is domestic use only. The future reliability will decrease at Webuye compared with the present one due to large increase of the water demands, although the estimated future reliability conforms to the target value mentioned in Sub-section 4.2.1. Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised river flows resources, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.4.4.

Figures 4.4.2 and 4.4.3 show estimated river flow for 2010 and 2030 at the reference points in LVNCA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Points (LVNCA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

4.5 Water Resources Development Plan for the Lake Victoria South Catchment Area

4.5.1 Development Strategy for LVSCA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.3 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in LVSCA are as follows:

Present and Future Water Demands (LVSCA)

(Unit: MCM/year)

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

Source: JICA Study Team

The projected 2030 water demands showed a great increase of about 4.6 times compared with the present demands due to considerable increase in population to 12.72 million and irrigation areas to 126,424 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in LVSCA:

Present Water Supply Reliability at Reference Points (LVSCA)

Reference Point	1GD03 (Nyando River)	1JG05 (Sondu River)	1KB03 (Gucha River)	1KC03 (Migori River)	1LA04 (Mara River)
Present Water Supply Reliability	1/2	1/5	1/2	1/3	1/20

Note: The water supply reliability of 1/2, 1/3, 1/5 or 1/20 means that water demands are satisfied by water resources under the drought condition with probability of once in 2, 3, 5 or 20 years.
Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and new structures/facilities are required to be developed.

As the estimated available 2030 surface water of 5,749 MCM/year is far larger than the groundwater of 188 MCM/year in the catchment area, the development will focus on surface water.

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

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

b) The inter-basin water transfer facility from Itare and Londiani dams to RVCA will be developed to supply domestic water to the Greater Nakuru Area where heavily concentrated domestic water demands are expected in 2030, but both surface water and groundwater resources are insufficient. The Amala transfer scheme to RVCA is also included in the plan, since the detailed design is ongoing. Furthermore, the inter-basin water transfer facility from Nandi Forest Dam is included. The volumes of water transferred from Itare, Londiani and Amala dams to RVCA are included in the water demands mentioned in Sub-section 4.6.1 for RVCA. The volume of water transferred from Nandi Forest Dam to LVSCA is included in the water demands mentioned in Sub-section 4.5.1 for LVSCA.

c) Dams are essential to be developed over the catchment area in order to satisfy the sharply increased and widely expanded future large water demands such as domestic, industrial and irrigation water demands in the catchment area. Candidates of dam development for maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992) and ii) dams under design and/or planning by the government including the Kenya Vision 2030 flagship projects.

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

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

4.5.2 Conditions of Water Balance Study for LVSCA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study followed the policies of water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for LVSCA. Prior to the surface water balance study, the amounts of the water demands to be supplied by the groundwater were subtracted from the total water demands. Water demands of livestock, wildlife and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the water balance study, because these demands are small in amount representing about 2% of the available water resources in the catchment area, and are distributed widely apart from the rivers. The livestock, wildlife, and fishery demands will be supplied by the surface water with small dams/water pans.

Conditions of the surface water balance study are summarised as follows:

i) The model consists of 32 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities as illustrated in Figure 4.3.8;

ii) Monthly mean values of the water resources and demands are applied;

iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and

iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

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

a) Nyando Dam and Awasi Dam: Nyando Dam site (catchment area of 1,286 km^2) and Awasi Dam site (catchment area of 1,509 km^2) are closely located on the Nyando River. Nyando Dam was selected to be studied in the water balance since Awasi Dam was not proposed in the NWMP (1992) due to limited storage efficiency. Studies by the government for Nyando Dam were ongoing.

b) Katieno Dam and Namba Kodero Dam: Katieno Dam site (catchment area of 3,002 km^2) on Kuja River and Namba Kodero Dam site (catchment area of 2,769 km^2) on Migori River are closely located. Katieno Dam was selected to be studied in the water balance since Katieno Dam had larger storage efficiency compared with Namba Kodero Dam and some studies by the government for Katieno Dam were made.

Operation of Magwagwa Dam reservoir for the water balance study was set to have a constant discharge for hydropower generation throughout the year, meeting the prime purpose of the hydropower generation among others as stated in the detailed design report of MORDA.

4.5.3 Proposed Water Resources Development Plan for LVSCA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – Dams (LVSCA)

(Unit: MCM)

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

Note: D/D=Detailed design, Pre-F/S=Prefeasibility study
Source: JICA Study Team

Table 4.4.1 presents the details of the proposed dams.

2) Water Transfers

Proposed Plan – Water Transfers (LVSCA)

(Unit: MCM/year)

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

Source: JICA Study Team

3) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (LVSCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fishery	Total Volume	Remarks
Small Dam/ Water Pan	33	37	106	18	194	Total no. of small dams/ water pans = 3,880

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

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

The proposed volumes mentioned above for domestic use were estimated based on water deficits calculated after supplying available water from dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation sub-sector.

4) Boreholes

Proposed Plan – Boreholes (LVSCA)

(Unit: MCM/year)

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

Note: Excluding the abstraction volume of the existing boreholes of 36 MCM/year.
Source: JICA Study Team

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

Figure 4.5.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in LVSCA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (LVSCA)

(Unit: MCM/year)

Sub-sector	Water Demand (2030)	Water Resources Allocation (2030)	
		Surface Water	Groundwater
Domestic	464	374	90
Industrial	41	21	20
Irrigation	1,158	1,107	51
Livestock	106	106	0
Wildlife	3	3	0
Fisheries	15	15	0
Total	1,787	1,626	161

Source: JICA Study Team

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in LVSCA is summarised in Table 4.5.1 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 in LVSCA is summarised below as well as that for 2010:

Water Supply Reliability at Reference Point (LVSCA)

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

Source: JICA Study Team

The future water supply reliability at the reference points of Ahero in Nyando River and Migori in Migori River is estimated at 1/5, since water demand downstream of the reference points is irrigation use mainly. The future water supply reliability at the reference points of Rongo in Gucha River and Masai-Mara in Mara River is estimated at 1/10, since water demand downstream of the reference points is domestic use only. The estimated future water supply reliability at the reference point of Sondu in Sondu River is 1/20 due to constant water release from Magwagwa Dam for hydropower generation. The future reliability will decrease at Masai-Mara compared with the present one due to large increase of the water demands, although the estimated future reliability conforms to the target value mentioned in Sub-section 4.2.1. Appropriate water resources development and management will be required to maintain the target reliability.

The naturalised river flows, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.4.4.

Figures 4.5.2 to 4.5.6 show estimated river flow for 2010 and 2030 at the reference points in LVSCA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Points (LVSCA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

4.6 Water Resources Development Plan for the Rift Valley Catchment Area

4.6.1 Development Strategy for RVCA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.4 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in RVCA are as follows:

Present and Future Water Demands (RVCA)

(Unit: MCM/year)

Sub-sector	Present Water Demand (2010)	Future Water Demand (2030)
Domestic	129	264
Industrial	10	23
Irrigation	143	1,393
Livestock	70	123
Wildlife	1	1
Fisheries	4	8
Total	357	1,812

Source: JICA Study Team

The projected 2030 water demands showed a great increase of about 5.1 times compared with the present demands due to increase in population to 7.45 million and irrigation areas to 101,753 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in RVCA:

Present Water Supply Reliability at Reference Points (RVCA)

Reference Point	2B21 (Turkwel River)	2C16 (Kerio River)	2K06 (Ewaso Ng'iro South River)	2GB01 (Malewa River)
Present Water Supply Reliability	1/20	1/7	1/2	1/3

Note: The water supply reliability of 1/2, 1/3, 1/7 or 1/20 means that water demands are satisfied by water resources under the drought condition with probability of once in 2, 3, 7 or 20 years.
Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and new structures/facilities are required to be developed.

Although the projected available 2030 surface water of 3,045 MCM/year is larger than the groundwater of 102 MCM/year in the catchment area, majority of the surface water is distributed along the catchment borders with LVNCA and LVSCA, and to the areas adjacent to the most upstream section of the Athi and Tana rivers, therefore, the development plan will focus on the efficient combination of surface water and groundwater to meet the widely distributed water demands.

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

a) The inter-basin water transfer facility from Itare and Londiani dams in LVSCA to RVCA will be developed to supply domestic water to the Greater Nakuru Area, where heavily concentrated domestic water demands are expected in 2030 but both surface and groundwater resources are insufficient. In addition, the Amala inter-basin water transfer scheme from LVSCA will be included in the plan. The volumes of water transferred from Itare, Londiani and Amala dams to RVCA are included in the water demands mentioned in Sub-section 4.6.1 for RVCA.

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

c) Small dams and/or water pans will be developed in small rivers for small and scattered demands including rural domestic, livestock, wildlife, inland fisheries, and small scale irrigation water supply purposes at locations where suitable dam sites are not expected for large dams but the surface water is available. The small dams and water pans will be constructed in almost entire catchment area except for the northernmost part where rainfall is minimal.

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

4.6.2 Conditions of Water Balance Study for RVCA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study followed the policies of water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for RVCA. Prior to the surface water balance study, the amounts of the water demands to be supplied by groundwater were subtracted from the total water demands. Water demands of livestock, wildlife, and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the water balance study, because these demands are small in amount representing about 4% of the available water resources in the catchment area, and are 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 summarised as follows:

i) The model consists of 35 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities as illustrated in Figure 4.3.9;

ii) Monthly mean values of the water resources and demands are applied;

iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and

iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

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

a) Kimwarer Dam and Kipsang Dam: Kimwarer Dam site (catchment area of 160 km^2) and Kipsang Dam site (catchment area of 66 km^2) are closely located on the tributaries of the Kerio River. Kimwarer Dam was selected to be studied in the water balance since it had larger storage efficiency compared with Kipsang Dam and some studies were made by the government for Kimwarer Dam.

Operation of Arror and Oletukat dam reservoirs for the water balance study was set to have constant discharges respectively for hydropower generation throughout the year, meeting the prime purpose of the hydropower generation among others as stated in the final report or information of MORDA.

4.6.3 Proposed Water Resources Development Plan for RVCA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – Dams (RVCA)

(Unit: MCM)

Name of Dams	Storage Volume for Domestic/ Industrial	Storage Volume for Irrigation	Storage Volume for Hydropower	Total Storage Volume	Remarks
Murung-Sebit Dam	0.0	40.0	0.0	40.0	
Kimwarer Dam	17.0	90.0	0.0	107.0	Pre-F/S done (KVDA)
Arror Dam	2.0	(60.0)	60.0	62.0	D/D completed (MORDA)
Embobut Dam	1.0	29.0	0.0	30.0	Pre-F/S done (KVDA)
Waseges Dam	4.0	0.0	0.0	4.0	
Malewa Dam	34.0	0.0	0.0	34.0	
Upper Narok Dam	5.0	24.0	0.0	29.0	Flagship project
Oletukat Dam	10.0	(290.0)	290.0	300.0	D/D ongoing (ENSDA)
Leshota Dam	5.0	0.0	28.0	33.0	D/D ongoing (ENSDA)
Oldorko Dam	5.0	0.0	15.0	20.0	D/D ongoing (ENSDA)
Total	83.0	183.0	393.0	659.0	

Note: D/D=Detailed design, F/S=Feasibility study, Pre-F/S=Prefeasibility study
Source: JICA Study Team

Table 4.4.1 presents the details of the proposed dams.

2) Water Transfers

Proposed Plan – Water Transfers (RVCA)

(Unit: MCM/year)

Structures	Volume for Domestic	Volume for Hydropower/ Irrigation	Total Volume	Remarks
Inter-basin Water Transfer from Itare and Londiani Dams (LVSCA) to Nakuru	41	0	41	
Inter-basin Water Transfer from Amala Dam (LVSCA) to the Ewaso Ng'iro South River	0	82	82	D/D ongoing (ENSDA)

Source: JICA Study Team

3) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (RVCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fishery	Total Volume	Remarks
Small Dam/ Water Pan	27	23	123	9	182	Total no. of small dams/ water pans = 3,640

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

The total number of 3,640 small dams/water pans was estimated by applying the volume per small dam/water pan of 50,000 m^3 as the minimum capacity which was decided following the volume adopted in NWMP (1992) and assumptions based on the volumes of the existing small dams/water pans.

The proposed volumes mentioned above for domestic use were estimated based on water deficits calculated after supplying available water from dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation sub-sector.

4) Boreholes

Proposed Plan – Boreholes (RVCA)

(Unit: MCM/year)

Facilities	Volume for Domestic/Industrial	Volume for Irrigation	Total Volume	Remarks
Borehole	0	16	16	Total no. of boreholes = 160

Note: Excluding the abstraction volume of the existing boreholes of 115 MCM/year.
Source: JICA Study Team

The total number of 160 boreholes was estimated by applying the capacity per borehole of 100,000 m^3/year, which was decided based on the capacities of the existing boreholes.

Figure 4.6.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in RVCA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (RVCA)

(Unit: MCM/year)

Sub-sector	Water Demand (2030)	Water Resources Allocation (2030)	
		Surface Water	Groundwater
Domestic	264	213	51
Industrial	23	12	11
Irrigation	1,393	*1,377	16
Livestock	123	123	0
Wildlife	1	1	0
Fisheries	8	8	0
Total	1,812	1,734	78

Note: *=Including water demand of 560 MCM/year to be supplied by water resources of Ethiopia.
Source: JICA Study Team

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in RVCA is summarised in Table 4.6.1 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 in RVCA is summarised below as well as that for 2010:

Water Supply Reliability at Reference Point (RVCA)

Reference Point	Present (2010) Water Supply Reliability	Future (2030) Water Supply Reliability
Turkwel River (2B21), Lodwar	1/20	1/20
Kerio River (2C16), Kolowa	1/7	1/10
Ewaso Ng'iro South River (2K06), Narok	1/2	1/20
Malewa River (2GB01), Naivasha	1/3	1/10

Source: JICA Study Team

The future water supply reliability at the reference points of Lodwar in Turkwel River and Narok in Ewaso Ng'iro South River is estimated at 1/20 due to constant water release from Turkwel Dam in Turkwel River, and Oletukat, Leshota and Oldorko dams in Ewaso Ng'iro South River for hydropower generation. The future water supply reliability at the reference points of Kolowa in Kerio River and Naivasha in Malewa River is estimated at 1/10, since water demand downstream of the reference points is domestic use only.

The naturalised river flows, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.4.4.

Figures 4.6.2 to 4.6.5 show estimated river flow for 2010 and 2030 at the reference points in RVCA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Points (RVCA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

4.7 Water Resources Development Plan for the Athi Catchment Area

4.7.1 Development Strategy for ACA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.5 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in ACA are 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

The projected 2030 water demands showed an increase of about 1.8 times compared with the present demands due to the increase in population to 20.54 million including Nairobi and Mombasa and increase in irrigation areas to 91,006 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in ACA:

Present Water Supply Reliability at Reference Points (ACA)

Reference Point	3DB01 (Middle Athi River)	3HA12 (Lower Athi River)
Present Water Supply Reliability	1/2	1/1

Note: The water supply reliability of 1/1 or 1/2 means that water demands are satisfied by water resources under the drought condition with probability of once in 1 or 2 years.

Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and new structures/facilities are required to be developed.

As the total of the estimated available 2030 surface water of 1,334 MCM/year and the groundwater of 300 MCM/year in the catchment area is below than the 2030 water demands, the water resources development should focus not only on maximum exploitation of the surface water and the groundwater within the catchment area but also on the water transfer from the adjacent catchment area such as TCA.

Strategies for the 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 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 Sub-section 4.7.1 for ACA.
b) Dams are essential to be developed in the northwestern part of the catchment area, along the Athi River and in the coastal area including Mombasa in order to satisfy the sharply increased future large water demands expected in these areas such as domestic, industrial and irrigation water demands. Candidates of dam development for the maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992), and ii) dams under design and/or planning by the government including the Kenya Vision 2030 flagship projects.
c) Dams identified in the most upstream area of the Athi River will be newly developed only for domestic water supply purposes to Nairobi and satellite towns considering the limited water resources against the demands. These new dams are Upper Athi, Stony Athi, Kikuyu, Ruaka, Kamiti 1, Ruiru-A, and Ndarugu dams.
d) Dams, intra-basin water transfer expansion schemes from the existing springs and the Athi River, and/or desalination will be incorporated into the development plan for the domestic water supply to Mombasa and coastal area.
e) Small dams and/or water pans will be developed in the small rivers over the catchment area for small and scattered demands including rural domestic, livestock, wildlife, inland fisheries, and small scale irrigation water supply purposes at locations where suitable dam sites are not expected for large dams but the surface water is available.
f) Groundwater will be exploited for domestic, industrial and irrigation uses where the surface water is not available or insufficient.

4.7.2 Conditions of Water Balance Study for ACA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study followed the policies of water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for ACA. Prior to the surface water balance study, the amounts of the water demands to be supplied by groundwater were subtracted from the total water demands. Water demands of livestock, wildlife, and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the balance study, because these demands are small in amount representing about 5% of the available water resources in the catchment area, 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 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 as illustrated in Figure 4.3.10;

ii) Monthly mean values of the water resources and demands are applied;

iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and

iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

4.7.3 Proposed Water Resources Development Plan for ACA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – 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 (Ndarugu 1) 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 (MORDA)
Total	696.2	993.0	1,689.2	

Note: D/D=Detailed design, F/S=Feasibility study, M/P=Master plan
Source: JICA Study Team

The water deficit of 142 MCM/year was estimated by the water balance study for the area of Nairobi and satellite towns. The balance study applied the new water resources development structures 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 of Nairobi and surrounding 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 would 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. The proposed dams are Stony Athi, Kamiti 1, Ruiru-A, and Ndarugu dams, and dams in TCA including Maragua 4, Karimenu 2 and Thika 3A dams.

Table 4.4.1 presents the details of the proposed dams.

2) Water Transfers

Proposed Plan – Water Transfers (ACA)

(Unit: MCM/year)

Structures	Volume for Domestic	Total Volume	Remarks
Intra-basin Water Transfer from Mzima Springs to Mombasa/ Kwale/ Ukunda (Expansion)	37	37	Flagship, (equivalent to 100,000 m^3/day), M/P ongoing (CWSB)
Intra-basin Water Transfer from the Athi River to Mombasa/ Malindi/ Kilifi/ Mtwapa (Expansion)	31	31	(equivalent to 85,000 m^3/day), M/P ongoing (CWSB)
Inter-basin Water Transfer from the TCA to Nairobi (Expansion)	168	168	F/S and M/P ongoing (AWSB)

Source: JICA Study Team based on the Feasibility Study by AWSR and CWSB, 2012

3) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (ACA)

(Unit: MCM)

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

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

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

The proposed volumes mentioned above for domestic use were estimated based on water deficits calculated after supplying available water from the dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation sub-sector.

4) Boreholes

Proposed Plan – Boreholes (ACA)

(Unit: MCM/year)

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

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

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

5) Desalination

A desalination of 93 MCM/year (equivalent to 255,000 m^3/d approximately) will be required in Mombasa according to the water balance study, although the interim result of the study made by CWSB (November 2012) suggests options of desalination amounts of 30,000 to 150,000 m^3/d.

Figure 4.7.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in ACA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (ACA)

(Unit: MCM/year)

Sub-sector	Water Demand (2030)	Water Resources Allocation (2030)	
		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 of 154 MCM/year to be supplied by groundwater resources of Tanzania.
Source: JICA Study Team

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in ACA is summarised in Table 4.7.1 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, except for Nairobi as discussed in Sub-section 4.7.3 (1).

The water supply reliability for 2030 at the reference points 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

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 4.4.4.

Figures 4.7.2 and 4.7.3 show estimated river flow for 2010 and 2030 at the reference points in ACA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Points (ACA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

4.8 Water Resources Development Plan for the Tana Catchment Area

4.8.1 Development Strategy for TCA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.6 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in TCA are as follows:

Present and Future Water Demands (TCA)

(Unit: MCM/year)

Sub-sector	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

The projected 2030 water demands showed an increase of about 3.6 times compared with the present demands due to the increase in population to 10.37 million and irrigation areas to 226,224 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in TCA:

Present Water Supply Reliability at Reference Points (TCA)

Reference Point	4BE10 (Upper Tana River)	4CC03 (Thika River)	4G01 (Lower Tana River)
Present Water Supply Reliability	1/1	1/7	1/2

Note: The water supply reliability of 1/1, 1/2 or 1/7 means that water demands are satisfied by water resources under the drought condition with probability of once in 1, 2 or 7 years.

Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and new structures/facilities are required to be developed.

As the estimated available 2030 surface water of 7,261 MCM/year is far larger than the groundwater of 567 MCM/year in the catchment area, the development will focus on the surface water. However, almost all surface water is available on the western hilly area of the catchment area while in the eastern area, the surface water is scarce. Therefore, water resources development in the eastern side of the catchment area needs to rely on groundwater.

Strategies for the water resources development in TCA 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) Inter-basin water transfer facilities to ACA from dams located in the most upstream section of the catchment area will be developed to supply domestic water to Nairobi and satellite towns where heavily concentrated domestic water demands are expected in 2030 but 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 4.7.1 for ACA.
b) Dams are essential to be developed in the western part of the catchment area where sharply increased future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidates of dam development for the maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992), and ii) dams under design and/or planning 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 the 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 to Kitui from Masinga Dam and to Mwingi from Kiambere Dam.
e) Small dams and/or water pans will be developed in the small rivers over the catchment area for small and scattered demands including rural domestic, livestock, wildlife, inland fisheries, and small scale irrigation water supply purposes at locations where suitable dam sites are not expected for large dams but the surface water is available.
f) The available groundwater is rich in the middle reach of the Tana River. Groundwater will be exploited where surface water is not available or insufficient.

4.8.2 Conditions of Water Balance Study for TCA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study followed the policies of water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for TCA. Prior to the surface water balance study, the amounts of the water demands to be supplied by groundwater were subtracted from the total water demands. Water demands of livestock, wildlife, and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the water balance study, because these demands are small in amount representing about 1% of the available water resources in the catchment area, and are 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 summarised as follows:

i) The model consists of 39 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities as illustrated in Figure 4.3.11;
ii) Monthly mean values of the water resources and demands are applied;
iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and
iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

Operation of High Grand Falls Dam reservoir for the water balance study was set to have a constant discharge for hydropower generation throughout the year, meeting the prime purpose of the hydropower generation among others as stated in the detailed design report of MORDA.

4.8.3 Proposed Water Resources Development Plan for TCA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – 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: D/D=Detailed design, F/S=Feasibility study, M/P=Master plan,
Source: JICA Study Team

Table 4.4.1 presents the details of the proposed dams.

2) Water Transfers

Proposed Plan – Water Transfers (TCA)

(Unit: MCM/year)

Structures	Volume for Domestic	Total Volume	Remarks
Intra-basin Water Transfer from Masinga Dam to Kitui (Expansion)	23	23	
Intra-basin Waer Transfer from Kiambere Dam to Mwingi (Expansion)	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 the TCA to Nairobi in the ACA (Expansion)	168	168	F/S and M/P ongoing (AWSB)

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

3) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (TCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fishery	Total 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 3,020 small dams/water pans was estimated by applying the volume per small dam/water pan of 50,000 m^3 as the minimum capacity which was decided following the volume adopted in NWMP (1992) and assumptions based on the volumes of the existing small dams/water pans.

The proposed volumes mentioned above for domestic use were estimated based on the water deficits calculated after supplying available water from the dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation sub-sector.

4) Boreholes

Proposed Plan – Boreholes (TCA)

(Unit: MCM/year)

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

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

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

Figure 4.8.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in TCA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (TCA)

(Unit: MCM/year)

Sub-sector	Water Demand (2030)	Water Resources Allocation (2030)	
		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

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in TCA is summarised in Table 4.8.1 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 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

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 river flows, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.4.4.

Figures 4.8.2 to 4.8.4 show estimated river flow for 2010 and 2030 at the reference points in TCA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Points (TCA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

4.9 Water Resources Development Plan for the Ewaso Ng'iro North Catchment Area

4.9.1 Development Strategy for ENNCA

The present water demand (2010) estimate and future water demand projection for 2030 are stated in Sub-section 2.3.7 and Section 3.4, respectively. The estimated present water demands as well as the projected 2030 water demands in ENNCA are as follows:

Present and Future Water Demands (ENNCA)

(Unit: MCM/year)

Sub-sector	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

The projected 2030 water demands showed a great increase of about 3.5 times compared with the present demands due to the increase in population to 4.40 million and irrigation areas to 49,379 ha as expected in 2030.

According to the water balance calculation between the present water resources and present water demands under the present water resources structures condition, the present water supply reliability at the reference points is as follows for the supply of domestic, industrial and irrigation water in ENNCA:

Present Water Supply Reliability at Reference Point (ENNCA)

Reference Point	5ED01 (Ewaso Ng'iro North River)
Present Water Supply Reliability	1/1

Note: The water supply reliability of 1/1 means that water demands are satisfied by water resources under the drought condition with probability of once in 1 year.
Source: JICA Study Team

According to Figure 3.3.2 as well as the above mentioned present water supply reliability, it is certain that the existing water resources structures/facilities will not satisfy the greatly increased 2030 water demands with the target water supply reliability of 1/10 for domestic and industrial uses and 1/5 for irrigation use, and, new structures/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, majority of the surface water is distributed at the foot of Mount Kenya in the southwest of the catchment area. The rest of the area needs to rely on 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.

a) Dams are essential to be developed in the southwest part of the catchment area where sharply increased future large water demands such as domestic, industrial and irrigation water demands are expected in 2030. Candidates of dam development for the maximum surface water exploitation include in principle i) dams proposed by the NWMP (1992) and ii) dams under design and/or planning by the government including the Kenya Vision 2030 flagship projects.

b) Small dams and/or water pans will be developed in the small rivers almost over the entire catchment area, except where there is less rainfall such as in the northwestern and eastern part of the catchment area. These will be used for small and scattered water demands including rural domestic, livestock, wildlife, inland fisheries, and small scale irrigation water supply purposes. The small dams and water pans are constructed at locations where suitable dam sites are not expected for large dams but the surface water is available.

c) Groundwater will be exploited for domestic, industrial and irrigation uses where surface water is not available or insufficient.

4.9.2 Conditions of Water Balance Study for ENNCA

The water balance study was carried out for the year 2030 between the available water resources and projected water demands in order to assess the magnitudes of the water shortage, and to quantify the water resources volumes to be stored or transferred. Estimated figures of the available 2030 water resources consisting of the surface water and groundwater cover the 20-year period from 2021 to 2040 and the projected water demands are for the year 2030.

The water balance study followed the policies of water allocation as stated in Sub-sections 4.2.2 and 4.3.2 (2), a summary of which are as follows: i) the reserve has the highest priority; ii) the existing water uses for domestic, industrial and irrigation as well as existing inter-basin transfers have the second priority; iii) new domestic and industrial water use takes the third priority; iv) new livestock, wildlife and inland fishery water supplies have the fourth priority; v) new irrigation water supply takes the fifth priority; and vi) hydropower use takes the lowest priority.

The surface water balance study for 2030 was conducted by applying the surface water resources and demands to a computation model developed for ENNCA. Prior to the surface water balance study, the amounts of the water demands to be supplied by groundwater were subtracted from the total water demands. Water demands of livestock, wildlife, and inland fisheries to be supplied from surface water were excluded from the surface water demand applied in the balance study, because these demands are small in amount representing about 3% of the available water resources in the catchment area, 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 summarised as follows:

- i) The model consists of 27 sub-basins, water demand points, and the existing water resources infrastructures and candidates for future development such as dams and water transfer facilities as illustrated in Figure 4.3.12;
- ii) Monthly mean values of the water resources and demands are applied;
- iii) The amount of the reserve is determined as the 95% value of the naturalised present daily flow duration curve with the probability of once in 10 years as tabulated in Table 4.3.1; and
- iv) Return flow rates of 25%, 5%, and 100% for urban domestic water supply, paddy irrigation, and hydropower generation, respectively, are applied.

4.9.3 Proposed Water Resources Development Plan for ENNCA

(1) Proposed Water Resources Development Plan

To utilise the allocated amount of surface water and groundwater, the following new water resources structures/facilities will be required, in addition to the direct intake facilities from the rivers and other water bodies. The structures/facilities and their required volumes were derived from the water balance study.

Based on the results of the water balance study, the required new water resources structures/facilities are as follows:

1) Dams

Proposed Plan – 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: F/S=Feasibility study
Source: JICA Study Team

Table 4.4.1 presents the details of the proposed dams.

2) Small Dams/Water Pans

Proposed Plan – Small Dams/Water Pans (ENNCA)

(Unit: MCM)

Structures	Volume for Domestic	Volume for Irrigation	Volume for Livestock	Volume for Wildlife/ Fishery	Total 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 1,820 small dams/water pans was estimated by applying the volume per small dam/water pan of 50,000 m^3 as the minimum capacity which was decided following the volume adopted in NWMP (1992) and assumptions based on the volumes of the existing small dams/water pans.

The proposed volumes mentioned above for domestic use were estimated based on the water deficits calculated after supplying available water from the dams and boreholes. The volumes for irrigation use were estimated considering the conditions of the irrigation subsector.

3) Boreholes

Proposed Plan – Boreholes (ENNCA)

(Unit: MCM/year)

Facilities	Volume for Domestic/Industry	Volume for Irrigation	Total Volume	Remarks
Borehole	48	108	156	Total no. of boreholes = 1,560

Note: Excluding the abstraction volume of the existing boreholes of 35 MCM/year.
Source: JICA Study Team

The total number of 1,560 boreholes was estimated by applying the capacity per borehole of 100,000 m^3/year, which was decided based on the capacities of the existing boreholes.

Figure 4.9.1 shows the locations of the proposed dams and water transfers.

(2) Water Resources Allocation Plan

The results of the water balance study gave the 2030 water demands divided into surface water and groundwater in ENNCA to satisfy the water demands, as shown in Table 4.4.2 and summarised below.

Water Resources Allocation Plan (ENNCA)

(Unit: MCM/year)

Sub-sector	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

(3) Evaluation of Proposed Water Resources Development Plan

The balance between water demand and supply for 2030 in ENNCA is summarised in Table 4.9.1 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 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

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 river flows, reserves, water demands, yields of the water resources development structures, and water supply reliabilities estimated at the reference points are tabulated in Table 4.4.4.

Figure 4.9.2 show estimated river flow for 2010 and 2030 at the reference point in ENNCA under 2010 and 2030 surface water resources, demands and structures conditions with the following cases:

Study Cases of River Discharges Estimate at Reference Point (ENNCA)

Study Case	River Discharge	Water Demand	Water Resources Structures
Case 1	Discharge under 2010 Climate	2010 Water Demand	Existing Structures
Case 2	Discharge under 2010 Climate	2030 Water Demand	Existing and Proposed Structures
Case 3	Discharge under 2030 Climate	2010 Water Demand	Existing Structures
Case 4	Discharge under 2030 Climate	2030 Water Demand	Existing and Proposed Structures

Source: JICA Study Team

CHAPTER 5 COST ESTIMATE

5.1 Basic Conditions for Cost Estimate

Project costs of the prospective water resources structures/facilities were estimated to evaluate the projects economically and to give the necessary data for the discussion on financing. This chapter covers the cost estimate for the dams, water transfer facilities, and small dams/water pans, and excludes the estimates for boreholes which were discussed in the water supply and irrigation sub-sectors. The project cost estimate was carried out through the following methods:

a) Project costs of the dams including dam-related structures such as spillways, river outlets, river diversions, and so forth were estimated using the dam project cost curve prepared based on the available cost information, in case no cost data is available for the dam projects. This cost curve method was applied in the cost estimate of this study because the same method was applied for the NWMP (1992). A type of fill dam was assumed in the cost estimate. The cost curve shows the relationship between dam project costs and fill dam embankment volumes.

   In case the cost data is available for the dam projects, the data will be used with some adjustments.

b) Project costs of the water transfer facilities were estimated based on the available cost data with adjustments.

c) The small dams/water pans were represented in the water resources development plan by a typical small dam with a height of 6.5 m and storage capacity of 50,000 m^3 as defined in the NWMP (1992). The project cost of a typical small dam was therefore estimated based on the collected actual cost data of small dam of similar size.

The available existing costs were at the price level of 2010 to 2012. Since price escalation was marginal in those years, especially for foreign currency in which the construction of dams and water transfers depends, price adjustment was not carried out and the existing cost data were directly used.

The project costs consist of direct construction costs, indirect construction costs (administration and engineering services), and physical contingencies. Land acquisition cost was not included in the project costs; therefore, this was estimated separately.

Operation and maintenance (O&M) costs of the proposed water resources structures/facilities were assumed based on the costs applied in the NWMP (1992) and some other master plan studies.

Basic conditions for the estimate are as follows:

a) The project costs are at the price level of November 1, 2012,
b) Exchange rates applied are US$1.0 = KSh85.24 as of November 1, 2012,
c) Land acquisition cost was assumed at KSh100,000 per ha, where no other data are available.

5.2 Cost Estimates for Proposed Plans

5.2.1 Project Cost Estimate for Dams Including O&M Cost

A dam project cost curve was prepared based on the available cost information as summarised in Table 5.2.1. The dam cost information includes project costs estimated for the dams under construction, or under detailed design or feasibility study stages. The derived cost curve is shown in Figure 5.2.1.

The project costs of the proposed dams were estimated by applying the cost curve mentioned above, or by adopting the collected dam project costs data directly or with some adjustments. The estimated dam projects costs are shown in Table 5.2.2.

The O&M costs of the dams were assumed to be 0.5% of the project costs, since the NWMP (1992) as well as some other master plan studies adopted the same figure for the O&M costs.

5.2.2 Project Cost Estimate for Water Transfer Facilities Including O&M Cost

The cost data available for the water transfer facilities are tabulated as follows:

Available Cost Data for Water Transfer Facilities

Structures	Dimensions	Project Cost	Data Source
Tunnel from Itare Dam to Nakuru	2.85 m wide and 4.9 m high, 14.5 km long	US$51.2 million (1997 price)	Nakuru Water Supply and Sanitation Study, Full Technical and Long Term Water Supply Source Report, February 1998, NWCPC
Steel Pipeline from Itare Dam to Nakuru	90 km long, 1.20 m diameter	US$75.3 million (1997 price)	Nakuru Water Supply and Sanitation Study, Full Technical and Long Term Water Supply Source Report, February 1998, NWCPC
Water transfer from TCA to Nairobi			
Second Mzima Pipeline	Pipelines of 1,500 mm dia and 220 km long and 300 mm dia and 30 km long, with a 3 km long tunnel and a pumping station	US$414.1 million (2012 price)	Water Supply Master Plan for Mombasa and Other Towns Within Coast Province, Pre-Feasibility Study for All Options – Final Report, 2012, CWSB
Sabaki Extension (Baricho Shallow Well)	Transmission mains of 700 mm dia and 40 km long and 800 mm dia and 100 km long, with wells and pumping stations	US$175.6 million (2012 price)	Water Supply Master Plan for Mombasa and Other Towns Within Coast Province, Pre-Feasibility Study for All Options – Final Report, 2012, CWSB

Source: JICA Study Team based on data described in the above reports

For the recently conducted studies on water transfer schemes, costs estimates in these studies were applied. The schemes included the Second Mzima, Sabaki extension, scheme from the Tana River to Nairobi, and scheme from the Tana River to Lamu.

Recent data on construction costs of pipelines by pipe diameter as tabulated below were also utilised in the cost estimate.

Available Cost Data for Pipelines

Pipe Diameter	Project Cost	Data Source
300 mm	US$300/ m	Water Supply Master Plan for Mombasa and Other Towns Within Coast Province, Pre-Feasibility Study for All Options – Final Report, 2012, CWSB
600 mm	US$600/ m	

Source: JICA Study Team based on data described in the above reports

The estimated cost of the proposed water transfer facilities is listed in Table 5.2.3.

The O&M costs for the water transfer facilities were determined to be 0.5% of the project costs, similar to the case of the dams.

5.2.3 Project Cost Estimate for Small Dams/Water Pans Including O&M Cost

The cost data available for the small dam is given as follows:

Available Cost Data for Small Dam

Structures	Dimensions	Project Cost	Data Source
Small Dam/Pan	Storage capacity of 18,000 m^3	KSh6 million (2011 price)	NWCPC

Source: JICA Study Team

Based on the above data, the cost of the typical small dam was estimated to be KSh16 million in proportion to the storage capacity.

The O&M costs for the small dams/water pans were determined to be 0.5% of the project costs, similar to the case of the dams.

5.3 Allocation of Dam Costs

Construction costs and operation and maintenance (O&M) costs of the proposed dams were allocated to the related projects for water supply, irrigation, and hydropower development in proportion to the reservoir storage volumes required for the respective projects in principle. The required storage volumes of the proposed dams are shown in Table 4.4.1, which were estimated by the water balance study.

Allocation of the dam costs to the flood control purpose was not carried out because effects of dams on flood control could not be analysed due to insufficient data for the study on flood hydrographs and topography and flood control spaces of the dam reservoirs could not be determined. The spaces shown in Table 4.4.1 are those which can be used to store flood flows.

CHAPTER 6 ECONOMIC EVALUATION

6.1 Evaluation Method and Basic Conditions

The economic viability of the proposed dam projects was evaluated based on the estimated economic costs and benefits of related water subsectors. The economic decision-making criteria consists of the following:

a) Economic Internal Rate of Return (EIRR);
b) Net Present Value (NPV); and
c) Benefit and Cost Ratio (B/C Ratio).

The following assumptions were made for the economic analysis of the water resources dam development projects:

a) Price Level

Investment costs and O&M costs were estimated at the price level of November 1, 2012. All prices are expressed in US$ currency. Foreign exchange rate was set at KSh85.24 to US$1.00, ¥79.98 to US$1.00, and KSh110.48 to €1.00.

b) Economic Value

The prices of internationally tradable goods and services were valued on the basis of the international border prices, which were often expressed in the World Bank’s Commodity Prices and Price Forecast. The prices of non-traded goods and services were converted from their financial value to economic value by applying a standard conversion factor of 0.90.

c) Discount Rate

The discount rate reflects the opportunity cost of capital to the national economy. In the water sector, 10% of the opportunity cost of capital prevails; therefore, this study assumes a 10% discount rate.

d) Economic Life of Projects

The economic life of single-purpose water supply dam projects is set at 30 years. However, part of the mechanical facilities has economic life of 15 years; therefore, this will be replaced in 15 years within the economic life cycle. The economic life for single- and multi-purpose dam projects including irrigation and hydropower was assumed to be 50 years. The replacement period of irrigation facilities is set every 20 years.

e) Implementation

The implementation period of single- and multi-purpose dams was set at four years, except for Magwagwa and High Grand Falls (HGF) projects, in which a construction period of five years was assumed. The construction of irrigation and water supply facilities was scheduled as described in the implementation schedule for each subsector.

f) Cost of Multi-purpose Dams

Since the construction of multi-purpose dam will be carried out together with the construction of hydropower facilities, the construction cost of the dam is integrated into the cost of hydropower, if the project includes a hydropower component. On the other hand, the construction of the single- and multipurpose dams will normally be implemented in advance of the construction of irrigation and water supply facilities. Therefore, if a project includes either irrigation or water supply components but does not include hydropower, the cost of single- and multipurpose dam will be taken separately from each subsector in order to implement the dam and the subsector individually.

There are 54 selected single- and multi-purpose projects that went through a preliminary evaluation for economic analysis. The economic evaluation of hydropower subsector in HGF is based on the results of the F/S in 2011, and this report did not perform additional analysis.

The details of the economic benefit for hydropower, irrigation, and water supply are described in each sectoral report.

6.2 Economic Cost

(1) Investment Cost

For economic evaluation, the economic investment cost was converted to its equivalent economic value to remove transfer payments such as taxes and subsidies. The construction costs of dams were estimated on the basis of the existing F/S and past experience of dam construction in Kenya. The investment costs of Nandi Forest, Nzoia (34B), Nzoia (42A), Magwagwa, Arror and High Grand Falls dams were based on the existing F/S and D/D. Land acquisition cost was calculated for the estimated reservoir area. The physical contingency was included in the investment cost.

The highest economic investment costs will be that of the High Grand Falls multi-purpose project (US$4,795 million), followed by Ndarugu single-purpose project (US$1,782 million), and Magwagwa multi-purpose project (US$ 838 million). In terms of financial cost, the total required cost for water resources development was estimated at US$20,220 million.

(2) Annual Operation and Maintenance Cost

The annual O&M cost for water source facility (dam) was estimated at 0.5% of the initial construction cost. The annual O&M for each subsector was described in each sectoral report. The O&M cost was further converted to its economic value.

6.3 Results of Economic Evaluation

The results of the economic evaluation for 54 selected water resources dam development projects showed that 28 projects have an EIRR greater than 10%, 11 projects were found to be marginally viable with an EIRR of more than 8%, and the remaining 15 projects have an EIRR of less than 8%. The multi-purpose projects including hydropower, irrigation, and water supply are likely to have a higher economic viability, with the average EIRR of 12.2%.

Since the above stated results were at the master plan level based on preliminary costs and benefits estimates, further detailed studies are required for economic analysis of the specific projects.

CHAPTER 7 IMPLEMENTATION PROGRAMME

7.1 General

The proposed water resources development plans toward the target year of 2030 are explained in Chapter 4 for the respective catchment areas, and their project costs are described in Chapter 5.

This chapter presents the implementation programmes for the proposed projects identified in the water resources development plans in order to show a guide in the materialisation of the plans. The individual projects will have EIAs which will address all issues including land acquisition and compensation.

7.2 Criteria for Prioritisation of Implementation

In order to prepare the implementation programmes, the proposed water resources development projects were prioritised considering the following criteria:

Priority ranking 1: Projects whose finances for implementation were ready, or almost ready,

Priority ranking 2: Projects whose detailed designs or feasibility studies were completed implying that the Kenyan side put higher priority on these projects, and

Priority ranking 3: Projects whose implementation is desired from the requirements of domestic and industrial water supply or irrigation water supply.

Within each of the above priority ranking, higher priority is given to projects, which are national flagship projects under the Kenya Vision 2030.

7.3 Implementation Programmes of the Proposed Plans

The implementation schedules were prepared for the proposed dams under the following conditions:

a) All the proposed development projects will be realised in the target year of 2030.
b) The schedule was prepared for three terms, i.e., short term (2013/14 to 2017/18), medium term (2018/19 to 2022/23) and long term (2023/24 to 2030/31).
c) The schedule followed the existing implementation schedules prepared by the government.
d) The schedule was prepared in close harmony with the requirements of other water subsectors such as water supply, irrigation, and hydropower generation subsectors.
e) The schedule was prepared so that annual disbursement costs are to be as even as possible.
f) The construction period of dams was set to four years based on experience, except for large dams such as High Grand Falls Dam and Magwagwa Dam whose period was set at five years. One year of procurement time and two years of feasibility and detailed design period were also assumed.

The implementation schedule for the proposed dam development plans were prepared on the basis of the criteria mentioned above for the respective catchment areas, as shown in Figure 7.3.1 and explained briefly below.

7.3.1 Implementation Schedule of Dams for the Lake Victoria North Catchment Area

Among the seven proposed dams in the LVNCA, Nandi Forest Dam will commence its implementation in 2015/16 in accordance with the schedule of MORDA. Siyoi Dam, one of the flagship projects, will start its construction in 2016/17 because of the urgent need to supply water to Kapenguria. Implementation of Nzoia Dams at 34B site and 42A site will follow; both are flagship projects and their detailed designs are ongoing.

7.3.2 Implementation Schedule of Dams for the Lake Victoria South Catchment Area

Among the ten proposed dams in the LVSCA, Magwagwa Dam will commence its construction in 2013/14 according to the schedule of MORDA. Itare Dam, as a flagship project, will start its feasibility study and detailed design in 2013/14 because of the urgent need to transfer water to the Nakuru area in the RVCA. Nyando Dam and Bunyunyu Dam, which are both flagship projects and whose designs are ongoing or completed, will start their constructions in 2018/19 and 2017/18, respectively. Katieno Dam will start its construction in 2018/19, because of the requirement of the irrigation development.

7.3.3 Implementation Schedule of Dams for the Rift Valley Catchment Area

Among the ten proposed dams in the RVCA, Arror Dam, whose detailed design was completed, will commence its construction in 2015/16 following the schedule of MORDA. Upper Narok Dam will commence its feasibility study and detailed design soon because of the urgent requirement for domestic water supply. Construction of Oletukat, Leshota and Oldorko dams will follow starting in 2017/18 to 2019/20; their detailed designs are ongoing.

7.3.4 Implementation Schedule of Dams for the Athi Catchment Area

Among the 16 proposed dams in the ACA, the feasibility study and detailed design of Ruiru-A Dam will commence in 2013/14 because of the urgent need of domestic water supply to Nairobi. Both Kamiti 1 and Stony Athi dams will start their detailed designs in 2014/15 for urgent implementation in order to supply domestic water to Nairobi. Thwake Dam, which is a flagship project and whose detailed design was completed, will start its construction in 2015/16. Kikuyu and Ruaka dams for Nairobi water supply, and Rare and Mwachi dams for Mombasa water supply will follow because of the requirement of water supply.

7.3.5 Implementation Schedule of Dams for the Tana Catchment Area

Among the ten proposed dams in the TCA, High Grand Falls Dam will commence its construction in accordance with the schedule of MORDA. Thiba Dam will also start its construction in 2014/15 according to NIB. Karimenu 2 and Maragua 4 dams will commence their construction in 2016/17 because of the urgency of water transfer to Nairobi. Chania-B Dam will follow to supply domestic water to Nairobi.

7.3.6 Implementation Schedule of Dams for the Ewaso Ng'iro North Catchment Area

Among the five proposed dams in the ENNCA, Isiolo Dam will start its construction in 2015/16 due to the urgent need of water supply in Isiolo. Nyahururu Dam, which is a flagship project, will follow.

7.4 Further Actions Recommended to be Taken

The following actions are recommended to be taken by the Kenyan government in the water resources development sub-sector in order to have efficient water resources development and management activities and to achieve the targets of Kenya Vision 2030:

(1) Periodic Update of the Water Resources Allocation Plan

This study has prepared the water resources allocation plans for the six catchment areas, which will be used by the government as a guide for undertaking appropriate water resources development and management activities. The allocation plans were prepared by applying the future water demand projections on the basis of the national development targets and socioeconomic frameworks of Kenya Vision 2030.

It is usual that the socioeconomic frameworks such as population and GDP values will show trends and figures different from those applied for this study after several years of plan preparation. Therefore, periodic updates of the water resources allocation plans are essential in order to attain more practical water resources development and management.

(2) Quantification of Reserve Specific to Each River

As stipulated in the current WRMA Guidelines, the reserve consisting of the ecological and basic human needs will be determined as the flow value that exceeds 95% of the time measured by the naturalised daily flow duration curve for each river in the case that no specific reserve is quantified. As there was no specific reserve quantified in any river, the 95% value was applied in estimating the quantity of the reserve utilised for the water resources allocation plans.

The estimated quantity of the reserve mentioned above was substantial compared with the water demands for domestic and irrigation water supply, and affected largely the allocation of the water resources to the water users. It is therefore required that the reserve will be quantified for each river based on the surveys on river ecology and water intake from rivers in order to make the water resources allocation plans more practical.

(3) Further Study of Potential Dam Sites

The proposed dams incorporated into the water resources allocation plans were selected from those in the list of the NWMP (1992), as well as from the dams studied and/or proposed by the government. The dam list of the NWMP (1992) was utilised for the allocation plan preparation since the list was provided based on the topographic conditions. These conditions have not changed since 1992.

However, social conditions of the listed dams such as residential areas and other land uses seem to have changed since 1992; and will change too. Therefore, further studies of potential dam sites should be carried out, especially in view of social environment, to incorporate the list of potential dams for further studies into the updated water resources allocation plans.

(4) Further Study of Allocation of Groundwater

In preparing the water resources allocation plans in this study, the groundwater was allocated to the water users by setting a general rule, which was applied nationwide in principle. The rule included the percentages of share between groundwater and surface water to the respective users.

Further studies on how to allocate the groundwater to the water demands considering the local conditions, in terms of the current situation of groundwater use, accessibility to the groundwater for distributed demands, etc. will be required in updating the allocation plans.

Tables

Table 1.2.1 Proposed Priority Dam Schemes in NWMP (1992) and Current Status as of November 2012

Catchment Area		NWMP (1992)				Current Status			
		Proposed Dams	Sub-basin	Stage	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
1.	LVN	1. Moiben (Chebara)	1BA	D/D	W	LVNWSB/ Eldoret Municipality	Completed (1997)	NWCPC	Operated by ELDOWAS.
		2. Mukulusi	1EA	M/P	W	LVNWSB	No further study is done.	NWCPC	
2.	LVS	3. Londiani	1GC	M/P	W	NWCPC/ LVSWSB	Pre-F/S done (2012)	NWCPC/ LVSWSB	2008-12 Flagship Projects under Vision 2030
		4. Kibos	1HA	M/P	W	LBDA/ LVSWSB	(No.51 site) At M/P level.	NWCPC	Integrated Flood Management for Nyando River Basin Study (2009).
		5. Itare	1JA	M/P	W	RVWSB	A study is done (1998).	NWCPC/ RVWSB	2008-12 Flagship Projects under Vision 2030, Nakuru Water Supply and Sanitation Study (1998)
		6. Sondu/Miriu	1JG	D/D	P, I	KenGen/ LBDA	Completed (2007)	KenGen, WRMA	
		7. Magwagwa	1JG	F/S	P, I	LBDA/ MORDA	F/S, D/D, T/D completed (2012)	MORDA	MORDA 18 Projects, Construction will start soon.
		8. Bunyunyu	1KB	M/P	W	NWCPC	D/D done (2011)	NWCPC	2008-12 Flagship Projects under Vision 2030
3.	RV	9. Chemususu	2ED	D/D	W	NWCPC	U/C (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		10. Kirandich	2EH	D/D	W	RVWSB	Completed (2000)	NWCPC, WRMA	
		11. Malewa	2GB	F/S	W	RVWSB	No further study is done.	RVWSB	
		12. Upper Narok	2KA	M/P	W	RVWSB/ NWCPC	No further study is done.	NWCPC	2008-12 Flagship Projects under Vision 2030
		13. Oldorko	2KB	Pre-F/S	P, I, W	ENSDA	F/S, D/D (to be completed in 2013)	MORDA/ ENSDA	MORDA 18 projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project
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	
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
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

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 table.

Table1.2.2 Proposed Water Transfer Schemes in NWMP (1992) and Current Status as of November 2012 (1/2)

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
1.	LVN	R1	1AG	Sio River	without dam	1AH		-	No further study is done.	LVNWSB	
		R2	1BA	Moiben Dam		1CB		Eldoret Municipality	Operational	NWCPC, LVNWSB	
		R3	1EA	Mukulusi Dam		1EB		LVNWSB	No further study is done.	NWCPC, LVSWSB	
2.	LVS	R4	1GC	Londiani Dam		1GC		NWCPC/ LVSWSB	Pre-F/S done.	NWCPC, LVSWSB	
		R5	1HA	Kibos Dam		1HA		LBDA/ LVSWSB	at M/P level	LVSWSB	
		R6	1KB	Bunyunyu Dam		1KA		NWCPC	D/D done.	NWCPC	
						1KB		NWCPC	D/D done.	NWCPC	
3.	RV	R7	2ED	Chemususu Dam		2EF		NWCPC/ RVWSB	Under construction	NWCPC	
						2EF		NWCPC/ RVWSB	Under construction	NWCPC	
		R8	2GB	Malewa Dam		2GC		RVWSB	No further study is done.	RVWSB	
						2GD		RVWSB	No further study is done.	RVWSB	
		R9	2KA	Upper Narok Dam		2KA		RVWSB/ NWCPC	No further study is done.	RVWSB	
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	
5.	Tana										
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	

Note: Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design
Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above table.

Table 1.2.2 Proposed Water Transfer Schemes in NWMP (1992) and Current Status as of November 2012 (2/2)

Inter-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
1.	LVN	E1	1BA	Moiben Dam		2CB		Eldoret Municipality	Operational	NWCPC, LVNWSB	Expansion for water treatment is ongoing.
		E2	1FF	Edzawa Dam	small dam	1HB		MWI/ NWCPC	No further study is done.	LVNWSB	
2.	LVS	E3	1JA	Itare Dam		2EC		RVWSB	A study was done.	RVWSB	Nakuru Water Supply and Sanitation Study (1998)
						2EG1		RVWSB	A study was done.	RVWSB	Nakuru Water Supply and Sanitation Study (1998)
						2FC		RVWSB	A study was done.	RVWSB	Nakuru Water Supply and Sanitation Study (1998)
						2FC		RVWSB	A study was done.	RVWSB	Nakuru Water Supply and Sanitation Study (1998)
3.	RV	E4	2GB	Malewa Dam		2FC		RVWSB	Some planning is done.	RVWSB	
		E5	2EH	Kirandich Dam		2CB		RVWSB	Operational	NWCPC, RVWSB	
		E6	2KB	Oloibortoto River	without dam	2H		Tanathi WSB	Under construction	TWSB	Partly serviced.
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
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	
6.	ENN	E16	5ED	Ewaso Ng'iro River		5EA		MWI/ NWCPC	No further study is done.	NWSB	

Note: Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design
Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above table.

Table 2.1.1 Summary of Strategies in the WRMA Catchment Management Strategies (2008) in terms of the Water Resources Development (1/2)

Catchment Area	Strategies in the WRMA Catchment Management Strategies (2008) in terms of the Water Resources Development by Catchment Area
Lake Victoria North	- Most of the catchment area lies within high rainfall area with mean annual rainfall of 1,300mm. However, a small portion in the lower reaches comprising of Siaya, Bondo and parts of Busia and Teso districts have relatively low rainfall of about 700mm annually. - According to the Poverty Reduction Strategy Paper (2000), the main constraint to development, income generation and food security is inadequate development of the water resource. - The region aims to conserve water resources and start new ways of harvesting and using surface and underground water. The surface water takes the form of tanks, reservoirs, pans and dams. The groundwater storage development takes the form of artificial groundwater recharge.
Lake Victoria South	- The region has a varied and contrasting situation with regard to water availability and need for storage. Kisii Highlands and upper regions of the Nyando catchment are endowed with sufficient rainfall of above 1,700mm and numerous springs. The need for storage is hence lower than in the lower regions of the Nyando catchment and in the catchments in Rachuonyo, Migori, Homabay, Transmara and Suba Districts. - Major multi-purpose dams have been proposed on rivers Nyando (Koru dam), Sondu-Miriu (Magwagwa dam) and Gucha-Migori (Gucha dam). The numerous springs in Kisii highlands and the upper region of the Nyando basin should be protected and the surrounding catchment conserved. - Rainwater harvesting is of paramount importance. The total storage capacity of the existing pans/ small dams has reduced from 12.7 MCM to 5.2 MCM. In order to recover the cumulative lost capacity of about 7.5 MCM, the affected pans/ small dams have to be rehabilitated and new ones constructed. Roof catchment for domestic water use will be widely promoted. Rock catchment and sand dams will be promoted in areas with sandy soils and granitic rock outcrops such as Seme in Kisumu sub-region and Homa bay and Rachuonyo in Kisii sub-region. - Potential for groundwater exploitation is quite high. Selected high yielding springs will be targeted. Artificial groundwater recharge will be explored as a groundwater storage improvement option. - Targets in terms of the water resources development include i) rehabilitation of 100 small dams/ pans by 2010; and (ii) development of 800,000 m^3 storage by 2010.
Rift Valley	- The catchment receives bimodal type of rainfall with a mean annual rainfall of 562mm, and the annual mean rainfall ranges between 200mm to 1,200mm from the lower to upper catchment respectively. - The region relies heavily on stored water both surface and ground water. Efforts have been made to construct small dams/ pans to particularly meet domestic and livestock water demand. - The groundwater aquifers are the main sources of water to meet the current water demand. Groundwater storage development takes the form of artificial groundwater recharge.

Continued

Table 2.1.1 Summary of Strategies in the WRMA Catchment Management Strategies (2008) in terms of the Water Resources Development (2/2)

Catchment Area	Strategies in the WRMA Catchment Management Strategies (2008) in terms of the Water Resources Development by Catchment Area
Athi	- The catchment has an annual average rainfall of 739mm. - In developing surface water storage the region will adopt a micro-(household level) to macro-(state level) strategy, promoting i) construction of large dams, ii) rehabilitation of small dams/ pans, and iii) construction of water harvesting facilities. - The water storage can be improved through the enhancement of groundwater storage. This will be through encouraging groundwater recharge infrastructure development. - Targets in terms of the water resources development include i) development of plans to meet 150,000m^3 capacity groundwater storage, ii) development of 1,940,500m^3 small-scale storages by 2013, and iii) promotion of 1.62 BCM storages on Athi River by 2013 at Munyu, Fourteen Falls, Site A13, Mavindini and Yatta Bridge.
Tana	- The catchment has an annual average rainfall of 679mm. - The Tana catchment area is home to the largest dam and reservoir capacity in Kenya. The existing dams are Kindaruma (1968), Kamburu (1975), Gitaru (1978), Masinga (1981), Kiambere (1988), Sasumua (1956) and Ndakaini (Thika, 1993). There is a need to construct the High Grand Falls Dam. In addition, many small dams/ pans have been constructed by private individuals, institutions and communities. - Under-exploited natural aquifers may be exploited. The promotion of natural groundwater recharge is recognized as of first priority. In considering the development of additional groundwater storage, artificial groundwater recharge techniques will be used as one way in which to ensure better use of water resources. - The region expects to carry out planned activities during the next 10 years, which include i) 2 dams of 1 MCM capacity, ii) a dam of 4-5 BCM capacity, iii) 5 small dams of 0.2 MCM capacity, iv) 5 sand dams/ check dams/ pans/ rock catchment of 100-1000m^3, v) groundwater survey and mapping, and vi) rainwater harvesting of 1000 households/ institutions.
Ewaso Ng'iro North	- The catchment has a mean annual rainfall of 411mm which ranges from over 800mm in the highlands to less than 400mm in the ASAL areas which comprise 90% of the total area of the catchment. - Options of surface water storage development are roof catchment, farm ponds, small dams/ pans, rock catchment, sand dams, and sub-surface dams as well as large dams. - In the case of reservoirs for which the principle purpose is to provide water for nomadic populations and their livestock, it is not always desirable to create reservoirs where water is available through-out the year. This might result in considerable concentration of people and livestock in the concerned area, in turn generating problems such as over-grazing, ecological degradation of the catchment areas, etc. - Artificial groundwater recharge techniques will be adopted to the areas where the development of additional groundwater storage is envisaged. - Targets in terms of the water resources development include i) development of 50,000m^3/ year groundwater storage at Oda by 2010, and ii) development of 18,000m^3/ year storage at 6 sand dams.

Source: JICA Study Team based on the WRMA Catchment Management Strategies for six catchment areas (2008).

Table 2.3.1 Dam Schemes Listed in NWMP (1992) and Current Status as of November 2012 (1/3)

Existing and On-going Dams in NWMP (1992)

Catchment Area		NWMP (1992)					Current Status			
		Existing and On-going Dams	Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year as of Dec. 1991	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
1.	LVN	1. Moiben (Chebara)	1BA	W	NWCPC	D/D	LVNWSB/ Eldoret Municipality	Completed (1997)	NWCPC	Operated by ELDOWAS.
		2. Twin Rivers	1CB	W	MOWD	1962	LVNWSB/ Eldoret Municipality	Operational	LVNWSB	
		3. Ellegirini	1CB	W	MOWD	1989	LVNWSB/ Eldoret Municipality	Operational	LVNWSB	
		4. Kipkarren	1CC	W	NMCPC	U/C	LVNWSB/ Eldoret Municipality	Completed (1991)	NWCPC	
		5. Lessos	1FD	W	MOWD	U/C	LVNWSB	Completed (1993)	NWCPC	The reservoir is silted currently.
2.	LVS	6. Gogo Falls	1KB	P	KPC	1958	KenGen	Operational	KenGen, WRMA	Pre-F/S done at site 200m d/s of the existing one (2010).
		7. Sondu/Miriu	1JG	P, I	KPC/ LBDA	D/D	KenGen/ LBDA	Completed (2007)	KenGen, WRMA	
3.	RV	8. Turkwel	2BC	P, I	MOE/ KVDA	1991	KVDA/ KenGen	Operational	KVDA, KenGen	
		9. Chemususu	2ED	W, I	NWCPC	D/D	NWCPC	U/C (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		10. Chemeron	2EH	W, I	MOWD	1984	RVWSB	Operational	KVDA	Silted up 10 years ago.
		11. Kirandich	2EH	W, I	NWCPC	D/D	RVWSB	Completed (2000)	NWCPC, WRMA	
		12. Turasha	2GC	W	NWCPC	U/C	MWI/ NWCPC	Completed (----)	NWCPC, WRMA	
4.	Athi	13. Kiserian	3AA	W	NWCPC	U/C	NWCPC	U/C (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		14. Ruaka (Kiambaa)	3BA	W	MOWD/ NWCPC	D/D	AWSB	Construction not started.	NWCPC	
		15. Ruiru	3BC	W	NCC	1950	NCC	Operational	NWCPC	
		16. Bathi	3BC	W	MOWD	1980	AWSB	-	NWCPC	
		17. Mulima	3EA	W	MOWD	1982	AWSB	Operational	MWI	
		18. Manooni	3EB	W	MOWD	1987	MWI	Partly operational	MWI	
		19. Muoni	3EB	W	MOWD	1987	MWI/ Tanathi WSB	Operational	MWI	
		20. Kikoneni	3K	W	MOWD	1981	MWI	-	MWI	
5.	Tana	21. Sasumua	4CA	W	NCC	1956	NCC	Operational	WRMA	Rehabilitated in 2010.
		22. Thika (Ndakaini)	4CB	W	NCC	U/C	MWI/ AWSB	Completed (1993)	NWCPC	Rehabilitated in 2009/10.
		23. Masinga	4DE	P	TARDA	1981	TARDA/ KenGen	Operational	KenGen	
		24. Kamburu	4ED	P	TRDC	1975	KenGen	Operational	KenGen	
		25. Gitaru	4ED	P	TRDC	1978	KenGen	Operational	KenGen	
		26. Kindaruma	4ED	P	TRDC	1968	KenGen	Operational	KenGen	Gross storage has reduced from 16 to 11mcm.
		27. Kiambere	4ED	P	TARDA	1988	TARDA/ KenGen	Operational	KenGen	
6.	ENN									

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, U/C=under construction
Source: JICA Study Team based on NWMP (1992) and information from the government agencies mentioned in the above table.

Table 2.3.1 Dam Schemes Listed in NWMP (1992) and Current Status as of November 2012 (2/3)

Future Development Potential Dams in 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
1.	LVN	01	Moi's Bridge	1BE	P, I, W	-	No further study is done.	WRMA	
		02	Hemsted Brg.	1BD	W, I, P	MOSSP/ MWI	Proposed in Pre-F/S (2010) as a future potential site.	MWI	There are two (2) alternative damsites at 33A and 33B.
		03	Kibolo	1CE	W				No information is found.
		04	Webuye Falls	1DA	P	MORDA	No further study is done.	MORDA	MORDA 18 Projects
		05	Teremi	1DB	P	MORDA	No further study is done.	MORDA	MORDA 18 Projects
		06	Kimondi	1FC	W, I				No information is found.
		07	Nandi Forest	1FD	I, P, W	LBDA/ MORDA	F/S done (2010), D/D completed (2011)	MORDA	MORDA 18 Projects
		08	Mushangumbo	1FE	P				No information is found.
2.	LVS	09	Nyando	1GD1	W, I, F	MORDA	(No.11 site) At M/P level	WRMA	Integrated Flood Management for Nyando River Basin Study (2009)
						NWCPC	(Koru at No.8A site) F/S done (2009), Preliminary design ongoing	NWCPC	2008-12 Flagship Projects under Vision 2030
		10	Timbilil	1JC	W	LVSWSB	Pre-F/S done	LVSWSB, WRMA	Kericho Water Supply
		11	Sisei	1JF	W				No information is found.
		12	Katieno	1KB	W	NIB/ LBDA	Pre-F/S done (2010)	NIB	Pre-F/S to compare Katieno with Gogo Falls
		13	Namba Kodero	1KC	W, P				No information is found.
		14	Amala	1LB1	W	-	No further study is done.	WRMA	
3.	RV	15	Kimwarer	2CB	W, P, I	KVDA	Pre-F/S done by KVDA	KVDA	
		16	Kipsang (Kipsaa)	2CB	W	-	No further study is done.	WRMA, KVDA	
		17	Arror	2CC	W	KVDA/ MORDA	F/S, D/D completed (2012)	MORDA	MORDA 18 Projects, Multipurpose (W, P, I)
		18	Sererwa	2CC	P, I, W	-	No further study is done.	WRMA	
		19	Waseges	2CC	W	-	No further study is done.	WRMA	
		20	Kamukuny	2CC	W, I	-	No further study is done.	WRMA	
		21	Aram	2EE	W	-	Dam completed (2010)	KVDA	No water supply yet.
		22	Ratat	2EE	W	NWCPC	No further study is done.	KVDA	
		23	Leshota	2KB	P, W	ENSDA	F/S, D/D ongoing (to be completed in 2013)	MORDA/ ENSDA	MORDA 18 Projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project
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.
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.

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 table.

Table 2.3.1 Dam Schemes Listed in NWMP (1992) and Current Status as of November 2012 (3/3)

Future Development Potential Dams in 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	

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 table.

Table 2.3.2 Dam Schemes Not Listed in NWMP (1992) and Current Status as of November 2012

Catchment Area		Identified Dams				Current Status			
			Dams not in NWMP (1992)	Sub-basin	Purpose	Related Agency/ Owner	Status/ Construction Year	Source of Information	Remarks
1.	LVN	1	Siyoi	1BC	W	NWCPC	F/S, D/D ongoing (to be completed in 2013)	NWCPC	2008-12 Flagship Projects under Vision 2030
		2	Nzoia (at site No. 34B)	1BG	W, F, I, P	NWCPC	F/S, D/D, T/D ongoing (to be completed in 2013)	NWCPC	(2008-12 Flagship Projects under Vision 2030)*
		3	Nzoia (at site No. 42A)	1EE	F, P	MOSSP/ MWI	F/S, D/D ongoing (to be completed in 2013)	MWI	(2008-12 Flagship Projects under Vision 2030)*, Under WKCDD&FMP
2.	LVS	4	Awasi	1GD1	I, P, F	NWCPC	No study is started.	NWCPC	2008-12 Flagship Projects under Vision 2030
		5	Ilooiterre	1KC	W, I, P	ENSDA	Pre-F/S done.	ENSDA	
		6	Sand River (Naikara)	1LA3	I, F, P	ENSDA/ MORDA	No study is started.	MORDA	MORDA Strategic Plan 2008-12
3.	RV	7	Murung-Sebit	2BB	W, I, F	KVDA	No study is started.	KVDA	
		8	Embobut	2CC	W, I, P	KVDA	Pre-F/S done.	KVDA	
		9	Perkerra	2EE	I	NWCPC	No study is started.	NWCPC	NWCPC Plans for Vision 2030
		10	Oletukat	2KA	W, P	ENSDA/ MORDA	F/S, D/D ongoing (to be completed in 2013)	MORDA/ ENSDA	MORDA 18 Projects, Lower Ewaso Ng'iro South River Multipurpose Dam Development Project
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
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
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

* = Flagship Project in Nzoia River stipulated in Kenya Vision 2030 is one multipurpose dam only without name of the dam.

Source: JICA Study Team based on information from the government agencies mentioned in the above table.

Table 2.3.3 Water Transfer Schemes Not in NWMP (1992) and Current Status as of November 2012

Intra-basin Bulk Water Transfer Schemes not in NWMP (1992)

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
1.	LVN								
2.	LVS								
3.	RV								
4.	Athi	-	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
		-	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
5.	Tana	-	4ED	Kiambere to Mwingi	4ED/ 4GE		Operational	Tanathi WSB	
6.	ENN								

Inter-basin Bulk Water Transfer Schemes not in NWMP (1992)

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Related Agency / Owner	Status/ Construction Year	Source of Information	Remarks
1.	LVN	-	1BC	Siyoi Dam*	1BC	NWCPC	F/S, D/D ongoing	NWCPC	
		-	1BG	Nzoia Dam (at No.34B site)*	1BG	NWCPC	F/S, D/D ongoing	NWCPC	
		-	1FD	Nandi Forest Dam	1HA1	LBDA/ MORDA	D/D completed	MORDA	
					1HA2	LBDA/ MORDA	D/D completed	MORDA	
2.	LVS	-	1GC	Koru Dam (at No.8A site)	1HA	NWCPC	Preliminary design ongoing	NWCPC	
		-	1JG	Magwagwa Dam	1GF	LBDA/ MORDA	F/S, D/D completed	MORDA	
		-	1LB1	Amala Transfer	2KA	ENSDA/ MORDA	F/S, D/D ongoing	ENSDA	
3.	RV								
4.	Athi		3EA	Maruba Dam*	3EA	NWCPC/ Thanathi WSB	Operational	NWCPC	
5.	Tana	-	4CA	Sasumua Dam	3BA	AWSB	Operational	AWSB	
		-	4HA	Umaa Dam*	4HA	NWCPC	Under construction	NWCPC	
6.	ENN	-	5EC	Badasa Dam*	5EC	NWCPC	Under construction	NWCPC	

Note: * = Listed by NWCPC as "Inter-basin Transfer Schemes."
Project Stage: M/P=master plan, Pre-F/S=prefeasibility study, F/S=feasibility study, D/D=detailed design

Source: JICA Study Team based on information from the government agencies mentioned in the above table.

Table 2.3.4 General Features of Proposed Priority Dam Schemes in NWMP (1992) and their Update as of November 2012 (1/2)

Catchment Area	Proposed Dams in NWMP (1992)	Sub-basin	Coordinates		River (Damsite)	Catchment Area (km^2)	Stage in 1992 (upper side) and *at Present (lower side)*	Purpose	Reservoir								Dam			Source of Information
			X	Y					N.W.L. (El.m)	L.W.L. (El.m)	Dead Storage (mcm)	Active Storage (mcm)	Gross Storage (mcm)	Surface Area (FSL) (ha)	Yield (m3/s)	Yield (m3/day)	Dam Crest (E1.m)	Dam Height (m)	Embank-ment Volume ($1000m^3$)	
1. Lake Victoria North	1. Moiben (Chebara)	1BA	777,700	97,900	Moiben	188	D/D *Complete*	W	2,361.6 -	2,337.1 -	1.22 -	18.38 -	19.60 -	137 -	0.68 -	58,666 -	2,366.6 -	42 -	414 -	NWMP (1992) *No information*
	2. Mukulusi	1EA	701,550	32,000	Mukulusi	341	M/P*	W	1,510.1	1,508.5	11.60	5.39	16.99	227	1.10	95,040	1,515.1	8	21	NWMP (1992)
2. Lake Victoria South	3. Londiani	1GC	786,800	9,986,800	Kipchorian	71	M/P *Pre-F/S*	W	2,325.6 -	2,297.2 -	1.60 -	49.30 -	50.90 *24*	436 -	0.47 -	40,608 -	2,330.6 -	50 *36*	1,720 -	NWMP (1992) *NWCPC (2012)*
	4. Kibos	1HA	703,500	500	Kibos	179	M/P*	W	1,482.1	1,471.6	2.20	4.93	7.13	68	0.95	82,080	1,487.1	39	700	NWMP (1992)
	5. Itare	1JA	780,500	9,951,500	Itare	185	M/P*	W	2,400.5	2,379.7	1.11	12.48	13.59	97	1.73	149,472	2,405.5	35	623	NWMP (1992)
	6. Sondu/Miriu	1JG	-	-	Sondu	3,360 *3,345*	D/D *Complete*	P, I *P, I*	- *1,402.5*	- *1,400.0*	- -	- *1.10*	- -	- -	- -	- -	- -	Weir *18*	- -	NWMP (1992) *Design report (1991)*
	7. Magwagwa	1JG	727,100	9,947,100	Sondu	3,160 *3,240*	F/S *D/D*	P, I *W,I,F,P*	1,665.0 *1,650.0*	1,603.0 *1,609.0*	107.00 -	701.00 *445*	808.00 -	2,349 *1,770*	- -	- -	1,670.0 -	110 *95*	4,388 *3,000*	NWMP (1992) *MORDA D/D Report (2011)*
	8. Bunyunyu	1KB	708,700 *710,480*	9,922,700 *9,922,785*	Kuja *Gucha*	120 *263*	M/P *F/D*	W *W, P*	1,834.3 *1,831*	1,832.7 -	3.40 -	1.34 *6.3*	4.74 *8.3*	243 *130*	0.61 -	52,704 -	1,837.3 -	16 *18.5*	108 *161*	NWMP (1992) *NWCPC F/D (2011)*
3. Rift Valley	9. Chemususu	2ED	-	-	Perkerra *Chemususu*	63 *64*	D/D *U/C*	W *W*	2,336.5 *2,339.5*	2,315.5 -	1.51 *1.50*	9.44 *10.00*	10.95 *11.50*	82 *82*	0.41 -	35,000 *35,000*	2,340.0 *2,343.0*	45 *45*	757 *662*	NWMP (1992) *NWCPC*
	10. Kirandich	2EH	-	-	Kirandich	28 *30*	D/D *Complete*	W *W*	1,774.4 *1,774.4*	1,756.5 *1,756.5*	0.75 *0.75*	3.25 *3.25*	4.52 *4.52*	28 *30*	0.13 -	11,000 -	1,780.0 *1,780.0*	50 *50*	420 *420*	NWMP (1992) *NWCPC F/D*
	11. Malewa	2GB	211,400	9,951,950	Malewa	635	F/S*	W	2,149.0	2,123.5	15.88	55.82	71.70	332	1.37	118,714	2,154.0	80	1,170	NWMP (1992)
	12. Upper Narok	2KA	814,100	9,894,600	Engare Narok	516	M/P*	W	1,985.5	1,975.5	3.10	6.99	10.09	79	1.20	103,680	1,988.5	29	368	NWMP (1992)
	13. Oldorko	2KB	174,150 *175,402*	9,832,400 *9,828,463*	E.Ngiro S.	5,696	Pre-F/S *D/D ongoing*	P, I, W	1,300.0 1,255	1,272.0 -	71.20 -	885.22 *20*	956.42 -	5115 -	- -	- -	1,305.0 -	55 *30*	4,480 -	NWMP (1992) *ENSDA (2012)*
4. Athi	14. Upper Athi (Mbagathi)	3AA	264,700	9,844,600	Athi	400	Pre-F/S*	W	1,551.7	1,542.9	3.00	7.30	10.30	112	0.30	25,920	1,554.7	26	171	NWMP (1992)
	15. Ruaka (Kiambaa)	3BA	252,900	9,867,300	Ruaka	100	D/D*	W	1,755.7	1,747.7	0.60	2.07	2.67	29	0.12	10,000	1,758.7	18	120	NWMP (1992)
	16. Ruiru-A	3BC	252,700	9,885,600	Ruiru	202	M/P *F/S ongoing*	W	1,898.9 -	1,855.8 -	1.21 -	17.83 *13.2*	19.04 -	87 -	0.35 -	30,240 -	1,903.9 -	69 *50*	1,528 -	NWMP (1992) *AWSB (2012)*
	17. Kikuyu	3BA	239,900	9,861,800	Nairobi	81	M/P*	W	2,006.6	1,989.9	0.49	10.50	10.99	106	0.25	21,600	2,009.6	25	221	NWMP (1992)
	18. Ndarugu (Ndarugu 1)	3CB	296,400	9,876,500	Ndarugu	360	M/P *F/S ongoing*	W, I *W*	1,451.3 -	1,429.8 -	9.27 -	214.95 *300*	224.22 -	1,876 -	6.10 -	527,040 -	1,456.3 -	36 -	1,302 -	NWMP (1992) *AWSB (2012)*
	19. Yatta	3FB	384,700	9,762,300	Athi	20,000	M/P*	I	782.1	764.2	100.00	280.20	380.20	2,561	13.50	1,166,400	787.1	52	4,988	NWMP (1992)
	20. Rare	3LA	581,200	9,620,200	Rare	6,246	F/S *D/D ongoing*	W	91.1 -	82.5 -	6.00 -	31.27 -	37.27 -	551 -	0.50 -	43,200 -	94.1 -	21 -	502 -	NWMP (1992) *No information*
	21. Mwachi (Mwache)	3MB *3MA*	557,700	9,559,200	Mwachi	*7,497* *2,250* -	M/P *P/D* *P/D*	W *W, I* *W*	85.6 *95.0* -	39.5 - -	8.00 - -	105.00 - *393.00*	113.00 *207.44* -	526 - *1,500*	2.75 - -	237,600 - *207,360*	90.6 *100.0* *100.0*	77 *89.5* *76*	3,217 - *4,580*	NWMP (1992) *MORDA P/D Report (2011)* *NWCPC P/D (2008)*
	22. Pemba	3HC	551,900	9,545,400	Pemba	866	M/P*	W	-	-	-	-	-	-	0.23	19,872	-	Weir	-	NWMP (1992)

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, P/D=preliminary design, D/D=detailed design, F/D=final design, U/C=under construction

* = No further substantial study has been made since NWMP (1992).

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

Table 2.3.4 General Features of Proposed Priority Dam Schemes in NWMP (1992) and their Update as of November 2012 (2/2)

Catchment Area		Proposed Dams in NWMP (1992)	Sub-basin	Coordinates X	Coordinates Y	River (Damsite)	Catchment Area (km^2)	Stage in 1992 (upper side) and *at Present (lower side)*	Purpose	Reservoir N.W.L. (El.m)	Reservoir L.W.L. (El.m)	Reservoir Dead Storage (mcm)	Reservoir Active Storage (mcm)	Reservoir Gross Storage (mcm)	Reservoir Surface Area (FSL) (ha)	Reservoir Yield (m3/s)	Reservoir Yield (m3/day)	Dam Crest (E1.m)	Dam Height (m)	Dam Embank-ment Volume ($1000m^3$)	Source of Information
5.	Tana	23. Chania-B	4CA	265,300	9,899,900	Chania	338	M/P*	W, I	1,790.6	1,720.6	2.03	48.99	51.02	150	1.30	112,320	1,795.6	101	3,816	NWMP (1992)
		24. Thiba	4DA	314,800	9,941,500	Thiba	173	F/S *D/D Review*	I *I*	1,380.0 *1,380.0*	1,359.0 *1,368.0*	1.30 *4.4*	16.73 *11.2*	18.03 *15.60*	122 -	- -	- -	1,385.0 *1,385.0*	35 *41*	1,200 *1,292*	NWMP (1992) *NIB (2012)*
		25. Mutonga	4FA	382,250	9,952,900	Tana	15,329 *15,365*	Pre-F/S *F/S*	P *P*	550.0 *550.0*	542.0 *538.5*	268.26 *49.50*	87.81 *82.50*	356.07 *132.00*	1,090 *1,090*	- -	- -	554.0 *555.0*	42 *47*	870 *810*	NWMP (1992) *JICA F/S (1998)*
		26. Low Grand Falls	4FB	392,900	9,969,750	Tana	17,459 *17,570*	Pre-F/S *F/S*	P *P*	512.0 *512.0*	500.0 *491.4*	742.01 *305.90*	857.78 *955.20*	1,599.79 *1,261.1*	6,720 *6,570*	- -	- -	516.0 *517.0*	79 *83*	5,820 *5,560*	NWMP (1992) *JICA F/S (1998)*
6.	Ewaso Ng'iro North	27. Rumuruti	5AA	216,500	16,650	Ewaso Narok	673	Pre-F/S*	W	2,012.8	2,010.4	2.00	0.95	2.95	63	0.03	2,592	2,015.8	16	109	NWMP (1992)
		28. Nyahururu	5AA	201,900	3,950	Nyahururu	29	M/P*	W	2,400.0	2,380.9	0.17	10.23	10.40	116	0.26	22,464	2,403.0	20	72	NWMP (1992)

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, P/D=preliminary design, D/D=detailed design, F/D=final design, U/C=under construction

* = No further substantial study has been made since NWMP (1992).

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

Table 2.3.5 General Features of Dam Schemes Listed in NWMP (1992) and their Update as of November 2012 (1/3)

Existing and On-going Dams in NWMP (1992)

Catchment Area		Existing and On-going Dams in NWMP (1992)	River Basin	Sub-basin	Coordinates X	Coordinates Y	River (Damsite)	Catchment Area (km^2)	Stage in 1992 (upper side) and *at Present (lower side)*	Purpose	Dam Type	Active Storage (mcm)	Gross Storage (mcm)	Surface Area (km^2)	Dam Height (m)	Remarks	Source of Information
1.	Lake Victoria North	1. Moiben (Chebara)	Moiben	1BA	777,700	97,900	Moiben	188	D/D *Complete (1997)*	W	Rockfill -	18.38 -	19.60 -	1.37 -	42 -	W/S to Eldoret town/environs	NWMP (1992) *No information*
		2. Twin Rivers	Kipkarren	1CB	-	-	Sosiani	305	Constructed, 1962	W	Gravity	-	-	-	-	W/S to Eldoret town/environs	NWMP (1992)
		3. Ellegirini	Kipkarren	1CB	-	-	Ellegirini	63	Constructed, 1989	W	Earth	-	2	-	24	W/S to Eldoret town/environs	NWMP (1992)
		4. Kipkarren	Kipkarren	1CC	-	-	Olare Onyonkie	59	U/C *Complete (1991)*	W	Earth -	- -	3 -	- -	22 -		NWMP (1992) *No information*
		5. Lessos	Yala	1FD	-	-	Cheolelach	6	U/C *Complete (1993)*	W	Earth -	- -	1 -	- -	25 -		NWMP (1992) *No information*
2.	Lake Victoria South	6. Gogo Falls*	Kuja	1KB	-	-	Kuja	3,022	Constructed, 1958	P	Gravity	-	-	-	25	Station power 2 MW	NWMP (1992)
		7. Sondu/Miriu	Sondu	1JG	-	-	Sondu	3,360 *3,345*	D/D *Complete (2007)*	P, I *P, I*	Gravity *Gravity*	- *1.10*	- -	- -	Weir *18*	Installation capacity 106MW *Installed capacity 60MW*	NWMP (1992) *Design report (1991)*
3.	Rift Valley	8. Turkwel	Turkwel	2BC	-	-	Turkwel	5,900	Constructed, 1991	P, I	Arch	-	1,650	*(65)*	155	Installation capacity 106MW	NWMP (1992)
		9. Chemususu	Perkerra	2ED	-	-	Perkerra *Chemususu*	81 *64*	D/D *U/C*	W, I *W*	Rockfill *Rockfill*	9.44 *10.00*	10.95 *11.50*	0.82 *0.82*	45 *45*	W/S to Nakuru town	NWMP (1992) *NWCPC*
		10. Chemeron	Perkerra	2EH	-	-	Nasagun	63	Constructed, 1984	W, I	Earth	-	5	-	31	*Silted up*	NWMP (1992), *KVDA*
		11. Kirandich	Perkerra	2EH	-	-	Kirandich	28 *30*	D/D *Complete (2000)*	W, I *W*	Rockfill *Rockfill*	3.25 *3.25*	4.52 *4.52*	0.28 *0.30*	50 *50*	W/S to Kabarnet town	NWMP (1992) *NWCPC F/D*
		12. Turasha	Malewa	2GC	-	-	Turasha	711	U/C *Complete (---)*	W	Gravity -	- -	- -	- -	17 -	W/S to Nakuru town	NWMP (1992) *No information*
4.	Athi	13. Kiserian	Athi	3AA	-	-	Kiserian	49	U/C *U/C*	W *W*	Rockfill *Earthfill*	- *1.10*	3 *1.22*	- *0.42*	21 *18*	W/S to Kajiado town/environs *W/S to Kiserian 15,720 m3/day*	NWMP (1992) *NWCPC F/D (2008)*
		14. Ruaka (Kiambaa)	Ruaka	3BA	252,900	9,867,300	Ruaka	100	D/D	W	Earth	2.07	2.67	0.29	18	W/S to Kiambu town/environs	NWMP (1992)
		15. Ruiru	Ruiru	3BC	-	-	Ruiru	131	Constructed, 1950	W	Gravity	-	3	-	18	W/S to Nairobi town/environs	NWMP (1992)
		16. Bathi	Ruiru	3BC	-	-	Bathi	15	Constructed, 1980	W	Rockfill	-	1	-	22	W/S to adjacent communities	NWMP (1992)
		17. Mulima	Thwake	3EA	-	-	Mulima	-	Constructed, 1982	W	Earth	-	1	-	17	W/S to adjacent communities	NWMP (1992)
		18. Manooni	Athi	3EB	-	-	Manooni	-	Constructed, 1987	W	Earth	-	1	-	17	W/S to adjacent communities	NWMP (1992)
		19. Muoni	Thwake	3EB	-	-	Muoni	20	Constructed, 1987	W	Earth	-	1	-	22	W/S to adjacent communities	NWMP (1992)
		20. Kikoneni	Ramisi	3K	-	-	Mkanda	72	Constructed, 1981	W	Earth	-	1	-	17	W/S to adjacent communities	NWMP (1992)
5.	Tana	21. Sasumua**	Tana	4CA	-	-	Chania	65	Constructed, 1956	W	Earth	-	16	-	45	W/S to Nairobi city	NWMP (1992)
		22. Thika *(Ndakaini)*	Tana	4CB	-	-	Thika	71	U/C *Complete (1993)*	W *W*	Earth w/core	- *69*	70 *70*	- *2.80*	65 *63*	W/S to Nairobi city	NWMP (1992) *Howard Humphreys (EA)*
		23. Masinga***	Tana	4DE	*342,802*	*9,903,032*	Tana	7,335	Constructed, 1981	P	Rockfill	-	1,560	*(120)*	70	Staion Power 40MW	NWMP (1992), *WRMA*
		24. Kamburu	Tana	4ED	*353,745*	*9,911,002*	Tana	9,520	Constructed, 1975	P	Rockfill (*1)	-	150	*(60)*	56	Station Power 94.4MW	NWMP (1992), *WRMA*
		25. Gitaru	Tana	4ED	*360,740*	*9,912,384*	Tana	9,525	Constructed, 1978	P	Rockfill	*(12.5)*	20	*(3.1)*	30	*(Installed capacity 225MW)*	NWMP (1992), *WRMA*
		26. Kindaruma	Tana	4ED	*367,736*	*9,910,752*	Tana	9,807	Constructed, 1968	P	Rockfill (*1)	-	16	*(2.4)*	24	Satation Power 44MW	NWMP (1992), *WRMA*
		27. Kiambere	Tana	4ED	*377,815*	*9,929,805*	Tana	11,975	Constructed, 1988	P	Rockfill	-	585	*(25)*	112	*(Installed capacity 168MW)*	NWMP (1992), *WRMA*
6.	Ewaso Ng'iro North																

Note: Purpose: W=water supply, I=irrigation, P=hydropower
Project Stage: D/D=detailed design, U/C=under construction, Pre-F/S=prefeasibility study, F/D=final design
*=Gogo Falls, Pre-F/S done by NIB in 2010 (dam height=34-36m, active storage=82-127mcm, surface area=16.7-22.7km2)
**=Sasumua, Rehabilitation done by AWSB in 2010 (repair of damaged spillway)
***=Masinga, Raising of the dam is studied by KenGen.
(*1)=rockfill dam with asphalt facing, ( )=data from websites of KenGen and KVDA

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

Table 2.3.5 General Features of Dam Schemes Listed in NWMP (1992) and their Update, as of November 2012 (2/3)

Future Development Potential Dams in NWMP (1992)

Catchment Area		Future Development Potential Dams in NWMP (1992)	Sub-basin	Coordinates X	Coordinates Y	River (Damsite)	Catchment Area (km^2)	Scheme Stage in 1992 (upper side) and *at Present (lower side)*	Purpose	Water Supply: Service Urban Centre	Irrigation: Large Irrigation Scheme	Hydropower: Hydropower Scheme	Reservoir: Dead Storage (mcm)	Reservoir: Active Storage (mcm)	Reservoir: Gross Storage (mcm)	Reservoir: Surface Area (km^2)	Dam: Dam Height (m)	Dam: Embank-ment Volume ($1000m^3$)	Remarks	Source of Information
1.	Lake Victoria North	01 Moi's Bridge	1BE	735,400	99,150	Koitobos	858	Pre-F/S*	P, I, W	-	-	Moi's Bridge	17.4	2,182.6	2,200.0	-	-	4,700	inter-basin w/transfer	NWMP (1992)
		02 Hemsted Brg.	1BD	729,000	85,650	Nzoia	3,825	M/P *Pre-F/S*	W, I, P *I, P, F*	Great Rift W/S -	Upper Nzoia -	Hemsted Brg. -	66.9 -	193.1 -	260.0 *125.8*	- *9.4*	- *45*	5,853 *446 (RCC)*	inter-basin w/transfer *Site 33A*	NWMP (1992) *SWECO/CAS Pre-F/S (2010)*
		03 Kibolo	1CE	733,500	62,000	Sosiani	609	-*	W	-	-	-	15.7	54.3	70.0	-	-	1,151		NWMP (1992)
		04 Webuye Falls	1DA	700,700	66,900	Nzoia	8,420	M/P*	P	-	-	Webuye Falls	239.8	-224.3	15.5	-	-	302		NWMP (1992)
		05 Teremi	1DB	676,250	91,250	Kuywa	138	F/S*	P	-	-	Teremi	0.8	3.0	3.8	-	-	530	rural hydro-electricity	NWMP (1992)
		06 Kimondi	1FC	729,100	27,850	Kimondi	692	-*	W, I	Great Rift W/S	-	-	17.8	774.2	792.0	-	-	4,406	inter-basin w/transfer	NWMP (1992)
		07 Nandi Forest	1FD	722,900	16,100	Yala	1,339	M/P *D/D*	I, P, W *P, I, W*	- *Yala, Kisumu*	Yala Swamp/ Kano plain *7,272ha*	Nandi Forest *50 MW*	8.0 -	467.0 -	475.0 *230.0*	- *11.88*	- *66.4*	6,279 -	multipurpose *By MORDA*	NWMP (1992) *MORDA (2012)*
		08 Mushangumbo	1FE	675,000	14,500	Yala	1,987	M/P*	P	-	-	Mushangumbo	39.7	210.3	250.0	-	-	1,852		NWMP (1992)
2.	Lake Victoria South	09 Nyando (Koru)	1GD1	747,100	9,978,800	Nyando	1,322 *1,286*	F/S *P/D ongoing*	W, I, F *F, I, W, P*	Great Rift W/S -	Kano Plain -	- *3.5MW*	34.0 -	291.0 *86.57*	325.0 *89.25*	- *6.5*	- *60*	14,272 -	inter-basin w/transfer *By NWCPC*	NWMP (1992) *NWCPC (2012)*
		10 Timbilil	1JC	-	-	Timbilil	33	Pre-F/S*	W	Kericho	-	-	0.2	14.8	15.0	-	-	1,100		NWMP (1992)
		11 Sisei	1JF	733,150	9,924,000	Kipsonoi	557	Pre-F/S*	W	-	-	-	13.9	31.1	45.0	-	-	322		NWMP (1992)
		12 Katieno	1KB	652,100	9,899,700	Kuja	3,002	- *Pre-F/S*	W *W, I, P*	- -	- -	- -	77.3 *28*	1,402.7 *82-127*	1,480.0 *110-155*	- *20.3-26.3*	- *21-23*	3,287 -		NWMP (1992) *NIB Pre-F/S (2010)*
		13 Namba Kodero	1KC	643,600	9,890,900	Migori	2,769	M/P*	W, P	-	-	Namba Kodero	34.6	270.4	305.0	-	-	1,578		NWMP (1992)
		14 Amala	1LB1	788,150	9,917,600	Amala	475	Pre-F/S*	W	Nakuru	-	-	0.6	36.4	37.0	-	-	1,853		NWMP (1992)
3.	Rift Vally	15 Kimwarer	2CB	785,850	30,100	Kimuwarer	160	F/S *Pre-F/S*	W, P, I	- -	Kimwarer *2,000 ha*	Kimwarer *20 MW*	7.4 -	129.6 *125*	137 -	- -	- -	4,425 -	multipurpose -	NWMP (1992) *KVDA (2012)*
		16 Kipsang (Kipsaa)	2CB	803,500	36,100	Kipsang	66	-*	W	-	-	-	3.4	15.4	18.8	-	-	900		NWMP (1992)
		17 Arror	2CC	776,800	132,800	Arror	35 *185*	- *D/D*	W *W, P, I*	- -	- -	- *60 MW*	0.2 *2*	7.8 *62*	8.0 *64*	- *2.75*	- *93*	263 *5,059*	*By MORDA*	NWMP (1992) *MORDA (2012)*
		18 Sererwa	2CC	784,900	111,300	Arror	185	F/S*	P, I, W	-	Arror	Arror	8.8	141.2	150.0	-	-	8,952	multipurpose	NWMP (1992)
		19 Waseges	2CC	183,950	31,800	Waseges	433	M/P*	W	-	-	-	13.5	13.5	27.0	-	-	846		NWMP (1992)
		20 Kamukuny	2CC	820,200	95,600	Kerio	6,024	-*	W, I	-	-	-	122.3	597.7	720.0	-	-	1,923	flow augmentation	NWMP (1992)
		21 Aram	2EE	814,500	19,600	Perkerra	501	M/P *Complete (2010)*	W	-	-	-	15.6	169.4	185.0	-	-	7,480	run-of-river type weir	NWMP (1992) *No information*
		22 Ratat	2EE	824,500	32,200	Perkerra	1,068	M/P*	W	-	-	-	33.3	62.7	96.0	-	-	1,697		NWMP (1992)
		23 Leshota	2KB	167,900 *166,323*	9,847,550 *9,849,331*	E. Ng'iro S.	5,119	Pre-F/S *D/D ongoing*	P, W	- -	- -	Leshota *54 MW*	64 -	451 *33*	515 -	- -	- *55*	14,190 -		NWMP (1992) *ENSDA (2012)*
4.	Athi	24 Munyu	3DA	297,500	9,877,500	Athi	5,590	F/S *F/S (2007)* *Study*	W, I, P *W, I, P*	Nairobi - *Machakos, Makueni*	- - *13,000ha*	Munyu - *40MW*	55.9 - -	569.1 - *575.0*	625.0 - -	- - -	- - -	2,960 - -	multipurpose *By NWCPC* *By MORDA*	NWMP (1992) *No information* *TARDA Concept Paper (2008)*
		25 Mbuuni	3EA	318,500	9,836,600	Thwake	398	-*	W	Machakos	-	-	19.9	-0.9	19.0	-	-	235		NWMP (1992)
		26 Kiteta	3EB	336,500	9,826,000	Kiteta	72	F/S *Pre-F/S (2008)*	W *W*	rural *16,000m3/day*	- -	- -	3.6 -	14.9 -	19.0 *13.0*	- -	- *35*	438 -		NWMP (1992) *NWCPC*
		27 Thwake	3FA	371,300	9,802,500	Athi	10,276	M/P *F/D*	I, W *W, I, P*	- *Makueni*	- *21,000ha*	- *20MW*	118.2 -	496.8 *594.0*	615.0 *825.0*	- *29.3*	- *84*	8,765 *18,400*		NWMP (1992) *NWCPC F/D (2009)*
		28 Tsavo	3G	438,450	968,350	Tsavo	4,050	F/S*	W	Tsavo	-	-	8.1	30.9	39.0	-	-	274		NWMP (1992)
		29 Baricho	3HD	585,800	9,655,300	Sabaki	34,240	M/P*	W	-	-	-	1,112.8	817.2	1,930.0	-	-	3,333		NWMP (1992)

Continued

Table 2.3.5 General Features of Dam Schemes Listed in NWMP (1992) and their Update, as of November 2012 (3/3)

Future Development Potential Dams in NWMP (1992)

Catchment Area (C.A.)	Future Development Potential Dams in NWMP (1992)	Sub-basin	Coordinates		River (Damsite)	Catchment Area (km²)	Scheme Stage in 1992 (upper side) and *at Present (lower side)*	Purpose	Water Supply	Irrigation	Hydropower	Reservoir				Dam		Remarks	Source of Information
			X	Y					Service Urban Centre	Large Irrigation Scheme	Hydropower Scheme	Dead Storage (mcm)	Active Storage (mcm)	Gross Storage (mcm)	Surface Area (km²)	Dam Height (m)	Embank-ment Volume (1000m³)		
5. Tana	30 Maragua 8	4BE	285,000	9,913,900	Maragua	210	M/P*	W	-	-	-	3.0	137.0	140.0	-	-	7,668		NWMP (1992)
	31 Ndiara	4CA	244,500	9,912,000	Ndiara	43	M/P*	W	-	-	-	0.0	12.0	12.0	-	-	1,500		NWMP (1992)
	32 High Grand Falls	4FB	392,650	9,969,800	Tana	17,459	Pre-F/S *D/D*	P, W, I *P, I, W, F*	- -	- *106,000 ha*	High Grand Falls *700MW*	231.0 -	5,094.0 -	5,325.0 *5,757.0*	- *163.26*	- *127*	30,000 *4,800* *(RCC)*	multipurpose	NWMP (1992) *MORDA (2012)*
	33 Adamson Falls	4GA	436,600	9,991,500	Tana	21,462	M/P*	P, W, I	-	-	Adamson Falls	400.0	609.0	1,009.0	-	-	2,910	multipurpose	NWMP (1992)
	34 Kora	4GB	474,350	9,992,300	Tana	24,874	M/P*	P, W, I	-	-	Kora	543.0	629.0	1,172.0	-	-	3,600	multipurpose	NWMP (1992)
	35 Umaa	4HA	-	-	- Nzeu	- *6.3*	- *U/C*	W *W*	- *Kitui, 2,300m3/day*	- -	- -	- -	- -	- *0.87*	- *0.08*	- *28*	- *125*		NWMP (1992) *NWCPC Final report (2007)*
	36 Mutuni	4HA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	37 Kitimui	4HA	391,300	9,860,000	Tiva	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
6. Ewaso Ng'iro North	38 Archers Post	5DA	335,500	63,200	E. Ng'iro	15,300	M/P*	W, I, P	-	-	-	310.7	214.3	525.0	-	-	10,620	flow augmentation	NWMP (1992)
	39 Crocodile Jaw	5DC	264,000	67,000	E. Ng'iro	8,583	M/P*	P, W, I	-	-	Crocodile Jaw	174.3	21.7	196.0	-	-	4,104	flow augmentation	NWMP (1992)
	40 Kirium	5DC	269,750	82,500	E. Ng'iro	8,825	M/P*	P	-	-	Kirium	179.2	0.0	117.0	-	-	19,629		NWMP (1992)
	41 Kihoto	5BC	267,600	27,650	E. Ng'iro	2,842	M/P*	W, I	-	-	-	57.7	672.3	730.0	-	-	6,756	flow augmentation	NWMP (1992)
	42 Nundoto	5CA	-	-	-	-	-*	W	Maralal	-	-	-	-	-	-	-	-	small dam	NWMP (1992)
	43 Lag-Bor	5EA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	44 Buna	5EA	-	-	-	-	-*	W	Buna	-	-	-	-	-	-	-	-		NWMP (1992)
	45 Habaswein	5EC	-	-	-	-	-*	W	Habaswein	-	-	-	-	-	-	-	-		NWMP (1992)
	46 Meri (Merti)	5EC	-	-	-	-	-*	W	Meri	-	-	-	-	-	-	-	-		NWMP (1992)
	47 Modogashe	5FA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	48 Dadab	5FA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	49 Kutulo-Elwak	5GA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	50 Takaba	5GA	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	51 Mandera	5GB	-	-	-	-	-*	W	Mandera	-	-	-	-	-	-	-	-		NWMP (1992)
	52 Neboi-Mandera	5GB	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	53 Rham Mandera	5GB	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	54 Arabic (Arabia)	5GB	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	55 Fino	5GB	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	56 Kalatiyo	5H	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)
	57 Markamari	5H	-	-	-	-	-*	W	-	-	-	-	-	-	-	-	-		NWMP (1992)

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, P/D=preliminary design, D/D=detailed design, F/D=final design, U/C=under construction
* = No further substantial study has been made since NWMP (1992).
Source: JICA Study Team based on NWMP (1992) and data from the government agencies mentioned in the above table.

Table 2.3.6 General Features of Dam Schemes Not Listed in NWMP (1992) as of November 2012

Dams not in NWMP (1992)

Catchment Area		Dams not in NWMP(1992)		Sub-basin	Coordinates		River (Damsite)	Catchment Area (km^2)	Stage	Purpose	Reservoir							Dam			Source of Information
					X	Y					N.W.L. (E1.m)	L.W.L. (E1.m)	Dead Storage (mcm)	Active Storage (mcm)	Gross Storage (mcm)	Surface Area (km^2)	Yield (m^3/day)	Dam Crest (E1.m)	Dam Height (m)	Embank-ment Volume ($1000m^3$)	
1.	Lake Victoria North	1	Siyoi	1BC	-	-	Siyoi	17 *115*	F/D *D/D ongoing*	W	- -	- -	1.50 -	3.64 *4.1*	5.14 *8.1*	0.53 *0.91*	24,300 -	- -	29 *28*	410 -	NWCPC, Final Dam Design Report (2008) *NWCPC (2012)*
		2	Nzoia (site 34B)	1BG	-	-	Nzoia	4,862	P/D *D/D ongoing*	W,F,I,P	1,675 *1,648*	- -	- -	- *203.7*	985.7 *210*	45.7 *16*	41,804 -	1,680 -	60 *30*	10,130 -	NWCPC, P/D (2010) *NWCPC (2012)*
		3	Nzoia (site 42A)	1EE	-	-	Nzoia	11,956	Pre-F/S *D/D ongoing*	F,P	- -	- -	- *177*	- -	386.7 *572*	41.3 *20.94*	- -	1,230 -	40 *38.8*	3,742 -	SWECO/CAS Pre-F/S (2010) *MWI (2012)*
2.	Lake Victoria South	4	Awasi	1GD1	735,900	9,984,500	Nyando	1,509	M/P -	I,P,F -	- -	- -	43.0 -	157.0 -	200.0 -	- -	- -	- -	- -	8,956 -	NWMP (1992), not proposed *NWCPC, No detailed information*
		5	Ilooiterre	1KC	-	-	Mogor	-	Pre-F/S	W,I	-	-	-	13.60	-	-	-	-	15	-	ENSDA (2012)
		6	Sand River (Naikara)	1LA3	-	-	-	-	-	I,F,P	-	-	-	-	-	-	-	-	-	-	MORDA, No detailed information
3.	Rift Valley	7	Murung-Sebit	2BB	-	-	-	-	-	W,I,F	-	-	-	40	-	-	-	-	-	-	KVDA (2012)
		8	Embobut	2CC	-	-	-	-	Pre-F/S	W,I,P	-	-	-	30	-	-	-	-	-	-	KVDA (2012)
		9	Perkerra	2EE	-	-	-	-	-	I	-	-	-	-	-	-	-	-	-	-	NWCPC, No detailed information
		10	Oletukat	2KA	825,411	9,859,384	Ewaso Ng'iro South	-	D/D ongoing	W,P	1,758	-	-	300	-	-	-	-	140	-	MORDA/ ENSDA (2012)
4.	Athi	11	Stony Athi	3AB	277,880	9,837,354	-	1,750	F/S ongoing	W	-	-	-	23	-	-	60,480	-	25	-	AWSB (2012)
		12	Kamiti 1	3BB	242,678	9,880,837	-	18	F/S ongoing	W	-	-	-	16	-	-	16,416	-	50	-	AWSB (2012)
		13	Maruba	3EA	-	-	Maruba	47.5	Rehabilitation complete	W	-	-	-	-	2.45	-	8,700	-	23	-	NWCPC, F/D (2008)
		14	Olkishunki	3FA	268,870	9,759,508	Olkejuado	-	Pre-F/S	W,I	-	-	-	1.2	-	-	-	-	15	-	ENSDA (2012)
		15	Lake Chala	3J	-	-	-	-	D/D ongoing	I,W	-	-	-	-	-	-	-	-	-	-	MORDA
		16	Olkejuado	-	-	-	-	-	-	I,F,P	-	-	-	-	-	-	-	-	-	-	MORDA
5.	Tana	17	Maragua 4	4BE	264,600	9,917,500	Maragua	76	- F/S ongoing	W	- -	- -	1 -	25 *33*	26 -	- -	- -	- -	- -	3,595 -	NWMP (1992), not proposed AWSB (2012)
		18	Karimenu 2	4CA	262,173	9,898,476	-	105	F/S ongoing	W	-	-	-	14	-	-	46,656	-	40	-	AWSB (2012)
		19	Thika 3A	4CC	281,985	9,892,264	-	288	F/S ongoing	W	-	-	-	13	-	-	39,744	-	40	-	AWSB (2012)
		20	Yatta	4CC	315,000	987,000	Thika	1,328	D/D complete	W	1,316	-	-	35	36	-	-	-	35	1,620	NWCPC (2012)
		21	Thua	-	-	-	Thua	-	-	W,I	-	-	-	-	-	-	-	-	-	-	No detailed information
6.	Ewaso Ng'iro North	22	Isiolo	5DA	-	-	Isiolo	-	F/S ongoing	W	-	-	-	-	25	-	-	-	60	-	NWCPC (2012)
		23	Badasa	5EC	390,290	10,249,373	Buji	13	Under construction	W	995.0	967.0	0.4	3.85	5.0	0.3	7,344	1,000.0	52.0	843	NWCPC, F/D
		24	Yame (Maralal)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NWCPC, No detailed information
		25	Wiyumiririe	-	-	-	-	-	-	W	-	-	-	-	1.5	-	10,000	-	20	-	NWCPC

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, P/D=preliminary design, D/D=detailed design, F/D=final design
Source: JICA Study Team based on data/ information from the government agencies mentioned in the above table and NWMP (1992).

Table 2.3.7 General Features of Proposed Water Transfer Schemes in NWMP (1992) as of November 2012 (1/2)

Intra-basin Bulk Water Transfer Schemes

Catchment Area		NWMP (1992)									
		Intra- basin Water Transfer									
		No.	Sub-basin	Water Source		Sub-basin	Notes	Demand Center	Yield for D & I Water (m3/day)	Dimensions of Structures	Source of Information
1.	Lake Victoria North	R1	1AG	Sio River	without dam	1AH		Busia	8,928*	-	LVNWSB
		R2	1BA	Moiben Dam		1CB		Eldoret	15,000 in total	Steel pipe (54km long, 600mm dia.), Future plan to expand to 28,000 m^3/day	LVNWSB
		R3	1EA	Mukulusi Dam		1EB		Kakamega	27,027*	-	LVSWSB
2.	Lake Victoria South	R4	1GC	Londiani Dam		1GC		Londiani	1,663*	-	LVSWSB
		R5	1HA	Kibos Dam		1HA		Kisumu	72,432*	-	LVSWSB
		R6	1KB	Bunyunyu Dam		1KA		Kisii	20,153*	-	NWCPC
						1KB		Keroka	1,376*	-	NWCPC
3.	Rift Valley	R7	2ED	Chemususu Dam		2EF		Eldama Ravine	3,000	Pipeline (70.5km long, 350-200mm dia.)	NWCPC/ RVWSB
						2EF		Mogotio		-	NWCPC/ RVWSB
		R8	2GB	Malewa Dam		2GC		Gilgil	11,096*	Pipeline (11.84km, 600/500mm dia.)	RVWSB
						2GD		Naivasha	29,336*	-	RVWSB
		R9	2KA	Upper Narok Dam		2KA		Narok	13,248*	-	RVWSB
4.	Athi	R10	3AA	Upper Athi Dam		3AA		Athi River	11,002*	-	AWSB
		R11	3BA	Kikuyu Dam		3BA		Kikuyu	9,239*	-	AWSB
		R12	3BA	Ruaka (Kiambaa) Dam		3BA		Karuri	7,431*	-	AWSB
						3BA		Kiambu	4,209*	-	AWSB
		R13	3BC	Ruiru A Dam		3AA		Nairobi	39,744**	-	AWSB
		R14	3CB	Ndarugu Dam		3BA		Nairobi	216,000**	(40km long)	AWSB
		R15	3AC	Munyu Dam		3BA	Alternative for Ndarugu Dam	Nairobi	299,163*	-	AWSB
		R16	3DA	Athi River	without dam	3EA		Machakos	53,078*	-	WRMA
		R17	3DA	Athi River	without dam	3EA		Kangundo	6,619*	-	WRMA
		R18	3DA	Athi River	without dam	3EA		Tala	1,872*	-	WRMA
		R19	3FA	Athi River	without dam	3FB		Mtito Andei	2,015*	-	WRMA
		R20	3MC	Pemba Dam		3MD2		Mombasa	2,592*	-	CWSB
		R21	3MB	Mwachi Dam		3MD1		Mombasa	103,445*	Pipeline (40km long)	CWSB
		R22	3LA	Rare Dam		3LB	Alternative for Sabaki P/L	Malindi	9,768*	Open canal	CWSB
5.	Tana									-	
6.	Ewaso Ng'iro North	R23	5AA	Nyahururu Dam		5AA		Nyahururu	8,415*	-	NWSB
		R24	5AA	Rumuruti Dam		5AA		Rumuruti	1,539*	-	NWSB

Note: * = Figures are based on NWMP (1992).

** = F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns (2012)

Source: JICA Study Team based on data from the government agencies mentioned in the above table.

Table 2.3.7 General Features of Proposed Water Transfer Schemes in NWMP (1992), as of November 2012 (2/2)

Inter-basin Bulk Water Transfer Schemes

Catchment Area		NWMP (1992)									
		Inter- basin Water Transfer									
		No.	Sub-basin	Water Source		Sub-basin	Notes	Demand Center	Yield for D & I Water (m3/day)	Dimensions of Structures	Source of Information
1.	Lake Victoria North	E1	1BA	Moiben Dam		2CB		Iten & Tambach	15,000 in total	Steel pipe (54km long, 600mm dia.), Future plan to expand to 28,000 m^3/day	LVNWSB
		E2	1FF	Edzawa Dam	small dam	1HB		Maseno	17,407*	-	LVNWSB
2.	Lake Victoria South	E3	1JA	Itare Dam		2EC		El burgon	9,664*	-	LVNWSB
						2EG1		Molo	8,715*	-	LVNWSB
						2FC		Njoro	7,049*	-	LVNWSB
						2FC		Nakuru	86,400*	-	LVNWSB
3.	Rift Valley	E4	2GB	Malewa Dam		2FC		Nakuru	17,951*	Pipeline (30km long, 600/500mm dia.)	RVWSB
		E5	2EH	Kirandich Dam		2CB		Kabarnet	2,496	(7km long, 400mm dia.), Future plan to expand to 20,000 m^3/day	RVWSB
		E6	2KB	Oloibortoto River	without dam	2H		Magadi	2,328*	(37km long, 150mm dia.)	TWSB
4.	Athi	E7	3AA	Kiserian Dam		3FA		Kajiado	5,377*	Rising main (2km long, 450mm dia.)	WRMA
		E8	3G	Second Mzima	without dam	3LA		Voi	100,000**	Pipeline (220km long, 1400mm dia.)	CWSB
						3MD2		Mombasa		-	CWSB
		E9	3HC	Sabaki Extension (Baricho Shallow Well)	without dam	3MD2	Alternative for Mwachi Dam	Mombasa	85,000**	Steel pipeline (60km long, 800mm dia.)	CWSB
						3LB	Alternative for Rare Dam	Malindi		-	CWSB
5.	Tana	E10	4CA	Chania B Dam		3BA		Nairobi	65,664*	-	AWSB
		E11	4CA	Komu Transfer	without dam	3CB		Ndarugu Dam	691,200*	Tunnel (2km long, 3.2m dia.)	AWSB
		E12	4CA	Komu Transfer	without dam	3DA	Alternative for Ndarugu Dam	Munyu Dam	691,200*	Tunnel (2km long, 3.2m dia.)	AWSB
		E13	4CB	Thika Dam System		3AA		Nairobi	414,700***	Tunnel (1km L-2.5m D, 3.4km-2.5m, 2.7km-3.0m)	AWSB
								Satellite	26,000***		
		E14	4DE	Masinga Dam	existing dam	4HA		Kitui	7,296	Pipeline (50km-400mm, 18km-280mm, 6km-225mm)	Tanathi WSB
		E15	4GF	Tana River	without dam	4KB		Lamu	5,719*	-	CWSB
6.	Ewaso Ng'iro North	E16	5ED	Ewaso Ng'iro River		5EA		Wajir	6,235*	-	NWSB

Note: * = Figures are based on NWMP (1992).

** = Water Supply M/P for Mombasa and Other Towns within Coast Province (2012)

*** = F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns (2012)

Source: JICA Study Team based on data from the government agencies mentioned in the above table.

Table 2.3.8 General Features of Water Transfer Schemes not in NWMP (1992) as of November 2012

Intra-basin Bulk Water Transfer Schemes not in NWMP (1992)

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Demand Center	Yield for D & I Water (m3/day)	Dimensions of Transfer Structures	Source of Information
1.	Lake Victoria North								
2.	Lake Victoria South								
3.	Rift Valley								
4.	Athi		3BA	Kikuyu Springs	3BA	Nairobi	4,800*		AWSB
			3BB	Ruiru Dam	3BB	Nairobi	21,700*		AWSB
			3BD	Others	3AA		80,000		AWSB
			3CB	Others	3AC		81,000		AWSB
			3G	Nol Turesh	3AC/3EA/3FA/3G	Satellite Town of Nairobi	970*		Tanathi WSB
			3G	Mzima Springs	3LA/3MB/Island		35,000**		CWSB
			3MC	Marere Boreholes	3MD2/Island		12,000**		CWSB
			3K	Tiwi Boreholes	3MD2		13,000**		CWSB
			3HB/3HC/3HD1	Baricho Shallow Wells	3LB/3MD1		90,000**		CWSB
5.	Tana		4ED	Kiambere to Mwingi	4ED/ 4GE		1,390		Tanathi WSB
6.	Ewaso Ng'iro North								

Inter-basin Bulk Water Transfer Schemes not in NWMP (1992)

Catchment Area		No.	Sub-basin	Water Source	Sub-basin	Demand Center	Yield for D & I Water (m3/day)	Dimensions of Transfer Structures	Source of Information
1.	Lake Victoria North		1BC	Siyoi Dam	1BC	Kapenguria	-	-	NWCPC
			1BG	Nzoia Dam (at 34B site)	1BG	Turbo/ Webuye	2,300	-	LVNWSB, NWCPC
			1FD	Nandi Forest Dam	1HA1	Kapsabet	42,850 for domestic, 5.5 m^3/s***for hydro/Irrigation (drought year)	Tunnel (17.2km, 3m dia.)	MORDA
					1HA2	Majengo			
2.	Lake Victoria South		1GC	Koru Dam	1HA	Kisumu	120,000	Canal (35km long)	NWCPC
			1JG	Magwagwa Dam	1GF			Tunnel (7.2km long)	MORDA
			1LB1	Amala Transfer	2KA	-	2.6 m^3/s****	Tunnel (3.8 km long)	ENSDA
3.	Rift Valley								
4.	Athi		3EA	Maruba Dam	3EA	Machakos	5,000	-	NWCPC
5.	Tana		4CA	Sasumua Dam	3BA	Nairobi	56,200*	-	AWSB
			4HA	Umaa Dam	4HA	Kitui	2,500	-	NWCPC
6.	Ewaso Ng'iro North		5EC	Badasa Dam	5EC	Marsabit	7,350	Pipeline (300m long, 250mm dia.)	NWCPC

Note: * = F/S and M/P for Developing New Water Sources for Nairobi and Satellite Towns (2012)
** = Water Supply M/P for Mombasa and Other Towns within Coast Province (2012)
*** = Final Study Report (2011), MORDA
**** = For domestic, irrigation and hydropower purposes

Source: JICA Study Team based on data from the government agencies mentioned in the above table.

Table 3.2.1 Estimated Monthly Mean Surface Water Resources by Sub-basin for 2010 (1/3)

(Unit: m^3/s)

CA	Sub-basin	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LVNCA	1AA	0.7	0.4	0.4	1.3	3.2	1.9	1.4	1.3	1.9	2.1	2.0	1.0
	1AB	1.5	1.0	1.0	2.5	5.8	4.0	3.3	3.4	4.0	4.2	3.8	2.0
	1AC	0.2	0.0	0.0	0.3	1.1	0.8	0.5	0.4	0.7	0.8	0.7	0.3
	1AD	0.9	0.5	0.5	1.6	4.0	2.4	1.6	1.2	2.0	2.5	2.6	1.5
	1AE	0.4	0.3	0.3	0.7	1.5	0.9	0.6	0.4	0.7	1.0	1.1	0.7
	1AF	1.1	0.8	0.8	1.9	4.0	2.6	1.8	1.5	2.2	2.7	2.8	1.7
	1AG	0.8	0.4	0.4	1.4	3.3	2.1	1.3	1.0	1.6	2.0	2.2	1.3
	1AH	0.6	0.3	0.3	1.6	3.1	1.5	0.8	0.6	1.4	1.9	2.2	1.2
	1BA	1.0	0.6	0.6	1.7	3.9	2.5	2.7	3.4	2.2	1.9	2.8	1.4
	1BB	3.6	2.5	2.4	5.3	12.5	8.7	9.6	11.5	7.9	6.8	8.7	4.3
	1BC	1.3	0.9	0.8	1.1	3.9	3.7	4.1	4.9	4.3	3.5	3.4	1.7
	1BD	2.3	1.9	1.8	1.9	4.0	3.7	3.9	4.7	4.7	3.7	3.7	2.6
	1BE	2.2	1.5	1.1	1.5	8.0	8.2	8.7	10.8	9.9	8.2	7.8	3.6
	1BG	3.3	2.5	2.3	3.4	9.7	8.5	8.5	10.3	10.1	9.1	7.7	4.1
	1BH	2.2	1.6	1.5	2.7	7.2	6.1	5.6	6.5	6.8	6.3	5.4	2.8
	1CA	2.4	2.0	1.9	2.3	4.4	3.6	3.9	4.7	4.1	3.1	3.4	2.7
	1CB	2.4	1.8	1.7	2.5	5.2	4.1	4.7	5.9	4.9	3.4	3.5	2.8
	1CC	4.3	3.6	3.4	5.1	7.8	6.5	7.4	8.4	7.2	5.5	5.6	4.7
	1CD	7.1	5.6	5.3	7.7	15.3	12.3	13.8	16.4	14.4	10.6	10.2	7.9
	1CE	1.7	1.4	1.4	1.7	3.6	3.2	3.2	3.6	3.8	3.2	2.5	1.8
	1DA	3.2	2.6	2.6	4.5	8.5	6.8	6.2	6.5	7.2	6.2	5.1	3.8
	1DB	5.0	4.1	4.0	6.8	12.8	10.2	9.1	9.7	10.3	10.2	9.1	5.8
	1DC	2.3	1.8	1.8	2.7	5.4	4.5	3.7	3.4	4.3	4.1	3.9	2.8
	1DD	2.6	2.1	2.0	3.2	5.9	4.7	3.6	3.2	4.1	4.3	4.3	3.2
	1EA	5.4	4.7	4.6	7.7	11.5	9.5	9.0	9.4	9.6	8.3	7.4	6.0
	1EB	4.4	3.9	3.9	5.9	8.4	6.9	6.0	6.1	6.7	6.3	5.9	4.8
	1EC	2.6	2.4	2.3	3.3	4.9	4.1	3.8	3.7	4.1	3.8	3.5	2.9
	1ED	1.1	0.9	0.9	1.4	2.3	1.8	1.4	1.3	1.6	1.7	1.7	1.3
	1EE	1.4	0.7	0.6	1.9	4.6	3.0	1.4	0.8	2.2	2.5	3.2	2.3
	1EF	1.0	0.1	0.0	1.1	4.8	2.1	0.2	0.1	1.4	1.7	3.1	2.1
	1EG	2.3	1.3	1.2	3.9	6.9	4.7	2.7	2.0	3.4	3.9	4.6	3.6
	1FA	0.7	0.5	0.4	1.2	2.3	1.8	2.2	2.6	2.1	1.4	1.4	1.0
	1FB	3.2	2.5	2.6	5.1	8.2	6.7	7.1	7.6	7.1	5.3	5.1	3.7
	1FC	2.0	1.6	1.5	2.8	4.5	3.8	3.7	3.9	3.9	3.0	2.9	2.3
	1FD	3.3	2.4	2.4	5.1	7.8	6.4	6.5	6.9	6.5	5.0	5.2	3.8
	1FE	5.0	3.5	3.6	8.2	13.2	9.9	8.2	8.2	9.3	8.1	7.6	6.2
	1FF	0.7	0.2	0.2	1.6	3.2	1.9	1.1	0.9	1.3	1.4	1.5	1.2
	1FG	1.9	0.3	0.3	4.5	8.7	3.1	0.3	0.3	2.1	2.7	5.2	3.9
LVSCA	1GA	3.1	1.9	2.0	6.3	8.8	6.1	6.6	7.9	6.6	4.5	5.2	3.8
	1GB	3.1	1.2	2.1	7.0	9.0	5.7	4.7	5.0	5.6	4.0	5.2	3.7
	1GC	6.3	4.6	4.3	10.1	14.9	9.9	10.2	12.7	10.8	8.6	9.5	7.5
	1GD	3.6	2.1	2.9	6.2	7.1	4.0	3.1	3.4	3.3	3.1	4.3	3.7
	1GE	1.3	0.3	0.5	2.0	4.3	1.6	0.6	0.4	0.6	0.7	1.6	0.7
	1GF	2.7	1.5	2.2	4.2	4.7	2.1	1.5	1.6	1.5	2.0	2.9	2.8
	1GG	2.5	1.5	1.8	5.5	7.3	4.6	4.3	5.3	4.7	3.5	4.2	3.0
	1HA1	2.3	1.2	1.7	4.3	5.8	3.1	2.1	2.2	2.6	2.3	2.8	3.0
	1HA2	0.7	0.0	0.2	0.9	1.3	0.2	0.1	0.0	0.1	0.2	0.5	1.1
	1HB1	1.1	0.3	0.2	1.8	3.6	2.0	0.8	0.4	0.7	1.0	1.6	2.0
	1HB2	0.8	0.3	0.4	1.7	2.6	1.4	0.6	0.4	0.6	0.7	1.0	1.3
	1HC	0.7	0.1	0.0	0.4	2.1	1.3	0.4	0.0	0.2	0.4	0.6	1.4
	1HD	3.3	1.4	1.4	6.0	9.6	6.0	3.1	1.8	3.2	3.5	4.7	4.4
	1HE	2.4	0.8	0.6	4.0	8.9	5.0	2.3	0.9	1.9	2.8	4.1	3.9
	1HF	1.2	0.3	0.0	0.0	1.2	2.1	0.7	0.0	0.1	0.2	0.3	1.0
	1HG	0.9	0.2	0.1	1.9	4.1	1.5	0.4	0.2	0.3	0.4	1.1	1.6
	1JA	7.7	6.0	6.2	12.2	15.9	10.7	9.3	9.7	10.0	9.0	10.5	8.9
	1JB	1.7	1.2	1.4	3.1	3.9	2.5	2.0	1.9	2.2	2.1	2.5	1.9
	1JC	3.6	2.9	2.9	5.9	7.6	5.2	4.6	4.7	4.9	4.7	5.1	4.1
	1JD	2.8	2.4	2.5	4.4	4.9	3.7	3.3	3.1	3.3	3.3	3.8	3.1
	1JE	3.9	2.9	3.6	7.2	8.0	5.0	3.4	2.8	3.8	3.7	4.8	4.5
	1JF	9.7	7.3	8.2	16.3	20.1	14.0	10.7	9.5	11.0	10.3	12.7	10.9
	1JG1	2.3	1.4	1.3	3.5	5.4	3.4	2.2	1.5	2.2	2.1	2.8	2.2
	1JG2	1.2	0.9	0.9	1.7	2.2	1.3	0.8	0.8	1.0	1.0	1.2	1.2
	1KA	1.8	0.9	1.2	3.9	6.1	3.7	1.8	1.1	2.1	2.3	3.0	2.8
	1KB	13.4	7.5	8.7	25.0	39.0	20.9	10.6	7.4	11.5	12.1	16.4	18.1
	1KC	13.1	9.5	9.4	21.8	32.3	17.8	9.6	5.8	7.4	8.8	12.6	16.8
	1LA1	7.4	5.3	5.6	12.2	15.4	9.2	6.7	6.7	7.2	6.3	8.5	8.3
	1LA2	6.9	5.4	5.1	9.1	12.2	7.7	4.6	3.5	4.3	4.3	5.1	6.8
	1LA3	11.2	9.8	7.7	14.7	21.0	9.0	4.4	2.7	2.8	2.5	3.7	8.8
	1LB1	10.9	7.9	8.0	16.7	20.7	11.7	7.8	7.1	8.0	6.8	9.6	11.0
	1LB2	6.4	7.1	5.0	8.9	15.3	6.6	1.9	0.5	0.6	0.5	1.4	4.4

Table 3.2.1 Estimated Monthly Mean Surface Water Resources by Sub-basin for 2010 (2/3)

(Unit: m^3/s)

CA	Sub-basin	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RVCA	2AA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2BA	2.4	0.9	0.3	1.4	10.5	10.0	12.8	16.7	11.6	8.0	8.8	3.2
	2BB	3.8	1.4	0.4	2.2	16.9	16.1	20.6	26.9	18.7	12.9	14.2	5.2
	2BC	3.2	1.1	0.5	1.2	12.1	12.9	15.8	20.7	17.0	12.4	12.2	4.9
	2BD	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.5	1.2	0.3	0.1	0.2
	2CA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2CB	9.6	4.9	4.0	10.1	31.8	21.4	27.1	39.6	26.9	12.0	20.5	13.2
	2CC	6.8	2.8	1.5	5.2	28.8	20.8	23.8	36.3	24.6	14.2	23.1	10.2
	2D	1.6	0.3	0.1	0.6	5.1	3.0	2.5	5.7	6.9	0.9	3.7	2.3
	2EA	0.7	0.5	0.3	0.5	1.5	1.0	1.5	2.6	2.4	0.9	0.9	0.7
	2EB	1.2	0.8	0.5	0.8	2.4	1.6	2.4	4.3	3.9	1.5	1.5	1.2
	2EC	1.1	0.8	0.5	0.8	2.0	1.5	1.6	2.9	3.3	1.8	1.8	1.3
	2ED	1.8	1.2	0.7	1.1	3.6	3.1	4.0	7.0	7.4	3.3	3.0	2.3
	2EE	2.1	1.1	0.9	1.9	6.5	4.4	6.3	10.5	7.8	2.7	3.4	2.8
	2EF	1.1	0.8	0.5	0.7	2.3	2.0	2.6	4.5	4.8	2.1	2.0	1.5
	2EG1	0.6	0.4	0.3	0.5	1.4	0.9	1.3	2.4	2.2	1.0	1.1	0.8
	2EG2	2.0	1.3	0.9	1.5	4.8	3.1	4.3	7.9	7.4	3.2	3.5	2.7
	2EH	0.8	0.3	0.5	1.2	3.1	1.7	2.5	4.5	3.0	0.8	1.8	1.2
	2EJ	0.1	0.0	0.0	0.0	0.6	0.0	0.0	0.9	0.9	0.0	0.4	1.4
	2EK	0.6	0.4	0.2	0.5	1.9	0.9	1.5	2.8	2.3	0.5	0.8	1.2
	2FA	0.5	0.4	0.2	0.3	1.1	0.8	0.8	1.0	1.3	0.8	0.9	0.7
	2FB	0.1	0.1	0.1	0.1	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2
	2FC	1.3	1.2	0.7	0.9	2.7	1.8	1.8	2.6	3.0	1.9	2.1	1.5
	2GA	0.6	0.6	0.3	0.4	1.4	1.1	0.9	1.0	1.1	0.7	0.9	0.7
	2GB	2.6	1.8	1.0	2.0	6.4	4.3	3.5	4.1	4.4	3.1	4.4	2.9
	2GC	3.0	1.8	1.2	3.9	9.7	5.4	2.9	2.2	2.8	3.1	6.0	3.9
	2GD	4.2	2.5	1.7	5.6	13.7	7.7	4.1	3.1	3.9	4.3	8.5	5.5
	2H-1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2H-2	2.0	2.6	0.8	1.6	3.9	1.2	0.3	0.1	0.0	0.0	0.1	1.2
	2H-3	0.8	1.1	0.4	0.6	1.0	0.5	0.1	0.0	0.0	0.0	0.0	0.4
	2J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2KA	12.7	11.1	6.5	14.7	28.7	12.0	5.7	3.6	3.7	2.7	5.0	8.7
	2KB	3.0	2.6	1.4	2.8	5.3	2.1	1.2	1.1	1.2	0.9	1.3	2.5
	2KC	1.8	1.9	0.6	0.7	2.3	1.0	0.3	0.1	0.0	0.0	0.0	0.9
ACA	3AA	3.3	2.7	2.2	3.4	6.0	2.7	1.6	1.4	1.3	1.3	2.1	2.9
	3AB	1.9	1.5	0.7	1.2	2.3	0.9	0.2	0.1	0.1	0.1	0.4	1.0
	3AC	1.9	1.2	0.6	1.5	3.3	1.1	0.3	0.1	0.1	0.1	0.8	1.8
	3BA	1.7	1.2	0.9	2.2	4.1	1.4	0.5	0.3	0.3	0.4	1.4	1.9
	3BB	1.2	1.0	0.8	1.8	2.9	1.1	0.5	0.4	0.4	0.4	1.2	1.4
	3BC	4.5	3.6	3.1	5.6	9.9	4.7	3.0	2.5	2.4	2.4	4.3	5.1
	3BD	1.8	1.4	1.2	2.5	4.2	1.7	1.0	0.9	0.8	0.8	1.7	2.1
	3CB	3.5	3.1	2.6	4.1	6.3	3.3	2.6	2.4	2.3	2.3	3.3	3.8
	3DA	2.9	1.9	1.4	2.1	3.4	1.1	1.2	1.5	1.5	1.5	2.2	3.4
	3DB	2.7	0.9	0.1	0.5	1.0	0.5	0.1	0.0	0.0	0.0	1.0	4.4
	3EA	3.8	1.7	0.6	1.3	2.3	0.6	0.1	0.0	0.0	0.0	1.4	3.8
	3EB	3.4	1.4	0.4	0.9	1.4	0.3	0.0	0.0	0.0	0.0	1.3	4.6
	3EC	3.3	1.2	0.3	0.8	1.1	0.3	0.0	0.0	0.0	0.0	1.1	4.7
	3ED	1.5	0.5	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.3	2.1
	3FA	11.6	3.8	1.3	1.6	2.5	1.8	1.2	1.1	1.1	1.0	1.8	7.4
	3FB	8.4	3.4	0.3	0.5	0.6	0.8	0.0	0.0	0.0	0.0	0.1	6.9
	3G	3.7	2.8	0.3	1.0	0.4	0.1	0.0	0.0	0.0	0.0	0.1	0.7
	3HA	0.7	0.5	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.7
	3HB	1.3	0.8	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.4	0.4	0.9
	3HC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.2
	3HD1	0.5	0.0	0.0	0.0	0.3	0.4	0.2	0.0	0.0	0.9	1.3	0.1
	3HD2	0.3	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.0	0.5	0.8	0.1
	3J	0.5	0.6	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	3K	1.1	0.9	0.5	0.9	7.2	2.0	1.0	0.4	0.1	5.0	11.5	0.8
	3LA	0.1	0.1	0.0	0.0	0.7	0.2	0.1	0.0	0.0	6.6	6.6	0.2
	3LB	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.7	0.0
	3MA-1	0.3	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.9	0.6
	3MA-2	0.1	0.1	0.0	0.0	0.7	0.1	0.1	0.0	0.0	0.6	2.4	0.1
	3MB	0.1	0.0	0.0	0.0	1.7	0.4	0.2	0.0	0.0	3.7	4.1	0.0
	3MC	0.0	0.0	0.0	0.0	0.9	0.1	0.1	0.0	0.0	1.4	1.7	0.0
	3MD1	0.1	0.0	0.0	0.1	6.1	1.9	0.5	0.1	0.0	5.7	4.3	0.1
	3MD2	0.0	0.0	0.0	0.0	0.3	0.2	0.1	0.0	0.0	0.5	0.4	0.0
	3N	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3.2.1 Estimated Monthly Mean Surface Water Resources by Sub-basin for 2010 (3/3)

(Unit: m^3/s)

CA	Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TCA	4AA	2.7	1.8	1.6	3.7	8.1	2.5	1.3	1.2	1.1	1.6	5.3	3.8
	4AB	3.6	2.7	2.3	4.3	10.0	4.2	2.5	2.1	2.0	2.4	6.1	4.4
	4AC	4.3	3.5	3.0	5.1	10.3	5.2	3.3	3.0	2.9	3.3	6.5	5.1
	4AD	5.1	3.9	3.3	7.1	13.9	6.2	3.7	3.3	3.1	3.9	8.5	6.4
	4BA	1.3	0.8	0.5	1.9	5.5	1.6	0.6	0.4	0.4	0.4	2.4	1.8
	4BB	2.9	2.0	1.7	5.7	10.2	3.3	1.7	1.5	1.3	2.0	6.0	4.0
	4BC	2.0	1.6	1.4	0.9	2.2	2.0	1.5	1.4	1.4	1.1	1.1	1.7
	4BD	5.1	3.6	3.0	9.7	17.5	5.9	3.1	2.8	2.5	3.6	10.2	7.0
	4BE	5.8	4.2	3.3	9.4	17.0	6.7	3.6	3.1	2.8	3.4	8.9	7.6
	4BF	3.2	2.7	2.5	4.6	6.6	2.9	2.3	2.2	2.2	2.2	3.6	3.8
	4BG	2.3	1.8	1.2	1.3	4.8	2.4	1.4	1.2	1.1	0.8	1.5	2.6
	4CA	8.5	7.2	6.6	11.5	16.7	9.4	7.0	6.4	6.2	6.9	11.1	9.8
	4CB	5.6	4.8	4.3	7.8	11.0	5.9	4.4	4.1	3.9	4.3	7.0	6.5
	4CC	5.7	4.3	3.5	5.6	9.3	4.4	3.1	2.8	2.8	2.6	4.3	6.2
	4DA	6.6	4.8	4.2	8.1	15.1	6.3	4.3	3.8	3.7	3.8	9.0	8.1
	4DB	3.1	1.9	1.6	6.3	9.1	2.6	1.4	1.2	1.1	1.7	7.6	5.1
	4DC	3.0	1.9	1.6	5.7	8.3	2.6	1.5	1.2	1.1	1.7	7.2	4.8
	4DD	0.9	0.6	0.3	0.4	1.3	0.6	0.4	0.3	0.3	0.2	0.7	1.0
	4DE	1.8	1.2	0.5	0.5	2.7	1.7	0.7	0.5	0.5	0.2	0.5	2.0
	4EA	11.0	6.3	5.7	19.9	21.8	6.0	4.3	4.1	4.0	7.8	32.6	20.2
	4EB	13.5	8.2	7.9	27.1	30.9	8.5	5.8	5.6	5.5	11.4	40.9	24.1
	4EC	7.2	5.6	5.0	9.2	11.9	6.0	4.9	4.6	4.4	4.8	11.3	10.0
	4ED	21.8	12.4	8.0	12.9	21.0	9.8	7.1	6.4	6.2	5.8	21.9	29.7
	4FA	21.7	9.9	7.3	27.6	38.5	8.8	5.2	4.7	4.5	10.5	55.5	42.0
	4FB	13.1	5.6	2.2	10.8	23.5	5.5	2.3	1.6	1.5	1.5	35.1	29.5
	4GA	11.7	6.0	3.5	4.7	16.3	6.0	3.6	3.0	2.8	1.8	29.7	26.7
	4GB	6.2	1.8	0.3	0.1	5.4	1.3	0.0	0.0	0.0	0.0	19.6	22.5
	4GC	1.8	0.6	0.0	0.0	2.3	0.8	0.0	0.0	0.0	0.0	0.0	2.8
	4GD	6.4	1.0	0.0	0.0	3.8	1.3	0.0	0.0	0.0	0.0	0.3	9.5
	4GE	8.2	0.8	0.0	0.0	2.2	0.6	0.0	0.0	0.0	0.0	0.0	5.6
	4GF	50.1	8.7	1.0	0.5	8.3	1.9	0.0	0.0	0.0	0.0	1.0	42.3
	4GG	5.6	1.2	0.3	0.0	2.9	1.0	0.2	0.0	0.0	0.0	4.6	5.7
	4HA	30.1	11.1	6.5	7.3	8.2	5.7	5.0	4.7	4.6	4.5	11.2	28.7
	4HB	16.2	4.8	1.3	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.4	3.1
	4HC	0.3	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3
	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
	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
	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
	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
ENNCA	5AA	2.1	1.3	0.7	1.8	4.7	2.4	2.9	4.7	4.4	1.7	2.3	1.7
	5AB	0.9	0.7	0.2	0.8	2.1	0.9	1.0	1.9	1.6	0.6	0.9	0.7
	5AC	0.6	0.5	0.1	0.4	2.5	0.7	0.6	1.0	1.4	0.3	0.7	0.7
	5AD	0.7	0.5	0.1	0.2	1.5	0.4	0.3	0.6	0.7	0.2	0.4	0.5
	5BA	0.7	0.7	0.3	0.5	2.3	0.8	0.2	0.4	0.4	0.3	1.3	0.8
	5BB	1.6	1.0	0.6	1.7	5.1	1.6	0.7	1.0	1.1	1.0	3.3	1.6
	5BC-1	4.4	2.0	1.2	3.3	12.1	3.4	1.9	2.8	2.9	2.0	7.0	4.5
	5BC-2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	5BD	1.5	1.0	0.5	1.1	3.3	1.3	1.1	1.9	1.9	0.9	1.6	1.3
	5BE	4.6	2.0	1.2	5.2	9.9	1.9	0.5	0.7	0.8	2.5	12.4	7.5
	5CA	2.1	0.9	0.2	0.7	3.9	2.0	1.3	2.2	2.7	0.6	2.0	2.7
	5CB	1.5	0.5	0.0	0.2	0.9	0.4	0.3	0.3	0.4	0.0	0.4	2.1
	5CC	1.3	0.5	0.1	0.3	1.6	0.6	0.3	0.6	1.2	0.1	1.1	2.5
	5DA	12.3	4.4	1.9	12.3	14.3	2.0	0.7	0.4	0.5	3.5	26.8	21.8
	5DB	2.7	1.3	0.2	0.5	1.4	0.3	0.1	0.3	0.3	0.1	1.5	2.8
	5DC	0.8	0.5	0.1	0.1	0.7	0.5	0.3	0.3	0.5	0.1	0.5	1.0
	5DD	1.1	0.6	0.0	0.1	0.6	0.3	0.1	0.4	0.5	0.1	0.3	1.3
	5EA	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	29.0	24.4
	5EB	1.3	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	29.7	28.3
	5EC	4.7	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	24.1	22.4
	5ED	23.4	7.0	1.9	5.3	23.6	1.4	0.0	0.0	0.0	0.0	56.8	74.6
	5FA	16.6	3.6	1.5	0.6	0.5	0.0	0.0	0.1	0.0	0.0	3.6	43.3
	5FB	1.9	0.4	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	7.4	11.7
	5G	1.3	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	29.7	28.3
	5HA	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.2	2.1	3.7	0.2
	5HB	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.2	0.2	1.4	3.7	0.2
	5J	16.4	6.1	2.8	18.0	48.2	14.2	6.2	3.2	1.8	5.6	50.5	32.7

Note: See Sectoral Report (B) for details.
Source: JICA Study Team

Table 3.2.2 Estimated Monthly Mean Surface Water by Sub-basin for 2030 (1/3)

(Unit: m^3/s)

CA	Sub-basin	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		Month											
LVNCA	1AA	0.7	0.5	0.7	2.4	3.7	1.9	1.3	1.6	2.0	2.2	2.3	1.2
	1AB	1.6	1.2	1.5	4.6	6.7	4.1	3.2	3.9	4.2	4.5	4.5	2.4
	1AC	0.1	0.0	0.1	0.8	1.4	0.8	0.5	0.6	0.8	0.8	0.9	0.4
	1AD	0.9	0.6	0.8	2.9	4.8	2.5	1.5	1.5	2.1	2.6	3.0	1.7
	1AE	0.4	0.3	0.4	1.2	2.0	1.0	0.6	0.5	0.7	1.0	1.3	0.8
	1AF	1.2	0.9	1.1	3.2	4.9	2.8	1.8	1.8	2.4	2.8	3.2	2.0
	1AG	0.8	0.5	0.6	2.4	3.9	2.1	1.3	1.2	1.7	2.0	2.5	1.5
	1AH	0.6	0.3	0.5	2.5	4.0	1.6	0.8	0.8	1.3	1.9	2.5	1.4
	1BA	1.1	0.6	0.6	2.7	4.1	2.6	3.0	3.5	1.9	2.3	2.7	1.5
	1BB	3.6	2.7	2.6	8.6	13.6	8.8	10.3	11.8	7.3	8.4	8.9	4.8
	1BC	1.9	1.4	1.3	3.3	6.6	5.4	5.8	6.8	5.6	5.6	5.0	2.7
	1BD	2.6	2.2	2.2	3.4	5.3	4.3	4.2	5.5	4.9	4.4	4.3	3.1
	1BE	3.0	2.0	1.8	5.2	11.4	9.3	9.0	11.6	10.4	9.9	9.1	4.8
	1BG	3.7	3.0	3.1	7.5	12.2	9.3	8.6	11.4	10.6	10.2	9.1	4.9
	1BH	2.5	2.0	2.2	5.7	8.9	6.6	5.8	7.4	7.3	7.0	6.5	3.5
	1CA	2.5	2.2	2.1	3.5	4.9	3.8	4.1	5.0	3.8	3.5	3.7	2.9
	1CB	2.4	1.9	1.8	4.1	5.5	4.2	4.8	5.8	4.3	3.9	4.0	2.9
	1CC	4.1	3.6	3.6	6.5	7.8	6.3	7.3	8.1	6.4	6.1	6.0	4.7
	1CD	7.3	6.1	6.1	12.3	16.5	12.9	14.3	17.4	13.6	12.3	12.1	8.6
	1CE	1.8	1.6	1.7	3.1	4.2	3.6	3.5	4.5	4.0	3.7	3.3	2.2
	1DA	3.4	3.0	3.5	7.2	9.5	7.3	6.5	8.4	8.4	7.8	7.3	4.6
	1DB	5.5	4.8	5.3	10.8	14.8	10.8	9.4	11.0	11.2	11.3	10.9	6.8
	1DC	2.5	2.1	2.2	4.3	6.4	4.8	3.8	4.2	4.8	4.6	4.8	3.3
	1DD	2.7	2.3	2.5	4.7	6.9	4.9	3.7	3.8	4.5	4.6	5.1	3.7
	1EA	5.6	5.1	5.7	10.4	12.2	10.0	9.3	11.0	10.4	9.8	9.4	6.8
	1EB	4.6	4.2	4.6	7.7	9.0	7.1	6.3	7.1	7.2	7.1	7.0	5.4
	1EC	2.7	2.5	2.7	4.4	5.4	4.3	3.9	4.6	4.9	4.8	4.6	3.4
	1ED	1.1	1.0	1.0	1.9	2.6	1.8	1.4	1.5	1.7	1.8	1.9	1.4
	1EE	1.2	0.7	0.8	2.6	5.7	3.1	1.3	1.3	2.1	2.6	3.6	2.5
	1EF	0.7	0.1	0.3	2.5	6.4	2.4	0.2	0.3	1.2	2.0	3.6	2.5
	1EG	2.2	1.3	1.6	5.0	8.0	4.7	2.7	2.7	3.4	4.2	5.1	4.0
	1FA	0.7	0.5	0.5	1.8	2.3	1.7	2.0	2.4	1.8	1.6	1.6	1.0
	1FB	3.0	2.6	3.0	6.6	8.1	6.6	6.9	7.8	6.7	6.2	6.1	4.1
	1FC	1.8	1.6	1.8	3.5	4.5	3.7	3.6	4.1	3.8	3.4	3.4	2.5
	1FD	2.9	2.5	2.8	6.4	8.0	6.3	6.4	7.1	6.2	5.8	6.0	4.1
	1FE	4.6	3.7	4.5	11.0	13.7	10.1	8.3	9.3	9.4	9.2	9.3	7.0
	1FF	0.7	0.2	0.6	2.8	3.6	2.2	1.2	1.2	1.4	1.6	1.9	1.5
	1FG	1.7	0.2	1.1	6.7	10.7	3.2	0.3	0.7	1.6	3.3	5.9	4.8
LVSCA	1GA	2.5	1.9	2.4	8.0	9.0	6.1	6.6	7.8	5.9	5.5	5.8	3.8
	1GB	2.3	1.4	2.4	9.4	9.4	5.6	4.8	5.5	5.2	5.5	6.1	3.9
	1GC	5.3	4.7	5.2	12.3	14.6	9.8	10.3	13.3	10.8	9.6	9.8	7.3
	1GD	1.4	0.5	1.1	7.1	6.2	2.7	1.0	1.7	1.7	2.4	3.1	2.3
	1GE	1.3	0.7	1.1	5.7	5.1	2.4	0.8	1.4	1.3	2.3	3.0	2.2
	1GF	1.0	0.3	0.8	4.9	4.3	1.6	0.3	0.5	0.3	1.3	2.2	2.1
	1GG	1.9	1.6	2.2	6.9	7.3	4.5	4.5	5.5	4.4	4.1	4.5	2.9
	1HA1	1.9	1.2	2.1	5.9	5.9	3.5	2.3	2.4	2.3	2.8	3.7	3.5
	1HA2	0.6	0.1	0.3	2.8	1.2	0.5	0.1	0.1	0.1	0.3	0.8	1.7
	1HB1	1.1	0.3	0.6	2.8	4.0	2.1	0.8	0.5	0.6	1.2	1.9	2.5
	1HB2	0.9	0.3	0.8	2.8	3.1	1.7	0.8	0.6	0.5	0.9	1.4	1.7
	1HC	1.2	0.2	0.5	1.8	3.3	1.9	0.5	0.1	0.1	0.5	1.1	2.4
	1HD	3.2	1.8	3.0	9.5	11.2	7.1	3.6	2.4	2.9	4.4	6.2	6.4
	1HE	2.3	1.1	2.2	7.3	9.9	5.2	2.3	1.1	1.7	3.4	5.6	5.2
	1HF	2.2	0.6	1.1	4.8	7.6	4.3	1.0	0.1	0.1	0.4	1.3	3.1
	1HG	1.0	0.3	0.7	3.5	5.2	1.4	0.3	0.1	0.1	0.5	1.8	2.3
	1JA	6.8	6.3	7.4	15.3	15.9	11.3	10.0	10.9	10.7	10.2	11.5	9.4
	1JB	1.4	1.3	1.8	3.9	4.0	2.7	2.2	2.2	2.3	2.4	2.8	2.1
	1JC	3.3	3.1	3.7	7.3	7.8	5.4	4.9	5.3	5.2	5.2	5.5	4.3
	1JD	2.7	2.5	3.0	5.4	5.7	4.4	3.6	3.4	3.6	3.9	4.3	3.7
	1JE	3.3	3.1	4.3	8.8	7.6	5.0	3.5	3.0	3.7	4.2	5.9	5.4
	1JF	8.8	7.7	9.9	20.4	20.4	14.8	11.3	10.4	11.4	11.9	14.8	13.3
	1JG1	1.6	1.1	1.5	4.5	5.3	3.5	2.1	1.7	2.0	2.5	3.1	2.9
	1JG2	0.6	0.3	0.4	1.3	1.8	1.0	0.4	0.3	0.4	0.6	0.8	1.1
	1KA	2.1	1.4	2.3	6.1	7.5	3.9	1.9	1.3	1.9	2.9	4.3	3.9
	1KB	14.7	10.1	15.3	40.1	48.9	22.7	10.7	7.2	9.4	14.4	22.5	25.3
	1KC	15.0	12.9	17.6	38.0	38.1	18.6	9.0	5.3	6.3	10.8	17.5	22.9
	1LA1	6.1	5.4	6.5	16.5	14.9	9.7	7.4	7.3	7.6	7.6	10.2	9.9
	1LA2	6.6	6.4	6.8	14.4	14.4	8.2	4.6	3.0	3.7	4.4	5.8	9.1
	1LA3	11.5	12.1	12.3	30.6	27.1	11.3	4.9	2.3	2.6	3.3	6.0	13.1
	1LB1	10.1	9.0	10.3	25.9	23.1	13.9	8.9	7.9	8.4	8.7	12.7	16.0
	1LB2	7.9	8.7	9.5	25.7	23.3	9.3	3.0	0.6	1.1	2.1	3.3	9.5

Table 3.2.2 Estimated Monthly Mean Surface Water by Sub-basin for 2030 (2/3)

(Unit: m^3/s)

CA	Sub-basin	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RVCA	2AA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2AB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2BA	3.2	1.4	0.8	5.0	13.3	11.2	14.6	17.4	10.8	11.8	10.3	4.1
	2BB	5.1	2.3	1.2	8.1	21.3	18.0	23.4	28.0	17.4	19.0	16.6	6.5
	2BC	4.2	1.6	1.0	7.8	19.0	15.2	16.6	22.0	16.2	17.4	15.5	6.4
	2BD	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.2	0.3
	2CA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2CB	10.3	5.7	3.1	24.5	34.6	21.6	27.2	33.6	16.0	14.8	20.1	13.2
	2CC	9.3	3.7	1.8	13.5	36.4	24.6	27.3	39.3	20.2	21.7	25.2	12.7
	2D	2.7	0.4	0.2	7.2	6.5	3.3	1.8	8.1	3.0	3.3	6.1	5.3
	2EA	0.8	0.4	0.2	1.1	1.8	1.2	1.7	2.4	1.5	1.0	1.3	1.1
	2EB	1.4	0.7	0.4	1.8	2.9	2.0	2.8	4.0	2.5	1.7	2.1	1.9
	2EC	1.3	0.9	0.6	1.3	3.1	2.1	2.1	3.4	3.0	2.2	2.1	2.4
	2ED	1.2	0.8	0.6	1.4	3.1	2.5	3.2	5.2	4.3	2.7	2.4	2.2
	2EE	2.2	1.2	0.7	4.9	7.1	4.8	6.9	9.7	5.1	3.5	4.2	3.1
	2EF	1.1	0.8	0.5	1.3	2.9	2.3	3.0	4.8	3.9	2.5	2.2	2.0
	2EG1	0.7	0.5	0.3	1.1	1.9	1.3	1.5	2.6	1.7	1.2	1.3	1.2
	2EG2	2.5	1.5	0.9	3.7	6.3	4.2	5.1	8.7	5.8	4.0	4.4	4.1
	2EH	1.2	0.5	0.4	3.3	3.5	2.2	2.7	4.0	1.5	1.2	2.0	1.4
	2EJ	0.6	0.2	0.1	1.3	0.8	0.3	0.3	1.6	0.6	0.7	1.2	1.2
	2EK	1.0	0.4	0.2	1.7	2.1	1.3	2.1	3.1	1.2	0.9	1.5	1.3
	2FA	0.6	0.4	0.3	0.5	1.2	0.8	0.8	1.0	1.0	0.8	1.1	1.0
	2FB	0.2	0.1	0.1	0.1	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3
	2FC	1.7	1.2	0.8	1.9	3.3	2.3	2.0	2.7	2.5	2.0	2.5	2.4
	2GA	1.1	0.8	0.5	1.2	1.9	1.3	1.1	0.9	0.9	0.8	1.3	1.2
	2GB	3.5	2.1	1.4	4.5	6.7	4.4	3.9	3.6	3.6	3.4	5.5	4.3
	2GC	3.9	2.2	1.9	7.0	10.3	5.8	3.4	2.2	2.7	3.8	7.4	5.6
	2GD	5.5	3.2	2.7	9.9	14.5	8.2	4.7	3.2	3.7	5.3	10.4	7.9
	2H-1	2.2	2.6	1.1	3.0	4.6	1.8	0.4	0.1	0.0	0.0	0.3	1.9
	2H-2	2.9	3.6	1.4	4.5	6.5	1.6	0.4	0.1	0.0	0.0	0.4	2.5
	2H-3	1.2	1.2	0.4	1.3	1.9	0.5	0.1	0.0	0.0	0.0	0.0	0.9
	2J	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2KA	12.5	11.5	9.6	28.4	29.7	14.2	6.5	3.4	3.3	3.4	8.6	15.0
	2KB	3.2	2.8	1.9	5.1	6.3	2.1	1.2	1.1	1.0	0.9	1.8	3.7
	2KC	2.3	2.5	0.8	2.0	4.6	1.2	0.3	0.1	0.0	0.0	0.0	2.6
ACA	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

Table 3.2.2 Estimated Monthly Mean Surface Water by Sub-basin for 2030 (3/3)

(Unit: m^3/s)

CA	Sub-basin	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
TCA	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
ENNCA	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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
	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

Note: See Sectoral Report (B) for details.
Source: JICA Study Team

Table 3.2.3 Estimated Annual Sustainable Yield of Groundwater by Sub-basin for 2010 and 2030

(Unite: MCM/year)

CA	Sub-basin	LVNCA and LVSCA	
		2010	2030
LVNCA	1AA	1.7	1.9
	1AB	0.8	0.3
	1AC	1.4	1.4
	1AD	2.8	2.8
	1AE	2.9	3.2
	1AF	4.5	4.7
	1AG	4.7	4.9
	1AH	6.8	7.7
	1BA	3.5	3.9
	1BB	5.5	6.2
	1BC	5.6	6.4
	1BD	1.7	1.6
	1BE	5.2	5.6
	1BG	3.7	4.0
	1BH	1.3	0.6
	1CA	2.8	2.9
	1CB	3.6	3.6
	1CC	2.8	2.5
	1CD	1.9	0.6
	1CE	0.9	0.3
	1DA	2.1	0.7
	1DB	2.9	0.9
	1DC	1.4	0.5
	1DD	1.5	0.5
	1EA	1.8	0.6
	1EB	1.5	0.5
	1EC	1.0	0.3
	1ED	0.5	0.1
	1EE	1.2	0.4
	1EF	5.5	6.3
	1EG	3.8	3.4
	1FA	2.3	2.5
	1FB	2.1	1.5
	1FC	1.9	1.9
	1FD	2.7	2.6
	1FE	4.0	3.2
	1FF	3.7	3.7
	1FG	11.5	13.5
LVSCA	1GA	1.8	1.7
	1GB	3.6	3.7
	1GC	4.8	4.1
	1GD	9.9	10.4
	1GE	6.1	6.3
	1GF	8.1	8.7
	1GG	1.6	1.7
	1HA1	2.2	2.2
	1HA2	7.5	9.1
	1HB1	2.2	2.3
	1HB2	1.4	1.2
	1HC	3.2	3.1
	1HD	7.3	6.3
	1HE	7.8	7.6
	1HF	4.4	4.1
	1HG	0.7	0.7
	1JA	7.7	6.8
	1JB	2.5	2.2
	1JC	2.1	1.2
	1JD	1.3	0.7
	1JE	8.7	9.2
	1JF	6.3	4.5
	1JG1	1.1	0.6
	1JG2	1.1	1.1
	1KA	6.5	6.2
	1KB	32.5	30.5
	1KC	23.0	22.7
	1LA1	7.8	7.2
	1LA2	3.1	1.2
	1LA3	7.2	5.7
	1LB1	5.9	3.3
	1LB2	14.1	12.1

CA	Sub-basin	RVCA and ACA	
		2010	2030
RVCA	2AA	0.7	1.4
	2AB	0.3	0.7
	2BA	1.2	1.0
	2BB	2.0	1.7
	2BC	2.0	1.3
	2BD	9.9	10.4
	2CA	0.1	0.2
	2CB	4.2	3.7
	2CC	17.3	18.4
	2D	12.4	12.2
	2EA	0.2	0.2
	2EB	0.3	0.2
	2EC	0.5	0.3
	2ED	0.9	0.6
	2EE	0.8	0.5
	2EF	0.7	0.5
	2EG1	1.8	1.8
	2EG2	0.9	0.4
	2EH	1.6	1.5
	2EJ	1.4	1.3
	2EK	0.4	0.4
	2FA	0.2	0.2
	2FB	0.2	0.2
	2FC	1.8	1.8
	2GA	0.2	0.1
	2GB	0.3	0.2
	2GC	4.1	3.7
	2GD	5.2	5.2
	2H-1	12.8	12.7
	2H-2	3.5	3.7
	2H-3	0.5	0.7
	2J	1.1	2.4
	2KA	6.3	6.7
	2KB	0.9	1.2
	2KC	5.0	4.8
ACA	3AA	1.9	1.6
	3AB	8.9	9.5
	3AC	5.7	6.1
	3BA	5.0	4.4
	3BB	2.7	2.5
	3BC	2.2	1.8
	3BD	3.9	3.5
	3CB	2.1	1.8
	3DA	5.0	5.8
	3DB	6.5	6.9
	3EA	4.2	5.2
	3EB	5.0	5.8
	3EC	3.6	4.1
	3ED	4.5	4.6
	3FA	34.6	39.9
	3FB	11.0	12.6
	3G	14.4	15.9
	3HA	2.4	2.6
	3HB	15.0	15.6
	3HC	12.9	10.8
	3HD1	13.4	13.8
	3HD2	1.3	1.0
	3J	8.8	9.6
	3KA	24.7	18.7
	3KB	2.3	1.9
	3LA	28.7	26.0
	3LB	3.2	2.6
	3MA-1	16.4	18.2
	3MA-2	9.6	7.6
	3MB	13.2	10.3
	3MC	7.6	6.4
	3MD1	16.1	12.6
	3MD2	1.8	1.3
	3N	6.4	9.1

CA	Sub-basin	TCA and ENNCA	
		2010	2030
TCA	4AA	4.7	0.6
	4AB	4.9	0.6
	4AC	3.5	0.4
	4AD	4.2	0.5
	4BA	2.2	0.3
	4BB	2.8	0.3
	4BC	1.9	0.2
	4BD	4.6	0.5
	4BE	5.8	0.7
	4BF	2.0	0.2
	4BG	1.8	0.2
	4CA	6.9	0.8
	4CB	4.4	0.5
	4CC	4.4	0.5
	4DA	5.7	0.7
	4DB	4.1	0.5
	4DC	4.5	0.5
	4DD	2.8	0.3
	4DE	2.2	0.3
	4EA	11.3	1.3
	4EB	19.6	2.3
	4EC	6.5	0.8
	4ED	8.8	1.0
	4FA	77.8	25.4
	4FB	118.2	117.2
	4GA	46.0	32.6
	4GB	34.7	37.6
	4GC	7.4	10.3
	4GD	30.3	34.5
	4GE	52.5	58.7
	4GF	54.3	70.1
	4GG	42.6	63.5
	4HA	22.1	28.0
	4HB	35.5	38.1
	4HC	11.3	12.1
	4JA	6.8	6.6
	4JB	1.5	4.9
	4KA	6.8	5.7
	4KB	8.0	7.5
ENNCA	5AA	6.0	5.1
	5AB	2.3	2.1
	5AC	3.3	3.1
	5AD	0.6	0.6
	5BA	1.6	1.4
	5BB	1.4	1.1
	5BC-1	8.1	7.4
	5BC-2	0.3	0.3
	5BD	0.8	0.6
	5BE	10.5	9.5
	5CA	4.7	3.6
	5CB	0.8	0.8
	5CC	0.7	0.9
	5DA	29.1	26.5
	5DB	2.8	3.1
	5DC	3.0	2.6
	5DD	1.0	1.3
	5EA	27.3	27.1
	5EB	51.8	44.2
	5EC	55.1	44.9
	5ED	170.9	157.2
	5FA	65.3	65.3
	5FB	5.8	5.3
	5G	22.5	25.1
	5HA	1.7	1.8
	5HB	4.7	4.6
	5J	44.0	29.3

Note: See Sectoral Report (B) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Domestic) (1/6)

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA 2010	2030	2050
LVNCA	1AA	0.06	0.05	0.08
	1AB	0.05	0.22	0.31
	1AC	0.04	0.05	0.07
	1AD	0.11	0.20	0.28
	1AE	0.08	0.04	0.06
	1AF	0.18	0.11	0.16
	1AG	0.16	0.10	0.14
	1AH	0.18	0.65	0.92
	1BA	0.08	0.07	0.09
	1BB	0.16	0.13	0.18
	1BC	0.08	0.35	0.49
	1BD	0.20	0.21	0.30
	1BE	0.25	0.41	0.58
	1BG	0.33	1.19	1.69
	1BH	0.15	0.86	1.22
	1CA	0.20	0.13	0.19
	1CB	0.15	1.62	2.32
	1CC	0.15	0.09	0.13
	1CD	0.08	0.08	0.12
	1CE	0.07	0.12	0.17
	1DA	0.20	0.44	0.62
	1DB	0.20	0.22	0.32
	1DC	0.16	0.14	0.19
	1DD	0.18	0.59	0.84
	1EA	0.12	0.13	0.18
	1EB	0.21	0.80	1.14
	1EC	0.12	0.08	0.11
	1ED	0.07	0.75	1.08
	1EE	0.11	0.08	0.12
	1EF	0.10	0.21	0.30
	1EG	0.16	0.33	0.47
	1FA	0.07	0.07	0.10
	1FB	0.08	0.05	0.07
	1FC	0.08	0.64	0.91
	1FD	0.09	0.13	0.19
	1FE	0.26	0.22	0.31
	1FF	0.20	1.29	1.85
	1FG	0.20	0.61	0.87
LVSCA	1GA	0.08	0.06	0.08
	1GB	0.08	0.07	0.10
	1GC	0.16	0.79	1.13
	1GD	0.15	0.93	1.33
	1GE	0.10	0.08	0.11
	1GF	0.08	0.04	0.06
	1GG	0.06	0.06	0.08
	1HA1	0.18	2.54	3.62
	1HA2	0.42	0.06	0.08
	1HB1	0.11	0.12	0.17
	1HB2	0.20	0.04	0.06
	1HC	0.10	0.10	0.15
	1HD	0.27	0.95	1.36
	1HE	0.28	0.30	0.42
	1HF	0.11	0.43	0.61
	1HG	0.05	0.14	0.21
	1JA	0.13	0.25	0.36
	1JB	0.03	0.04	0.06
	1JC	0.08	0.78	1.12
	1JD	0.06	0.06	0.08
	1JE	0.12	0.18	0.26
	1JF	0.16	0.29	0.41
	1JG1	0.09	0.11	0.16
	1JG2	0.02	0.02	0.03
	1KA	0.20	2.02	2.88
	1KB	1.11	2.08	2.97
	1KC	0.40	1.09	1.56
	1LA1	0.15	0.74	1.06
	1LA2	0.04	0.06	0.09
	1LA3	0.06	0.08	0.11
	1LB1	0.14	0.15	0.22
	1LB2	0.04	0.05	0.07

CA	Sub-basin	RVCA and ACA 2010	2030	2050
RVCA	2AA	0.01	0.03	0.04
	2AB	0.04	0.07	0.11
	2BA	0.06	0.07	0.09
	2BB	0.04	0.06	0.09
	2BC	0.14	0.19	0.27
	2BD	0.08	0.21	0.29
	2CA	0.01	0.02	0.03
	2CB	0.12	0.46	0.66
	2CC	0.12	0.18	0.26
	2D	0.08	0.13	0.19
	2EA	0.17	0.13	0.18
	2EB	0.15	0.12	0.18
	2EC	0.37	0.29	0.42
	2ED	0.02	0.16	0.22
	2EE	0.02	0.03	0.04
	2EF	0.01	0.03	0.04
	2EG1	0.07	0.36	0.52
	2EG2	0.14	0.15	0.21
	2EH	0.02	0.02	0.03
	2EJ	0.04	0.04	0.05
	2EK	0.02	0.02	0.03
	2FA	0.12	0.05	0.07
	2FB	0.06	0.04	0.06
	2FC	0.42	2.08	2.98
	2GA	0.07	0.28	0.40
	2GB	0.15	0.61	0.87
	2GC	0.12	0.15	0.22
	2GD	0.21	1.24	1.78
	2H-1	0.50	0.24	0.34
	2H-2	0.25	0.08	0.12
	2H-3	0.01	0.02	0.03
	2J	0.08	0.29	0.41
	2KA	0.20	0.43	0.61
	2KB	0.06	0.04	0.05
	2KC	0.09	0.03	0.04
ACA	3AA	0.80	1.89	2.71
	3AB	0.32	0.05	0.07
	3AC	1.30	0.04	0.06
	3BA	6.06	12.67	18.10
	3BB	0.97	0.55	0.78
	3BC	0.39	1.46	2.09
	3BD	0.31	0.29	0.42
	3CB	0.38	0.84	1.20
	3DA	0.38	0.06	0.08
	3DB	0.05	0.07	0.11
	3EA	0.46	2.22	3.17
	3EB	0.10	0.09	0.14
	3EC	0.13	0.23	0.33
	3ED	0.06	0.10	0.15
	3FA	0.34	0.77	1.10
	3FB	0.11	0.24	0.34
	3G	0.07	0.15	0.22
	3HA	0.01	0.01	0.01
	3HB	0.06	0.04	0.05
	3HC	0.17	0.09	0.13
	3HD1	0.04	0.02	0.03
	3HD2	0.02	0.01	0.02
	3J	0.04	0.16	0.23
	3K	0.37	0.66	0.94
	3LA	0.45	0.67	0.96
	3LB	0.06	0.95	1.36
	3MA-1	0.06	0.06	0.08
	3MA-2	0.03	0.07	0.10
	3MB	0.07	0.11	0.16
	3MC	0.03	0.14	0.20
	3MD1	2.22	5.04	7.20
	3MD2	0.54	0.02	0.02
	3N	0.03	0.06	0.09

CA	Sub-basin	TCA and ENNCA 2010	2030	2050
TCA	4AA	0.06	0.05	0.08
	4AB	0.10	0.09	0.13
	4AC	0.14	0.95	1.36
	4AD	0.17	0.19	0.27
	4BA	0.09	0.14	0.19
	4BB	0.04	0.04	0.06
	4BC	0.07	0.14	0.20
	4BD	0.17	0.32	0.45
	4BE	0.22	0.37	0.53
	4BF	0.16	0.47	0.67
	4BG	0.07	0.07	0.10
	4CA	0.16	0.14	0.20
	4CB	0.10	0.10	0.15
	4CC	0.22	0.54	0.77
	4DA	0.23	0.52	0.74
	4DB	0.15	0.14	0.20
	4DC	0.13	0.49	0.70
	4DD	0.04	0.04	0.06
	4DE	0.07	0.04	0.06
	4EA	0.14	0.16	0.23
	4EB	0.25	0.64	0.92
	4EC	0.13	0.21	0.31
	4ED	0.14	0.25	0.36
	4FA	0.20	0.63	0.90
	4FB	0.14	0.41	0.58
	4GA	0.04	0.07	0.10
	4GB	0.11	0.04	0.05
	4GC	0.05	0.23	0.33
	4GD	0.05	0.04	0.06
	4GE	0.24	0.19	0.28
	4GF	0.22	0.21	0.31
	4GG	0.13	0.08	0.12
	4HA	0.17	0.88	1.25
	4HB	0.02	0.05	0.08
	4HC	0.03	0.04	0.06
	4JA	0.06	0.05	0.08
	4JB	0.02	0.02	0.02
	4KA	0.04	0.03	0.04
	4KB	0.08	1.78	2.54
ENNCA	5AA	0.13	0.45	0.65
	5AB	0.06	0.06	0.09
	5AC	0.04	0.03	0.05
	5AD	0.02	0.02	0.03
	5BA	0.02	0.02	0.02
	5BB	0.04	0.04	0.06
	5BC-1	0.11	0.09	0.13
	5BC-2	0.00	0.00	0.01
	5BD	0.05	0.04	0.06
	5BE	0.11	0.36	0.52
	5CA	0.06	0.07	0.10
	5CB	0.02	0.03	0.04
	5CC	0.02	0.03	0.05
	5DA	0.13	0.44	0.62
	5DB	0.02	0.02	0.03
	5DC	0.01	0.02	0.02
	5DD	0.01	0.02	0.02
	5EA	0.14	0.36	0.51
	5EB	0.12	0.17	0.24
	5EC	0.06	0.12	0.18
	5ED	0.27	0.42	0.59
	5FA	0.16	0.19	0.28
	5FB	0.02	0.04	0.06
	5G	0.12	0.44	0.63
	5HA	0.03	0.09	0.13
	5HB	0.04	0.30	0.43
	5J	0.05	0.09	0.13

Note: See Sectoral Report (C) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Industrial) (2/6)

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA 2010	2030	2050
LVNCA	1AA	0.00	0.00	0.00
	1AB	0.00	0.01	0.02
	1AC	0.00	0.00	0.00
	1AD	0.00	0.01	0.02
	1AE	0.00	0.00	0.00
	1AF	0.00	0.00	0.00
	1AG	0.00	0.00	0.00
	1AH	0.00	0.03	0.06
	1BA	0.01	0.00	0.01
	1BB	0.01	0.01	0.01
	1BC	0.00	0.01	0.03
	1BD	0.02	0.01	0.02
	1BE	0.01	0.01	0.03
	1BG	0.01	0.05	0.11
	1BH	0.00	0.04	0.08
	1CA	0.02	0.01	0.02
	1CB	0.01	0.08	0.18
	1CC	0.01	0.00	0.01
	1CD	0.00	0.00	0.00
	1CE	0.00	0.00	0.01
	1DA	0.01	0.02	0.04
	1DB	0.00	0.00	0.01
	1DC	0.01	0.00	0.01
	1DD	0.00	0.03	0.05
	1EA	0.00	0.01	0.01
	1EB	0.01	0.10	0.22
	1EC	0.01	0.00	0.00
	1ED	0.00	0.04	0.08
	1EE	0.00	0.00	0.00
	1EF	0.00	0.00	0.01
	1EG	0.00	0.01	0.02
	1FA	0.00	0.00	0.01
	1FB	0.00	0.00	0.00
	1FC	0.00	0.03	0.07
	1FD	0.00	0.00	0.01
	1FE	0.00	0.00	0.01
	1FF	0.01	0.06	0.13
	1FG	0.00	0.02	0.05
LVSCA	1GA	0.00	0.00	0.00
	1GB	0.00	0.00	0.00
	1GC	0.01	0.04	0.08
	1GD	0.02	0.19	0.41
	1GE	0.01	0.00	0.01
	1GF	0.01	0.00	0.00
	1GG	0.00	0.00	0.00
	1HA1	0.03	0.62	1.36
	1HA2	0.09	0.00	0.00
	1HB1	0.01	0.00	0.00
	1HB2	0.04	0.00	0.00
	1HC	0.00	0.00	0.00
	1HD	0.01	0.04	0.08
	1HE	0.01	0.01	0.01
	1HF	0.00	0.02	0.04
	1HG	0.00	0.01	0.01
	1JA	0.00	0.01	0.02
	1JB	0.00	0.00	0.00
	1JC	0.01	0.11	0.24
	1JD	0.01	0.00	0.01
	1JE	0.00	0.00	0.01
	1JF	0.00	0.01	0.02
	1JG1	0.00	0.00	0.01
	1JG2	0.00	0.00	0.00
	1KA	0.01	0.10	0.21
	1KB	0.03	0.07	0.15
	1KC	0.01	0.04	0.09
	1LA1	0.00	0.03	0.07
	1LA2	0.00	0.00	0.00
	1LA3	0.00	0.00	0.00
	1LB1	0.00	0.00	0.01
	1LB2	0.00	0.00	0.00

CA	Sub-basin	RVCA and ACA 2010	2030	2050
RVCA	2AA	0.00	0.00	0.00
	2AB	0.00	0.00	0.00
	2BA	0.00	0.00	0.00
	2BB	0.00	0.00	0.00
	2BC	0.00	0.00	0.01
	2BD	0.00	0.00	0.00
	2CA	0.00	0.00	0.00
	2CB	0.00	0.02	0.03
	2CC	0.00	0.00	0.00
	2D	0.00	0.00	0.00
	2EA	0.04	0.02	0.05
	2EB	0.03	0.02	0.04
	2EC	0.08	0.05	0.11
	2ED	0.00	0.01	0.02
	2EE	0.00	0.00	0.00
	2EF	0.00	0.00	0.00
	2EG1	0.00	0.02	0.04
	2EG2	0.03	0.02	0.04
	2EH	0.00	0.00	0.00
	2EJ	0.00	0.00	0.00
	2EK	0.00	0.00	0.00
	2FA	0.01	0.00	0.01
	2FB	0.01	0.01	0.01
	2FC	0.06	0.44	0.95
	2GA	0.00	0.01	0.03
	2GB	0.00	0.03	0.06
	2GC	0.00	0.00	0.01
	2GD	0.01	0.06	0.13
	2H-1	0.03	0.01	0.02
	2H-2	0.01	0.00	0.01
	2H-3	0.00	0.00	0.00
	2J	0.00	0.00	0.00
	2KA	0.00	0.02	0.03
	2KB	0.00	0.00	0.00
	2KC	0.00	0.00	0.00
ACA	3AA	0.18	0.17	0.36
	3AB	0.04	0.00	0.00
	3AC	0.24	0.00	0.01
	3BA	1.40	2.79	6.11
	3BB	0.18	0.08	0.17
	3BC	0.02	0.07	0.15
	3BD	0.02	0.03	0.08
	3CB	0.05	0.12	0.25
	3DA	0.02	0.00	0.00
	3DB	0.00	0.00	0.00
	3EA	0.05	0.21	0.47
	3EB	0.01	0.00	0.00
	3EC	0.01	0.01	0.02
	3ED	0.00	0.00	0.01
	3FA	0.01	0.03	0.06
	3FB	0.00	0.01	0.01
	3G	0.00	0.00	0.01
	3HA	0.00	0.00	0.00
	3HB	0.01	0.00	0.00
	3HC	0.02	0.00	0.01
	3HD1	0.00	0.00	0.00
	3HD2	0.00	0.00	0.00
	3J	0.00	0.01	0.02
	3K	0.01	0.02	0.05
	3LA	0.02	0.02	0.05
	3LB	0.00	0.11	0.25
	3MA-1	0.00	0.00	0.00
	3MA-2	0.00	0.00	0.00
	3MB	0.00	0.00	0.00
	3MC	0.00	0.01	0.01
	3MD1	0.51	1.14	2.50
	3MD2	0.13	0.00	0.00
	3N	0.00	0.00	0.00

CA	Sub-basin	TCA and ENNCA 2010	2030	2050
TCA	4AA	0.00	0.00	0.00
	4AB	0.01	0.01	0.01
	4AC	0.01	0.13	0.29
	4AD	0.02	0.02	0.04
	4BA	0.01	0.01	0.03
	4BB	0.00	0.00	0.00
	4BC	0.00	0.00	0.01
	4BD	0.00	0.01	0.02
	4BE	0.00	0.01	0.03
	4BF	0.00	0.02	0.04
	4BG	0.00	0.00	0.00
	4CA	0.01	0.00	0.01
	4CB	0.00	0.00	0.00
	4CC	0.01	0.02	0.05
	4DA	0.00	0.02	0.04
	4DB	0.00	0.00	0.01
	4DC	0.00	0.02	0.05
	4DD	0.00	0.00	0.00
	4DE	0.00	0.00	0.00
	4EA	0.00	0.00	0.01
	4EB	0.01	0.03	0.06
	4EC	0.00	0.01	0.02
	4ED	0.00	0.01	0.01
	4FA	0.00	0.02	0.05
	4FB	0.00	0.01	0.02
	4GA	0.00	0.00	0.00
	4GB	0.00	0.00	0.00
	4GC	0.00	0.00	0.00
	4GD	0.00	0.00	0.00
	4GE	0.01	0.00	0.00
	4GF	0.01	0.00	0.00
	4GG	0.01	0.00	0.01
	4HA	0.01	0.04	0.09
	4HB	0.00	0.00	0.00
	4HC	0.00	0.00	0.00
	4JA	0.00	0.00	0.00
	4JB	0.00	0.00	0.00
	4KA	0.00	0.00	0.00
	4KB	0.00	0.93	2.01
ENNCA	5AA	0.00	0.02	0.04
	5AB	0.00	0.00	0.00
	5AC	0.00	0.00	0.00
	5AD	0.00	0.00	0.00
	5BA	0.00	0.00	0.00
	5BB	0.00	0.00	0.00
	5BC-1	0.00	0.00	0.01
	5BC-2	0.00	0.00	0.00
	5BD	0.00	0.00	0.00
	5BE	0.00	0.02	0.03
	5CA	0.00	0.00	0.00
	5CB	0.00	0.00	0.00
	5CC	0.00	0.00	0.00
	5DA	0.00	0.02	0.04
	5DB	0.00	0.00	0.00
	5DC	0.00	0.00	0.00
	5DD	0.00	0.00	0.00
	5EA	0.00	0.00	0.00
	5EB	0.00	0.00	0.00
	5EC	0.00	0.00	0.00
	5ED	0.00	0.00	0.01
	5FA	0.00	0.00	0.00
	5FB	0.00	0.00	0.00
	5G	0.00	0.00	0.00
	5HA	0.00	0.00	0.00
	5HB	0.00	0.00	0.00
	5J	0.00	0.00	0.00

Note: See Sectoral Report (C) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Irrigation) (3/6)

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA 2010	2030	2050
LVNCA	1AA	0.00	0.09	0.09
	1AB	0.00	0.07	0.07
	1AC	0.00	0.04	0.04
	1AD	0.01	0.09	0.09
	1AE	0.01	0.09	0.09
	1AF	0.01	0.15	0.15
	1AG	0.01	0.15	0.15
	1AH	0.02	0.17	0.17
	1BA	0.04	0.12	0.12
	1BB	0.03	0.56	0.56
	1BC	0.02	0.37	0.37
	1BD	0.01	0.40	0.40
	1BE	0.01	5.48	5.48
	1BG	0.01	6.49	6.49
	1BH	0.00	0.19	0.19
	1CA	0.01	0.26	0.26
	1CB	0.02	0.20	0.20
	1CC	0.01	0.25	0.25
	1CD	0.02	0.38	0.38
	1CE	0.00	3.52	3.52
	1DA	0.01	2.59	2.59
	1DB	0.00	0.73	0.73
	1DC	0.00	0.23	0.23
	1DD	0.00	0.25	0.25
	1EA	0.00	0.43	0.43
	1EB	0.00	0.74	0.74
	1EC	0.00	0.26	0.26
	1ED	0.00	0.02	0.02
	1EE	0.01	1.77	1.77
	1EF	0.04	1.68	1.68
	1EG	0.04	1.22	1.22
	1FA	0.00	0.13	0.13
	1FB	0.01	0.19	0.19
	1FC	0.01	0.10	0.10
	1FD	0.01	0.20	0.20
	1FE	0.01	0.73	0.73
	1FF	0.00	0.01	0.01
	1FG	0.10	7.28	7.28
LVSCA	1GA	0.06	0.19	0.19
	1GB	0.02	0.32	0.32
	1GC	0.05	0.08	0.08
	1GD	0.02	1.39	1.39
	1GE	0.25	0.48	0.48
	1GF	0.18	0.45	0.45
	1GG	0.30	0.06	0.06
	1HA1	0.02	0.30	0.30
	1HA2	0.29	2.77	2.77
	1HB1	0.31	0.31	0.31
	1HB2	0.29	0.30	0.30
	1HC	0.28	0.18	0.18
	1HD	0.40	0.51	0.51
	1HE	0.36	0.41	0.41
	1HF	0.59	0.63	0.63
	1HG	0.22	0.24	0.24
	1JA	0.04	0.93	0.93
	1JB	0.01	0.06	0.06
	1JC	0.01	0.34	0.34
	1JD	0.01	0.38	0.38
	1JE	0.03	0.81	0.81
	1JF	0.04	0.67	0.67
	1JG1	0.07	4.57	4.57
	1JG2	0.08	0.20	0.20
	1KA	0.07	0.62	0.62
	1KB	0.43	11.89	11.89
	1KC	0.03	1.82	1.82
	1LA1	0.04	0.47	0.47
	1LA2	0.01	0.10	0.10
	1LA3	0.02	1.00	1.00
	1LB1	0.03	2.28	2.28
	1LB2	0.02	0.83	0.83

CA	Sub-basin	RVCA and ACA 2010	2030	2050
RVCA	2AA	0.00	0.01	0.01
	2AB	0.27	0.27	0.27
	2BA	0.22	1.37	1.37
	2BB	0.27	6.32	6.32
	2BC	0.57	6.67	6.67
	2BD	0.69	0.80	0.80
	2CA	0.10	0.11	0.11
	2CB	0.42	2.15	2.15
	2CC	0.73	8.97	8.97
	2D	0.65	0.79	0.79
	2EA	0.03	0.03	0.03
	2EB	0.05	0.06	0.06
	2EC	0.05	0.07	0.07
	2ED	0.03	0.10	0.10
	2EE	0.09	0.13	0.13
	2EF	0.03	0.06	0.06
	2EG1	0.03	0.03	0.03
	2EG2	0.09	0.14	0.14
	2EH	0.04	0.08	0.08
	2EJ	0.09	0.09	0.09
	2EK	0.04	0.05	0.05
	2FA	0.03	0.04	0.04
	2FB	0.01	0.02	0.02
	2FC	0.10	0.10	0.10
	2GA	0.02	0.03	0.03
	2GB	0.04	0.04	0.04
	2GC	0.04	0.08	0.08
	2GD	0.09	0.10	0.10
	2H-1	0.68	0.70	0.70
	2H-2	0.40	0.41	0.41
	2H-3	0.00	0.01	0.01
	2J	0.00	0.00	0.00
	2KA	0.11	1.89	1.89
	2KB	0.10	11.76	11.76
	2KC	0.28	0.38	0.38
ACA	3AA	0.16	0.17	0.17
	3AB	0.37	0.40	0.40
	3AC	0.01	0.02	0.02
	3BA	0.03	0.05	0.05
	3BB	0.18	0.19	0.19
	3BC	0.18	0.19	0.19
	3BD	0.02	0.02	0.02
	3CB	0.03	0.09	0.09
	3DA	0.05	2.08	2.08
	3DB	0.03	0.18	0.18
	3EA	0.10	0.16	0.16
	3EB	0.11	0.16	0.16
	3EC	0.10	0.15	0.15
	3ED	0.09	0.12	0.12
	3FA	1.17	8.32	8.32
	3FB	0.71	0.87	0.87
	3G	2.23	2.30	2.30
	3HA	0.45	0.48	0.48
	3HB	0.67	0.80	0.80
	3HC	0.53	0.66	0.66
	3HD1	0.09	0.24	0.24
	3HD2	0.11	0.12	0.12
	3J	0.97	1.05	1.05
	3K	0.10	0.24	0.24
	3LA	1.90	1.98	1.98
	3LB	0.21	0.22	0.22
	3MA-1	0.89	0.92	0.92
	3MA-2	1.27	1.29	1.29
	3MB	0.05	0.06	0.06
	3MC	0.03	0.04	0.04
	3MD1	0.02	0.03	0.03
	3MD2	0.00	0.01	0.01
	3N	0.77	0.87	0.87

CA	Sub-basin	TCA and ENNCA 2010	2030	2050
TCA	4AA	0.25	0.27	0.27
	4AB	0.26	0.28	0.28
	4AC	0.17	0.19	0.19
	4AD	0.39	0.40	0.40
	4BA	0.18	0.20	0.20
	4BB	0.42	0.43	0.43
	4BC	1.34	1.35	1.35
	4BD	0.42	0.44	0.44
	4BE	0.58	0.60	0.60
	4BF	0.16	0.18	0.18
	4BG	0.20	0.22	0.22
	4CA	0.39	0.42	0.42
	4CB	0.26	0.28	0.28
	4CC	1.24	1.29	1.29
	4DA	4.17	4.21	4.21
	4DB	2.73	2.75	2.75
	4DC	0.77	0.79	0.79
	4DD	0.29	0.32	0.32
	4DE	0.15	0.18	0.18
	4EA	1.60	1.63	1.63
	4EB	1.26	1.31	1.31
	4EC	0.76	0.79	0.79
	4ED	1.98	2.11	2.11
	4FA	3.22	117.34	117.34
	4FB	3.96	5.00	5.00
	4GA	0.96	1.30	1.30
	4GB	0.40	0.78	0.78
	4GC	0.16	0.69	0.69
	4GD	0.70	2.20	2.20
	4GE	0.69	1.96	1.96
	4GF	1.09	3.77	3.77
	4GG	1.27	2.00	2.00
	4HA	0.15	0.49	0.49
	4HB	0.67	0.98	0.98
	4HC	0.51	0.63	0.63
	4JA	0.39	0.43	0.43
	4JB	0.15	0.19	0.19
	4KA	0.34	0.44	0.44
	4KB	0.38	0.50	0.50
ENNCA	5AA	0.04	0.11	0.11
	5AB	0.01	0.04	0.04
	5AC	0.10	0.15	0.15
	5AD	0.24	0.25	0.25
	5BA	0.10	0.12	0.12
	5BB	0.32	0.33	0.33
	5BC-1	0.24	0.39	0.39
	5BC-2	0.23	0.24	0.24
	5BD	0.05	0.06	0.06
	5BE	0.71	0.79	0.79
	5CA	0.12	0.16	0.16
	5CB	0.00	0.02	0.02
	5CC	0.00	0.02	0.02
	5DA	1.45	5.18	5.18
	5DB	0.16	0.20	0.20
	5DC	0.14	16.10	16.10
	5DD	0.04	3.14	3.14
	5EA	0.09	0.22	0.22
	5EB	0.15	0.46	0.46
	5EC	0.29	0.61	0.61
	5ED	0.00	1.14	1.14
	5FA	0.00	0.47	0.47
	5FB	0.03	0.06	0.06
	5G	0.00	0.12	0.12
	5HA	0.65	0.65	0.65
	5HB	0.00	0.02	0.02
	5J	0.00	0.26	0.26

Note: See Sectoral Report (E) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Livestock) (4/6)

(Unit: m^3/s)

LVNCA and LVSCA

CA	Sub-basin	2010	2030	2050
LVNCA	1AA	0.01	0.02	0.03
	1AB	0.01	0.02	0.03
	1AC	0.01	0.01	0.02
	1AD	0.01	0.03	0.04
	1AE	0.01	0.02	0.03
	1AF	0.02	0.05	0.07
	1AG	0.02	0.04	0.06
	1AH	0.02	0.05	0.06
	1BA	0.02	0.05	0.07
	1BB	0.03	0.07	0.10
	1BC	0.02	0.06	0.09
	1BD	0.03	0.07	0.10
	1BE	0.03	0.08	0.12
	1BG	0.04	0.09	0.12
	1BH	0.02	0.05	0.08
	1CA	0.03	0.06	0.09
	1CB	0.02	0.06	0.08
	1CC	0.02	0.06	0.08
	1CD	0.02	0.05	0.08
	1CE	0.01	0.03	0.04
	1DA	0.03	0.07	0.10
	1DB	0.03	0.07	0.10
	1DC	0.02	0.05	0.07
	1DD	0.02	0.05	0.06
	1EA	0.02	0.05	0.07
	1EB	0.02	0.06	0.08
	1EC	0.01	0.03	0.05
	1ED	0.01	0.02	0.03
	1EE	0.02	0.04	0.06
	1EF	0.02	0.04	0.05
	1EG	0.03	0.07	0.10
	1FA	0.01	0.02	0.03
	1FB	0.02	0.04	0.06
	1FC	0.01	0.03	0.04
	1FD	0.02	0.04	0.06
	1FE	0.04	0.11	0.15
	1FF	0.03	0.07	0.10
	1FG	0.04	0.10	0.15
LVSCA	1GA	0.02	0.04	0.05
	1GB	0.02	0.05	0.07
	1GC	0.03	0.08	0.11
	1GD	0.03	0.08	0.11
	1GE	0.02	0.05	0.06
	1GF	0.02	0.04	0.06
	1GG	0.01	0.03	0.05
	1HA1	0.02	0.05	0.08
	1HA2	0.03	0.07	0.11
	1HB1	0.03	0.07	0.10
	1HB2	0.02	0.04	0.06
	1HC	0.03	0.08	0.11
	1HD	0.05	0.13	0.18
	1HE	0.05	0.11	0.16
	1HF	0.03	0.08	0.12
	1HG	0.01	0.03	0.05
	1JA	0.03	0.07	0.10
	1JB	0.01	0.02	0.02
	1JC	0.01	0.03	0.05
	1JD	0.01	0.02	0.04
	1JE	0.04	0.09	0.14
	1JF	0.05	0.11	0.16
	1JG1	0.02	0.04	0.05
	1JG2	0.01	0.01	0.02
	1KA	0.03	0.08	0.11
	1KB	0.22	0.52	0.75
	1KC	0.20	0.49	0.69
	1LA1	0.05	0.12	0.16
	1LA2	0.05	0.13	0.18
	1LA3	0.11	0.25	0.36
	1LB1	0.06	0.15	0.21
	1LB2	0.08	0.20	0.28

RVCA and ACA

CA	Sub-basin	2010	2030	2050
RVCA	2AA	0.05	0.06	0.09
	2AB	0.10	0.12	0.18
	2BA	0.04	0.09	0.13
	2BB	0.06	0.13	0.19
	2BC	0.12	0.28	0.41
	2BD	0.25	0.42	0.60
	2CA	0.07	0.09	0.12
	2CB	0.05	0.10	0.14
	2CC	0.30	0.42	0.60
	2D	0.29	0.36	0.51
	2EA	0.01	0.02	0.03
	2EB	0.01	0.03	0.05
	2EC	0.02	0.06	0.08
	2ED	0.01	0.02	0.03
	2EE	0.01	0.01	0.02
	2EF	0.01	0.02	0.03
	2EG1	0.01	0.03	0.04
	2EG2	0.02	0.05	0.07
	2EH	0.00	0.01	0.01
	2EJ	0.04	0.06	0.08
	2EK	0.01	0.01	0.01
	2FA	0.01	0.03	0.04
	2FB	0.00	0.01	0.01
	2FC	0.04	0.10	0.14
	2GA	0.01	0.02	0.03
	2GB	0.03	0.07	0.09
	2GC	0.03	0.06	0.09
	2GD	0.03	0.07	0.09
	2H-1	0.08	0.19	0.28
	2H-2	0.03	0.06	0.09
	2H-3	0.01	0.02	0.02
	2J	0.26	0.32	0.45
	2KA	0.15	0.35	0.51
	2KB	0.04	0.10	0.15
	2KC	0.04	0.10	0.14
ACA	3AA	0.01	0.03	0.04
	3AB	0.03	0.07	0.10
	3AC	0.03	0.06	0.09
	3BA	0.04	0.09	0.12
	3BB	0.01	0.03	0.05
	3BC	0.03	0.07	0.10
	3BD	0.01	0.03	0.04
	3CB	0.01	0.03	0.05
	3DA	0.02	0.06	0.08
	3DB	0.02	0.04	0.06
	3EA	0.03	0.06	0.09
	3EB	0.02	0.05	0.08
	3EC	0.02	0.04	0.06
	3ED	0.01	0.03	0.05
	3FA	0.12	0.29	0.41
	3FB	0.03	0.07	0.11
	3G	0.05	0.12	0.17
	3HA	0.00	0.01	0.01
	3HB	0.01	0.02	0.03
	3HC	0.01	0.03	0.04
	3HD1	0.00	0.01	0.01
	3HD2	0.00	0.00	0.01
	3J	0.01	0.04	0.05
	3K	0.07	0.16	0.23
	3LA	0.05	0.11	0.16
	3LB	0.00	0.01	0.02
	3MA-1	0.02	0.05	0.07
	3MA-2	0.02	0.04	0.06
	3MB	0.02	0.05	0.07
	3MC	0.01	0.02	0.03
	3MD1	0.03	0.07	0.10
	3MD2	0.00	0.01	0.01
	3N	0.03	0.08	0.11

TCA and ENNCA

CA	Sub-basin	2010	2030	2050
TCA	4AA	0.01	0.03	0.04
	4AB	0.02	0.04	0.06
	4AC	0.01	0.04	0.05
	4AD	0.02	0.04	0.06
	4BA	0.01	0.03	0.04
	4BB	0.01	0.02	0.03
	4BC	0.01	0.02	0.03
	4BD	0.03	0.06	0.09
	4BE	0.03	0.06	0.09
	4BF	0.02	0.04	0.06
	4BG	0.01	0.03	0.04
	4CA	0.02	0.05	0.07
	4CB	0.01	0.03	0.04
	4CC	0.03	0.06	0.09
	4DA	0.03	0.07	0.10
	4DB	0.02	0.04	0.06
	4DC	0.01	0.03	0.05
	4DD	0.01	0.02	0.03
	4DE	0.01	0.03	0.05
	4EA	0.02	0.06	0.08
	4EB	0.03	0.08	0.12
	4EC	0.02	0.04	0.06
	4ED	0.04	0.10	0.14
	4FA	0.05	0.13	0.18
	4FB	0.05	0.13	0.19
	4GA	0.02	0.04	0.05
	4GB	0.05	0.07	0.09
	4GC	0.02	0.03	0.04
	4GD	0.03	0.04	0.06
	4GE	0.06	0.14	0.20
	4GF	0.06	0.12	0.17
	4GG	0.03	0.05	0.08
	4HA	0.03	0.08	0.12
	4HB	0.03	0.04	0.06
	4HC	0.02	0.03	0.05
	4JA	0.05	0.06	0.09
	4JB	0.03	0.04	0.06
	4KA	0.04	0.05	0.08
	4KB	0.07	0.10	0.15
ENNCA	5AA	0.03	0.07	0.09
	5AB	0.01	0.03	0.04
	5AC	0.01	0.03	0.04
	5AD	0.01	0.01	0.02
	5BA	0.00	0.01	0.01
	5BB	0.01	0.02	0.03
	5BC-1	0.02	0.05	0.08
	5BC-2	0.00	0.00	0.00
	5BD	0.01	0.02	0.03
	5BE	0.02	0.05	0.07
	5CA	0.02	0.04	0.06
	5CB	0.01	0.01	0.01
	5CC	0.02	0.02	0.03
	5DA	0.03	0.06	0.08
	5DB	0.01	0.02	0.03
	5DC	0.01	0.03	0.04
	5DD	0.00	0.01	0.01
	5EA	0.22	0.27	0.39
	5EB	0.16	0.20	0.28
	5EC	0.06	0.07	0.10
	5ED	0.11	0.20	0.28
	5FA	0.15	0.19	0.27
	5FB	0.05	0.06	0.08
	5G	0.46	0.56	0.80
	5HA	0.10	0.13	0.18
	5HB	0.18	0.23	0.33
	5J	0.11	0.13	0.19

Note: See Sectoral Report (C) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Wildlife) (5/6)

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA		
		2010	2030	2050
LVNCA	1AA	0.00	0.00	0.00
	1AB	0.00	0.00	0.00
	1AC	0.00	0.00	0.00
	1AD	0.00	0.00	0.00
	1AE	0.00	0.00	0.00
	1AF	0.00	0.00	0.00
	1AG	0.00	0.00	0.00
	1AH	0.00	0.00	0.00
	1BA	0.00	0.00	0.00
	1BB	0.00	0.00	0.00
	1BC	0.00	0.00	0.00
	1BD	0.00	0.00	0.00
	1BE	0.00	0.00	0.00
	1BG	0.00	0.00	0.00
	1BH	0.00	0.00	0.00
	1CA	0.00	0.00	0.00
	1CB	0.00	0.00	0.00
	1CC	0.00	0.00	0.00
	1CD	0.00	0.00	0.00
	1CE	0.00	0.00	0.00
	1DA	0.00	0.00	0.00
	1DB	0.00	0.00	0.00
	1DC	0.00	0.00	0.00
	1DD	0.00	0.00	0.00
	1EA	0.00	0.00	0.00
	1EB	0.00	0.00	0.00
	1EC	0.00	0.00	0.00
	1ED	0.00	0.00	0.00
	1EE	0.00	0.00	0.00
	1EF	0.00	0.00	0.00
	1EG	0.00	0.00	0.00
	1FA	0.00	0.00	0.00
	1FB	0.00	0.00	0.00
	1FC	0.00	0.00	0.00
	1FD	0.00	0.00	0.00
	1FE	0.00	0.00	0.00
	1FF	0.00	0.00	0.00
	1FG	0.00	0.00	0.00
LVSCA	1GA	0.00	0.00	0.00
	1GB	0.00	0.00	0.00
	1GC	0.00	0.00	0.00
	1GD	0.00	0.00	0.00
	1GE	0.00	0.00	0.00
	1GF	0.00	0.00	0.00
	1GG	0.00	0.00	0.00
	1HA1	0.00	0.00	0.00
	1HA2	0.00	0.00	0.00
	1HB1	0.00	0.00	0.00
	1HB2	0.00	0.00	0.00
	1HC	0.00	0.00	0.00
	1HD	0.00	0.00	0.00
	1HE	0.00	0.00	0.00
	1HF	0.00	0.00	0.00
	1HG	0.00	0.00	0.00
	1JA	0.00	0.00	0.00
	1JB	0.00	0.00	0.00
	1JC	0.00	0.00	0.00
	1JD	0.00	0.00	0.00
	1JE	0.00	0.00	0.00
	1JF	0.00	0.00	0.00
	1JG1	0.00	0.00	0.00
	1JG2	0.00	0.00	0.00
	1KA	0.00	0.00	0.00
	1KB	0.01	0.01	0.01
	1KC	0.01	0.01	0.01
	1LA1	0.00	0.00	0.00
	1LA2	0.00	0.00	0.00
	1LA3	0.01	0.01	0.01
	1LB1	0.01	0.01	0.01
	1LB2	0.01	0.01	0.01

CA	Sub-basin	RVCA and ACA		
		2010	2030	2050
RVCA	2AA	0.00	0.00	0.00
	2AB	0.00	0.00	0.00
	2BA	0.00	0.00	0.00
	2BB	0.00	0.00	0.00
	2BC	0.00	0.00	0.00
	2BD	0.00	0.00	0.00
	2CA	0.00	0.00	0.00
	2CB	0.00	0.00	0.00
	2CC	0.00	0.00	0.00
	2D	0.00	0.00	0.00
	2EA	0.00	0.00	0.00
	2EB	0.00	0.00	0.00
	2EC	0.00	0.00	0.00
	2ED	0.00	0.00	0.00
	2EE	0.00	0.00	0.00
	2EF	0.00	0.00	0.00
	2EG1	0.00	0.00	0.00
	2EG2	0.00	0.00	0.00
	2EH	0.00	0.00	0.00
	2EJ	0.00	0.00	0.00
	2EK	0.00	0.00	0.00
	2FA	0.00	0.00	0.00
	2FB	0.00	0.00	0.00
	2FC	0.00	0.00	0.00
	2GA	0.00	0.00	0.00
	2GB	0.00	0.00	0.00
	2GC	0.00	0.00	0.00
	2GD	0.00	0.00	0.00
	2H-1	0.00	0.00	0.00
	2H-2	0.00	0.00	0.00
	2H-3	0.00	0.00	0.00
	2J	0.01	0.01	0.01
	2KA	0.00	0.00	0.00
	2KB	0.00	0.00	0.00
	2KC	0.00	0.00	0.00
ACA	3AA	0.00	0.00	0.00
	3AB	0.00	0.00	0.00
	3AC	0.00	0.00	0.00
	3BA	0.00	0.00	0.00
	3BB	0.00	0.00	0.00
	3BC	0.00	0.00	0.00
	3BD	0.00	0.00	0.00
	3CB	0.00	0.00	0.00
	3DA	0.00	0.00	0.00
	3DB	0.00	0.00	0.00
	3EA	0.00	0.00	0.00
	3EB	0.00	0.00	0.00
	3EC	0.00	0.00	0.00
	3ED	0.00	0.00	0.00
	3FA	0.01	0.01	0.01
	3FB	0.01	0.01	0.01
	3G	0.01	0.01	0.01
	3HA	0.00	0.00	0.00
	3HB	0.00	0.00	0.00
	3HC	0.00	0.00	0.00
	3HD1	0.00	0.00	0.00
	3HD2	0.00	0.00	0.00
	3J	0.00	0.00	0.00
	3K	0.00	0.00	0.00
	3LA	0.01	0.01	0.01
	3LB	0.00	0.00	0.00
	3MA-1	0.00	0.00	0.00
	3MA-2	0.00	0.00	0.00
	3MB	0.00	0.00	0.00
	3MC	0.00	0.00	0.00
	3MD1	0.00	0.00	0.00
	3MD2	0.00	0.00	0.00
	3N	0.00	0.00	0.00

CA	Sub-basin	TCA and ENNCA		
		2010	2030	2050
TCA	4AA	0.00	0.00	0.00
	4AB	0.00	0.00	0.00
	4AC	0.00	0.00	0.00
	4AD	0.00	0.00	0.00
	4BA	0.00	0.00	0.00
	4BB	0.00	0.00	0.00
	4BC	0.00	0.00	0.00
	4BD	0.00	0.00	0.00
	4BE	0.00	0.00	0.00
	4BF	0.00	0.00	0.00
	4BG	0.00	0.00	0.00
	4CA	0.00	0.00	0.00
	4CB	0.00	0.00	0.00
	4CC	0.00	0.00	0.00
	4DA	0.00	0.00	0.00
	4DB	0.00	0.00	0.00
	4DC	0.00	0.00	0.00
	4DD	0.00	0.00	0.00
	4DE	0.00	0.00	0.00
	4EA	0.00	0.00	0.00
	4EB	0.00	0.00	0.00
	4EC	0.00	0.00	0.00
	4ED	0.00	0.00	0.00
	4FA	0.00	0.00	0.00
	4FB	0.00	0.00	0.00
	4GA	0.00	0.00	0.00
	4GB	0.00	0.00	0.00
	4GC	0.00	0.00	0.00
	4GD	0.00	0.00	0.00
	4GE	0.00	0.00	0.00
	4GF	0.00	0.00	0.00
	4GG	0.00	0.00	0.00
	4HA	0.00	0.00	0.00
	4HB	0.00	0.00	0.00
	4HC	0.00	0.00	0.00
	4JA	0.00	0.00	0.00
	4JB	0.00	0.00	0.00
	4KA	0.00	0.00	0.00
	4KB	0.00	0.00	0.00
ENNCA	5AA	0.00	0.00	0.00
	5AB	0.00	0.00	0.00
	5AC	0.00	0.00	0.00
	5AD	0.00	0.00	0.00
	5BA	0.00	0.00	0.00
	5BB	0.00	0.00	0.00
	5BC-1	0.00	0.00	0.00
	5BC-2	0.00	0.00	0.00
	5BD	0.00	0.00	0.00
	5BE	0.00	0.00	0.00
	5CA	0.00	0.00	0.00
	5CB	0.00	0.00	0.00
	5CC	0.00	0.00	0.00
	5DA	0.00	0.00	0.00
	5DB	0.00	0.00	0.00
	5DC	0.00	0.00	0.00
	5DD	0.00	0.00	0.00
	5EA	0.00	0.00	0.00
	5EB	0.00	0.00	0.00
	5EC	0.00	0.00	0.00
	5ED	0.00	0.00	0.00
	5FA	0.00	0.00	0.00
	5FB	0.00	0.00	0.00
	5G	0.00	0.00	0.00
	5HA	0.00	0.00	0.00
	5HB	0.00	0.00	0.00
	5J	0.00	0.00	0.00

Note: See Sectoral Report (C) for details.
Source: JICA Study Team

Table 3.3.1 Water Demands for 2010, 2030 and 2050 by Sub-basin (Fisheries) (6/6)

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA 2010	2030	2050
LVNCA	1AA	0.00	0.01	0.01
	1AB	0.01	0.01	0.02
	1AC	0.00	0.01	0.01
	1AD	0.01	0.01	0.02
	1AE	0.00	0.00	0.00
	1AF	0.01	0.01	0.02
	1AG	0.01	0.02	0.02
	1AH	0.01	0.02	0.03
	1BA	0.00	0.01	0.01
	1BB	0.01	0.02	0.02
	1BC	0.00	0.01	0.01
	1BD	0.01	0.01	0.02
	1BE	0.00	0.01	0.01
	1BG	0.01	0.01	0.02
	1BH	0.01	0.01	0.01
	1CA	0.01	0.01	0.02
	1CB	0.01	0.02	0.03
	1CC	0.01	0.02	0.03
	1CD	0.00	0.01	0.01
	1CE	0.00	0.01	0.01
	1DA	0.00	0.00	0.00
	1DB	0.01	0.02	0.03
	1DC	0.00	0.01	0.01
	1DD	0.01	0.02	0.02
	1EA	0.00	0.00	0.01
	1EB	0.01	0.03	0.04
	1EC	0.01	0.01	0.02
	1ED	0.00	0.01	0.01
	1EE	0.00	0.01	0.01
	1EF	0.01	0.02	0.02
	1EG	0.01	0.02	0.03
	1FA	0.01	0.01	0.01
	1FB	0.00	0.00	0.01
	1FC	0.00	0.01	0.01
	1FD	0.00	0.01	0.01
	1FE	0.02	0.03	0.05
	1FF	0.01	0.03	0.04
	1FG	0.01	0.03	0.04
LVSCA	1GA	0.01	0.01	0.01
	1GB	0.00	0.02	0.03
	1GC	0.01	0.02	0.02
	1GD	0.01	0.01	0.01
	1GE	0.01	0.01	0.01
	1GF	0.00	0.01	0.01
	1GG	0.00	0.03	0.04
	1HA1	0.01	0.04	0.06
	1HA2	0.01	0.01	0.01
	1HB1	0.01	0.02	0.03
	1HB2	0.01	0.03	0.05
	1HC	0.00	0.01	0.02
	1HD	0.01	0.01	0.02
	1HE	0.02	0.00	0.00
	1HF	0.01	0.01	0.02
	1HG	0.00	0.00	0.00
	1JA	0.01	0.01	0.01
	1JB	0.00	0.01	0.01
	1JC	0.00	0.01	0.01
	1JD	0.00	0.02	0.02
	1JE	0.00	0.00	0.01
	1JF	0.01	0.03	0.05
	1JG1	0.00	0.09	0.13
	1JG2	0.00	0.04	0.05
	1KA	0.02	0.01	0.01
	1KB	0.05	0.00	0.00
	1KC	0.02	0.00	0.00
	1LA1	0.00	0.00	0.00
	1LA2	0.00	0.00	0.00
	1LA3	0.00	0.00	0.00
	1LB1	0.00	0.00	0.00
	1LB2	0.00	0.00	0.00

CA	Sub-basin	RVCA and ACA 2010	2030	2050
RVCA	2AA	0.00	0.00	0.00
	2AB	0.00	0.00	0.00
	2BA	0.00	0.00	0.00
	2BB	0.00	0.00	0.00
	2BC	0.00	0.00	0.00
	2BD	0.00	0.00	0.00
	2CA	0.00	0.00	0.00
	2CB	0.01	0.03	0.04
	2CC	0.00	0.00	0.00
	2D	0.00	0.00	0.00
	2EA	0.00	0.00	0.00
	2EB	0.01	0.02	0.02
	2EC	0.00	0.01	0.01
	2ED	0.00	0.01	0.01
	2EE	0.00	0.00	0.00
	2EF	0.00	0.00	0.00
	2EG1	0.01	0.01	0.01
	2EG2	0.01	0.02	0.02
	2EH	0.00	0.00	0.00
	2EJ	0.02	0.04	0.05
	2EK	0.01	0.02	0.03
	2FA	0.00	0.00	0.01
	2FB	0.00	0.00	0.00
	2FC	0.00	0.00	0.00
	2GA	0.00	0.01	0.01
	2GB	0.02	0.04	0.05
	2GC	0.01	0.01	0.02
	2GD	0.00	0.01	0.01
	2H-1	0.00	0.01	0.02
	2H-2	0.00	0.00	0.00
	2H-3	0.00	0.00	0.00
	2J	0.00	0.00	0.00
	2KA	0.00	0.00	0.00
	2KB	0.00	0.00	0.00
	2KC	0.00	0.00	0.00
ACA	3AA	0.00	0.00	0.01
	3AB	0.01	0.01	0.02
	3AC	0.00	0.01	0.01
	3BA	0.02	0.04	0.06
	3BB	0.00	0.01	0.01
	3BC	0.01	0.02	0.03
	3BD	0.01	0.02	0.03
	3CB	0.01	0.02	0.03
	3DA	0.01	0.02	0.03
	3DB	0.00	0.00	0.00
	3EA	0.01	0.03	0.04
	3EB	0.00	0.01	0.01
	3EC	0.01	0.03	0.04
	3ED	0.00	0.00	0.00
	3FA	0.00	0.01	0.01
	3FB	0.01	0.01	0.02
	3G	0.01	0.02	0.02
	3HA	0.00	0.00	0.00
	3HB	0.00	0.00	0.00
	3HC	0.00	0.00	0.00
	3HD1	0.00	0.00	0.01
	3HD2	0.00	0.01	0.01
	3J	0.01	0.01	0.02
	3K	0.01	0.02	0.03
	3LA	0.01	0.02	0.02
	3LB	0.01	0.02	0.03
	3MA-1	0.00	0.00	0.01
	3MA-2	0.00	0.00	0.00
	3MB	0.00	0.00	0.00
	3MC	0.00	0.01	0.01
	3MD1	0.01	0.01	0.02
	3MD2	0.00	0.00	0.01
	3N	0.00	0.00	0.01

CA	Sub-basin	TCA and ENNCA 2010	2030	2050
TCA	4AA	0.01	0.03	0.04
	4AB	0.01	0.03	0.04
	4AC	0.01	0.02	0.02
	4AD	0.01	0.02	0.02
	4BA	0.01	0.02	0.03
	4BB	0.00	0.01	0.01
	4BC	0.01	0.01	0.02
	4BD	0.01	0.02	0.04
	4BE	0.01	0.02	0.03
	4BF	0.01	0.01	0.02
	4BG	0.00	0.01	0.01
	4CA	0.00	0.01	0.01
	4CB	0.01	0.01	0.02
	4CC	0.01	0.02	0.02
	4DA	0.01	0.03	0.04
	4DB	0.01	0.01	0.02
	4DC	0.00	0.00	0.00
	4DD	0.00	0.01	0.01
	4DE	0.00	0.01	0.01
	4EA	0.01	0.01	0.02
	4EB	0.01	0.01	0.02
	4EC	0.01	0.02	0.03
	4ED	0.01	0.01	0.02
	4FA	0.01	0.02	0.03
	4FB	0.02	0.04	0.05
	4GA	0.00	0.00	0.00
	4GB	0.00	0.00	0.00
	4GC	0.00	0.00	0.00
	4GD	0.00	0.01	0.01
	4GE	0.01	0.01	0.02
	4GF	0.01	0.03	0.04
	4GG	0.00	0.01	0.01
	4HA	0.01	0.03	0.04
	4HB	0.00	0.01	0.01
	4HC	0.00	0.00	0.00
	4JA	0.00	0.00	0.00
	4JB	0.00	0.00	0.00
	4KA	0.00	0.00	0.01
	4KB	0.00	0.01	0.01
ENNCA	5AA	0.08	0.02	0.02
	5AB	0.01	0.03	0.04
	5AC	0.06	0.01	0.02
	5AD	0.01	0.03	0.04
	5BA	0.00	0.00	0.01
	5BB	0.01	0.01	0.01
	5BC-1	0.02	0.03	0.05
	5BC-2	0.00	0.00	0.00
	5BD	0.01	0.01	0.02
	5BE	0.01	0.01	0.01
	5CA	0.01	0.03	0.04
	5CB	0.00	0.00	0.00
	5CC	0.00	0.00	0.00
	5DA	0.00	0.00	0.01
	5DB	0.00	0.00	0.00
	5DC	0.01	0.02	0.02
	5DD	0.00	0.00	0.00
	5EA	0.00	0.00	0.00
	5EB	0.00	0.00	0.00
	5EC	0.00	0.00	0.00
	5ED	0.01	0.02	0.03
	5FA	0.00	0.00	0.00
	5FB	0.00	0.00	0.00
	5G	0.00	0.00	0.00
	5HA	0.00	0.00	0.00
	5HB	0.00	0.00	0.00
	5J	0.00	0.00	0.00

Note: See Sectoral Report (C) for details.
Source: JICA Study Team

Table 3.3.2 Present (2010) Surface Water and Groundwater Demands by Sub-basin

(Unit: MCM/year)

CA	Sub-basin	LVNCA and LVSCA		
		Total	SW	GW
LVNCA	1AA	2.49	2.02	0.47
	1AB	2.25	1.87	0.39
	1AC	1.65	1.34	0.32
	1AD	4.41	3.64	0.77
	1AE	3.20	2.54	0.66
	1AF	6.86	5.44	1.42
	1AG	6.25	5.07	1.19
	1AH	7.51	6.30	1.21
	1BA	4.76	4.12	0.64
	1BB	7.36	6.01	1.35
	1BC	4.06	3.53	0.53
	1BD	8.14	6.48	1.66
	1BE	9.63	7.80	1.83
	1BG	12.56	10.19	2.37
	1BH	5.79	4.69	1.09
	1CA	8.30	6.58	1.73
	1CB	6.92	5.77	1.15
	1CC	6.45	5.27	1.19
	1CD	4.01	3.39	0.62
	1CE	2.92	2.37	0.55
	1DA	7.80	6.17	1.64
	1DB	7.90	6.49	1.41
	1DC	6.11	4.82	1.29
	1DD	6.65	5.42	1.23
	1EA	4.53	3.62	0.91
	1EB	8.40	6.79	1.61
	1EC	4.63	3.67	0.96
	1ED	2.51	2.01	0.50
	1EE	5.10	4.21	0.88
	1EF	5.11	4.41	0.70
	1EG	7.66	6.51	1.15
	1FA	2.75	2.25	0.50
	1FB	3.60	2.94	0.66
	1FC	3.19	2.67	0.52
	1FD	4.01	3.33	0.68
	1FE	10.61	8.60	2.01
	1FF	7.99	6.58	1.41
	1FG	11.54	10.08	1.46
LVSCA	1GA	3.76	3.28	0.48
	1GB	6.15	5.59	0.56
	1GC	7.65	6.57	1.08
	1GD	14.74	13.57	1.17
	1GE	10.12	9.33	0.79
	1GF	13.35	12.69	0.66
	1GG	3.48	3.10	0.38
	1HA1	16.83	15.29	1.54
	1HA2	27.81	23.79	4.03
	1HB1	14.42	13.67	0.75
	1HB2	17.65	15.84	1.81
	1HC	6.37	5.73	0.64
	1HD	23.88	22.20	1.69
	1HE	22.96	21.17	1.79
	1HF	24.31	23.59	0.71
	1HG	9.36	9.06	0.30
	1JA	6.41	5.62	0.79
	1JB	1.37	1.20	0.17
	1JC	3.65	3.06	0.59
	1JD	2.70	2.25	0.45
	1JE	6.16	5.41	0.75
	1JF	8.30	7.32	0.99
	1JG1	5.51	4.94	0.58
	1JG2	3.38	3.24	0.14
	1KA	10.73	9.44	1.29
	1KB	60.38	53.30	7.08
	1KC	20.97	18.43	2.53
	1LA1	7.56	6.65	0.91
	1LA2	3.46	3.20	0.26
	1LA3	7.02	6.66	0.36
	1LB1	8.02	7.13	0.89
	1LB2	5.79	5.54	0.26

CA	Sub-basin	RVCA and ACA		
		Total	SW	GW
RVCA	2AA	1.94	1.62	0.32
	2AB	10.26	9.30	0.95
	2BA	7.75	6.21	1.54
	2BB	9.15	8.07	1.08
	2BC	20.79	16.95	3.84
	2BD	25.35	23.19	2.16
	2CA	4.77	4.45	0.32
	2CB	15.13	11.84	3.29
	2CC	29.35	26.05	3.30
	2D	26.12	24.02	2.10
	2EA	7.50	2.38	5.13
	2EB	7.45	3.06	4.39
	2EC	16.54	5.18	11.36
	2ED	1.69	1.19	0.50
	2EE	2.91	2.39	0.53
	2EF	1.39	1.04	0.36
	2EG1	3.42	1.55	1.87
	2EG2	8.52	4.27	4.25
	2EH	1.75	1.30	0.45
	2EJ	5.23	4.21	1.02
	2EK	2.21	1.63	0.58
	2FA	5.30	2.00	3.30
	2FB	2.53	0.81	1.73
	2FC	18.94	6.57	12.37
	2GA	3.43	1.38	2.05
	2GB	7.09	3.04	4.05
	2GC	5.73	2.50	3.23
	2GD	10.20	4.28	5.92
	2H-1	34.51	20.53	13.98
	2H-2	18.08	11.11	6.97
	2H-3	0.73	0.34	0.40
	2J	10.56	8.45	2.11
	2KA	14.17	8.75	5.42
	2KB	5.94	4.20	1.74
	2KC	10.83	8.25	2.58
ACA	3AA	42.85	32.14	10.71
	3AB	25.97	22.12	3.86
	3AC	51.97	29.04	22.92
	3BA	247.98	167.08	80.90
	3BB	43.20	30.52	12.69
	3BC	26.94	22.63	4.31
	3BD	16.92	11.94	4.99
	3CB	27.24	22.23	5.01
	3DA	17.63	11.40	6.23
	3DB	4.24	3.30	0.93
	3EA	20.23	14.91	5.32
	3EB	7.60	5.71	1.89
	3EC	8.44	6.79	1.66
	3ED	5.09	4.22	0.86
	3FA	51.60	47.10	4.50
	3FB	27.02	25.40	1.62
	3G	73.16	72.21	0.95
	3HA	14.55	14.37	0.18
	3HB	23.28	22.20	1.08
	3HC	24.14	21.24	2.90
	3HD1	7.85	7.11	0.74
	3HD2	8.24	7.84	0.40
	3J	41.40	40.88	0.53
	3K	19.51	14.76	4.74
	3LA	75.78	68.86	6.92
	3LB	9.12	8.42	0.70
	3MA-1	32.36	31.63	0.73
	3MA-2	43.61	43.04	0.57
	3MB	4.47	3.33	1.14
	3MC	2.34	1.85	0.49
	3MD1	87.88	57.13	30.74
	3MD2	21.53	13.50	8.03
	3N	27.04	26.53	0.51

CA	Sub-basin	TCA and ENNCA		
		Total	SW	GW
TCA	4AA	9.70	8.80	0.90
	4AB	12.62	11.01	1.61
	4AC	10.36	8.36	2.00
	4AD	17.55	14.87	2.68
	4BA	8.99	7.57	1.41
	4BB	13.55	12.95	0.60
	4BC	33.12	32.15	0.97
	4BD	18.49	15.80	2.70
	4BE	22.03	19.04	2.99
	4BF	9.95	7.70	2.24
	4BG	7.40	6.49	0.91
	4CA	15.38	12.92	2.45
	4CB	10.11	8.80	1.30
	4CC	38.29	34.92	3.37
	4DA	103.32	100.09	3.23
	4DB	67.38	65.17	2.22
	4DC	22.20	20.42	1.78
	4DD	7.44	6.84	0.60
	4DE	5.59	4.70	0.89
	4EA	32.74	30.74	2.00
	4EB	31.13	27.64	3.49
	4EC	18.19	16.34	1.85
	4ED	39.89	37.90	1.99
	4FA	63.71	60.92	2.80
	4FB	74.64	72.67	1.97
	4GA	18.27	17.74	0.53
	4GB	11.92	10.27	1.65
	4GC	4.96	4.30	0.66
	4GD	14.39	13.66	0.73
	4GE	22.23	18.50	3.73
	4GF	28.76	25.52	3.24
	4GG	28.09	25.89	2.19
	4HA	9.90	7.52	2.38
	4HB	13.44	13.08	0.36
	4HC	10.53	10.12	0.41
	4JA	10.34	9.40	0.94
	4JB	4.19	3.89	0.30
	4KA	8.40	7.74	0.67
	4KB	11.35	10.32	1.03
ENNCA	5AA	8.63	6.17	2.46
	5AB	3.01	1.92	1.09
	5AC	5.34	4.55	0.79
	5AD	5.73	5.31	0.41
	5BA	2.55	2.19	0.36
	5BB	7.61	6.77	0.84
	5BC-1	8.86	6.81	2.05
	5BC-2	4.26	4.19	0.08
	5BD	2.78	1.90	0.88
	5BE	16.92	14.75	2.18
	5CA	5.10	4.01	1.09
	5CB	0.83	0.48	0.35
	5CC	1.24	0.79	0.45
	5DA	30.70	28.21	2.49
	5DB	3.98	3.52	0.46
	5DC	3.52	3.29	0.23
	5DD	1.09	0.91	0.18
	5EA	12.86	10.27	2.59
	5EB	11.47	9.19	2.29
	5EC	8.68	7.48	1.20
	5ED	12.33	7.24	5.09
	5FA	9.96	6.91	3.05
	5FB	2.59	2.24	0.35
	5G	18.05	15.84	2.21
	5HA	16.07	15.44	0.63
	5HB	7.07	6.32	0.74
	5J	4.81	3.92	0.89

Source JICA Study Team

Table 3.4.1 Annual Deficit by Sub-basin under Present (2010) Water Demands and Existing Water Resources Structures Conditions

(Unit: MCM/year)

CA	Sub-basin	LVNCA and LVSCA Domestic and	Irrigation	Total
LVNCA	1AA	-0.28	-0.10	-0.38
	1AB	-0.21	-0.01	-0.23
	1AC	-0.50	-0.01	-0.51
	1AD	-0.48	-0.11	-0.59
	1AE	-0.61	-0.17	-0.78
	1AF	-1.14	-0.18	-1.32
	1AG	-1.18	-0.15	-1.33
	1AH	-1.37	-0.52	-1.89
	1BA	-0.41	-0.51	-0.92
	1BB	-0.40	-0.33	-0.73
	1BC	-0.40	-0.32	-0.72
	1BD	-1.07	-0.10	-1.17
	1BE	-1.31	-0.17	-1.49
	1BG	-2.10	-0.13	-2.23
	1BH	-0.76	-0.05	-0.81
	1CA	-1.08	-0.19	-1.27
	1CB	-0.17	0.00	-0.17
	1CC	-0.47	-0.10	-0.57
	1CD	-0.10	-0.12	-0.22
	1CE	0.00	0.00	0.00
	1DA	-0.26	0.00	-0.26
	1DB	-0.82	-0.04	-0.86
	1DC	-0.34	-0.01	-0.35
	1DD	-0.66	0.00	-0.66
	1EA	-0.56	-0.07	-0.63
	1EB	-0.91	-0.01	-0.92
	1EC	-0.65	-0.04	-0.68
	1ED	-0.27	0.00	-0.27
	1EE	0.00	0.00	0.00
	1EF	0.00	0.00	0.00
	1EG	-0.98	-0.44	-1.43
	1FA	-0.30	-0.03	-0.33
	1FB	-0.21	-0.07	-0.28
	1FC	-0.16	-0.05	-0.22
	1FD	-0.20	-0.09	-0.28
	1FE	-0.96	-0.07	-1.03
	1FF	-1.70	-0.01	-1.71
	1FG	0.00	0.00	0.00
LVSCA	1GA	0.00	0.00	0.00
	1GB	-0.01	-0.23	-0.25
	1GC	-0.58	-0.11	-0.69
	1GD	-0.63	-4.77	-5.40
	1GE	-1.35	-7.62	-8.98
	1GF	-0.17	-2.45	-2.62
	1GG	-0.07	-0.14	-0.22
	1HA1	-0.90	-7.43	-8.33
	1HA2	-2.78	-17.58	-20.36
	1HB1	-0.29	-10.56	-10.85
	1HB2	-0.31	-10.65	-10.96
	1HC	-2.55	-2.94	-5.49
	1HD	-1.45	-9.94	-11.39
	1HE	-1.06	-10.71	-11.77
	1HF	-2.50	-32.90	-35.40
	1HG	-0.51	-9.45	-9.96
	1JA	0.00	0.00	0.00
	1JB	-0.03	-0.01	-0.04
	1JC	-0.21	0.00	-0.21
	1JD	0.00	0.00	0.00
	1JE	-0.16	-0.04	-0.20
	1JF	-0.26	0.00	-0.26
	1JG1	0.00	0.00	0.00
	1JG2	0.00	0.00	0.00
	1KA	-0.48	-0.52	-1.00
	1KB	-1.56	-1.62	-3.18
	1KC	-0.78	-0.05	-0.83
	1LA1	-0.31	0.00	-0.31
	1LA2	-0.04	0.00	-0.04
	1LA3	-0.12	-0.15	-0.27
	1LB1	0.00	0.00	0.00
	1LB2	-0.13	-0.59	-0.72

CA	Sub-basin	RVCA and ACA Domestic and	Irrigation	Total
RVCA	2AA	-0.05	0.00	-0.05
	2AB	-0.16	-5.97	-6.13
	2BA	-0.09	-1.41	-1.51
	2BB	-0.06	-1.78	-1.84
	2BC	0.00	0.00	0.00
	2BD	-0.03	-1.90	-1.93
	2CA	-0.06	-2.16	-2.22
	2CB	-0.26	-3.94	-4.20
	2CC	-0.05	-5.15	-5.20
	2D	-0.37	-14.43	-14.79
	2EA	-0.86	-0.28	-1.14
	2EB	-0.75	-0.63	-1.38
	2EC	-2.44	-0.75	-3.19
	2ED	-0.05	-0.38	-0.43
	2EE	-0.05	-0.64	-0.68
	2EF	-0.04	-0.36	-0.39
	2EG1	-0.25	-0.35	-0.60
	2EG2	-0.78	-1.15	-1.93
	2EH	-0.04	-0.46	-0.50
	2EJ	-0.19	-2.16	-2.35
	2EK	-0.09	-0.75	-0.84
	2FA	-0.54	-0.45	-0.99
	2FB	-0.38	-0.12	-0.50
	2FC	-2.65	-1.25	-3.90
	2GA	-0.23	-0.20	-0.43
	2GB	-0.24	-0.09	-0.33
	2GC	-0.19	-0.05	-0.24
	2GD	-0.28	-0.18	-0.46
	2H-1	-2.74	-15.00	-17.74
	2H-2	-1.31	-8.88	-10.19
	2H-3	-0.07	0.00	-0.07
	2J	-0.35	0.00	-0.35
	2KA	-0.49	-0.42	-0.91
	2KB	-0.14	-0.26	-0.40
	2KC	-0.50	-3.39	-3.89
ACA	3AA	-11.70	-9.33	-21.02
	3AB	-5.93	-12.15	-18.08
	3AC	-20.61	-2.22	-22.83
	3BA	-128.26	-10.58	-138.84
	3BB	-15.23	-4.87	-20.10
	3BC	-1.92	-8.10	-10.02
	3BD	-0.90	-5.14	-6.04
	3CB	-0.46	-9.41	-9.87
	3DA	-0.54	-0.47	-1.00
	3DB	-0.20	-0.81	-1.00
	3EA	-8.26	-2.21	-10.47
	3EB	-1.58	-2.99	-4.57
	3EC	-2.23	-2.82	-5.05
	3ED	-0.99	-2.43	-3.42
	3FA	-3.02	-28.82	-31.84
	3FB	-0.56	-14.97	-15.53
	3G	-1.24	-68.67	-69.91
	3HA	-0.08	-11.66	-11.74
	3HB	-0.65	-16.55	-17.20
	3HC	-2.91	-17.91	-20.82
	3HD1	-0.48	-5.27	-5.75
	3HD2	-0.40	-7.30	-7.70
	3J	-0.93	-39.24	-40.17
	3K	-1.83	-4.08	-5.91
	3LA	-7.86	-58.65	-66.51
	3LB	-1.40	-6.58	-7.98
	3MA-1	-1.31	-29.13	-30.44
	3MA-2	-0.52	-41.62	-42.14
	3MB	-1.11	-1.53	-2.64
	3MC	-0.40	-1.04	-1.44
	3MD1	-55.40	-0.57	-55.97
	3MD2	-13.19	-0.12	-13.31
	3N	-0.59	-24.78	-25.37

CA	Sub-basin	TCA and ENNCA Domestic and	Irrigation	Total
TCA	4AA	-0.13	-3.35	-3.48
	4AB	-0.20	-3.13	-3.33
	4AC	-0.68	-1.96	-2.64
	4AD	-0.28	-3.62	-3.90
	4BA	-0.56	-2.73	-3.29
	4BB	0.00	-5.17	-5.17
	4BC	-0.42	-17.51	-17.93
	4BD	-1.88	-7.53	-9.41
	4BE	-2.36	-8.06	-10.42
	4BF	-0.77	-0.51	-1.28
	4BG	-0.74	-2.80	-3.54
	4CA	-0.46	-0.55	-1.02
	4CB	-0.11	-0.30	-0.41
	4CC	-2.68	-21.37	-24.05
	4DA	0.00	-48.69	-48.69
	4DB	-0.29	-37.07	-37.36
	4DC	-0.26	-6.11	-6.38
	4DD	-0.26	-4.08	-4.34
	4DE	-0.50	-1.71	-2.21
	4EA	-0.19	-7.60	-7.79
	4EB	-0.13	-1.05	-1.17
	4EC	-0.18	-1.39	-1.57
	4ED	-0.44	-12.37	-12.81
	4FA	-0.30	-14.63	-14.93
	4FB	-0.49	-24.85	-25.34
	4GA	-0.20	-6.74	-6.94
	4GB	-0.45	-2.54	-2.99
	4GC	-0.21	-0.43	-0.63
	4GD	-0.13	-4.77	-4.90
	4GE	-1.33	-5.40	-6.73
	4GF	-0.94	-8.69	-9.63
	4GG	-0.80	-9.84	-10.64
	4HA	-0.35	-0.03	-0.39
	4HB	-0.32	-8.17	-8.49
	4HC	-0.44	-8.97	-9.41
	4JA	-0.98	-6.14	-7.12
	4JB	-0.29	-2.37	-2.67
	4KA	-0.64	-5.26	-5.90
	4KB	-1.33	-5.97	-7.30
ENNCA	5AA	-0.60	-0.45	-1.04
	5AB	-0.24	-0.18	-0.42
	5AC	-0.13	-0.70	-0.83
	5AD	-0.12	-3.64	-3.76
	5BA	-0.10	-1.03	-1.13
	5BB	-0.27	-2.76	-3.03
	5BC-1	-0.01	-1.04	-1.05
	5BC-2	-0.02	-1.76	-1.78
	5BD	-0.15	-0.26	-0.40
	5BE	-0.33	-5.06	-5.39
	5CA	-0.46	-1.82	-2.28
	5CB	-0.19	0.00	-0.19
	5CC	-0.28	0.00	-0.28
	5DA	-0.42	-8.48	-8.90
	5DB	-0.30	-2.79	-3.09
	5DC	-0.08	-0.95	-1.02
	5DD	-0.04	-0.24	-0.28
	5EA	-1.72	-1.58	-3.30
	5EB	-1.53	-2.62	-4.15
	5EC	-0.80	-4.93	-5.73
	5ED	-2.84	0.00	-2.84
	5FA	-2.04	0.00	-2.04
	5FB	-0.23	-0.54	-0.77
	5G	-1.47	0.00	-1.47
	5HA	-0.42	-11.79	-12.21
	5HB	-0.50	0.00	-0.50
	5J	-0.60	0.00	-0.60

LVNCA Total	-23	-4	-27	RVCA Total	-17	-75	-92	TCA Total	-23	-313	-336
LVSCA Total	-19	-130	-150	ACA Total	-293	-452	-745	ENNCA Total	-16	-53	-68

Note: Deficit for domestic and industrial uses is estimated with 10-year probability and that for irrigation use is estimated with 5-year probability.

Source JICA Study Team

Table 3.4.2 Annual Deficit by Sub-basin under Future (2030) Water Demands and Existing Water Resources Structures Conditions

(Unit: MCM/year)

CA	Sub-basin	LVNCA and LVSCA Domestic and	Irrigation	Total
LVNCA	1AA	-0.03	-7.87	-7.90
	1AB	-0.53	-1.39	-1.92
	1AC	-0.21	-0.84	-1.05
	1AD	-0.91	-12.73	-13.64
	1AE	-0.03	-17.88	-17.90
	1AF	-0.06	-15.16	-15.22
	1AG	-0.11	-12.31	-12.42
	1AH	-5.40	-64.72	-70.11
	1BA	0.00	-5.44	-5.44
	1BB	0.00	-4.91	-4.91
	1BC	-1.15	-4.53	-5.68
	1BD	0.00	-3.52	-3.52
	1BE	0.00	-6.23	-6.23
	1BG	-5.12	-9.35	-14.47
	1BH	-3.74	-5.84	-9.58
	1CA	0.00	-3.00	-3.00
	1CB	-13.48	-4.58	-18.06
	1CC	0.00	-1.52	-1.52
	1CD	0.00	0.00	0.00
	1CE	0.00	0.00	0.00
	1DA	0.00	0.00	0.00
	1DB	0.00	-1.59	-1.59
	1DC	0.00	0.00	0.00
	1DD	0.00	0.00	0.00
	1EA	0.00	-1.86	-1.86
	1EB	-0.12	-2.07	-2.19
	1EC	0.00	-1.56	-1.56
	1ED	-6.48	-1.19	-7.67
	1EE	0.00	-1.21	-1.21
	1EF	0.00	-16.58	-16.58
	1EG	-1.32	-36.73	-38.04
	1FA	-0.20	-1.25	-1.45
	1FB	0.00	-0.69	-0.69
	1FC	-3.42	-1.39	-4.81
	1FD	0.00	-1.38	-1.38
	1FE	0.00	-3.43	-3.43
	1FF	-18.88	-6.81	-25.69
	1FG	0.00	-49.92	-49.92
LVSCA	1GA	0.00	-1.59	-1.59
	1GB	0.00	-5.23	-5.23
	1GC	-2.06	-5.73	-7.80
	1GD	-5.78	-43.98	-49.76
	1GE	-0.46	-31.74	-32.19
	1GF	-0.07	-31.31	-31.38
	1GG	0.00	-3.00	-3.00
	1HA1	-42.45	-50.29	-92.74
	1HA2	-0.05	-62.56	-62.61
	1HB1	-0.15	-57.58	-57.72
	1HB2	0.00	-53.41	-53.41
	1HC	-0.67	-86.36	-87.04
	1HD	-4.54	-51.41	-55.95
	1HE	-0.94	-49.93	-50.88
	1HF	-7.72	-122.65	-130.37
	1HG	-1.27	-38.75	-40.02
	1JA	0.00	-7.19	-7.19
	1JB	0.00	-6.42	-6.42
	1JC	-2.99	-1.88	-4.87
	1JD	-0.08	-1.22	-1.30
	1JE	0.00	-12.22	-12.22
	1JF	0.00	-16.83	-16.83
	1JG1	0.00	-1.95	-1.95
	1JG2	-0.03	-5.05	-5.08
	1KA	-17.73	-38.52	-56.24
	1KB	-2.28	-298.10	-300.38
	1KC	-0.56	-109.94	-110.49
	1LA1	-0.91	-9.81	-10.72
	1LA2	0.00	-0.23	-0.23
	1LA3	-0.15	-2.52	-2.67
	1LB1	0.00	-2.73	-2.73
	1LB2	-0.06	-3.25	-3.31

CA	Sub-basin	RVCA and ACA Domestic and	Irrigation	Total
RVCA	2AA	-0.33	-8.23	-8.56
	2AB	-0.95	-29.17	-30.12
	2BA	-0.22	-3.71	-3.93
	2BB	-0.07	-3.94	-4.02
	2BC	0.00	0.00	0.00
	2BD	0.00	0.00	0.00
	2CA	-0.09	-10.56	-10.64
	2CB	-5.03	-24.23	-29.27
	2CC	-0.62	-40.48	-41.09
	2D	-1.16	-90.05	-91.22
	2EA	-2.18	-2.38	-4.56
	2EB	-1.71	-3.62	-5.33
	2EC	-6.10	-5.32	-11.42
	2ED	-2.50	-1.23	-3.73
	2EE	0.00	-3.40	-3.40
	2EF	-0.24	-1.01	-1.25
	2EG1	-7.37	-2.58	-9.96
	2EG2	-2.11	-6.31	-8.42
	2EH	0.00	-2.82	-2.82
	2EJ	-0.35	-15.94	-16.29
	2EK	-0.22	-5.53	-5.75
	2FA	-0.58	-3.52	-4.10
	2FB	-0.72	-1.17	-1.90
	2FC	-59.23	-14.27	-73.50
	2GA	-5.94	-2.79	-8.73
	2GB	-5.05	-3.31	-8.37
	2GC	0.00	-0.25	-0.25
	2GD	-27.28	-10.62	-37.91
	2H-1	-4.71	-110.69	-115.40
	2H-2	-1.86	-105.06	-106.92
	2H-3	-0.44	-96.31	-96.75
	2J	-5.62	-65.70	-71.32
	2KA	-2.41	-8.94	-11.35
	2KB	-0.05	-6.48	-6.53
	2KC	-0.09	-32.16	-32.25
ACA	3AA	-50.44	-23.21	-73.66
	3AB	-0.13	-38.48	-38.61
	3AC	-0.38	-14.44	-14.83
	3BA	-361.58	-65.87	-488.02
	3BB	-10.56	-48.01	-58.56
	3BC	-27.16	-91.73	-118.88
	3BD	-4.46	-43.97	-48.43
	3CB	-15.86	-60.27	-76.13
	3DA	-12.02	-23.83	-35.85
	3DB	-1.59	-14.24	-15.83
	3EA	-29.48	-21.74	-51.22
	3EB	-2.36	-31.78	-34.14
	3EC	-4.22	-37.74	-41.96
	3ED	-2.57	-32.73	-35.30
	3FA	-13.30	-349.62	-362.91
	3FB	-2.94	-234.57	-237.51
	3G	-3.12	-470.50	-473.61
	3HA	-0.04	-92.45	-92.49
	3HB	-0.35	-148.02	-148.37
	3HC	-1.33	-48.05	-49.38
	3HD1	-0.26	-10.11	-10.37
	3HD2	-0.19	-10.45	-10.64
	3J	-4.35	-253.57	-257.91
	3K	-8.95	-35.71	-44.67
	3LA	-13.82	-410.66	-424.48
	3LB	-29.70	-13.24	-42.94
	3MA-1	-0.67	-263.75	-264.42
	3MA-2	-0.61	-263.11	-263.72
	3MB	-0.80	-14.64	-15.43
	3MC	-3.37	-8.60	-11.96
	3MD1	-188.46	-11.38	-199.84
	3MD2	-0.14	-1.07	-1.21
	3N	-1.18	-108.87	-110.06

CA	Sub-basin	TCA and ENNCA Domestic and	Irrigation	Total
TCA	4AA	0.00	-20.04	-20.04
	4AB	0.00	-21.56	-21.56
	4AC	-10.47	-26.65	-37.11
	4AD	0.00	-18.69	-18.69
	4BA	0.00	-17.65	-17.65
	4BB	0.00	-18.10	-18.10
	4BC	-2.13	-127.45	-129.58
	4BD	0.00	-3.49	-3.49
	4BE	-3.00	-52.04	-55.05
	4BF	-7.82	-26.58	-34.40
	4BG	-0.57	-21.00	-21.57
	4CA	0.00	-23.25	-23.25
	4CB	0.00	-30.50	-30.50
	4CC	-6.20	-86.85	-93.05
	4DA	-1.09	-430.80	-431.89
	4DB	0.00	-260.16	-260.16
	4DC	0.00	-17.47	-17.47
	4DD	-0.18	-34.80	-34.98
	4DE	-0.27	-14.22	-14.49
	4EA	0.00	-15.12	-15.12
	4EB	0.00	-22.85	-22.85
	4EC	-3.29	-62.13	-65.42
	4ED	-3.59	-116.37	-119.96
	4FA	0.00	-79.49	-79.49
	4FB	-1.17	-271.81	-272.98
	4GA	-0.08	-50.41	-50.48
	4GB	-0.06	-170.46	-170.52
	4GC	-1.35	-69.72	-71.08
	4GD	-0.14	-274.95	-275.10
	4GE	-0.85	-281.83	-282.68
	4GF	-1.09	-480.98	-482.07
	4GG	-0.58	-189.95	-190.53
	4HA	-6.04	-33.99	-40.03
	4HB	-0.51	-322.02	-322.53
	4HC	-0.48	-243.65	-244.13
	4JA	-0.55	-564.53	-565.08
	4JB	-0.11	-214.51	-214.61
	4KA	-0.20	-477.47	-477.67
	4KB	-60.92	-515.31	-576.22
ENNCA	5AA	-5.13	-9.74	-14.86
	5AB	-0.29	-3.64	-3.93
	5AC	-0.04	-15.96	-16.00
	5AD	-0.02	-11.64	-11.65
	5BA	0.00	-10.08	-10.08
	5BB	0.00	-31.22	-31.22
	5BC-1	0.00	-19.48	-19.48
	5BC-2	-0.04	-26.35	-26.38
	5BD	0.00	-5.13	-5.13
	5BE	-3.85	-49.40	-53.25
	5CA	-0.84	-24.47	-25.31
	5CB	-0.49	-2.53	-3.02
	5CC	-0.63	-3.36	-3.99
	5DA	-5.47	-146.38	-151.85
	5DB	-0.27	-29.02	-29.29
	5DC	-0.12	-20.16	-20.28
	5DD	-0.15	-3.74	-3.90
	5EA	-7.47	-37.55	-45.02
	5EB	-2.28	-40.25	-42.53
	5EC	-2.80	-52.24	-55.04
	5ED	-5.27	-570.73	-576.01
	5FA	-2.87	-1018.19	-1021.05
	5FB	-0.69	-12.48	-13.17
	5G	-6.52	-131.00	-137.52
	5HA	-6.24	-38.38	-44.62
	5HB	-1.47	-55.92	-57.39
	5J	-1.44	-18.10	-19.54

LVNCA Total	-61	-309	-371	RVCA Total	-145	-722	-867	TCA Total	-113	-5,709	-5,822
LVSCA Total	-91	-1,213	-1,304	ACA Total	-796	-3,296	-4,153	ENNCA Total	-54	-2,387	-2,442

Note: Deficit for domestic and industrial uses is estimated with 10-year probability and that for irrigation use is estimated with 5-year probability.

Source JICA Study Team

Table 4.3.1 Reserve Quantity by Sub-basin for Water Balance Study

(Unit: m^3/s)

CA	Sub-basin	LVNCA and LVSCA	CA	Sub-basin	RVCA and ACA	CA	Sub-basin	TCA and ENNCA
LVNCA	1AA	0.3	RVCA	2AA	0.0	TCA	4AA	1.0
	1AB	0.7		2AB	0.0		4AB	1.5
	1AC	0.0		2BA	0.0		4AC	4.8
	1AD	1.0		2BB	0.0		4AD	2.2
	1AE	0.2		2BC	0.0		4BA	7.4
	1AF	0.6		2BD	0.0		4BB	0.8
	1AG	0.2		2CA	0.0		4BC	9.9
	1AH	1.0		2CB	0.0		4BD	1.6
	1BA	0.2		2CC	0.0		4BE	13.5
	1BB	1.6		2D	0.0		4BF	1.8
	1BC	0.7		2EA	0.0		4BG	16.4
	1BD	4.2		2EB	0.0		4CA	4.1
	1BE	2.8		2EC	0.0		4CB	2.7
	1BG	7.0		2ED	0.0		4CC	9.4
	1BH	1.0		2EE	0.0		4DA	3.2
	1CA	1.5		2EF	0.0		4DB	0.4
	1CB	1.2		2EG1	0.0		4DC	0.5
	1CC	2.8		2EG2	0.0		4DD	3.5
	1CD	4.1		2EH	0.0		4DE	26.3
	1CE	8.0		2EJ	0.0		4EA	8.3
	1DA	17.3		2EK	0.0		4EB	4.5
	1DB	3.3		2FA	0.0		4EC	3.7
	1DC	22.1		2FB	0.0		4ED	39.7
	1DD	23.8		2FC	0.0		4FA	52.1
	1EA	4.0		2GA	0.0		4FB	53.5
	1EB	7.5		2GB	0.0		4GA	56.3
	1EC	2.1		2GC	0.0		4GB	55.0
	1ED	10.4		2GD	0.0		4GC	53.5
	1EE	34.1		2H-1	0.0		4GD	51.0
	1EF	33.5		2H-2	0.0		4GE	49.1
	1EG	0.8		2H-3	0.0		4GF	43.8
	1FA	0.2		2J	0.0		4GG	35.2
	1FB	1.8		2KA	0.0		4HA	3.3
	1FC	3.0		2KB	0.0		4HB	0.0
	1FD	1.5		2KC	0.0		4HC	0.0
	1FE	6.8	ACA	3AA	1.2		4JA	0.0
	1FF	0.0		3AB	0.1		4JB	0.0
	1FG	4.3		3AC	6.1		4KA	0.0
LVSCA	1GA	0.6		3BA	4.8		4KB	0.0
	1GB	0.8		3BB	0.3	ENNCA	5AA	0.2
	1GC	2.0		3BC	2.0		5AB	0.1
	1GD	1.3		3BD	0.7		5AC	0.3
	1GE	0.0		3CB	1.5		5AD	0.0
	1GF	0.0		3DA	8.5		5BA	0.1
	1GG	0.3		3DB	8.9		5BB	0.2
	1HA1	0.4		3EA	0.0		5BC-1	0.8
	1HA2	0.0		3EB	0.0		5BC-2	0.8
	1HB1	0.0		3EC	0.0		5BD	0.3
	1HB2	0.0		3ED	0.0		5BE	0.1
	1HC	0.0		3FA	10.1		5CA	0.1
	1HD	0.0		3FB	9.1		5CB	0.0
	1HE	0.0		3G	0.0		5CC	0.0
	1HF	0.0		3HA	8.9		5DA	1.6
	1HG	0.0		3HB	5.8		5DB	0.0
	1JA	3.2		3HC	0.0		5DC	1.3
	1JB	0.5		3HD1	2.5		5DD	1.2
	1JC	1.7		3HD2	0.0		5EA	0.0
	1JD	6.6		3J	0.0		5EB	0.0
	1JE	0.7		3K	0.0		5EC	0.0
	1JF	3.9		3LA	0.0		5ED	0.0
	1JG1	10.2		3LB	0.0		5FA	0.0
	1JG2	10.5		3MA-1	0.0		5FB	0.0
	1KA	0.0		3MA-2	0.0		5G	0.0
	1KB	2.3		3MB	0.0		5HA	0.0
	1KC	1.7		3MC	0.0		5HB	0.0
	1LA1	1.2		3MD1	0.0		5J	0.0
	1LA2	4.8		3MD2	0.0			
	1LA3	5.7		3N	0.0			
	1LB1	1.6						
	1LB2	0.0						

Source: JICA Study Team based on WRMA Guidelines for Water Allocation

Table 4.4.1 Proposed Dams

Catch-ment Area		Name of Dam	Sub-basin	Relevant County	Purpose [1)]	Effective Storage (MCM)	Yield (m^3/s)	Study Stage [2)]	Estimated Cost (KSh million)
LVNCA	1	Siyoi	1BC	Trans-Nzoia, West Pokot	W (Kapenguria)	4.1	4.7	D/D to be completed in 2013	2,898
	2	Moi's Bridge	1BE	Trans-Nzoia	W (Moi's Bridge, Matunda), I (19,800 ha)	214.0	11.4	NWMP 2030	5,114
	3	Nzoia (34B)	1BG	Bungoma,	I (24,000 ha), P (16 MW), F	203.7	33.4	D/D to be completed in 2013	4,006
	4	Kibolo	1CE	Uasin Gishu	W (Lumakanda), I (11,500 ha)	40.0	21.7	NWMP 2030	5,455
	5	Teremi	1DB	Bungoma	W (Kimilili, Bungoma, Chwele)	3.0	36.2	NWMP 2030	3,580
	6	Nzoia (42A)	1EE	Siaya	I (10,470 ha), P (25 MW), F	395.0	93.1	D/D to be completed in 2013	8,694
	7	Nandi Forest	1FD	Nandi	W (Yala, Kisumu in LVSCA), I (7,272 ha in LVSCA), P (50 MW)	220.0	74.1	D/D completed	17,474
		Total				1,079.8	274.7		47,221
LVSCA	8	Londiani	1GC	Kericho	W (Londiani, Kipkerion and RVCA)	25.0	2.6	Pre-F/S done in 2012	6,137
	9	Nyando (Koru)	1GD1	Kisumu, Kericho	W (Muhoroni, Awasi, Ahero, Kisumu), I (3,000 ha), F	86.6	4.6	Preliminary Design ongoing	19,179
	10	Kibos	1HA	Nandi	W (Kisumu), F	26.0	1.0	NWMP 2030	8,950
	11	Itare	1JA	Nakuru	W (Litein and RVCA)	20.0	0.0	NWMP 2030	5,114
	12	Magwagwa	1JG	Bomet, Nyamira	W, I (15,000 ha), P (115 MW), F	445.0	20.2	D/D completed	20,202
	13	Bunyunyu	1KB	Kisii	W (Rongo, Tabaka, Suneka, Kisii, Awendo, Ogembo, Keroko)	6.3	0.1	Final Design completed	2,046
	14	Katieno	1KB	Migori	I (40,500ha)	201.0	21.5	Pre-F/S done	5,455
	15	Ilooiterre	1KC	Narok	W, I (3,000 ha)	13.6	2.6	Proposed by ENSDA	1,449
	16	Sand River (Naikara)	1LA3	Narok	W, F	20.0	0.1	NWMP 2030	5,711
	17	Amala	1LB1	Bomet, Narok	W, I (5,000 ha and RVCA)	175.0	4.8	NWMP 2030	20,031
		Total				1,018.5	57.5		94,274
RVCA	18	Murung-Sebit	2BB	West Pokot	I (850 ha), F	40.0	10.1	Proposed by KVDA	6,819
	19	Kimwarer	2CB	Elgiyo Marakwet	W, I (2,000 ha), P (20 MW)	107.0	4.3	Pre-F/S done	13,638
	20	Arror	2CC	Elgiyo Marakwet	W, I (10,850 ha), P (80 MW), F	62.0	3.0	D/D completed	11,422
	21	Embobut	2CC	West Pokot	W, I (2,000 ha), P (45 MW)	30.0	10.1	Pre-F/S done	3,239
	22	Waseges	2EB	Baringo	W	4.0	0.2	NWMP 2030	3,239
	23	Malewa	2GB	Nyandarua	W (Naivasha)	34.0	1.4	NWMP 2030	4,262
	24	Upper Narok	2KA	Narok	W (Narok), I (2,000 ha), F	29.0	2.2	NWMP 2030	5,967
	25	Oletukat	2KA	Narok	W, P (36 MW)	300.0	4.7	F/S, D/D to be completed in 2013	38,784
	26	Leshota	2KB	Narok	W, P (54 MW)	33.0	1.6	F/S, D/D to be completed in 2013	7,842
	27	Oldorko	2KB	Narok	W, I (15,000 ha with Oletukat Dam), P (90 MW)	20.0	6.4	F/S, D/D to be completed in 2013	2,898
		Total				659.0			98,110
ACA	28	Upper Athi	3AA	Machakos	W (Nairobi)	24.0	0.2	NWMP 2030	2,813
	29	Stony Athi	3AB	Machakos	W (Nairobi)	23.0	0.2	F/S and M/P ongoing	4,006
	30	Kikuyu	3BA	Nairobi	W (Nairobi)	31.0	1.3	NWMP 2030	4,092
	31	Ruaka (Kiambaa)	3BA	Nairobi	W (Nairobi)	4.0	0.9	D/D completed	1,961
	32	Kamiti 1	3BB	Kiambu	W (Nairobi)	16.0	0.1	F/S and M/P ongoing	6,308
	33	Ruiru-A (Ruiru 2)	3BC	Kiambu	W (Nairobi)	18.0	0.9	NWMP 2030	6,990
	34	Ndarugu	3CB	Kiambu	W (Nairobi)	300.0	0.3	F/S and M/P ongoing	5,029
	35	Munyu	3DA	Machakos	I (15,000 ha), P (40 MW)	575.0	8.8	F/S done	10,229
	36	Mbuuni	3EA	Machakos	W (Machakos, Kangundo Tala)	10.0	0.4	NWMP 2030	2,557
	37	Kiteta	3EB	Makueni	W	16.0	0.2	Pre-F/S done	2,983
	38	Thwake	3FA	Makueni, Kitui	W, I (17,000 ha), P (20 MW)	594.0	29.5	Final Design completed	8,439
	39	Olkishunki	3FA	Kajiado	W	1.2	0.1	Proposed by ENSDA	1,364
	40	Pemba	3HC	Kwale	W (Kwale)	19.0	0.5	NWMP 2030	5,455
	41	Lake Chala	3J	Taita Taveta	W (Taveta), F	6.0	0.0	D/D ongoing	1,534
	42	Rare	3LA	Kilifi	W (Mombasa)	36.0	0.1	D/D to be completed in 2013	3,580
	43	Mwachi	3MA	Kwale	W (Mombasa, Mtwapa)	16.0	0.2	Preliminary Design completed	4,262
		Total				1,689.2	43.6		71,602
TCA	44	Maragua 4	4BE	Muranga	W (Nairobi in ACA)	33.0	3.1	F/S and M/P ongoing	6,990
	45	Ndiara	4CA	Kiambu	W (Nairobi in ACA)	12.0	2.5	NWMP 2030	6,990
	46	Chania-B	4CA	Kiambu	W (Nairobi in ACA)	49.0	0.0	NWMP 2030	14,065
	47	Karimenu 2	4CA	Kiambu	W (Nairobi in ACA)	14.0	8.4	F/S and M/P ongoing	3,665
	48	Thika 3A	4CC	Kiambu	W (Nairobi in ACA)	13.0	2.3	F/S and M/P ongoing	3,239
	49	Yatta	4CC	Kiambu,	W (Matuu)	35.0	0.7	D/D completed	1,364
	50	Thiba	4DA	Kirinyaga, Embu	I (9,485 ha)	11.2	4.5	D/D completed	7,416
	51	High Grand Falls	4FB	Kitui, Tharaka	W (Garissa, Madogo, Hola, Masalani, Lamu), I (106,000 ha), P (700 MW), F	5,000.0	81.5	D/D completed	89,161
	52	Kora	4GA	Tana River, Isiolo	I (25,000 ha)	537.0	165.5	NWMP 2030	13,127
	53	Mutuni	4HA	Kitui	W (Kitui)	17.0	0.4	NWMP 2030	3,239
	54	Kitimui	4HA	Kitui, Machakos	W (Kitui)	8.0	0.3	NWMP 2030	4,859
		Total				5,729.2	269.3		154,115
ENNCA	55	Nyahururu	5AA	Nyandarua	W (Nyahururu, Rumuruti)	11.0	0.4	NWMP 2030	852
	56	Rumuruti	5AA	Laikipia	W (Rumuruti)	1.0	0.3	NWMP 2030	938
	57	Kihoto	5BC	Laikipia	I (18,000 ha)	389.0	16.4	NWMP 2030	13,894
	58	Isiolo	5DA	Isiolo	W (Isiolo)	21.0	0.0	F/S ongoing	2,642
	59	Archers' Post	5DA	Isiolo, Samburu	W, I (4,000 ha)	100.0	36.2	NWMP 2030	17,900
		Total				522.0	53.2		36,226
		Grand Total				10,697.7	698.3		501,548

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

Source: JICA Study Team based on data from MWI, NWCPC, NIB, MORDA, RDAs, WSBs

Table 4.4.2 Surface Water and Groundwater Demands by Sub-basin for 2030

(Unit: MCM/year)

CA	Sub-basin	LVNCA and LVSCA Total	SW	GW
LVNCA	1AA	7.14	5.49	1.65
	1AB	12.41	12.11	0.30
	1AC	4.25	2.94	1.31
	1AD	12.55	10.00	2.55
	1AE	6.31	3.60	2.70
	1AF	13.59	9.34	4.25
	1AG	12.45	8.12	4.33
	1AH	31.26	24.33	6.93
	1BA	7.70	4.78	2.91
	1BB	25.20	20.32	4.88
	1BC	27.13	21.72	5.41
	1BD	22.83	21.23	1.61
	1BE	198.35	192.93	5.43
	1BG	257.81	253.79	4.02
	1BH	36.48	35.88	0.59
	1CA	14.95	12.25	2.70
	1CB	62.16	58.53	3.63
	1CC	15.44	13.25	2.19
	1CD	16.45	15.84	0.62
	1CE	115.13	114.83	0.30
	1DA	97.44	96.77	0.67
	1DB	34.27	33.35	0.93
	1DC	21.94	21.48	0.46
	1DD	38.54	38.06	0.48
	1EA	24.72	24.14	0.58
	1EB	63.97	63.49	0.47
	1EC	15.26	14.93	0.32
	1ED	26.53	26.38	0.15
	1EE	130.86	130.46	0.40
	1EF	62.75	57.67	5.08
	1EG	52.94	49.58	3.36
	1FA	8.29	6.45	1.85
	1FB	11.13	9.70	1.42
	1FC	26.44	24.49	1.95
	1FD	14.04	11.67	2.38
	1FE	43.41	40.19	3.22
	1FF	46.38	42.63	3.75
	1FG	259.82	248.87	10.96
LVSCA	1GA	10.32	8.74	1.58
	1GB	21.34	18.01	3.34
	1GC	32.41	28.37	4.04
	1GD	84.03	75.33	8.70
	1GE	20.09	15.87	4.21
	1GF	17.28	11.78	5.49
	1GG	6.17	4.66	1.51
	1HA1	112.46	110.30	2.15
	1HA2	94.35	87.66	6.69
	1HB1	16.82	14.50	2.32
	1HB2	13.56	12.33	1.23
	1HC	11.78	8.97	2.81
	1HD	52.29	45.98	6.31
	1HE	26.76	19.34	7.42
	1HF	37.58	33.47	4.11
	1HG	13.18	12.53	0.65
	1JA	39.76	33.80	5.97
	1JB	3.90	2.05	1.86
	1JC	40.18	38.96	1.22
	1JD	15.17	14.42	0.75
	1JE	34.34	26.50	7.83
	1JF	34.81	30.37	4.44
	1JG1	151.01	150.45	0.56
	1JG2	8.53	7.59	0.94
	1KA	83.42	77.19	6.23
	1KB	525.67	498.22	27.46
	1KC	106.88	89.08	17.79
	1LA1	37.43	30.49	6.94
	1LA2	8.21	7.04	1.17
	1LA3	29.94	26.64	3.30
	1LB1	70.53	67.33	3.20
	1LB2	27.22	17.49	9.73

CA	Sub-basin	RVCA and ACA Total	SW	GW
RVCA	2AA	3.16	2.35	0.81
	2AB	12.30	11.65	0.65
	2BA	17.18	16.14	1.04
	2BB	92.35	90.64	1.71
	2BC	127.24	125.96	1.28
	2BD	38.46	32.82	5.64
	2CA	5.94	5.70	0.24
	2CB	62.05	58.46	3.60
	2CC	201.22	191.57	9.66
	2D	35.21	27.29	7.92
	2EA	6.48	6.31	0.17
	2EB	7.77	7.53	0.23
	2EC	14.93	14.66	0.27
	2ED	7.76	7.11	0.64
	2EE	4.28	3.77	0.51
	2EF	2.29	1.80	0.50
	2EG1	13.65	11.86	1.80
	2EG2	9.27	8.86	0.41
	2EH	3.09	1.76	1.33
	2EJ	7.38	6.10	1.28
	2EK	3.00	2.62	0.38
	2FA	4.34	4.19	0.16
	2FB	2.22	2.02	0.20
	2FC	87.64	85.81	1.82
	2GA	11.22	11.10	0.12
	2GB	25.49	25.27	0.23
	2GC	10.33	6.96	3.36
	2GD	46.95	41.77	5.18
	2H-1	33.88	21.85	12.03
	2H-2	15.02	11.30	3.72
	2H-3	1.61	0.93	0.68
	2J	19.25	16.88	2.37
	2KA	65.62	60.67	4.95
	2KB	245.15	244.16	1.00
	2KC	13.65	11.43	2.23
ACA	3AA	79.55	77.90	1.65
	3AB	17.99	8.46	9.53
	3AC	6.78	0.72	6.06
	3BA	505.22	500.78	4.45
	3BB	28.28	25.83	2.45
	3BC	64.81	63.03	1.77
	3BD	18.28	14.78	3.50
	3CB	45.50	43.73	1.76
	3DA	174.20	168.36	5.84
	3DB	10.55	6.39	4.16
	3EA	47.00	41.92	5.08
	3EB	10.08	4.46	5.61
	3EC	14.75	10.71	4.03
	3ED	8.71	4.27	4.45
	3FA	269.50	246.93	22.58
	3FB	39.42	31.90	7.52
	3G	14.56	7.89	6.67
	3HA	15.38	14.70	0.68
	3HB	25.91	22.03	3.88
	3HC	25.84	20.08	5.75
	3HD1	13.14	8.06	5.08
	3HD2	8.48	7.87	0.61
	3J	10.88	8.30	2.58
	3K	32.24	24.78	7.46
	3LA	87.73	67.42	20.31
	3LB	43.93	33.76	10.17
	3MA-1	32.61	25.06	7.55
	3MA-2	45.98	35.34	10.64
	3MB	7.41	5.70	1.72
	3MC	6.25	0.00	1.45
	3MD1	199.05	152.98	46.08
	3MD2	1.27	0.98	0.29
	3N	8.90	4.24	4.65

CA	Sub-basin	TCA and ENNCA Total	SW	GW
TCA	4AA	11.17	10.62	0.55
	4AB	12.49	11.91	0.58
	4AC	41.61	41.19	0.41
	4AD	19.62	19.12	0.50
	4BA	11.64	11.38	0.26
	4BB	14.30	13.97	0.33
	4BC	35.44	35.21	0.23
	4BD	25.34	24.80	0.54
	4BE	29.71	29.03	0.69
	4BF	21.87	21.63	0.24
	4BG	8.58	8.37	0.21
	4CA	16.43	15.61	0.82
	4CB	11.99	11.46	0.52
	4CC	50.81	50.29	0.52
	4DA	114.12	113.45	0.67
	4DB	69.31	68.83	0.49
	4DC	35.67	35.14	0.53
	4DD	8.41	8.07	0.34
	4DE	6.23	5.98	0.25
	4EA	36.08	34.75	1.33
	4EB	44.48	42.17	2.31
	4EC	23.10	22.33	0.77
	4ED	46.37	45.34	1.03
	4FA	1,522.87	1,510.99	11.88
	4FB	117.71	81.78	35.92
	4GA	33.63	24.23	9.40
	4GB	355.17	348.92	6.24
	4GC	18.23	13.27	4.96
	4GD	37.13	23.77	13.36
	4GE	49.71	24.82	24.89
	4GF	72.98	44.39	28.59
	4GG	51.27	26.72	24.55
	4HA	45.12	32.06	13.06
	4HB	24.42	16.08	8.34
	4HC	16.21	13.65	2.56
	4JA	14.35	11.47	2.88
	4JB	5.50	3.92	1.58
	4KA	9.85	7.73	2.12
	4KB	99.32	91.82	7.50
ENNCA	5AA	20.80	16.80	4.00
	5AB	4.97	3.31	1.66
	5AC	5.67	4.04	1.63
	5AD	6.69	6.27	0.42
	5BA	3.40	2.56	0.84
	5BB	8.28	7.38	0.90
	5BC-1	13.58	9.18	4.39
	5BC-2	4.45	4.26	0.19
	5BD	3.63	3.02	0.61
	5BE	28.48	20.87	7.61
	5CA	7.72	5.22	2.50
	5CB	1.60	0.84	0.76
	5CC	2.30	1.40	0.90
	5DA	106.20	94.90	11.31
	5DB	5.59	4.06	1.53
	5DC	257.02	255.79	1.23
	5DD	28.73	28.08	0.66
	5EA	25.51	10.27	15.24
	5EB	23.84	8.92	14.92
	5EC	21.29	7.17	14.12
	5ED	56.07	7.49	48.58
	5FA	26.87	6.06	20.81
	5FB	4.67	2.37	2.30
	5G	35.45	17.75	17.70
	5HA	25.23	23.42	1.82
	5HB	10.64	7.20	3.44
	5J	15.20	15.20	0.00

Source JICA Study Team

Table 4.4.3 Balance between Water Resources and Water Demands in 2030 (LVNCA)

(Unit: MCM/year)

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

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

Source: JICA Study Team

Table 4.4.4 Naturalised River Flow, Reserve, Water Demand, Yield and Water Supply Reliability at Reference Points

Catch-ment Area	Reference Point	River Name	Catchment Area at Reference Point (km^2)	Naturalised River Flow (1/10 Drought Discharge) *3	Reserve (m^3/s) *1	Present (2010) Water Demand (m^3/s) *2		Future (2030) Water Demand (m^3/s) *2		Yield of Water Resources Development (m^3/s)	Present (2010) Water Supply Reliability	Future (2030) Water Supply Reliability
						Upstream of Reference Point	Downstream of Reference Point	Upstream of Reference Point	Downstream of Reference Point			
LVNCA	1DA02	Nzoia	8,417	15.8	15.9	1.8	0.3	22.6	2.7	23.2	1/7	1/5
	1FG01	Yala	2,388	6.5	6.7	0.7	0.1	3.7	4.4	7.3	1/7	1/10
LVSCA	1GD03	Nyando	2,625	1.5	1.6	0.9	0.7	3.3	2.1	3.8	1/2	1/5
	1JG05	Sondu	3,318	10.1	10.5	0.7	0.1	7.2	4.3	10.7	1/5	1/20
	1KB03	Gucha	1,114	0.3	0.4	0.6	0.2	6.0	1.9	7.1	1/2	1/10
	1KC03	Migori	3,046	1.4	1.5	0.3	0.5	2.2	3.6	5.0	1/3	1/20
	1LA04	Mara	1,475	4.1	4.3	0.3	0.1	3.4	0.1	3.1	1/20	1/10
RVCA	2B21	Turkwel	13,510	0.0	0.0	1.7	0.9	15.2	1.0	13.6	1/20	1/20
	2C16	Kerio	3,710	0.0	0.0	1.1	0.7	10.2	9.4	17.8	1/7	1/10
	2K06	Ewaso Ng'iro South	581	0.0	0.0	0.1	0.4	1.6	2.3	3.4	1/2	1/20
	2GB01	Malewa	1,596	0.0	0.0	0.1	0.1	0.7	0.6	1.1	1/3	1/10
ACA	3DB01	Athi (Middle)	6,813	8.1	8.6	13.1	0.1	23.3	0.1	10.2	1/2	1/5
	3HA12	Athi (Lower)	25,203	8.7	8.9	19.1	0.1	38.5	0.1	19.4	1/1	1/10
TCA	4BE10	Tana (Upper)	3,915	13.4	13.5	5	0.1	6.7	0.5	2.1	1/1	1/10
	4CC03	Thika	1,321	8.5	8.5	1.5	0.7	1.6	1.0	0.5	1/7	1/10
	4G01	Tana (Lower)	32,892	53.2	53.5	30.7	0.1	148.7	10.3	128.2	1/2	1/5
ENNCA	5ED01	Ewaso Ng'iro North	14,300	1.5	1.6	3.2	1.7	24.4	5.5	25.0	1/1	1/5

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

Source: JICA Study Team

Table 4.5.1 Balance between Water Resources and Water Demands in 2030 (LVSCA)

(Unit: MCM/year)

No.	Sub basin	CA (km^2)	Major Domestic Demand Centre	Domestic and Industrial										Irrigation								Livestock			Wildlife			Fisheries			Summary						
								Surface Water								Surface Water							SW			SW			SW			Surface Water					
				Demand	Demand (Domestic)	Demand(Industrial)	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance	Demand	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance
1	1GA	454	Yala, Siaya	1.9	1.8	0.0	0.0	0.6	0.0	0.0	0.0	1.3	0.0	6.9	0.0	5.9	0.0	0.0	0.7	0.3	0.0	1.2	1.2	0.0	0.1	0.1	0.0	0.3	0.3	0.0	10.3	6.5	0.0	0.0	2.2	1.6	0.0
2	1GB	522		2.2	2.2	0.0	0.0	0.3	0.0	0.0	0.0	1.9	0.0	16.9	0.0	14.7	0.0	0.0	0.8	1.5	0.0	1.6	1.6	0.0	0.1	0.1	0.0	0.6	0.6	0.0	21.3	15.0	0.0	0.0	3.0	3.3	0.0
3	1GC	902	Kipkelion, Londiani	26.2	25.0	1.2	-2.1	20.4	2.1	0.0	0.0	3.7	0.0	3.1	0.0	1.5	0.0	0.0	1.3	0.3	0.0	2.5	2.5	0.0	0.1	0.1	0.0	0.5	0.5	0.0	32.4	21.8	2.1	0.0	4.5	4.0	0.0
4	1GD	652	Ahero, Awasi, Muhoroni	35.3	29.4	5.9	-4.6	24.3	4.6	0.0	0.0	6.4	0.0	45.9	-13.0	8.6	34.0	0.0	1.0	2.3	0.0	2.5	2.5	0.0	0.1	0.1	0.0	0.3	0.3	0.0	84.0	32.8	38.6	0.0	3.8	8.7	0.0
	Reference Point (1GD03)																																				
5	1GE	371		2.7	2.5	0.2	-0.5	0.8	0.5	0.0	0.0	1.4	0.0	15.7	-33.5	12.4	0.0	0.0	0.5	2.8	0.0	1.4	1.4	0.0	0.0	0.0	0.0	0.3	0.3	0.0	20.1	13.2	0.5	0.0	2.3	4.2	0.0
6	1GF	317		1.3	1.3	0.0	-0.1	0.1	0.0	0.0	0.0	1.2	0.0	14.4	0.0	9.6	0.0	0.0	0.5	4.3	0.0	1.3	1.3	0.0	0.0	0.0	0.0	0.3	0.3	0.0	17.3	9.7	0.0	0.0	2.0	5.5	0.0
7	1GG	385		1.9	1.8	0.0	0.0	1.1	0.0	0.0	0.0	0.8	0.0	2.3	0.0	1.0	0.0	0.0	0.6	0.7		1.0	1.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	6.2	2.1	0.0	0.0	2.6	1.5	0.0
8	1JA	849	Litein	8.1	7.9	0.2	0.0	5.0	0.0	0.0	0.0	3.1	0.0	29.1	0.0	24.6	0.0	0.0	1.7	2.8	0.0	2.2	2.2	0.0	0.1	0.1	0.0	0.2	0.2	0.0	39.8	29.6	0.0	0.0	4.2	6.0	0.0
9	1JB	178		1.3	1.3	0.0	0.0	0.6	0.0	0.0	0.0	0.7	0.0	1.8	0.0	0.3	0.0	0.0	0.4	1.2	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.3	0.3	0.0	3.9	0.9	0.0	0.0	1.2	1.9	0.0
10	1JC	340	Kericho	28.2	24.7	3.5	-3.0	21.2	0.0	0.0	5.7	1.2	0.0	10.5	0.0	9.9	0.0	0.0	0.7	0.0		1.1	1.1	0.0	0.0	0.0	0.0	0.3	0.3	0.0	40.2	31.1	0.0	0.0	7.9	1.2	0.0
11	1JD	217		1.8	1.7	0.1	-0.1	0.9	0.0	0.0	0.2	0.7	0.0	12.0	0.0	11.5	0.0	0.0	0.4	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.5	0.5	0.0	15.2	12.4	0.0	0.0	2.0	0.7	0.0
12	1JE	581	Nyansiongo	5.8	5.7	0.1	0.0	2.8	0.0	0.0	0.0	3.0	0.0	25.3	0.0	19.4	0.0	0.0	1.2	4.8	0.0	3.0	3.0	0.0	0.1	0.1	0.0	0.2	0.2	0.0	34.3	22.1	0.0	0.0	4.4	7.8	0.0
13	1JF	990	Sotik	9.2	9.0	0.2	0.0	4.8	0.0	0.0	0.0	4.4	0.0	20.8	0.0	18.8	0.0	0.0	2.0	0.1	0.0	3.6	3.6	0.0	0.1	0.1	0.0	1.0	1.0	0.0	34.8	23.6	0.0	0.0	6.7	4.4	0.0
14	1JG1	230		3.5	3.4	0.1	-1.2	1.7	0.0	0.0	1.2	0.6	0.0	143.4	-33.8	7.0	136.0	0.0	0.5	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	2.9	2.9	0.0	151.0	8.7	136.0	0.0	5.8	0.6	0.0
	Reference Point (1JG05)																																				
15	1JG2	89		0.6	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.4	0.0	6.3	0.0	5.6	0.0	0.0	0.2	0.5	0.0	0.4	0.4	0.0	0.0	0.0	0.0	1.2	1.2	0.0	8.5	5.8	0.0	0.0	1.8	0.9	0.0
16	1KA	469		66.7	63.6	3.0	-17.7	41.3	17.7	0.0	1.4	6.2	0.0	14.0	0.0	13.4	0.0	0.0	0.7	0.0	0.0	2.4	2.4	0.0	0.1	0.1	0.0	0.3	0.3	0.0	83.4	54.6	17.7	0.0	4.8	6.2	0.0
17	1KB	3,453	Keroko, , Awendo, Ogembo	67.7	65.5	2.2	-2.3	42.9	2.3	0.0	0.0	22.6	0.0	441.0	-156.4	18.2	413.0	0.0	4.9	4.9	0.0	16.6	16.6	0.0	0.4	0.4	0.0	0.0	0.0	0.0	525.7	61.1	415.3	0.0	21.9	27.5	0.0
	Reference Point (1KB03)																																				
18	1KC	2,921	Migori, Kehancha	35.7	34.5	1.3	-0.6	25.1	0.6	0.0	0.0	10.0	0.0	55.5	-6.1	12.6	31.0	0.0	4.1	7.8	0.0	15.3	15.3	0.0	0.4	0.4	0.0	0.0	0.0	0.0	106.9	37.8	31.6	0.0	19.7	17.8	0.0
	Reference Point (1FG01)																																				
19	1LA1	924	Bomet	24.5	23.5	1.0	-0.9	18.4	0.0	0.0	0.0	6.1	0.0	9.1	0.0	7.5	0.0	0.0	0.8	0.9	0.0	3.6	3.6	0.0	0.1	0.1	0.0	0.1	0.1	0.0	37.4	25.9	0.0	0.0	4.6	6.9	0.0
20	1LA2	1,008		2.0	2.0	0.0	0.0	0.8	0.0	0.0	0.0	1.2	0.0	2.1	0.0	1.3	0.0	0.0	0.8	0.0	0.0	4.0	4.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	8.2	2.1	0.0	0.0	5.0	1.2	0.0
	Reference Point (1LA04)																																				
21	1LA3	3,024		2.4	2.4	0.0	-0.2	0.5	0.2	0.0	0.0	1.8	0.0	19.3	0.0	15.7	0.0	0.0	2.0	1.5	0.0	8.0	8.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	29.9	16.2	0.2	0.0	10.3	3.3	0.0
22	1LB1	1,475		4.9	4.8	0.1	0.0	2.1	0.0	0.0	0.0	2.8	0.0	60.8	-8.1	14.2	45.0	0.0	1.2	0.4	0.0	4.7	4.7	0.0	0.2	0.2	0.0	0.0	0.0	0.0	70.5	16.2	45.0	0.0	6.1	3.2	0.0
23	1LB2	2,677		1.4	1.4	0.0	-0.1	0.1	0.0	0.0	0.0	1.4	0.0	19.2	0.0	8.6	0.0	0.0	2.2	8.3	0.0	6.2	6.2	0.0	0.3	0.3	0.0	0.0	0.0	0.0	27.2	8.7	0.0	0.0	8.8	9.7	0.0
24	1HA1	350	Kisumu	99.4	80.0	19.4	-55.9	41.3	26.7	15.7	13.5	2.2	0.0	9.9	0.0	9.4	0.0	0.0	0.6	0.0	0.0	1.7	1.7	0.0	0.0	0.0	0.0	1.4	1.4	0.0	112.5	50.6	26.7	15.7	17.2	2.2	0.0
25	1HA2	543		1.8	1.8	0.0	-1.0	0.2	0.0	0.0	0.0	1.6	0.0	89.9	-77.5	10.9	0.0	73.0	0.9	5.1	0.0	2.3	2.3	0.0	0.1	0.1	0.0	0.3	0.3	0.0	94.3	11.1	0.0	73.0	3.5	6.7	0.0
26	1HB1	487		3.7	3.6	0.0	-0.1	0.7	0.0	0.0	0.7	2.3	0.0	10.1	0.0	9.4	0.0	0.0	0.7	0.0	0.0	2.2	2.2	0.0	0.1	0.1	0.0	0.7	0.7	0.0	16.8	10.1	0.0	0.0	4.4	2.3	0.0
27	1HB2	267		1.4	1.4	0.0	-0.5	0.2	0.0	0.0	0.0	1.2	0.0	9.8	0.0	9.3	0.0	0.0	0.4	0.0	0.0	1.3	1.3	0.0	0.0	0.0	0.0	1.1	1.1	0.0	13.6	9.5	0.0	0.0	2.8	1.2	0.0
28	1HC	336		3.3	3.2	0.0	-0.7	1.0	0.0	0.0	0.0	2.3	0.0	5.6	0.0	4.2	0.0	0.0	0.9	0.6	0.0	2.4	2.4	0.0	0.1	0.1	0.0	0.4	0.4	0.0	11.8	5.1	0.0	0.0	3.8	2.8	0.0
28	1HD	779	Oyugis, Nyamira, Kendu Bay	31.3	30.1	1.2	-4.5	19.5	0.0	0.0	5.5	6.3	0.0	16.6	0.0	15.3	0.0	0.0	1.3	0.0	0.0	3.9	3.9	0.0	0.1	0.1	0.0	0.4	0.4	0.0	52.3	34.8	0.0	0.0	11.2	6.3	0.0
29	1HE	737		9.5	9.3	0.2	-0.9	2.5	0.0	0.0	0.0	7.0	0.0	13.4	0.0	11.9	0.0	0.0	1.2	0.4	0.0	3.6	3.6	0.0	0.1	0.1	0.0	0.1	0.1	0.0	26.8	14.4	0.0	0.0	5.0	7.4	0.0
30	1HF	861	Homa Bay	14.1	13.6	0.5	-7.7	2.8	0.0	0.0	7.2	4.1	0.0	20.4	0.0	19.0	0.0	0.0	1.4	0.0	0.0	2.6	2.6	0.0	0.1	0.1	0.0	0.4	0.4	0.0	37.6	21.7	0.0	0.0	11.7	4.1	0.0
31	1HG	336	Mbita point	4.7	4.5	0.2	-1.3	2.0	0.0	0.0	2.0	0.7	0.0	7.3	0.0	6.8	0.0	0.0	0.5	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	13.2	8.8	0.0	0.0	3.7	0.7	0.0
				504.3	463.6	40.7	-106.0	248.1	93.6	15.7	37.6	110.4	0.0	1158.4	-328.4	338.2	659.0	73.0	36.7	51.4	0.0	106.3	106.3	0.0	3.3	3.3	0.0	15.0	15.0	0.0	1787.4	624.0	713.7	88.7	199.0	161.9	0.0

Note: 1GC: Londiani Dam, 1GD,1GE : Nyando (Koru) Dam, 1HA1: Kibos Dam and Nyando (Koru) Dam, 1JG1: Magwagwa Dam, 1KA: Bynyunyu Dam, 1KB: Katieno Dam, 1KC: Ilooiterre Dam 1LA03: Sand River Dam, 1LB1: Amala Dam

Source: JICA Study Team

Table 4.6.1 Balance between Water Resources and Water Demands in 2030 (RVCA)

(Unit: MCM/year)

No.	Sub basin	CA (km^2)	Major Domestic Demand Centre	Domestic and Industrial										Irrigation								Livestock			Wildlife			Fisheries			Summary						
								Surface Water								Surface Water							SW			SW			SW			Surface Water					
				Demand	Demand (Domestic)	Demand(Industrial)	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance	Demand	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance
1	2AA	10,480		0.8	0.8	0.0	0.0	0.3	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.0	1.9	1.9	0.0	0.1	0.1	0.0	0.0	0.0	0.0	3.2	0.3	0.0	0.0	2.0	0.8	0.0
2	2AB	10,143		2.3	2.3	0.0	-1.2	0.5	0.0	0.0	1.2	0.7	0.0	6.0	0.0	6.0	0.0	0.0	0.0	0.0	0.0	3.9	3.9	0.0	0.1	0.1	0.0	0.0	0.0	0.0	12.3	6.5	0.0	0.0	5.2	0.7	0.0
3	2BA	1,316		2.1	2.1	0.0	-0.5	0.6	0.0	0.0	0.5	1.0	0.0	12.3	0.0	12.1	0.0	0.0	0.1	0.0	0.0	2.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	12.7	0.0	0.0	3.4	1.0	0.0
4	2BB	2,116		2.0	2.0	0.0	-0.1	0.2	0.1	0.0	0.0	1.7	0.0	86.0	-21.4	66.0	19.9	0.0	0.2	0.0	0.0	4.2	4.2	0.0	0.0	0.0	0.0	0.1	0.1	0.0	92.4	66.2	20.0	0.0	4.5	1.7	0.0
5	2BC	3,446		6.1	6.0	0.1	-2.2	2.7	0.0	0.0	2.2	1.3	0.0	112.0	0.0	41.7	70.0	0.0	0.3	0.0	0.0	9.0	9.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	127.2	44.4	70.0	0.0	11.6	1.3	0.0
	Reference Point (2B21)															0.0																					
6	2BD	12,943	Lodwar	6.5	6.5	0.0	0.0	3.1	0.0	0.0	0.0	3.4	0.0	18.6	0.0	15.1	0.0	0.0	1.2	2.3	0.0	13.3	13.3	0.0	0.1	0.1	0.0	0.0	0.0	0.0	38.5	18.2	0.0	0.0	14.6	5.6	0.0
7	2CA	3,770		0.7	0.7	0.0	-0.5	0.0	0.0	0.0	0.5	0.2	0.0	2.5	0.0	2.2	0.0	0.0	0.3	0.0	0.0	2.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	2.2	0.0	0.0	3.5	0.2	0.0
8	2CB	2,434	Iten/Tambach, Kabarnet	15.1	14.6	0.5	-4.7	6.9	4.7	0.0	0.0	3.5	0.0	42.9	-15.5	26.9	15.7	0.0	0.2	0.1	0.0	3.2	3.2	0.0	0.0	0.0	0.0	0.9	0.9	0.0	62.1	33.8	20.4	0.0	4.3	3.6	0.0
	Reference Point (2C16)															0.0																					
9	2CC	11,494		5.7	5.7	0.0	-0.6	0.9	0.6	0.0	0.0	4.2	0.0	182.2	-86.2	33.3	142.5	0.0	0.9	5.4	0.0	13.2	13.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	201.2	34.3	143.1	0.0	14.2	9.7	0.0
10	2D	13,108		4.1	4.1	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	19.6	0.0	15.3	0.0	0.0	1.6	2.6	0.0	11.4	11.4	0.0	0.1	0.1	0.0	0.1	0.1	0.0	35.2	15.3	0.0	0.0	13.1	7.9	0.0
11	2EA	428		4.8	4.0	0.8	-3.2	1.4	0.0	0.0	2.1	0.2	0.0	0.9	0.0	0.7	0.0	0.0	0.2	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	2.1	0.0	0.0	3.0	0.2	0.0
12	2EB	709		4.4	3.9	0.6	-3.0	1.2	1.7	0.0	1.3	0.2	0.0	1.7	0.0	1.4	0.0	0.0	0.3	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.5	0.5	0.0	7.8	2.7	1.7	0.0	3.2	0.2	0.0
13	2ED	420	Eldama Ravine	5.2	5.0	0.2	-2.6	2.0	0.0	0.0	2.6	0.6	0.0	1.8	0.0	1.6	0.0	0.0	0.2	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.2	0.2	0.0	7.8	3.5	0.0	0.0	3.6	0.6	0.0
14	2EE	593		1.0	0.9	0.0	0.0	0.5	0.0	0.0	0.0	0.5	0.0	2.8	0.0	2.5	0.0	0.0	0.3	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	4.3	3.0	0.0	0.0	0.8	0.5	0.0
15	2EF	387		0.9	0.9	0.0	-0.1	0.3	0.0	0.0	0.1	0.5	0.0	0.8	0.0	0.6	0.0	0.0	0.2	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.1	0.1	0.0	2.3	0.8	0.0	0.0	1.0	0.5	0.0
16	2EC	880		10.9	9.3	1.6	-8.6	7.9	0.0	0.0	2.7	0.3	0.0	2.0	0.0	1.6	0.0	0.0	0.4	0.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	0.3	0.3	0.0	14.9	9.5	0.0	0.0	5.2	0.3	0.0
17	2EG1	389	Molo	12.0	11.5	0.5	-7.7	9.7	0.0	0.0	0.5	1.8	0.0	0.4	0.0	0.3	0.0	0.0	0.2	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.3	0.3	0.0	13.7	9.9	0.0	0.0	1.9	1.8	0.0
18	2EG2	1,298		5.2	4.7	0.6	-3.4	1.5	0.0	0.0	3.4	0.4	0.0	1.8	0.0	1.2	0.0	0.0	0.6	0.0	0.0	1.6	1.6	0.0	0.0	0.0	0.0	0.5	0.5	0.0	9.3	2.7	0.0	0.0	6.2	0.4	0.0
19	2EH	554		0.6	0.6	0.0	0.0	0.2	0.0	0.0	0.0	0.4	0.0	2.3	0.0	1.1	0.0	0.0	0.3	0.9	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	1.3	0.0	0.0	0.5	1.3	0.0
20	2EJ	1,399		1.2	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	3.2	0.0	2.6	0.0	0.0	0.6	0.0	0.0	1.8	1.8	0.0	0.0	0.0	0.0	1.2	1.2	0.0	7.4	2.6	0.0	0.0	3.6	1.3	0.0
21	2EK	609		0.7	0.7	0.0	-0.2	0.1	0.0	0.0	0.1	0.4	0.0	1.3	0.0	1.0	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.7	0.7	0.0	3.0	1.1	0.0	0.0	1.4	0.4	0.0
22	2FA	543		1.6	1.6	0.1	-1.2	0.3	0.0	0.0	1.2	0.2	0.0	1.6	0.0	0.9	0.0	0.0	0.7	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	4.3	1.2	0.0	0.0	3.0	0.2	0.0
23	2FB	140		1.5	1.3	0.2	-1.1	0.3	0.0	0.0	1.1	0.2	0.0	0.4	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.5	0.0	0.0	1.5	0.2	0.0
24	2FC	1,484	Nakuru, Njoro	79.8	65.7	14.0	-51.9	27.8	0.0	41.0	9.1	1.8	0.0	4.7	0.0	2.8	0.0	0.0	1.9	0.0	0.0	3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.6	30.6	0.0	41.0	14.2	1.8	0.0
25	2GA	402	Gilgil	9.2	8.8	0.4	-6.7	2.4	5.8	0.0	0.9	0.1	0.0	1.1	0.0	0.6	0.0	0.0	0.5	0.0	0.0	0.7	0.7	0.0	0.0	0.0	0.0	0.2	0.2	0.0	11.2	3.0	5.8	0.0	2.4	0.1	0.0
26	2GB	931	Ol Kalou	20.1	19.2	0.8	-2.9	16.9	0.0	0.0	2.9	0.2	0.0	2.2	0.0	1.1	0.0	0.0	1.1	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	1.1	1.1	0.0	25.5	18.0	0.0	0.0	7.3	0.2	0.0
	Reference Point (2GB01)															0.0																					
27	2GC	745		5.0	4.9	0.1	0.0	2.8	0.0	0.0	0.0	2.2	0.0	3.0	0.0	0.9	0.0	0.0	0.9	1.2	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.4	0.4	0.0	10.3	3.7	0.0	0.0	3.2	3.4	0.0
28	2GD	1,051	Naivasha	41.2	39.3	1.9	-27.4	8.6	26.8	0.0	0.6	5.2	0.0	3.5	0.0	2.2	0.0	0.0	1.3	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	0.2	0.2	0.0	47.0	10.8	26.8	0.0	4.2	5.2	0.0
29	2H-1	5,104	, Mai Mahiu	7.8	7.6	0.2	0.0	0.5	0.0	0.0	0.0	11.6	0.0	19.6	0.0	18.3	0.0	0.0	0.9	0.4	0.0	6.1	6.1	0.0	0.0	0.0	0.0	0.4	0.4	0.0	33.9	18.7	0.0	0.0	7.4	12.0	0.0
30	2H-2	2,257		2.7	2.6	0.1	0.0	0.0	0.0	0.0	0.0	3.7	0.0	10.4	0.0	10.0	0.0	0.0	0.4	0.0	0.0	1.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	10.0	0.0	0.0	2.3	3.7	0.0
31	2H-3	988		0.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.3	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.2	0.0	0.0	0.7	0.7	0.0
32	2J	27,556	Lokichogio, Kakuma	9.0	9.0	0.0	-6.6	0.0	0.0	0.0	6.6	2.4	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	10.0	10.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	19.2	0.0	0.0	0.0	16.9	2.4	0.0
33	2KA	5,130	Narok	13.9	13.4	0.5	-1.5	8.4	1.5	0.0	0.0	4.1	0.0	40.5	-9.3	4.1	32.0	0.0	3.5	0.9	0.0	11.2	11.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.6	12.5	33.5	0.0	14.8	4.9	0.0
	Reference Point (2K06)															0.0																					
34	2KB	1,663		1.2	1.1	0.0	0.0	0.3	0.0	0.0	0.0	0.9	0.0	240.7	-161.1	8.5	231.0	0.0	1.1	0.1	0.0	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	245.2	8.7	231.0	0.0	4.4	1.0	0.0
35	2KC	1,999		0.9	0.9	0.0	-0.1	0.0	0.1	0.0	0.0	0.8	0.0	9.7	0.0	6.3	0.0	0.0	1.9	1.4	0.0	3.1	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	6.4	0.1	0.0	5.0	2.2	0.0
				287.1	263.7	23.4	-137.8	108.4	41.1	41.0	39.5	62.4	0.0	839.0	-293.6	289.0	511.0	0.0	23.2	15.7	0.0	122.9	122.9	0.0	0.8	0.8	0.0	7.6	7.6	0.0	1,257.4	397.4	552.2	41.0	194.0	78.1	0.0

Note: Irrigation Demand: Excluding the Todonyang- Omo irrigation project (35,000 ha, 560MCM/year) to be supplied water by a dam in Ethiopia

2BB:Embobut Dam, 2CB:Kimwarer Dam, 2CC:Arror Dam and Murung-Sebit 2EB:Waseges Dam, 2GA:Malewa Dam, 2KA:Upper Narok Dam, 2KB:Oletukat Dam 2KB:Leshota Dam, 2KB:Oldorko Dam

2BA; Turkwel Dam

Source: JICA Study Team

Table 4.7.1 Balance between Water Resources and Water Demands in 2030 (ACA)

(Unit: MCM/year)

No.	Sub basin	CA (km²)	Major Domestic Demand Centre	Domestic and Industrial											Irrigation								Livestock			Wildlife			Fisheries			Summary							
								Surface Water									Surface Water							SW			SW			SW			Surface Water						
				Demand	Demand (Domestic)	Demand(Industrial)	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Desalination	Groundwater	Balance	Demand	Deficit	River Water	Dam	Transfer	Small Dam/ Water Pans	Groundwater	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	Small Dam/ Water Pans	Balance	Demand	River Water	Dam	Transfer	Small Dam/ Water Pans	Desalination	Groundwater	Balance
1	3AA	724	Kiserian, Ngong, Ongata Rongai, Mavoko, Kiteng	65.0	59.7	5.2	-52.4	12.4							13.4	0.0	13.1	0.0	0.0	0.3	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	79.5	25.5						
2	3AB	1,790		1.6	1.6	0.1	-0.1	0.4							13.8	0.0	13.0	0.0	0.0	0.8	0.0	0.0	2.1	2.1	0.0	0.1	0.1	0.0	0.4	0.4	0.0	18.0	13.4						
3	3AC	843		1.4	1.3	0.1	-0.4	0.4							3.1	0.0	2.7	0.0	0.0	0.4	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	6.8	3.1						
4	3BA	889	Karuri, Nairobi, Kikuyu, Limuru	487.6	399.6	88.0	-447.6	68.2							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 4.8.1 Balance between Water Resources and Water Demands in 2030 (TCA)

(Unit: MCM/year)

No.	Sub basin	CA (km²)	Major Domestic Demand Centre	Domestic: Demand	Domestic: Demand (Domestic)	Domestic: Demand(Industrial)	Domestic: Deficit	Domestic: Surface Water: River Water	Domestic: Surface Water: Dam	Domestic: Surface Water: Transfer	Domestic: Surface Water: Small Dam/ Water Pans	Domestic: Groundwater	Domestic: Balance	Irrigation: Demand	Irrigation: Deficit	Irrigation: Surface Water: River Water	Irrigation: Surface Water: Dam	Irrigation: Surface Water: Transfer	Irrigation: Surface Water: Small Dam/ Water Pans	Irrigation: Groundwater	Irrigation: 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
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
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
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
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
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
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
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
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
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
	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
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
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
	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
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
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
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
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
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
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
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
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
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
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
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
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
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
	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
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
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
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
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
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
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
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
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
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
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
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
				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

No.	Sub basin	Livestock: Demand	Livestock: SW: Small Dam/ Water Pans	Livestock: Balance	Wildlife: Demand	Wildlife: SW: Small Dam/ Water Pans	Wildlife: Balance	Fisheries: Demand	Fisheries: SW: Small Dam/ Water Pans	Fisheries: Balance	Summary: Demand	Summary: Surface Water: River Water	Summary: Surface Water: Dam	Summary: Surface Water: Transfer	Summary: Surface Water: Small Dam/ Water Pans	Summary: Groundwater	Summary: Balance
1	4AA	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	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	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	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	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	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	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	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	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	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	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	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	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)																
14	4CC	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	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	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	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	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	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	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	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	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	3.1	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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
		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 4.9.1 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 5.2.1 Available Cost Data for Dams

Catchment Area		Dam	Sub-basin	Project Status	Cost	Notes	Data Source	Conversion/ Adjustment	Cost (US$ million)	Embankment Volume	Data Source
				Collected Dam Cost Data				Converted/Adjusted Dam Cost		Filldam Embankment Volume	
LVNCA	1	Nzoia 34B	1BG	D/D ongoing	KSh 4,000 M	2012 price	Information from NWCPC (November 2012)	Converted to US$	46.9	1.4 MCM	Adjusted based on P/D Report (December 2010) in proportion to dam height
LVNCA	2	Nzoia 42A	1EE	D/D ongoing	US$102 M	2010 price	Pre-F/S Report for Flood Control in Nzoia (March 2010)		102	3.7 MCM	Pre-F/S Report for Flood Control in Nzoia (March 2010)
LVNCA	3	Nandi Forest	1FD	D/D completed	US$205 M	2012 price	Information from MORDA (November 2012) based on D/D Report (September 2011)		205	5.4 MCM	RCC dam volume was converted to fill volume based on D/D Report (September 2011)
LVSCA	4	Magwagwa	1JG	D/D completed	KSh 20,400 M	2011 price	Investment Plan Report (July 2011)	Converted to US$	237	3.0 MCM	D/D Report (December 2011)
LVSCA	5	Bunyunyu	1KB	D/D completed	KSh 2,000 M	2010 price	Information from NWCPC (November 2012)	Converted to US$	23.5	0.2 MCM	NWCPC Final Design Report (June 2010)
RVCA	6	Arror	2CC	D/D completed	US$134 M	2012 price	Infromation from MORDA (November 2012) based on Final Report (May 2012)		134	5.1 MCM	Final Report (May 2012)
RVCA	7	Chemususu	2ED	U/C	KSh 5,032 M	2010 price	Information from NWCPC (May 2012)	Converted to US$	59	0.7 MCM	NWCPC
ACA	8	Kiserian	3AA	U/C	KSh 1,060 M	2010 price	Information from NWCPC (May 2012)	Converted to US$	12.4	0.1 MCM	Final Design Report (September 2008)
ACA	9	Ndarugu	3CB	F/S and M/P ongoing	US$58.9 M	2012 price, Storage volume of 300 MCM	AWSB, F/S and M/P Report for Nairobi and Satellite Towns (2012)		58.9	1.8 MCM	Volume in NWMP (1992) was adjusted in proportion to storage volume.
ACA	10	Mwachi	3MA	P/D completed	US$94 M	2012 price	Information from MORDA (November 2012)		94	4.6 MCM	MORDA F/S Report (September 2011)
TCA	11	Maragua 4	4BE	F/S and M/P ongoing	US$81.7 M	2012 price, Storage volume of 33 MCM	AWSB, F/S and M/P Report for Nairobi and Satellite Towns (2012)		81.7	4.7 MCM	Volume in NWMP (1992) was adjusted in proportion to storage volume.
TCA	12	Thiba	4DA	D/D completed	KSh 6,143 M	2011 price, Direct construction cost only	D/D Report (2011)	Converted to US$, indirect costs (20%) added	86.5	1.3 MCM	D/D Report (2012)
TCA	13	High Grand Falls	4FB	D/D completed	US$1,046 M	2011 price	F/S Report (February 2011)		1,046	42 MCM	RCC dam volume was converted to fill volume based on D/D Report (March 2012)
ENNCA	14	Badasa	5EC	U/C	KSh 2,500 M	2010 price	Information from NWCPC (May 2012)	Converted to US$	29.3	0.8 MCM	NWCPC Final Design Report

Note: M/P=Master Plan, Pre-F/S=Pre-feasibility Study, F/S=Feasibility Study, P/D=Preliminary Design, D/D=Detailed Design, U/C=Under Constructio
Exchange rate applied: US$1.0=KSh 85.24.

Source: JICA Study Team based on data from the government agencies mentioned in the above tab

Table 5.2.2 Estimated Costs of Proposed Dams

Catchment Area	No.	Name of Dam	Sub-basin	Purpose 1)	Effective Storage (MCM)	Study Stage 2)	Dam Cost (KSh million)	Land Cost (KSh million)	Total Cost (KSh million)
LVNCA	1	Siyoi	1BC	W	4.1	D/D to be completed in 2013	2,898	9	2,907
	2	Moi's Bridge	1BE	W, I	214.0	NWMP 2030	5,114	358	5,472
	3	Nzoia (34B)	1BG	I, P, F	203.7	D/D to be completed in 2013	4,006	34	4,040
	4	Kibolo	1CE	W, I	40.0	NWMP 2030	5,455	43	5,498
	5	Teremi	1DB	W	3.0	NWMP 2030	3,580	34	3,614
	6	Nzoia (42A)	1EE	I, P, F	395.0	D/D to be completed in 2013	8,694	247	8,941
	7	Nandi Forest	1FD	W, I, P	220.0	D/D completed	17,474	145	17,619
		Total			1,079.8		47,221	870	48,091
LVSCA	8	Londiani	1GC	W	25.0	Pre-F/S done in 2012	6,137	43	6,180
	9	Nyando (Koru)	1GD1	W, I, F	86.6	Preliminary Design ongoing	19,179	85	19,264
	10	Kibos	1HA	W, F	26.0	NWMP 2030	8,950	85	9,035
	11	Itare	1JA	W	20.0	NWMP 2030	5,114	17	5,131
	12	Magwagwa	1JG	W, I, P, F	445.0	D/D completed	20,202	213	20,415
	13	Bunyunyu	1KB	W	6.3	Final Design completed	2,046	34	2,080
	14	Katieno	1KB	I	201.0	Pre-F/S done	5,455	477	5,932
	15	Ilooiterre	1KC	W, I	13.6	Pre-F/S done	1,449	9	1,458
	16	Sand River (Naikara)	1LA3	W, F	20.0	Proposed by MORDA	5,711	17	5,728
	17	Amala	1LB1	W, I	175.0	NWMP 2030	20,031	26	20,057
		Total			1,018.5		94,274	1,006	95,280
RVCA	18	Murung-Sebit	2BB	I, F	40.0	Proposed by KVDA	6,819	68	6,887
	19	Kimwarer	2CB	W, I, P	107.0	Pre-F/S done	13,638	77	13,715
	20	Arror	2CC	W, I, P, F	62.0	D/D completed	11,422	34	11,456
	21	Embobut	2CC	W, I, P	30.0	Pre-F/S done	3,239	34	3,273
	22	Waseges	2EB	W	4.0	NWMP 2030	3,239	34	3,273
	23	Malewa	2GB	W	34.0	NWMP 2030	4,262	43	4,305
	24	Upper Narok	2KA	W, I, F	29.0	NWMP 2030	5,967	43	6,010
	25	Oletukat	2KA	W, P	300.0	F/S, D/D to be completed in 2013	38,784	384	39,168
	26	Leshota	2KB	W, P	33.0	F/S, D/D to be completed in 2013	7,842	77	7,919
	27	Oldorko	2KB	W, I, P	20.0	F/S, D/D to be completed in 2013	2,898	60	2,958
		Total			659.0		98,110	854	98,964
ACA	28	Upper Athi (Mbagathi)	3AA	W	24.0	NWMP 2030	2,813	17	2,830
	29	Stony Athi	3AB	W	23.0	F/S and M/P ongoing	4,006	43	4,049
	30	Kikuyu	3BA	W	31.0	NWMP 2030	4,092	26	4,118
	31	Ruaka (Kiambaa)	3BA	W	4.0	D/D completed	1,961	0	1,961
	32	Kamiti 1	3BB	W	16.0	F/S and M/P ongoing	6,308	60	6,368
	33	Ruiru-A (Ruiru 2)	3BC	W	18.0	F/S and M/P ongoing	6,990	9	6,999
	34	Ndarugu (Ndarugu 1)	3CB	W	300.0	F/S and M/P ongoing	5,029	307	5,336
	35	Munyu	3DA	I, P	575.0	F/S done	10,229	503	10,732
	36	Mbuuni	3EA	W	10.0	NWMP 2030	2,557	9	2,566
	37	Kiteta	3EB	W	16.0	Pre-F/S done	2,983	26	3,009
	38	Thwake	3FA	W, I, P	594.0	Final Design completed	8,439	503	8,942
	39	Olkishunki	3FA	W	1.2	Pre-F/S done	1,364	17	1,381
	40	Pemba	3HC	W	19.0	NWMP 2030	5,455	17	5,472
	41	Lake Chala	3J	W, F	6.0	D/D ongoing	1,534	17	1,551
	42	Rare	3LA	W	36.0	D/D to be completed in 2013	3,580	68	3,648
	43	Mwachi	3MA	W	16.0	Preliminary Design completed	4,262	128	4,390
		Total			1,689.2		71,602	1,750	73,352
TCA	44	Maragua 4	4BE	W	33.0	F/S and M/P ongoing	6,990	68	7,058
	45	Ndiara	4CA	W	12.0	NWMP 2030	6,990	68	7,058
	46	Chania-B	4CA	W	49.0	NWMP 2030	14,065	17	14,082
	47	Karimenu 2	4CA	W	14.0	F/S and M/P ongoing	3,665	34	3,699
	48	Thika 3A	4CC	W	13.0	F/S and M/P ongoing	3,239	34	3,273
	49	Yatta	4CC	W	35.0	D/D completed	1,364	17	1,381
	50	Thiba	4DA	I	11.2	D/D completed	7,416	17	7,433
	51	High Grand Falls	4FB	W, I, P, F	5,000.0	D/D completed	89,161	10,450	99,611
	52	Kora	4GA	I	537.0	NWMP 2030	13,127	128	13,255
	53	Mutuni	4HA	W	17.0	NWMP 2030	3,239	34	3,273
	54	Kitimui	4HA	W	8.0	NWMP 2030	4,859	51	4,910
		Total			5,729.2		154,115	10,918	165,033
ENNCA	55	Nyahururu	5AA	W	11.0	NWMP 2030	852	17	869
	56	Rumuruti	5AA	W	1.0	NWMP 2030	938	9	947
	57	Kihoto	5BC	I	389.0	NWMP 2030	13,894	298	14,192
	58	Isiolo	5DA	W	21.0	F/S ongoing	2,642	26	2,668
	59	Archers' Post	5DA	W, I	100.0	NWMP 2030	17,900	94	17,994
		Total			522.0		36,226	444	36,670
		Grand Total			10,697.7		501,548	15,842	517,390

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

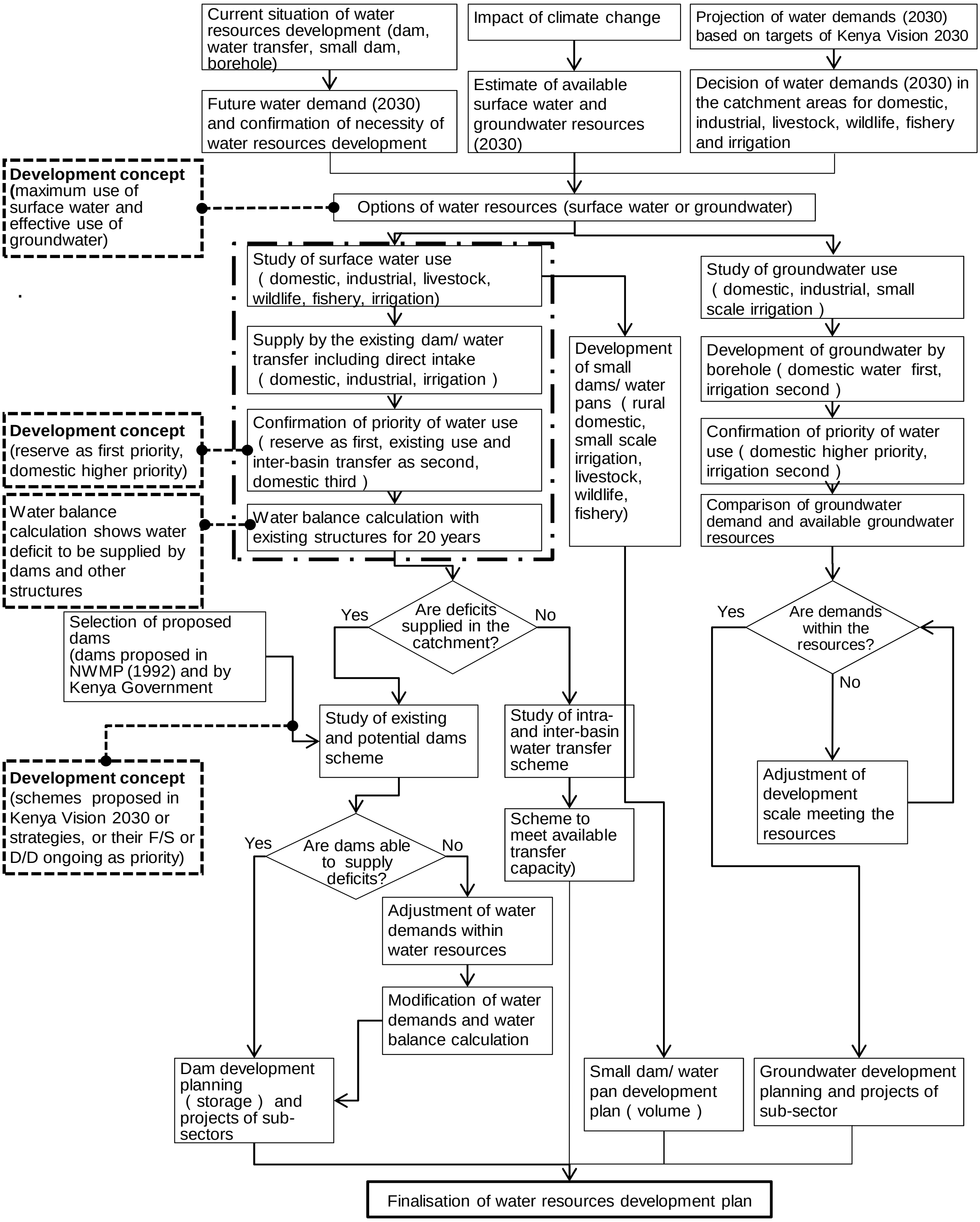
Source: JICA Study Team based on data from MWI, NWCPC, NIB, MORDA, RDAs, and WSBs

Table 5.2.3 Estimated Costs of Proposed Water Transfer Facilities

Catchment Area	Wter Transfer Scheme		Intra-basin or Inter-basin	Purpose	Capacity, Dimensions	Estimated Cost (KSh million)	Data Sources
LVNCA	1	Moiben Dam to Eldoret/ Iten (Expansion)	Intra-basin	W	Capacity of 5 MCM/year, Pipeline of 600 mm dia, 60 km long	3,069	NWMP 2030
	2	Nandi Forest Dam to LVSCA	Inter-basin	W, I, P	Capacity of 189 MCM/year	(Included in dam cost)	MORDA
	Total					3,069	
LVSCA	3	Itare and Londiani Dams to Nakuru	Inter-basin	W	Capacity of 41 MCM/year, Tunnel of 14.5 km long, Pipeline of 120 km long	25,742	RVWSB
	4	Amala Transfer from Amala Dam to RVCA	Inter-basin	W, I, P	Capacity of 82 MCM/year, Tunnel of 3.8 km long	2,301	ENSDA
	Total					28,043	
ACA	5	Second Mzima Pipeline from Mzima Springs to Mombasa (Expansion)	Intra-basin	W	Capacity of 100,000 m^3/day (37 MCM/year), Pipeline	35,289	CWSB
	6	Sabaki Scheme (Expansion)	Intra-basin	W	Capacity of 85,000 m^3/day (31 MCM/year), Pipeline	15,002	CWSB
	Total					50,291	
TCA	7	TCA to Nairobi in ACA (Expansion)	Inter-basin	W	Capacity of 168 MCM/year, Tunnels and pipelines	74,244	AWSB
	8	Tana River (High Grand Falls Dam) to Lamu Port	Intra-basin	W	Capacity of 69 MCM/year, Pipeline	26,936	CWSB
	9	Masinga Dam to Kitui (Expansion)	Intra-basin	W	Capacity of 23 MCM/year, Pipeline of 300 mm dia, 70 km long	1,790	NWMP 2030
	10	Kiambere Dam to Mwingi (Expansion)	Intra-basin	W	Capacity of 2 MCM/year, Pipeline of 300 mm dia, 30 km long	767	NWMP 2030
	Total					103,737	
Grand Total						185,140	

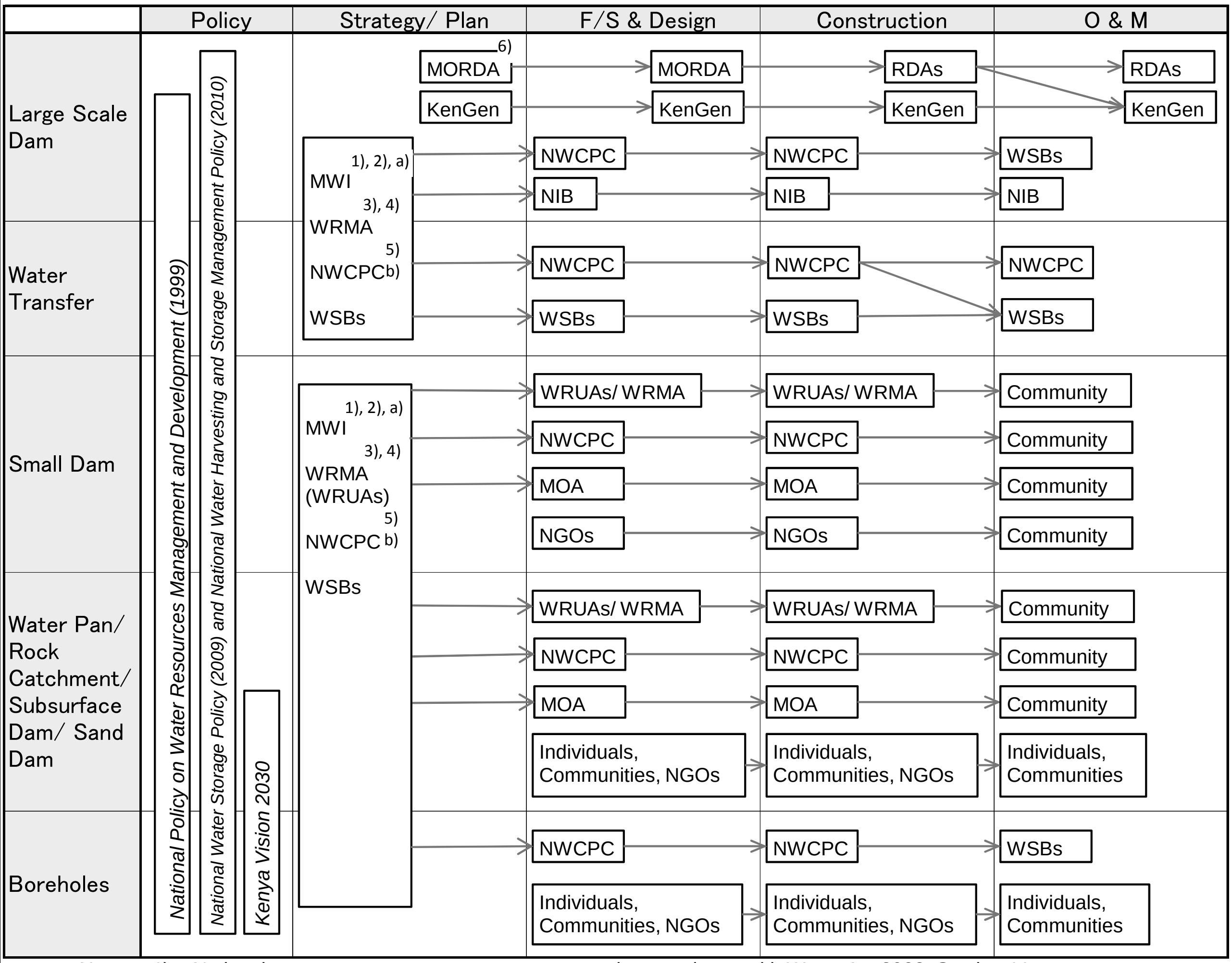
Notes: W=Domestic and industrial water supply, I=Irrigation, P=Hydropower
Source: JICA Study Team based on the data collected from MORDA, RDAs and WSBs

Figures



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.1.1 Study Flow for Water Resources Development Plan**
JAPAN INTERNATIONAL COOPERATION AGENCY	

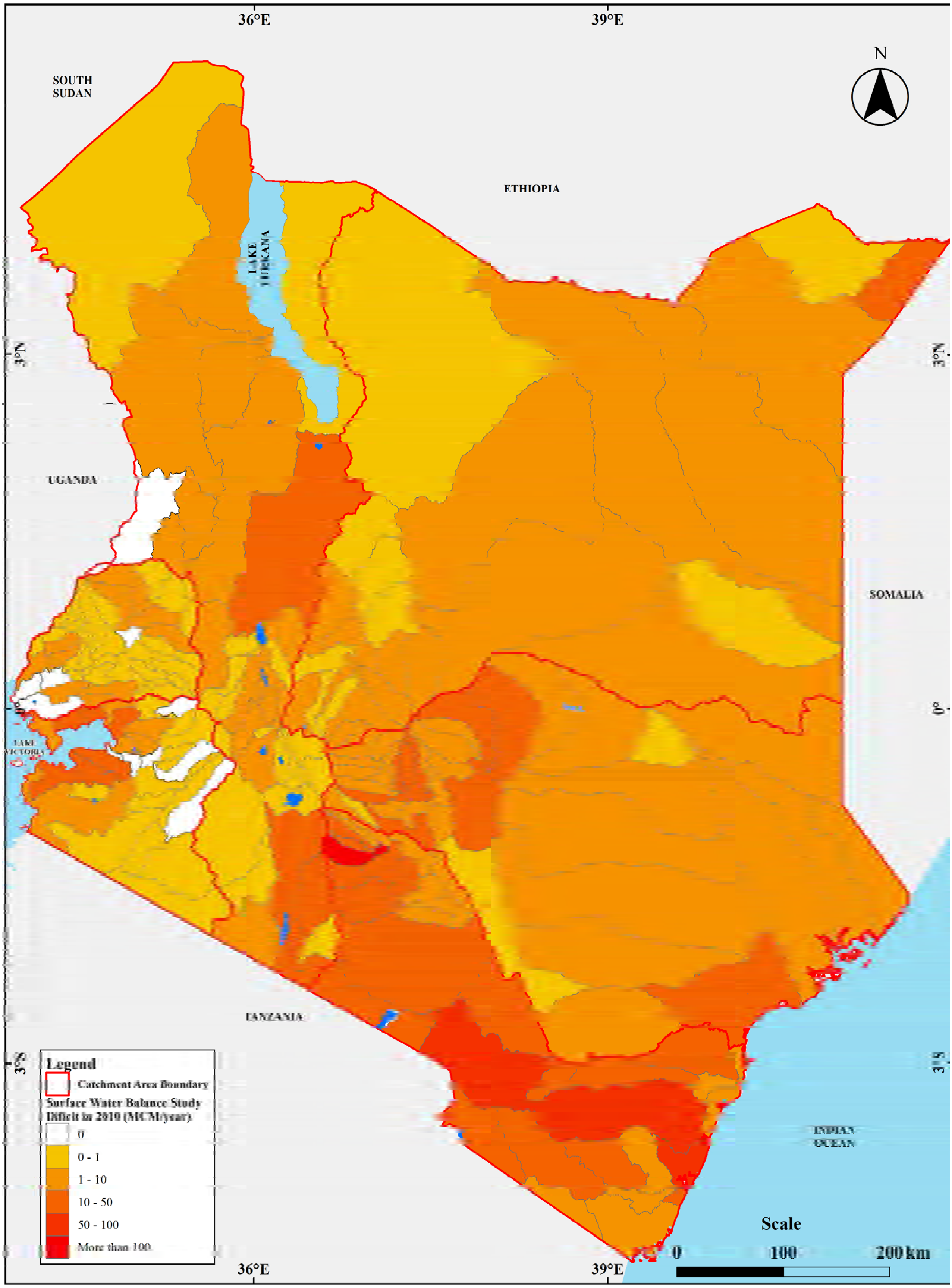


Notes: 1) = National water resources management strategy in accordance with Water Act 2002, Section 11
2) = Ministerial strategic plan 2009-2012 (May 2009), Water sector strategic plan 2010-2015 (June 2010),
3) = Catchment management strategy in accordance with Water Act 2002, Section 15
4) = WRMA strategic plan 2009-2012 (September 2009)
5) = NWCPC strategic plan 2010-2015 (--)
6) = MORDA strategic plan 2008-2012 (--)

a) = State schemes in accordance with Water Act 2002, Section 19
b) = Construction of works for state scheme in accordance with Water Act 2002, Section 22

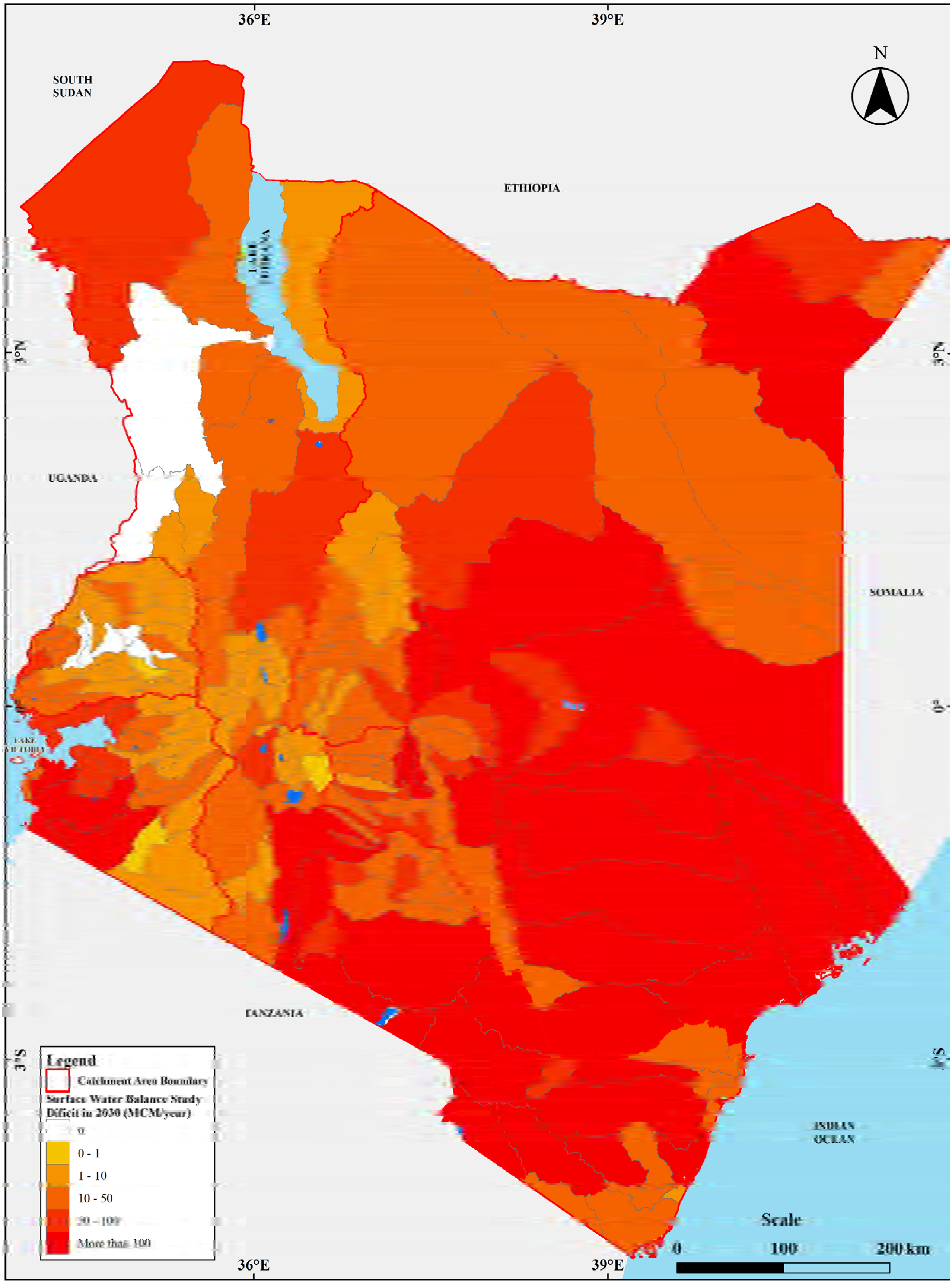
Source: JICA Study Team, based on information from MWI, WRMA, NWCPC, MORDA, KenGen

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.2.1 Organisations in relation to Water Resources Development**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

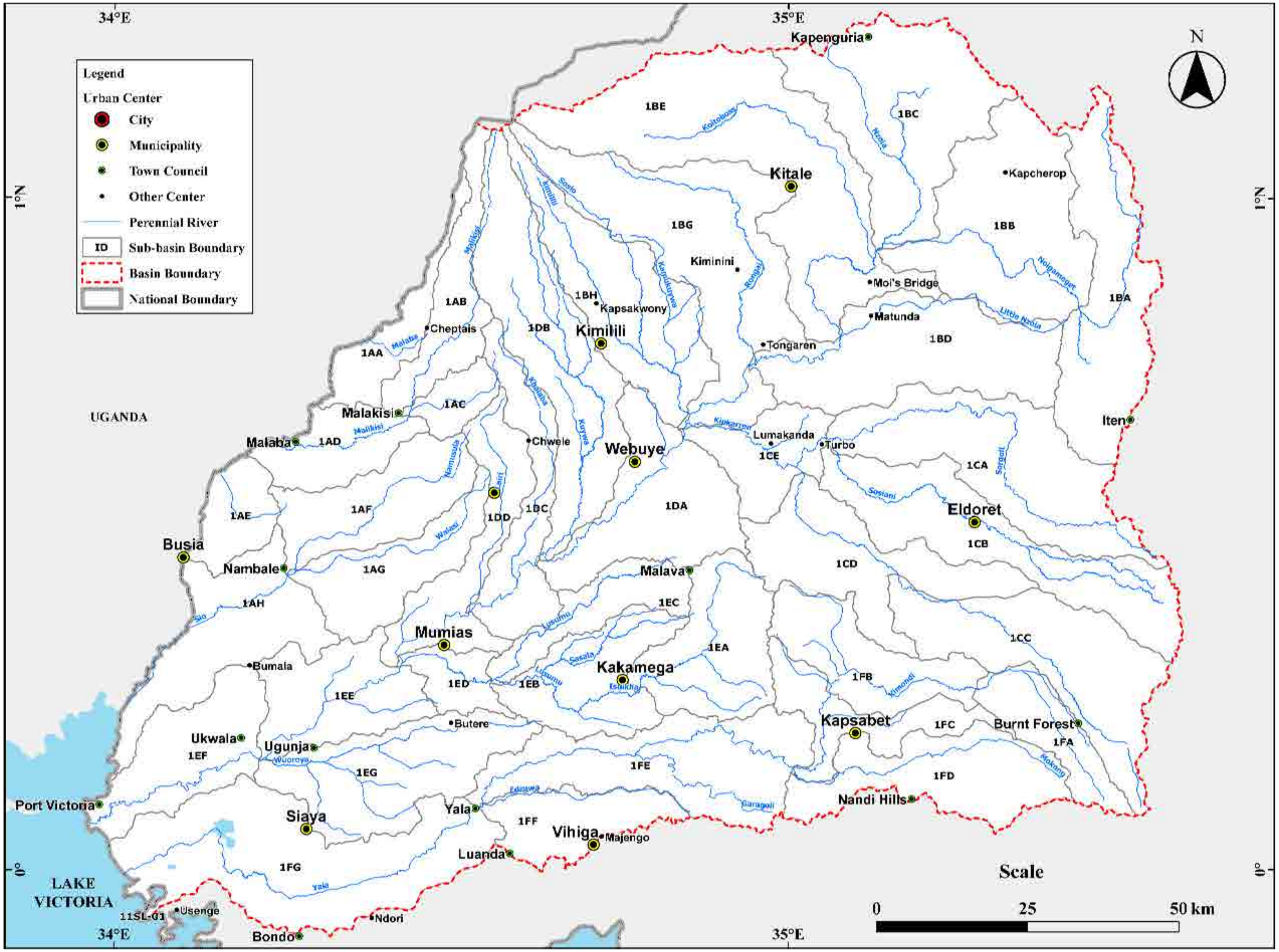
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.4.1** **Annual Deficit for 10-Year Probable Drought under Present (2010) Water Demand Condition**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.4.2**
JAPAN INTERNATIONAL COOPERATION AGENCY	**Annual Deficit for 10-Year Probable Drought under Future (2030) Water Demand Condition**

Source: JICA Study Team



THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.1
Sub-basin Division Map
(LVNCA)

Source: JICA Study Team

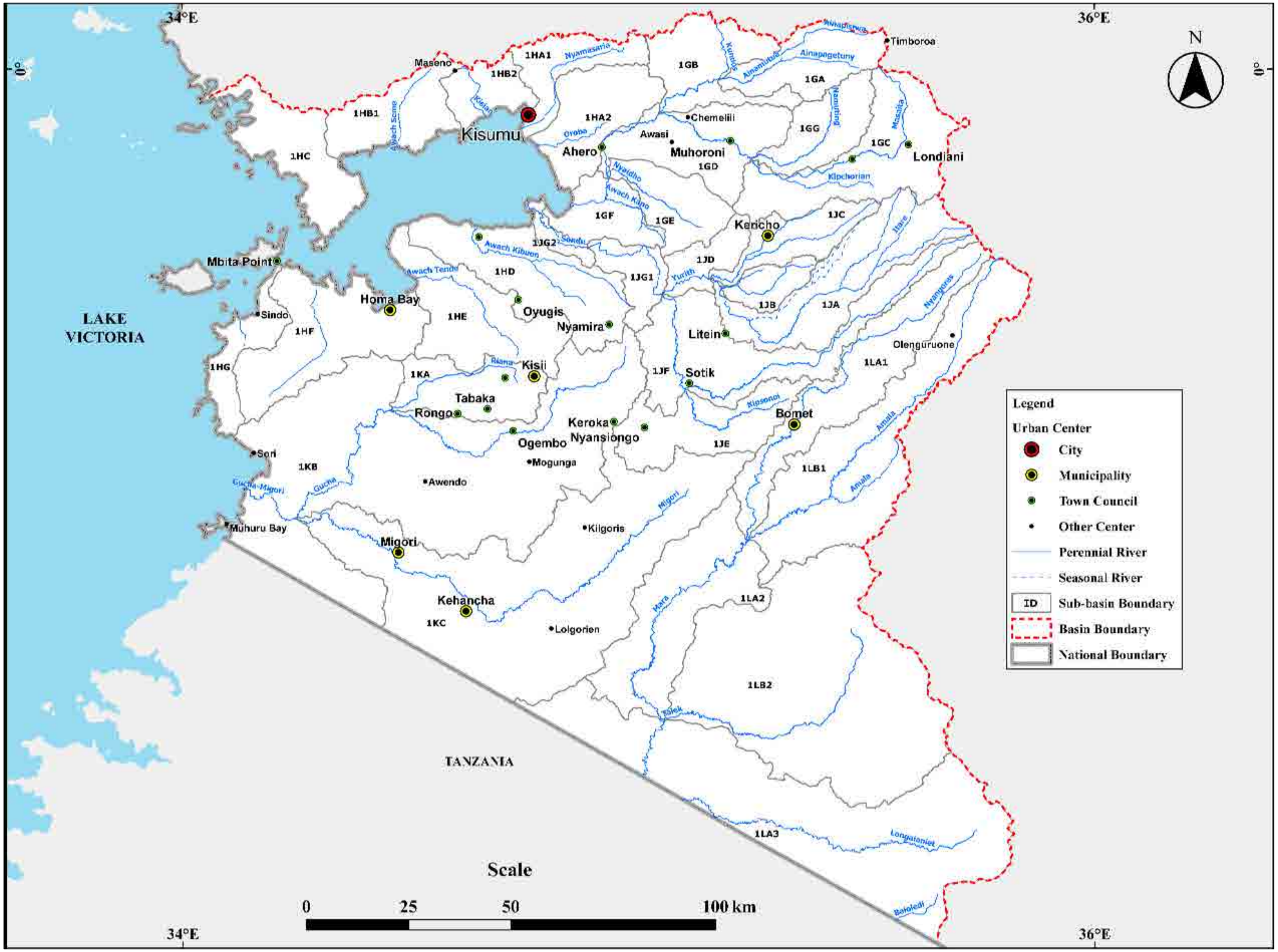
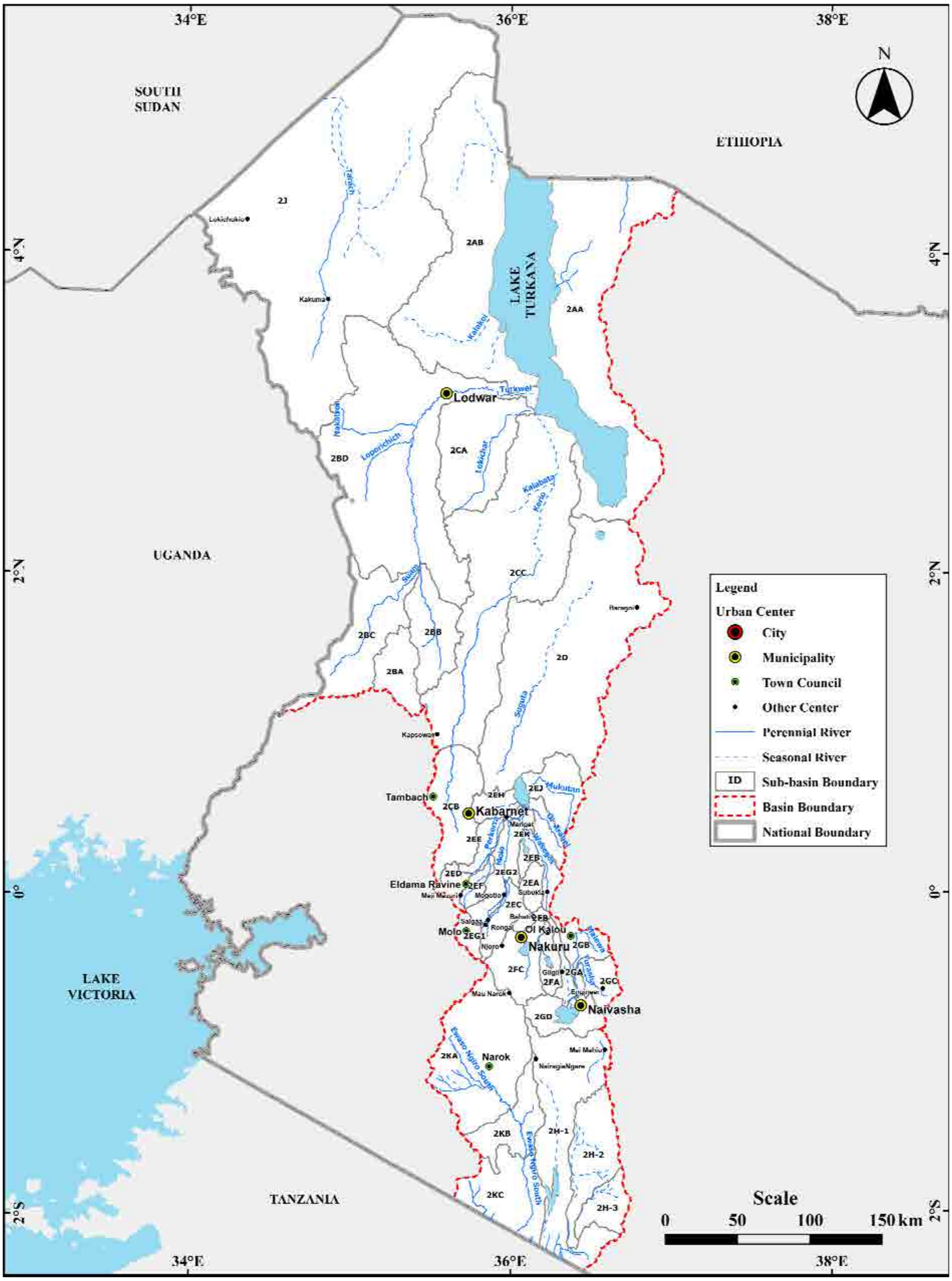


Figure 4.3.2
Sub-basin Division Map
(LVSCA)

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

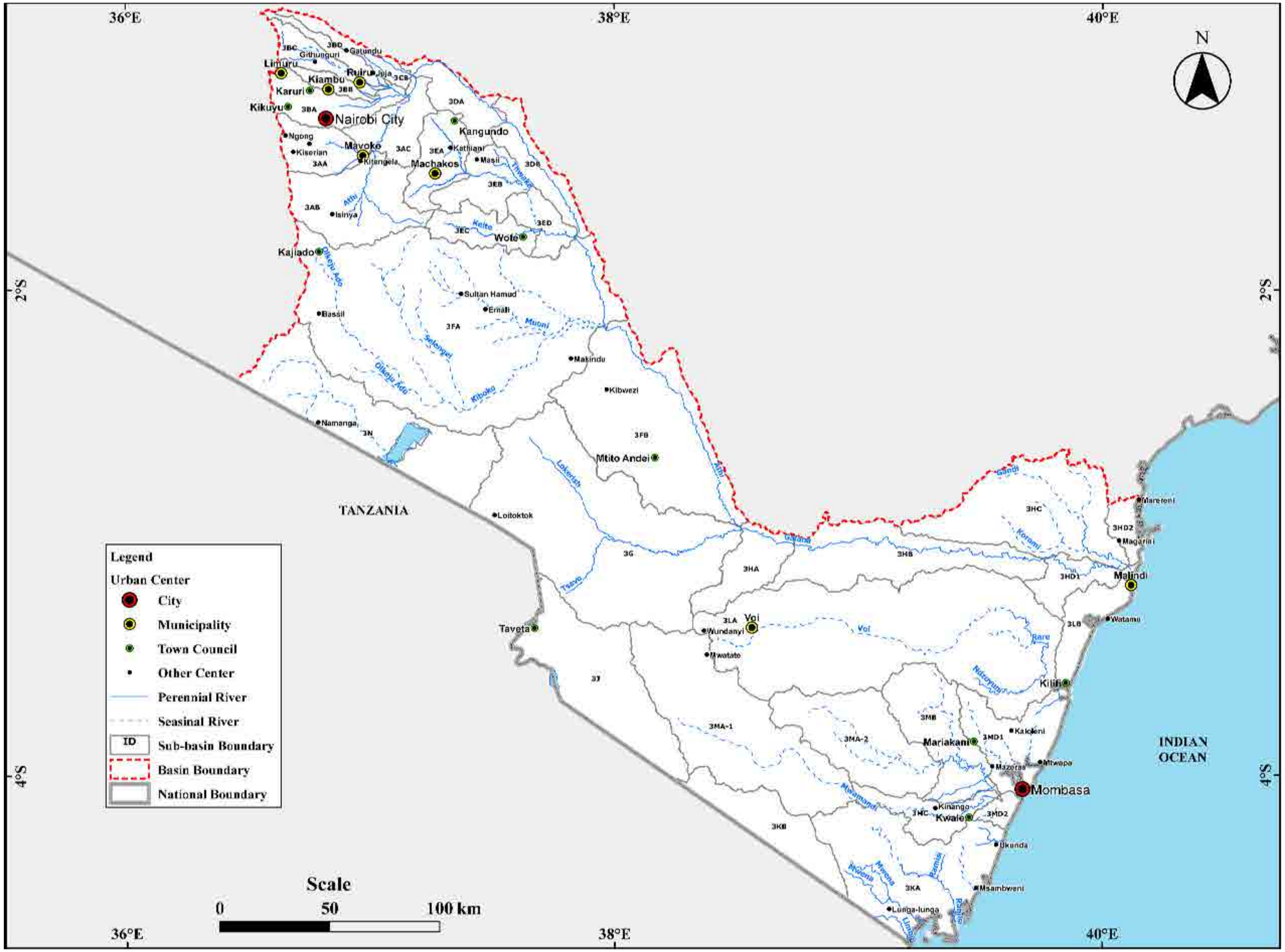
JAPAN INTERNATIONAL COOPERATION AGENCY



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.3.3 Sub-basin Division Map (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

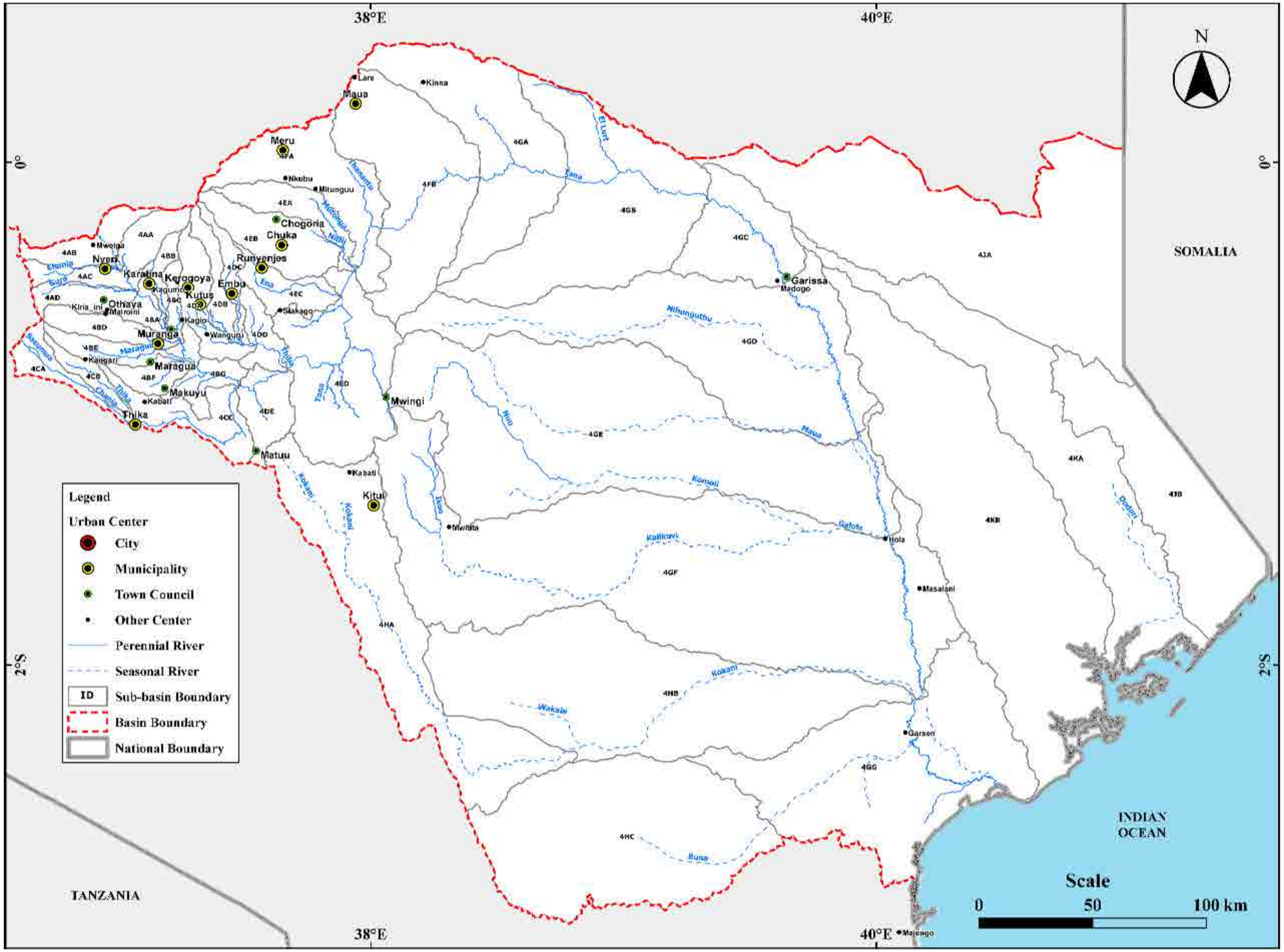
Source: JICA Study Team



THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.4
Sub-basin Division Map
(ACA)

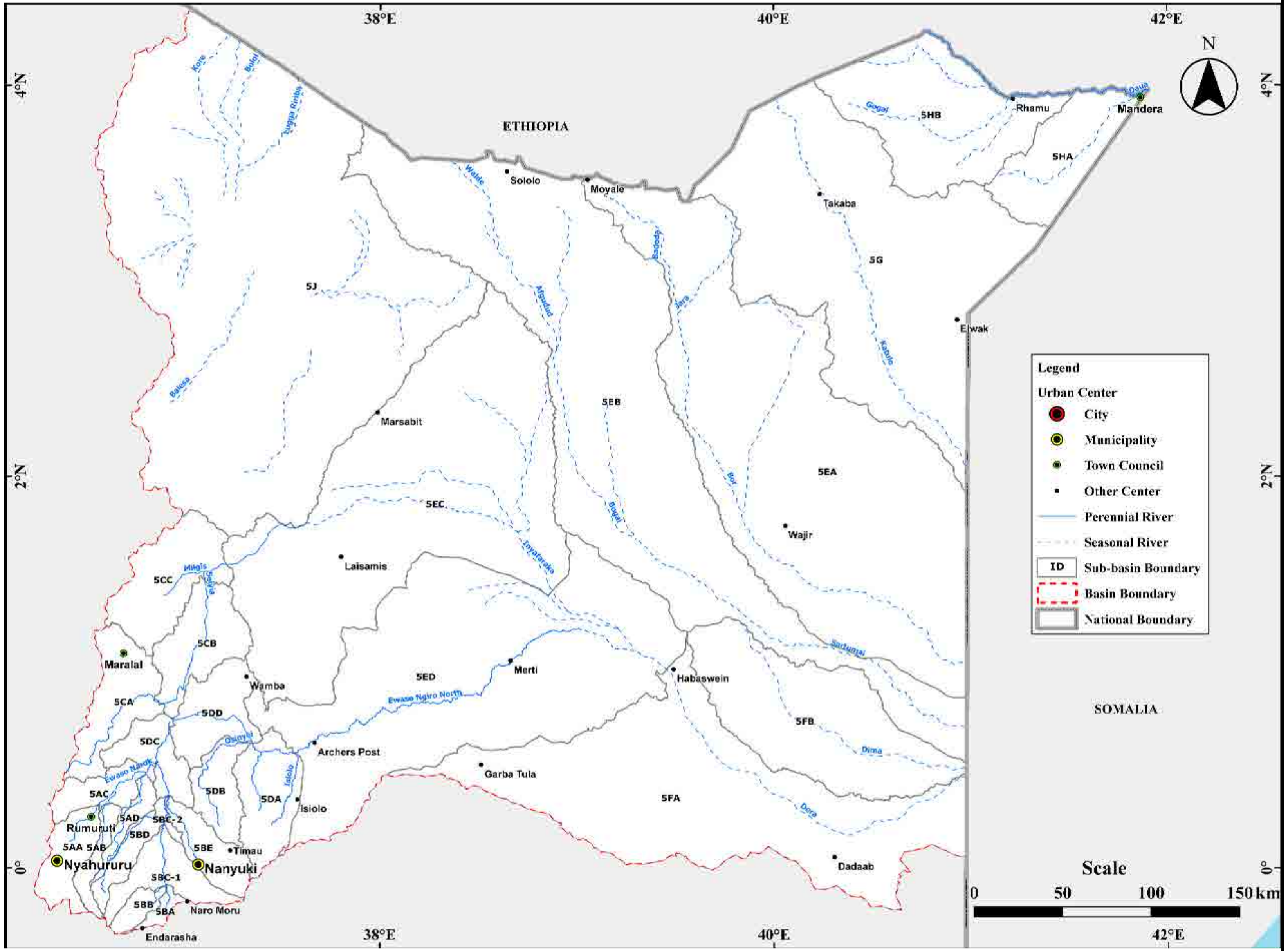


Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.5
Sub-basin Division Map
(TCA)



Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

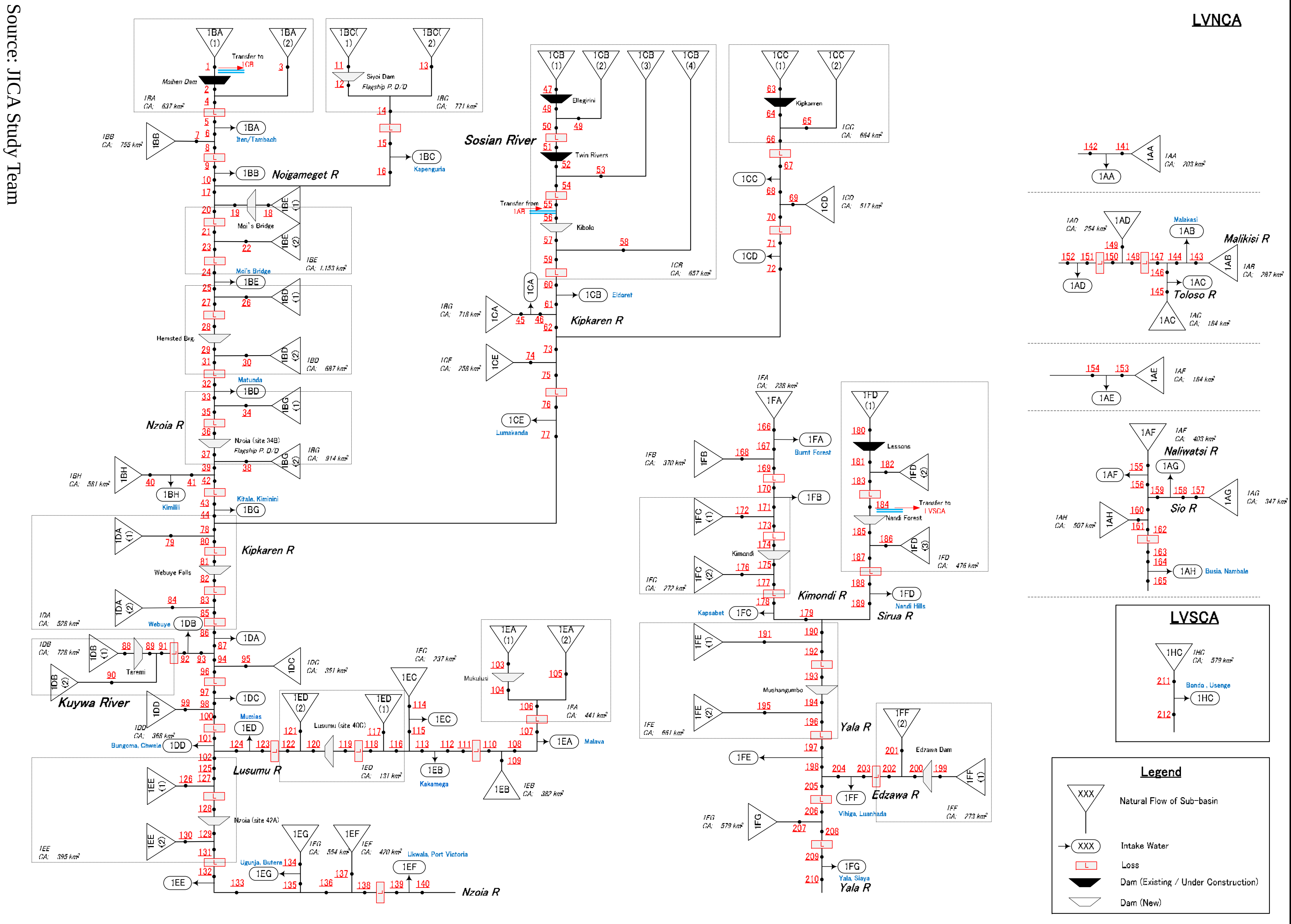
Figure 4.3.6
Sub-basin Division Map
(ENNCA)

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.7
Surface Water Balance Study Model
(LVNCA)

Source: JICA Study Team



THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Source: JICA Study Team

LVSCA

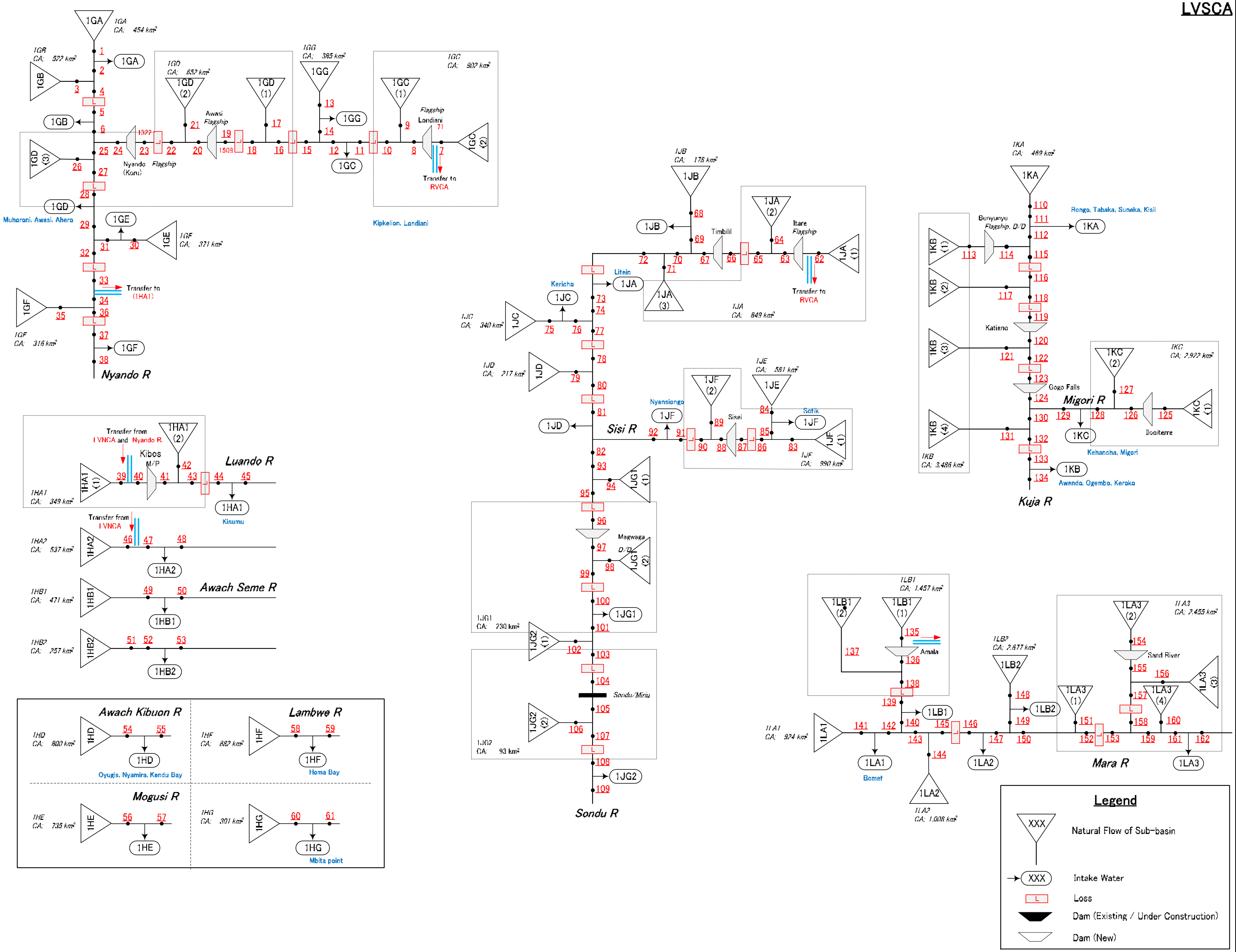


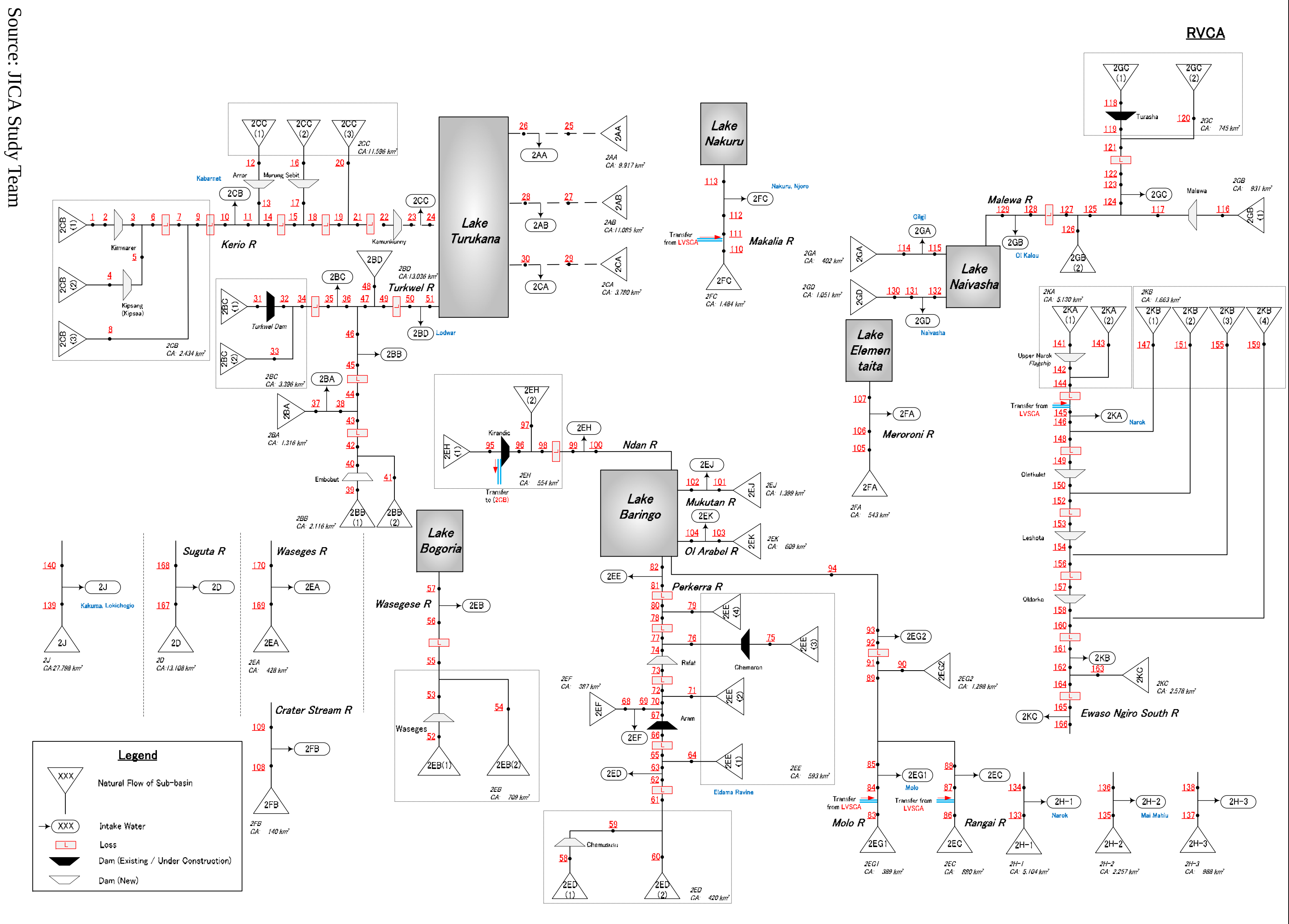
Figure 4.3.8
Surface Water Balance Study Model (LVSCA)

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.9 Surface Water Balance Study Model (RVCA)

Source: JICA Study Team

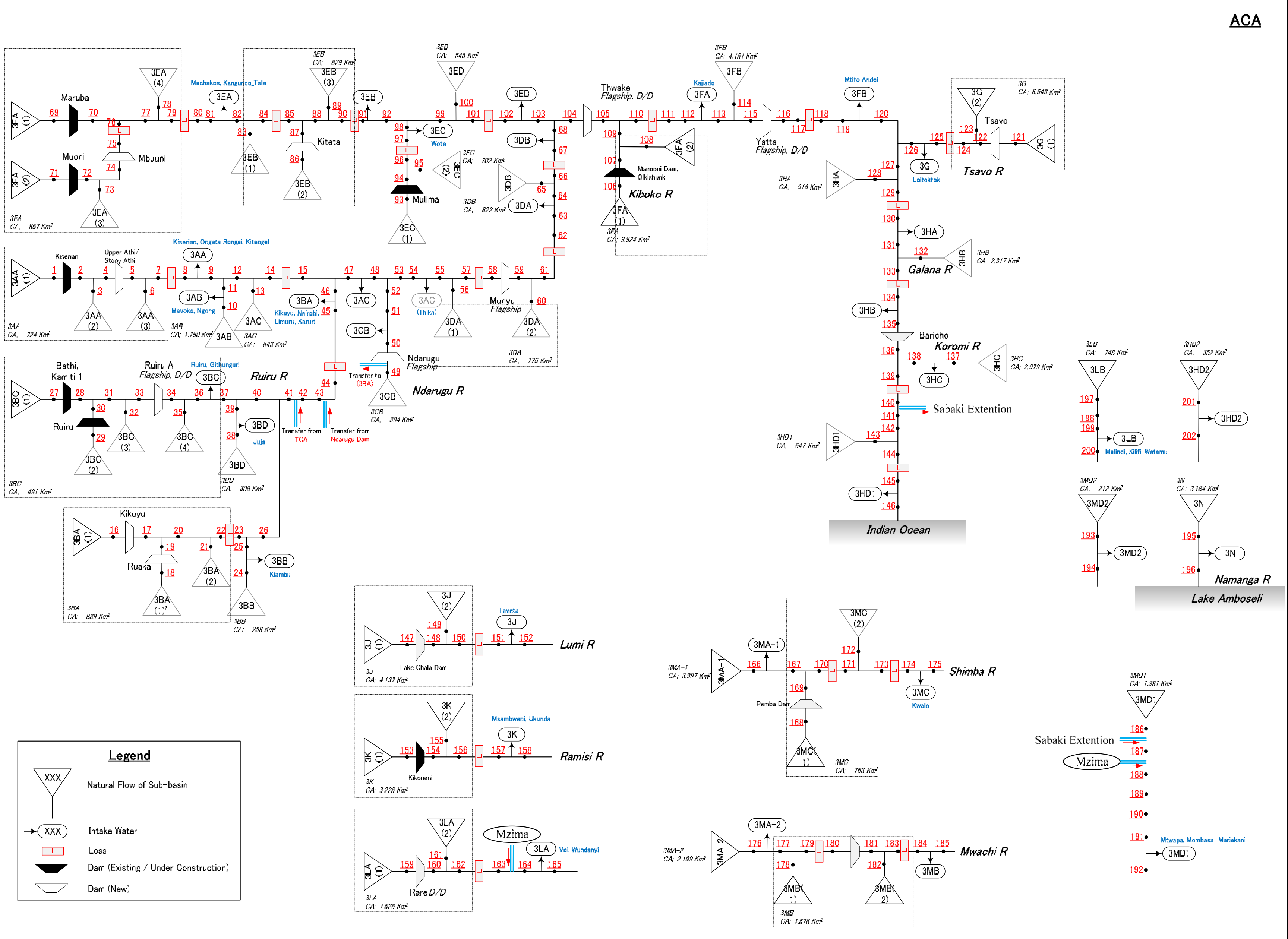


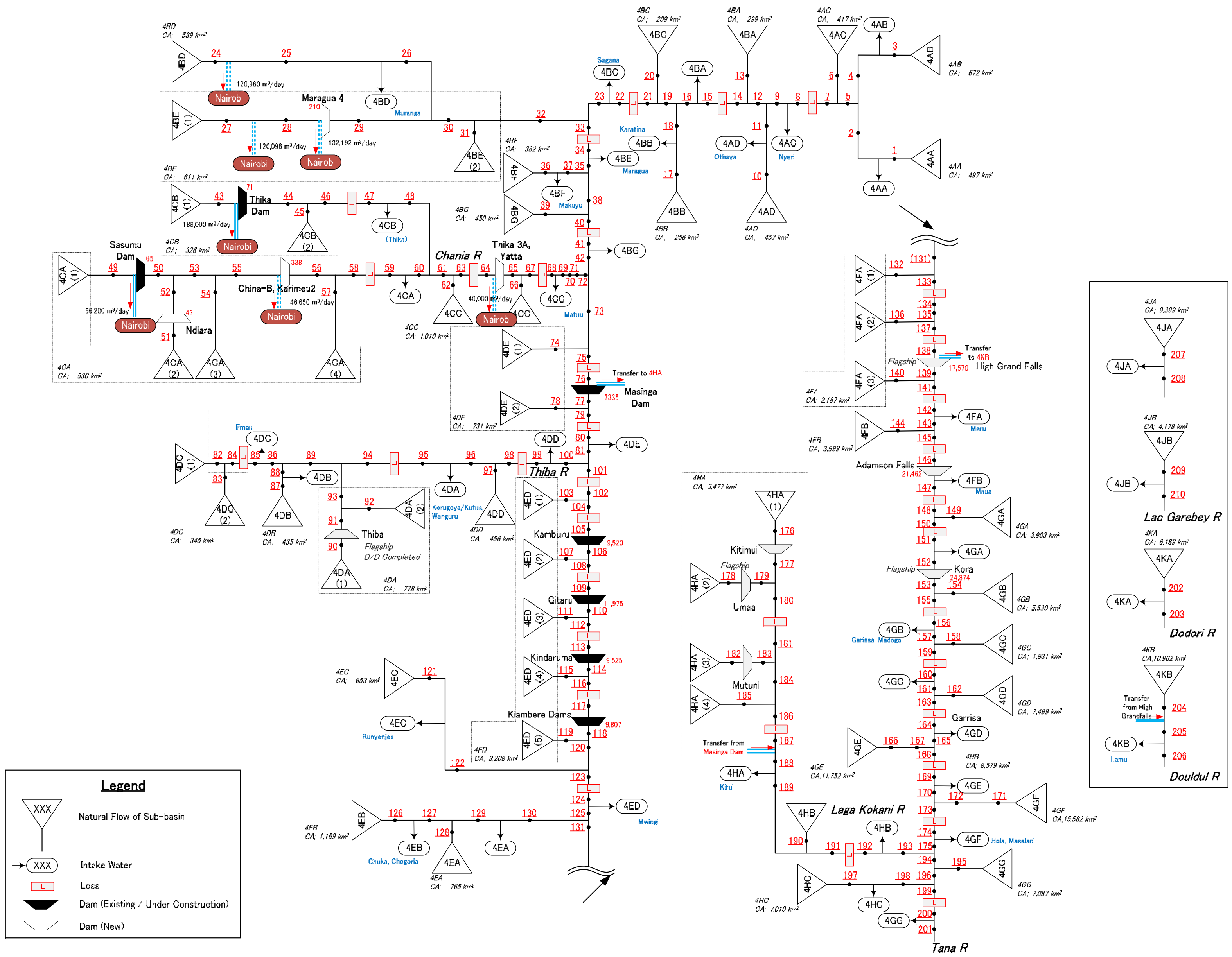
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.3.10
Surface Water Balance Study Model
(ACA)

Source: JICA Study Team





Source: JICA Study Team

Figure 4.3.11 Surface Water Balance Study Model (TCA)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

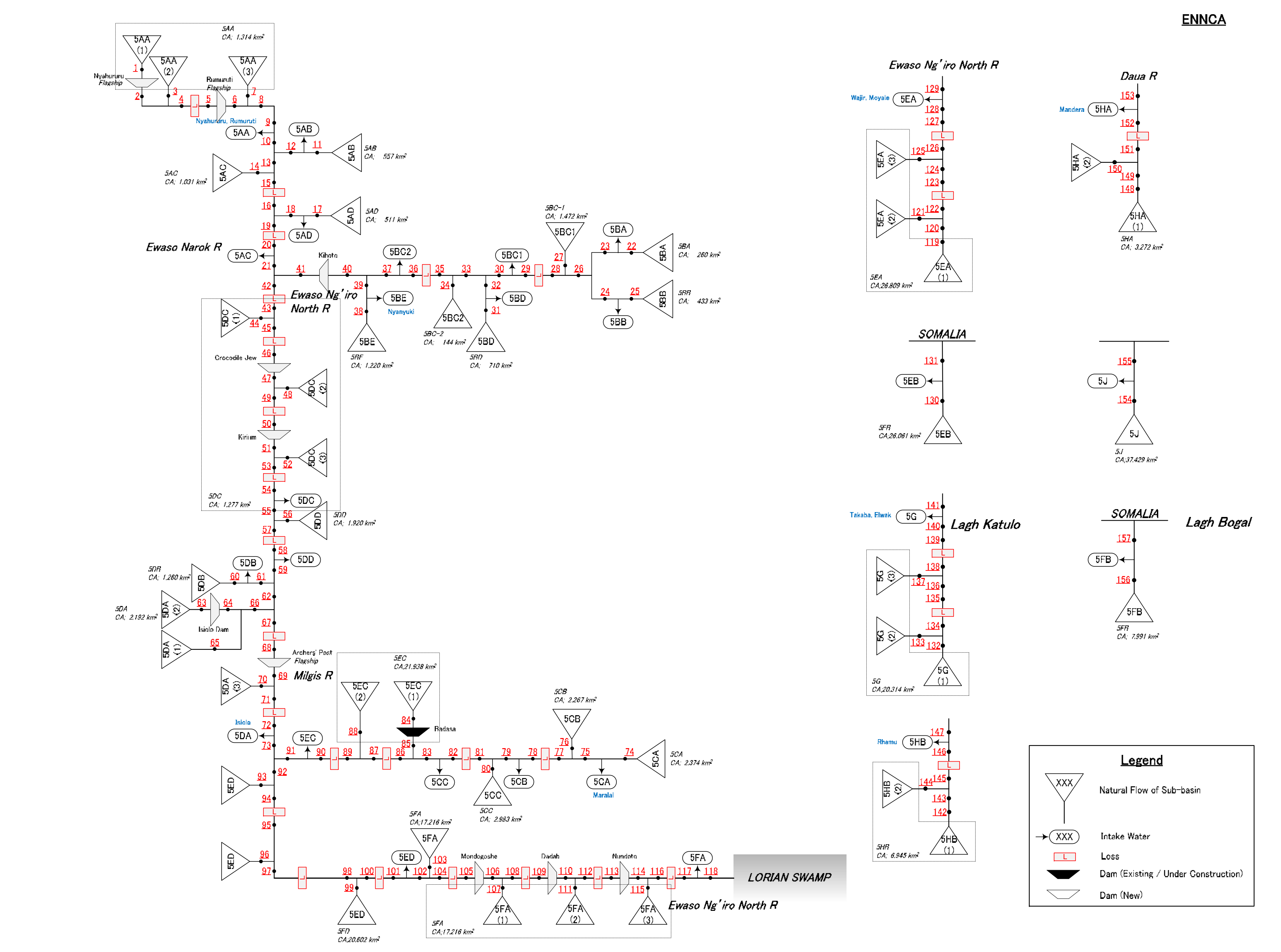
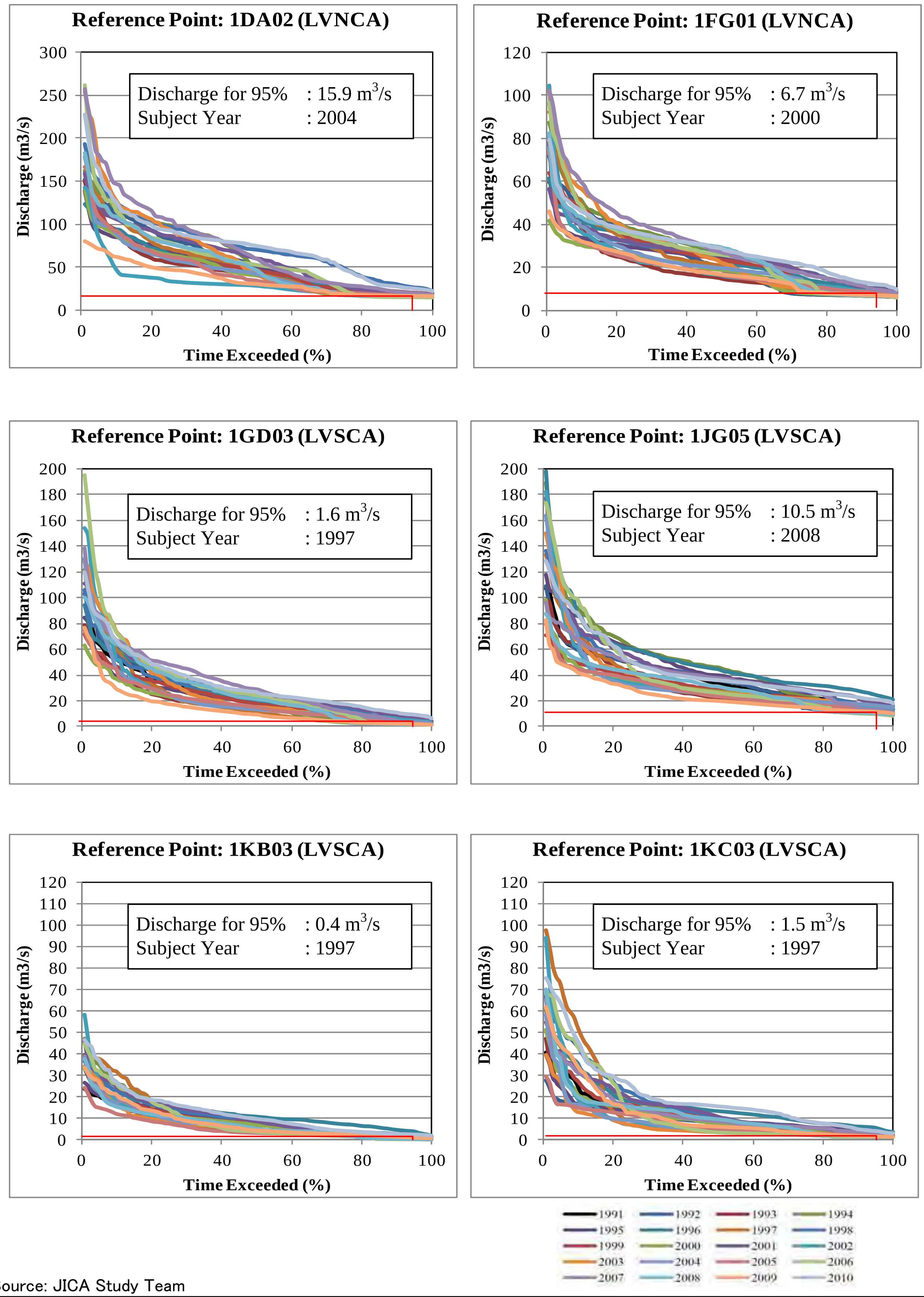


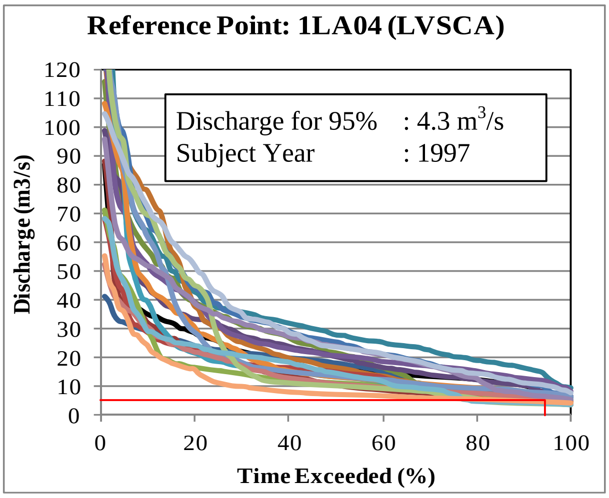
Figure 4.3.12 Surface Water Balance Study Model (ENNCA)

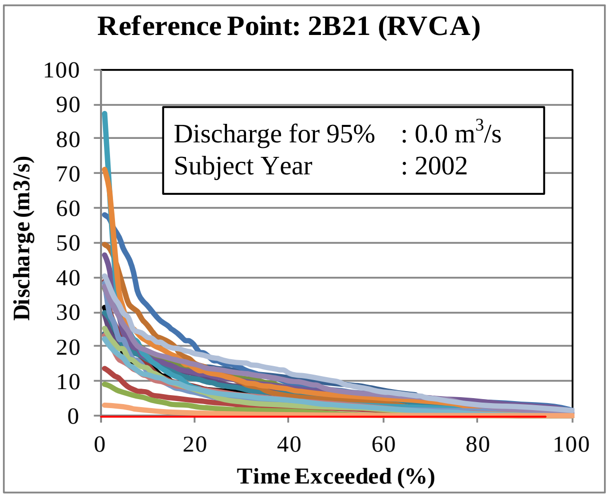
Source: JICA Study Team

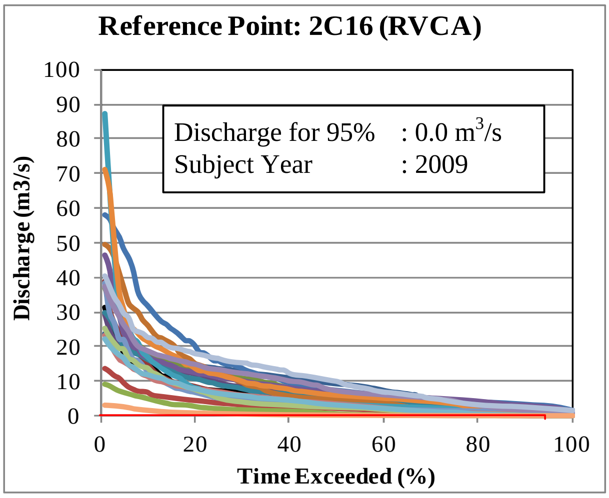


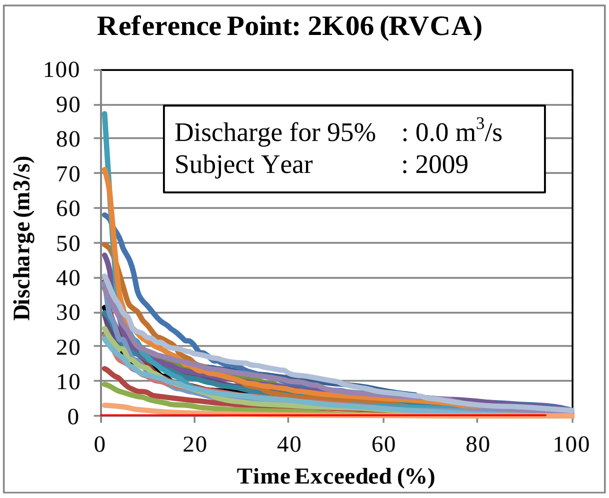
Source: JICA Study Team

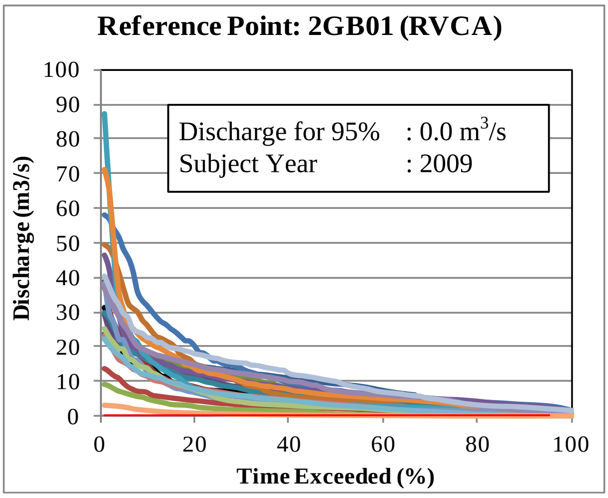
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.3.13 Simulated Flow Duration Curves for Estimate of Reserves at Reference Points (1/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

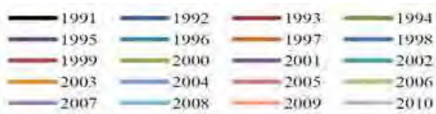










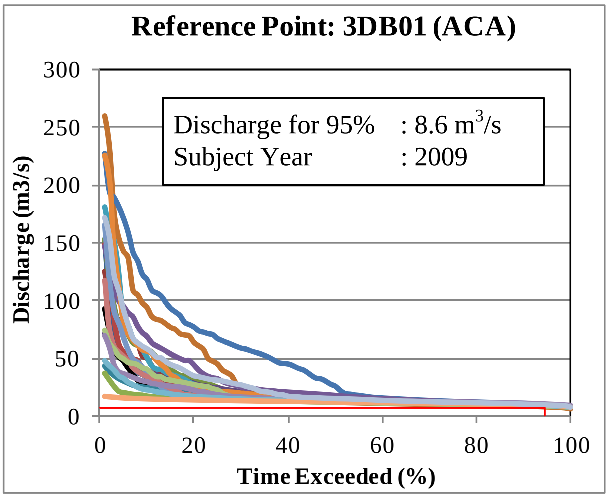


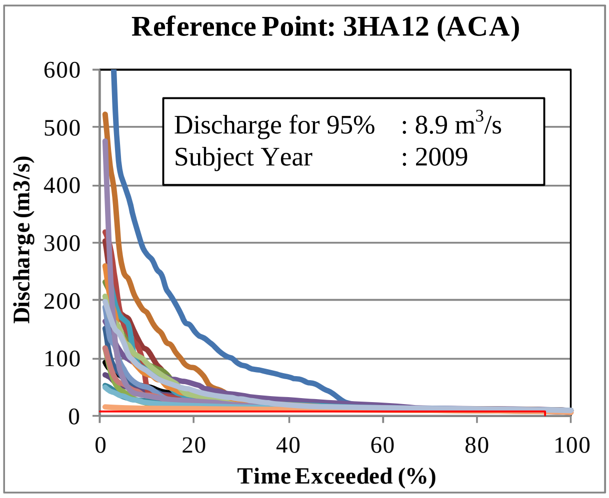
Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

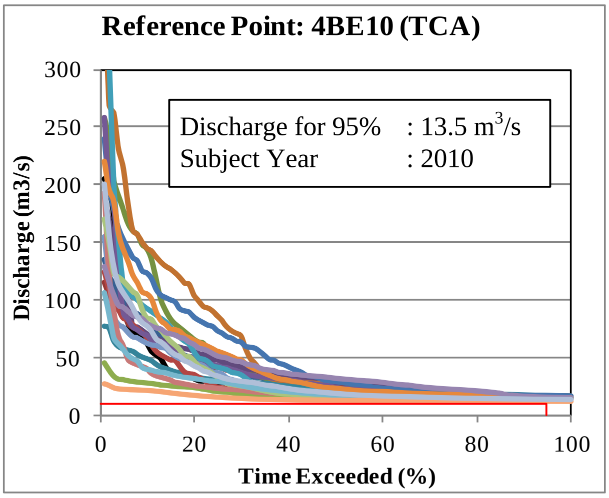
JAPAN INTERNATIONAL COOPERATION AGENCY

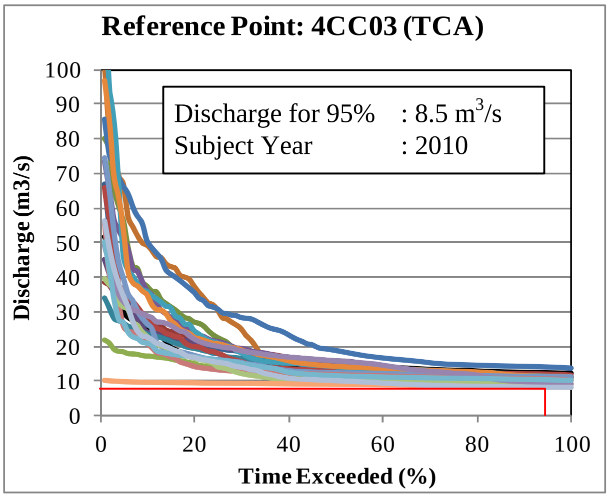
Figure 4.3.13
Simulated Flow Duration Curves for Estimate of Reserves at Reference Points (2/3)

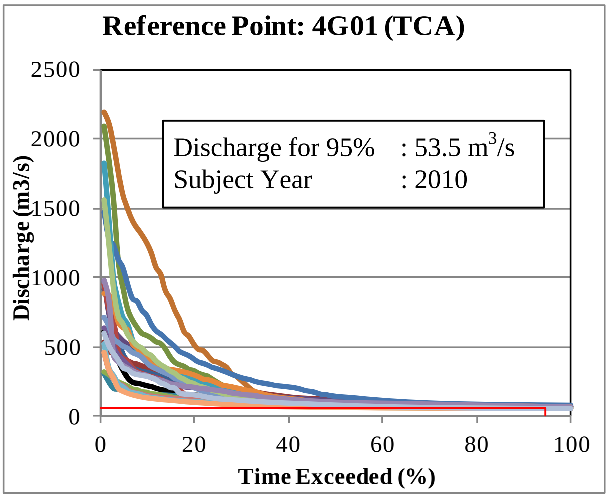


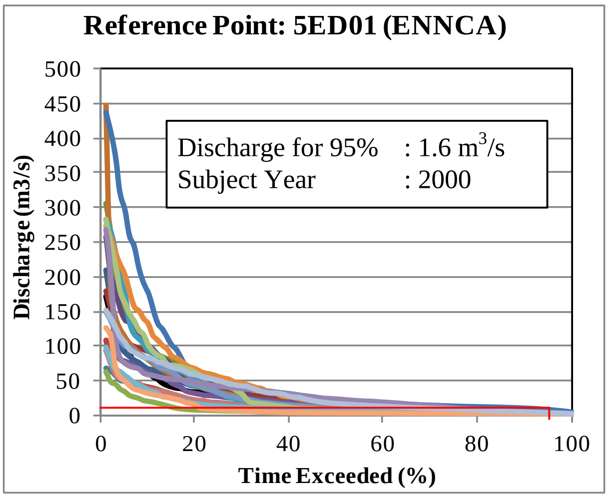


Note: Drought year is 1997 (Q95=8.5 m3/s, 2/20 year), however, considering selected year in upstream and downstream, this point is selected in 2009 (3/20 year).



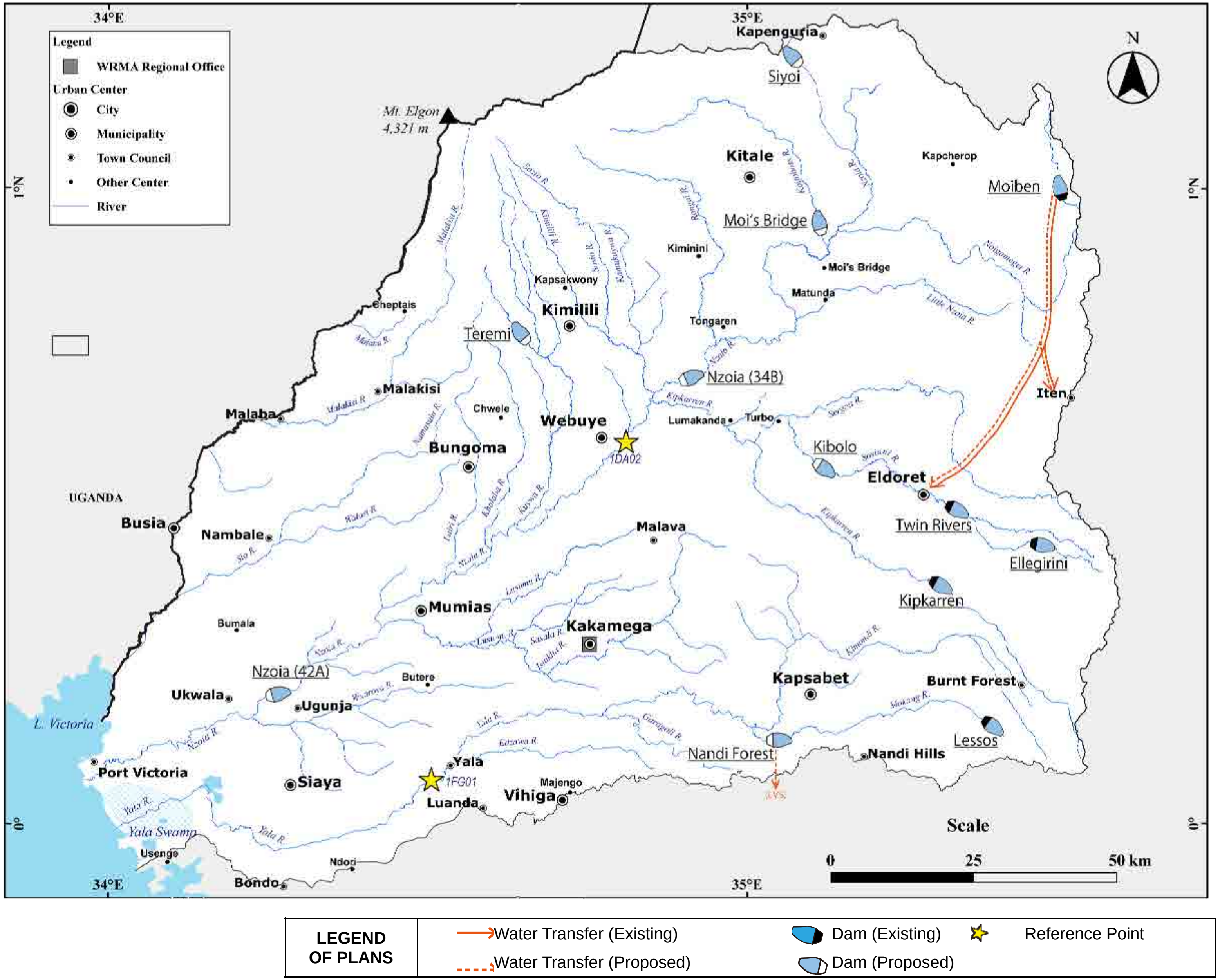






Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.3.13** **Simulated Flow Duration Curves for Estimate of Reserves at Reference Points (3/3)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

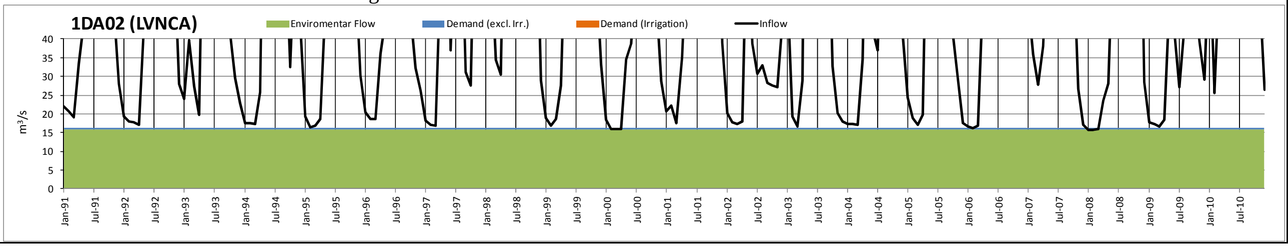
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

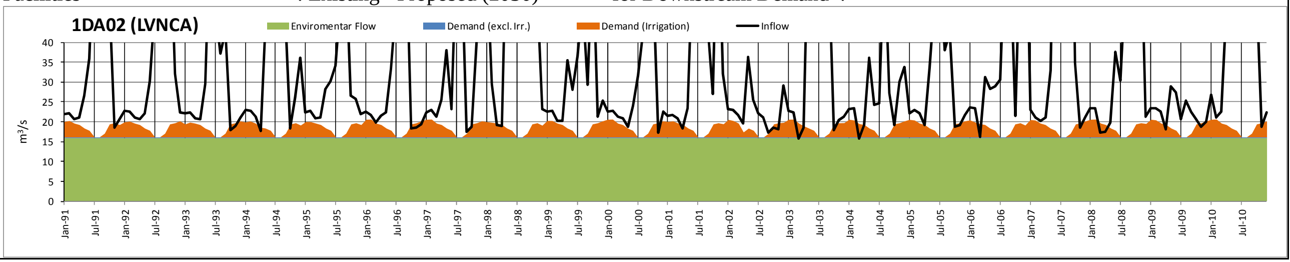
Figure 4.4.1
Proposed Development Plans for Dams and Water Transfers (LVNCA)

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

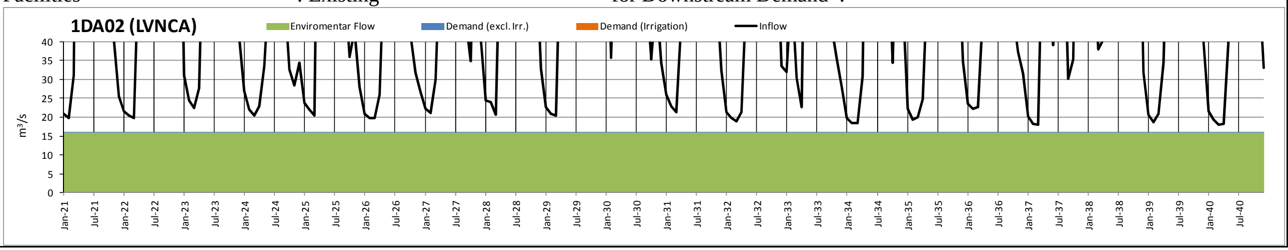
River Flow	: Present (1991-2010)	Reserve:	15.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.2	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



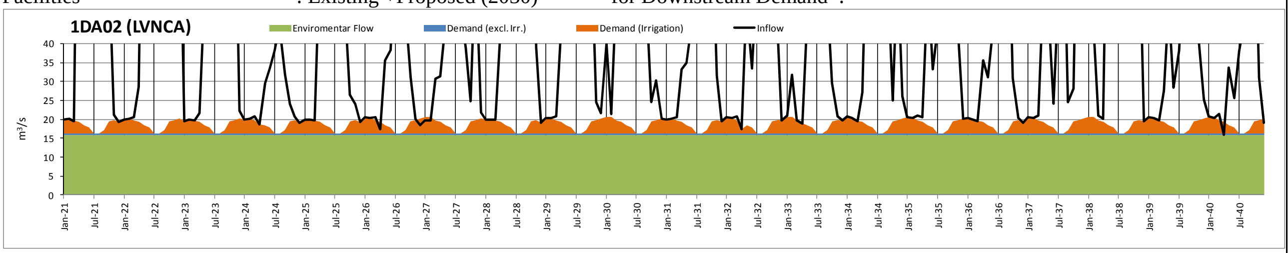
River Flow	: Present (1991-2010)	Reserve:	15.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	3.6	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



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



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



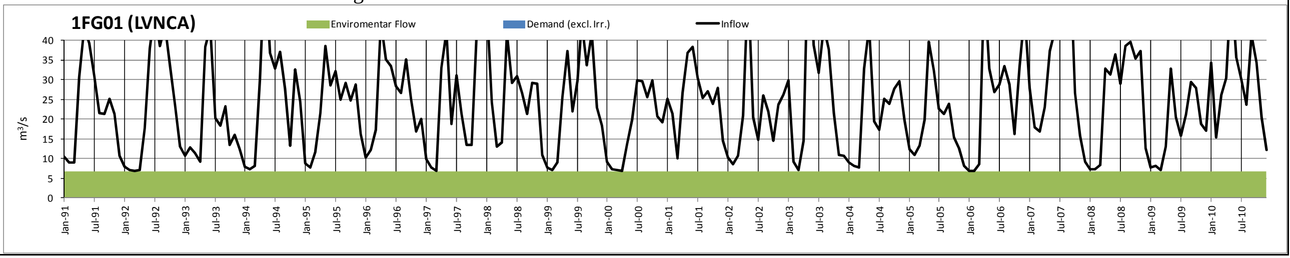
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

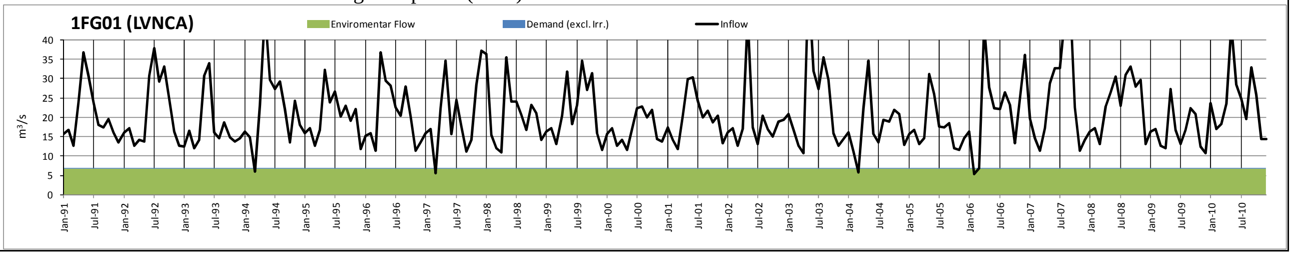
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.4.2** **River Flow at Reference Point 1DA02 under Present and Future Water Demands and Facilities Conditions (LVNCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

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

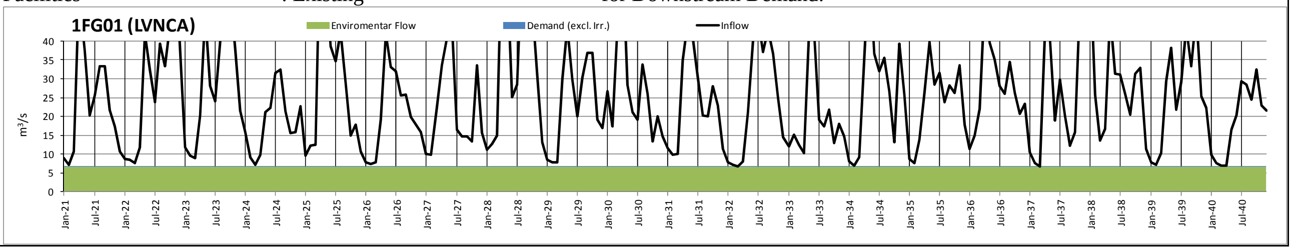
River Flow	: Present (1991-2010)	Reserve:	6.7	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



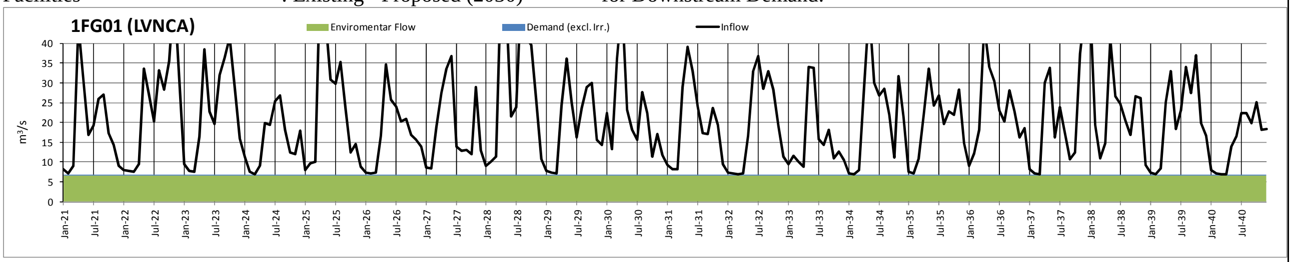
River Flow	: Present (1991-2010)	Reserve:	6.7	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.2	(m^3/s)



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



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.4.3 River Flow at Reference Point 1FG01 under Present and Future Water Demands and Facilities Conditions (LVNCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Source: JICA Study Team

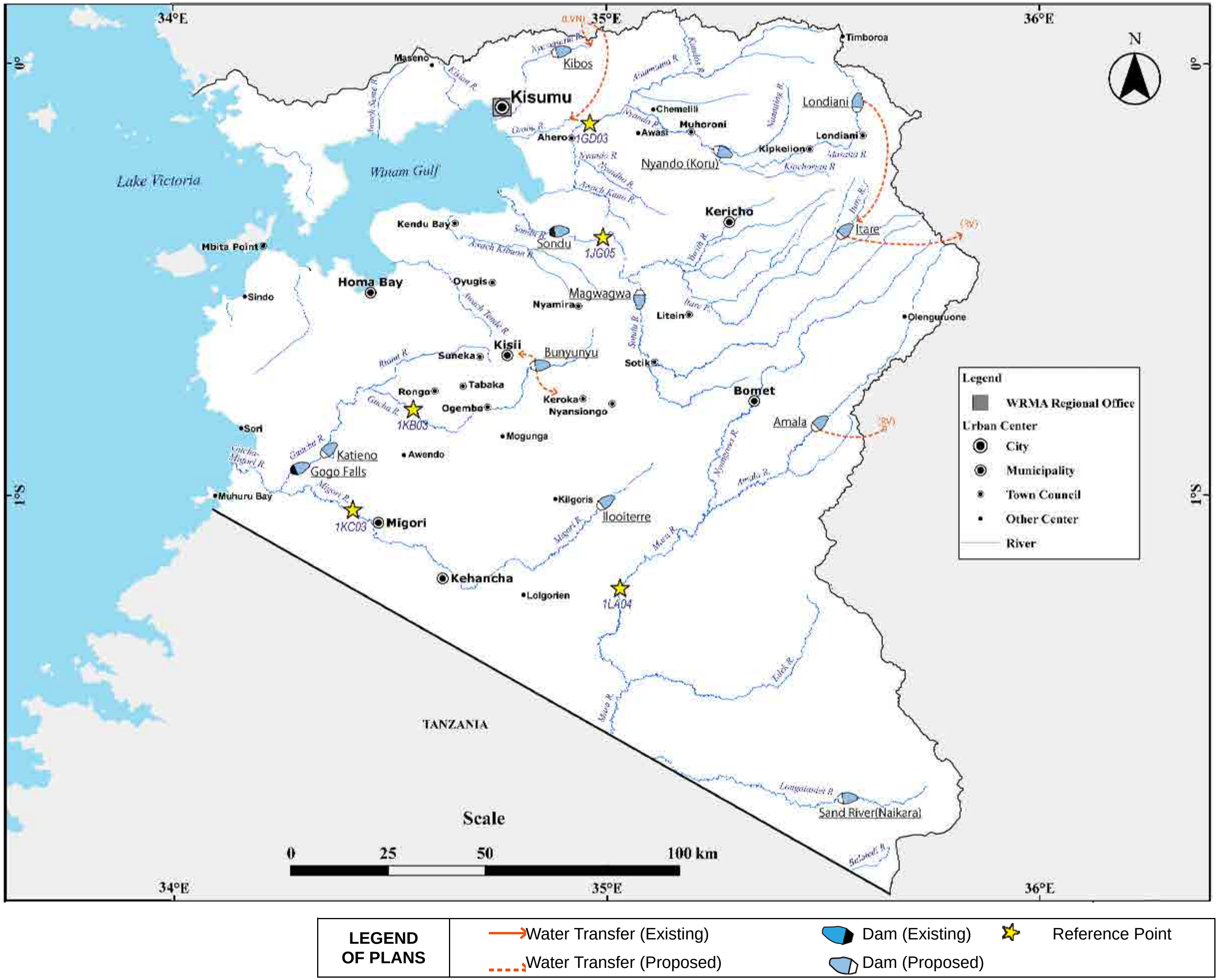
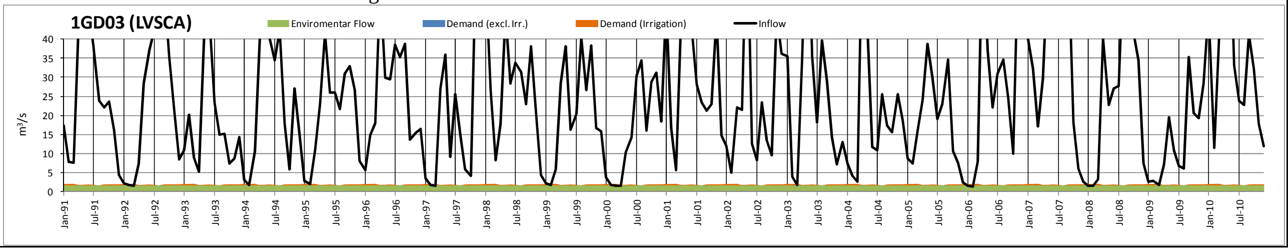


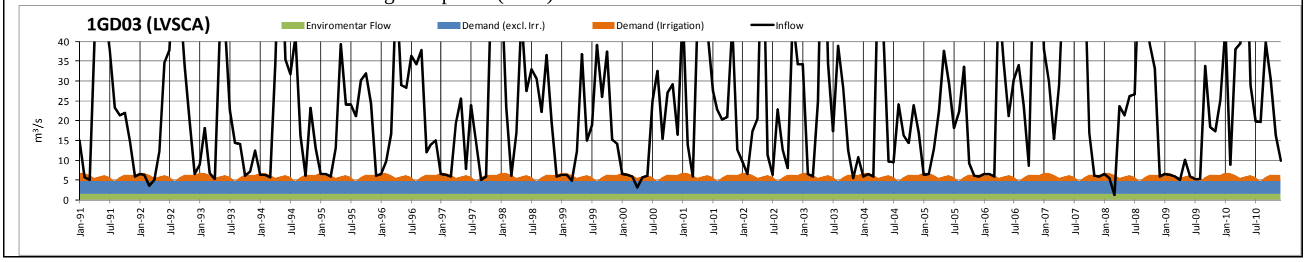
Figure 4.5.1 Proposed Development Plans for Dams and Water Transfers (LVSCA)

River Name: Nyando River (LVSCA)
Reference Point: 1GD03

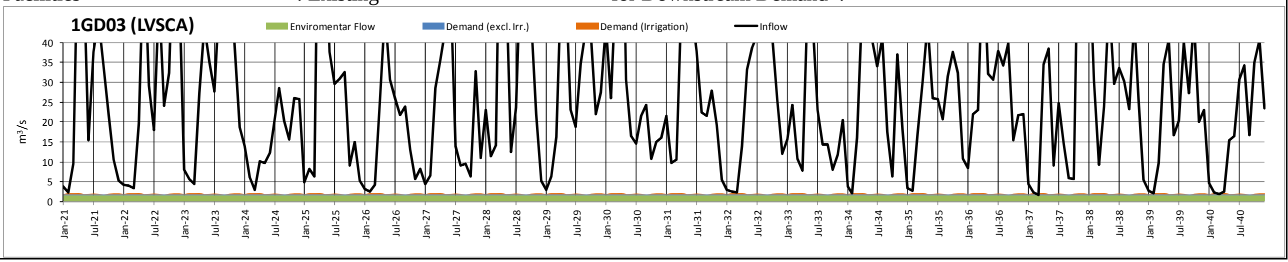
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	0.4	(m^3/s)
Facilities	: Existing			



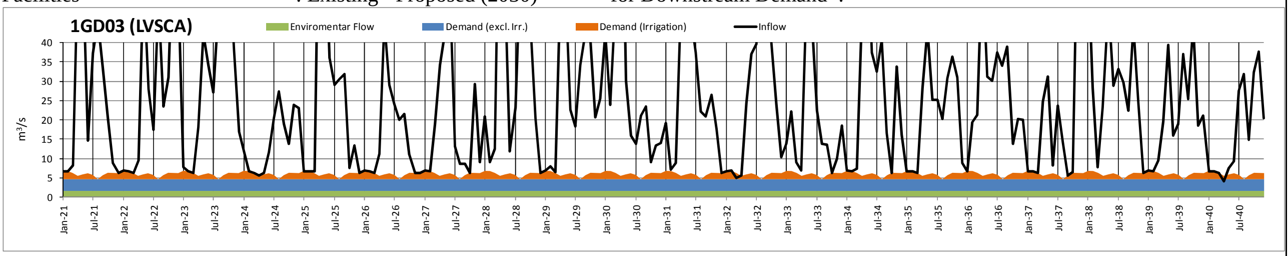
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.5	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	0.4	(m^3/s)
Facilities	: Existing			



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.5	(m^3/s)
Facilities	: Existing +Proposed (2030)			



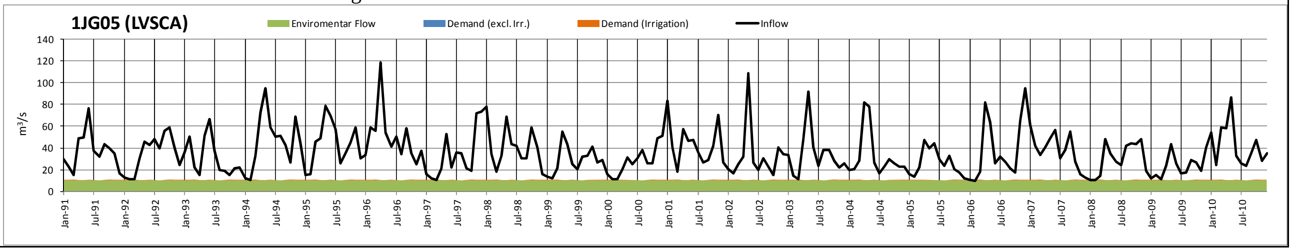
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

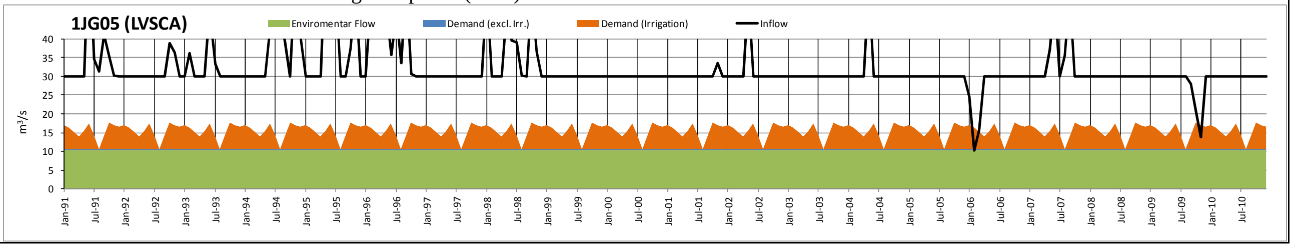
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.2** **River Flow at Reference Point 1GD03 under Present and Future Water Demands and Facilities Conditions (LVSCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Sondu River (LVSCA)
Reference Point: 1JG05

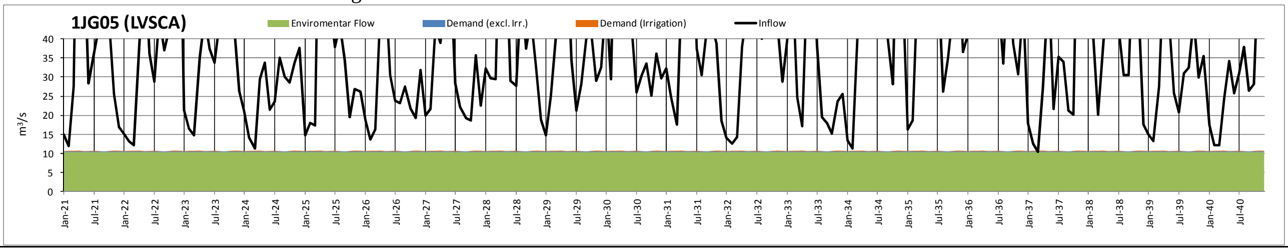
River Flow	: Present (1991-2010)	Reserve:	10.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.2	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



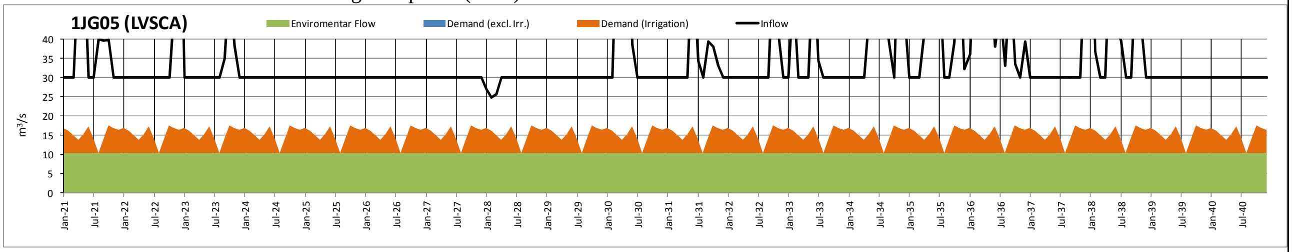
River Flow	: Present (1991-2010)	Reserve:	10.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	5.4	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	10.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.2	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	10.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	5.4	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



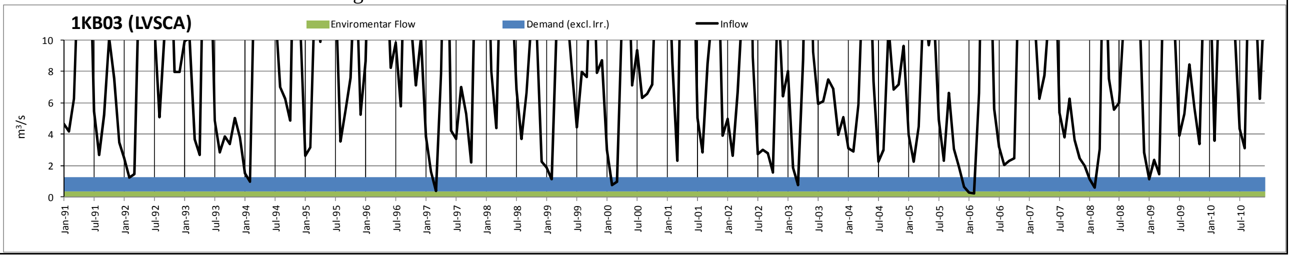
Note: * Irrigation water demand is the average irrigation water demand during March, April, May and June.
Hydropower discharge is constant from the proposed Magwagwa Dam.

Source: JICA Study Team

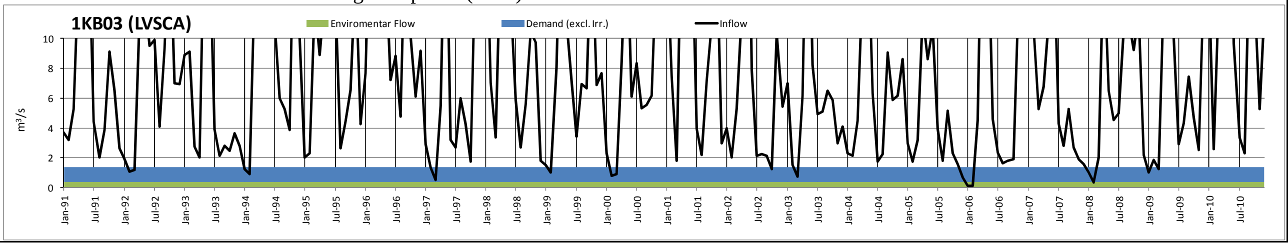
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.3 River Flow at Reference Point 1JG05 under Present and Future Water Demands and Facilities Conditions (LVSCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Gucha River (LVSCA)
Reference Point: 1KB03

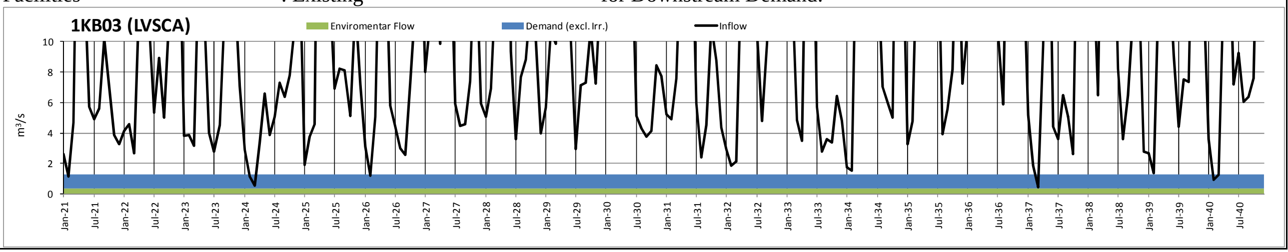
River Flow	: Present (1991-2010)	Reserve:	0.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.9	(m^3/s)
Facilities	: Existing			



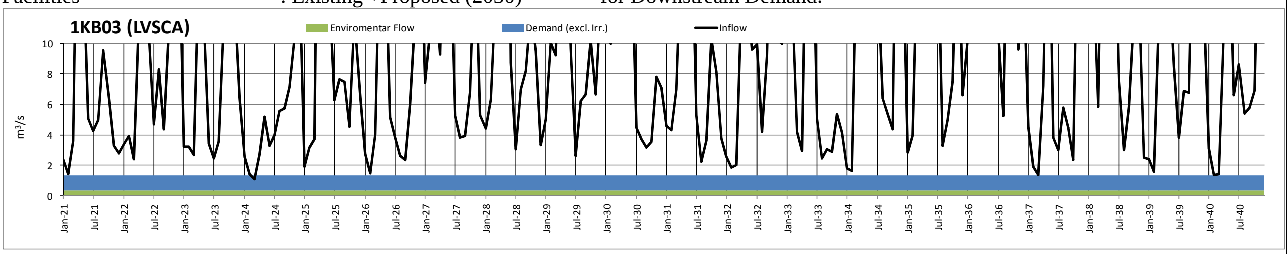
River Flow	: Present (1991-2010)	Reserve:	0.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.0	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River Flow	: Future (2021-2040)	Reserve:	0.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	0.9	(m^3/s)
Facilities	: Existing			



River Flow	: Future (2021-2040)	Reserve:	0.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.0	(m^3/s)
Facilities	: Existing +Proposed (2030)			

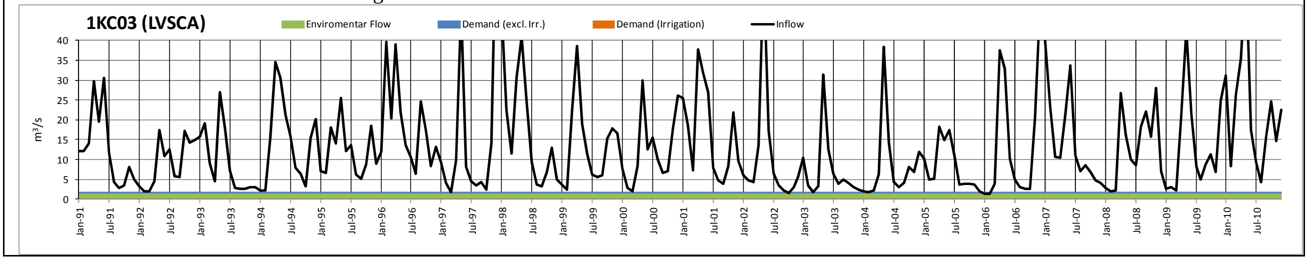


Source: JICA Study Team

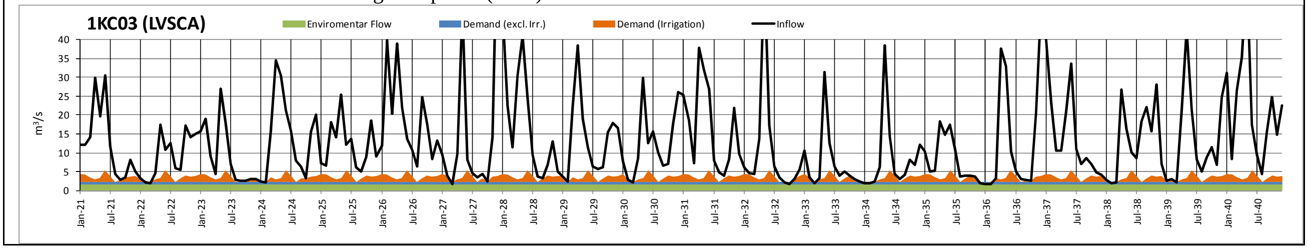
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.4** **River Flow at Reference Point 1KB03 under Present and Future Water Demands and Facilities Conditions (LVSCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Migori River (LVSCA)
Reference Point: 1KC03

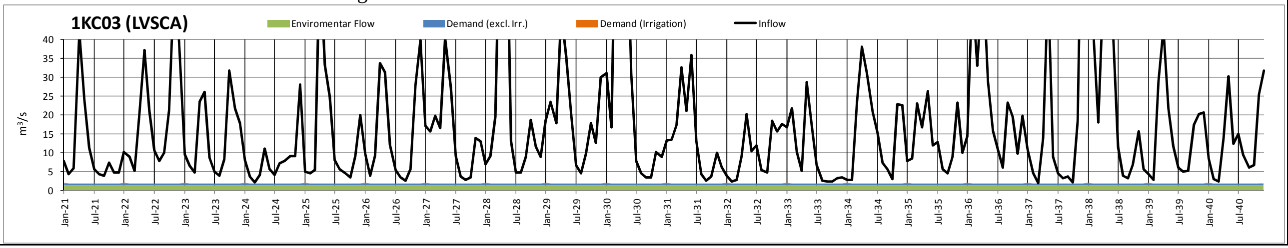
River Flow	: Present (1991-2010)	Reserve:	1.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.4	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



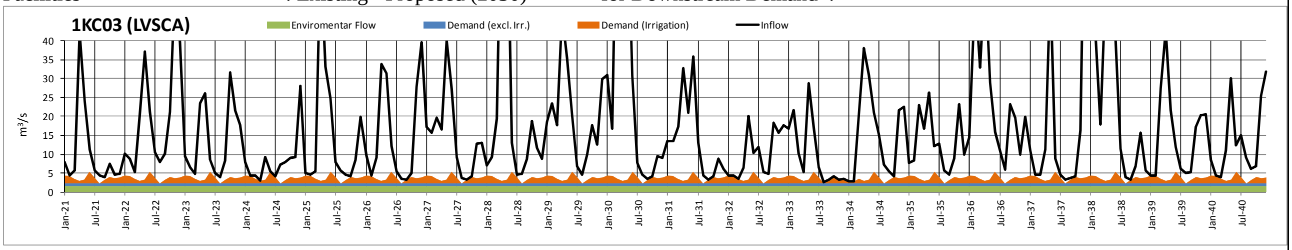
River Flow	: Present (1991-2010)	Reserve:	1.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	2.3	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	1.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.4	(m^3/s)
Facilities	: Existing	for Downstream Demand*:		



River Flow	: Future (2021-2040)	Reserve:	1.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	2.3	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:		



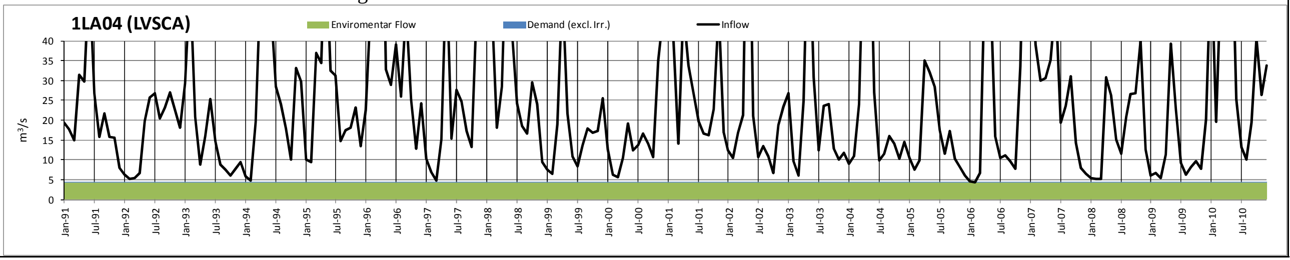
Note:* Irrigation water demand is the average irrigation water demand during March, April, May and June.

Source: JICA Study Team

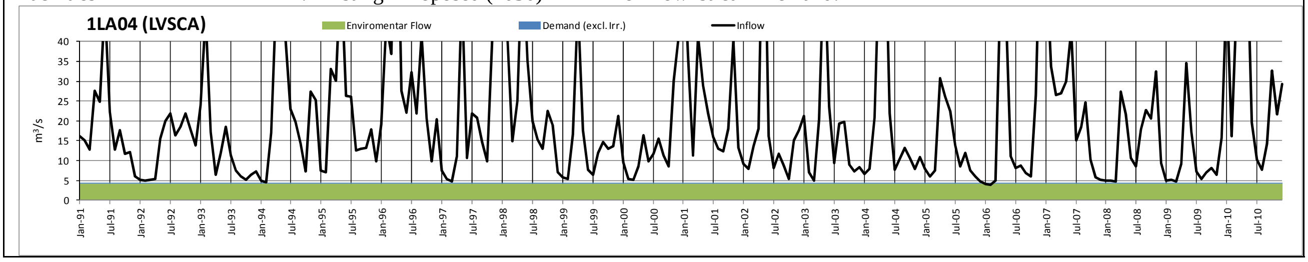
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.5 River Flow at Reference Point 1KC03 under Present and Future Water Demands and Facilities Conditions (LVSCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Mara River (LVSCA)
Reference Point: 1LA04

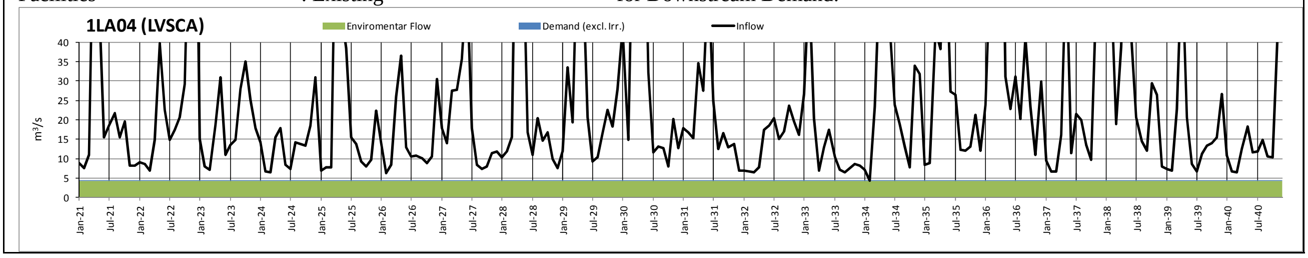
River Flow	: Present (1991-2010)	Reserve:	4.3	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



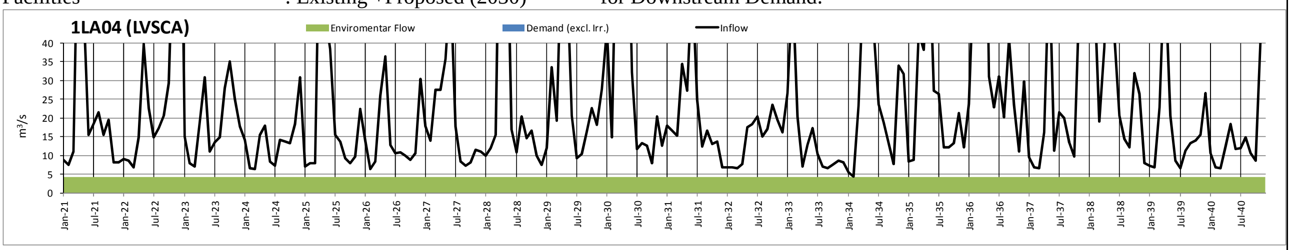
River Flow	: Present (1991-2010)	Reserve:	4.3	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	4.3	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)

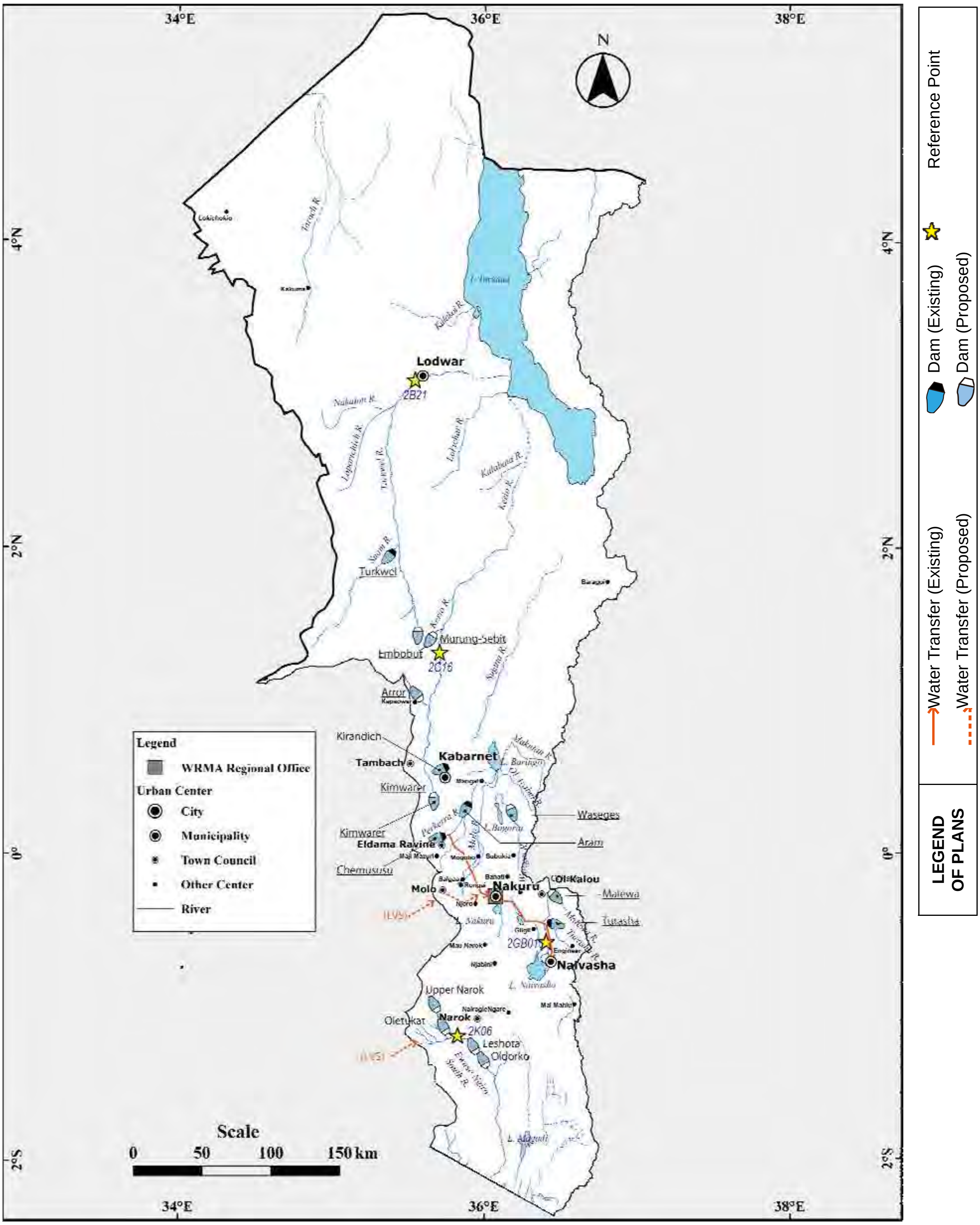


River Flow	: Future (2021-2040)	Reserve:	4.3	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)



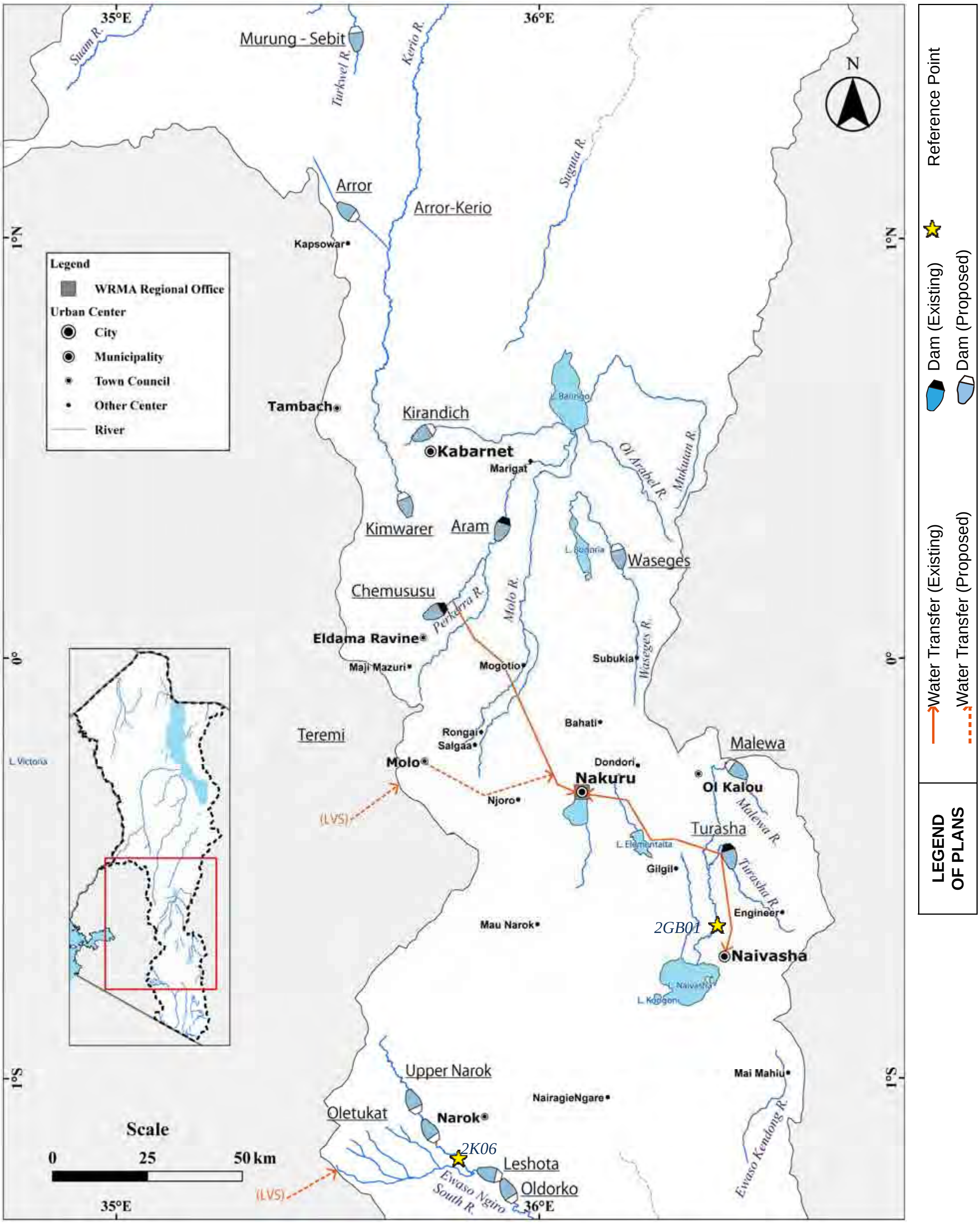
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.5.6** **River Flow at Reference Point 1LA04 under Present and Future Water Demands and Facilities Conditions (LVSCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.1 Proposed Development Plans for Dams and Water Transfers (RVCA) (1/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

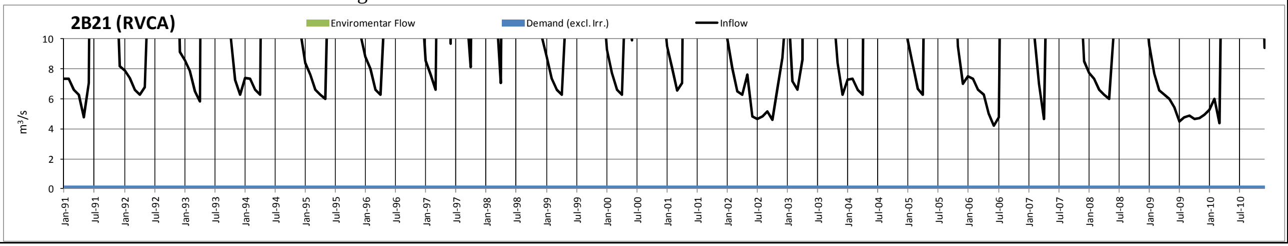


Source: JICA Study Team

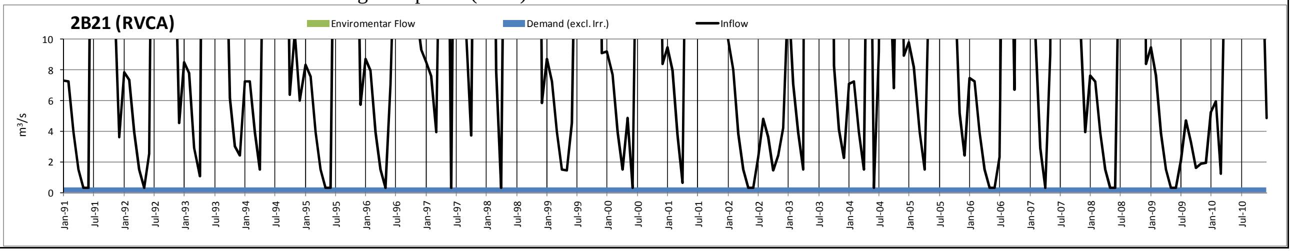
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.1 Proposed Development Plans for Dams and Water Transfers (RVCA) (2/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Turkwel River (RVCA)
Reference Point: 2B21

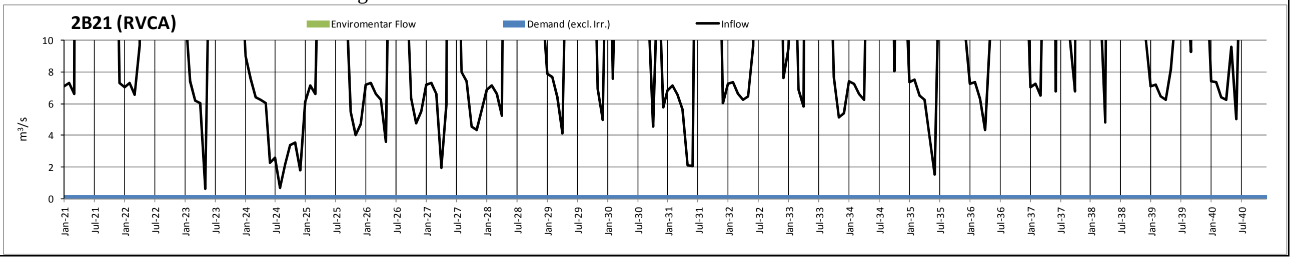
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.3	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



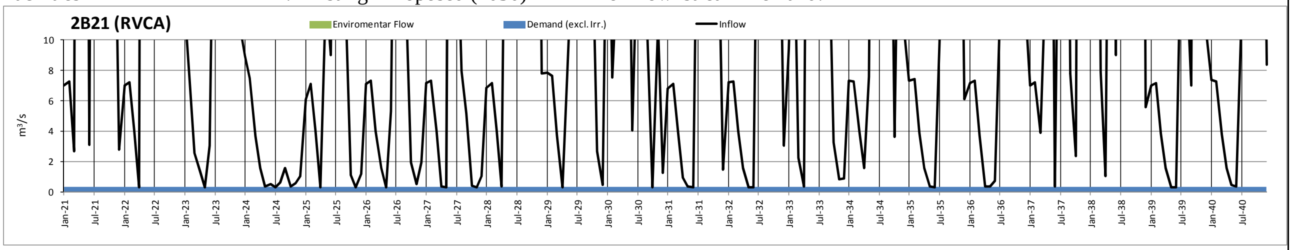
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.3	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.3	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.3	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		

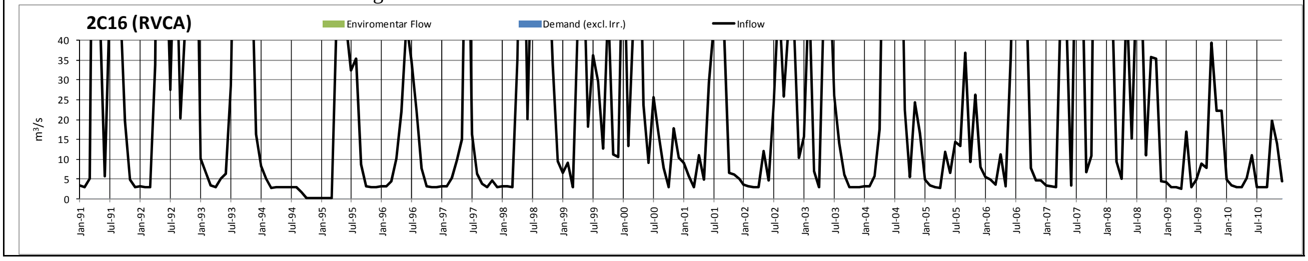


Source: JICA Study Team

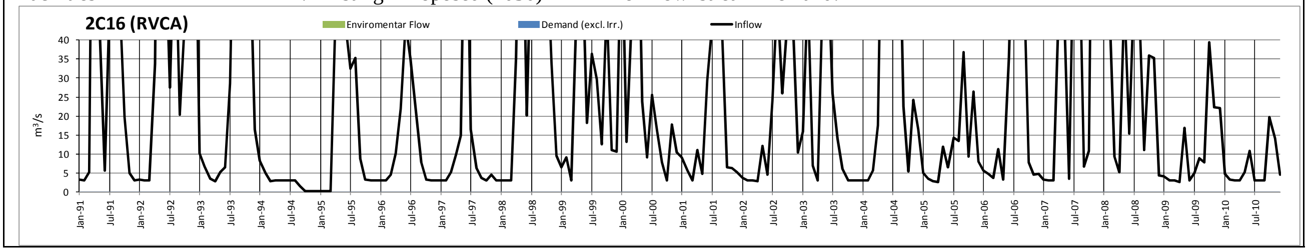
Figure 4.6.2
River Flow at Reference Point 2B21 under Present and Future Water Demands and Facilities Conditions (RVCA)

River Name: Kerio River (RVCA)
Reference Point: 2C16

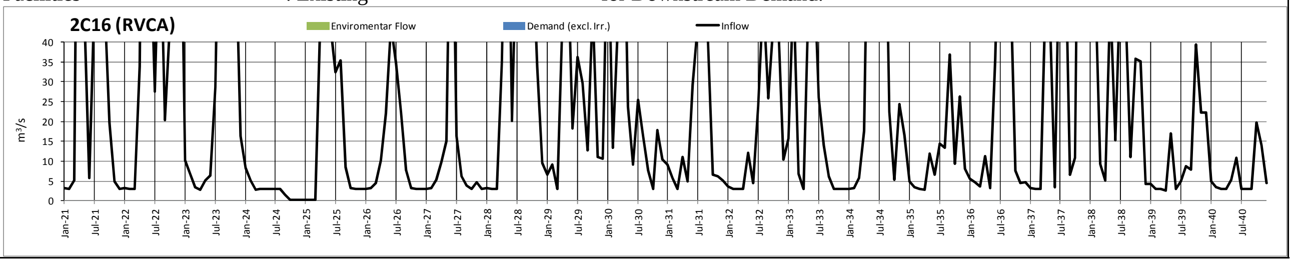
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



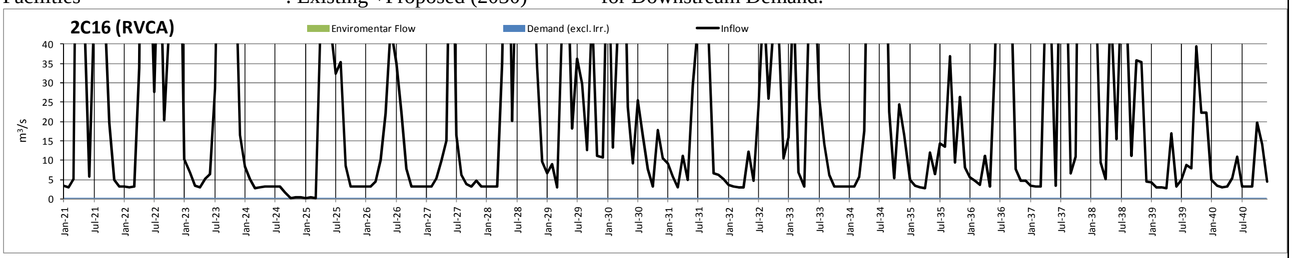
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)

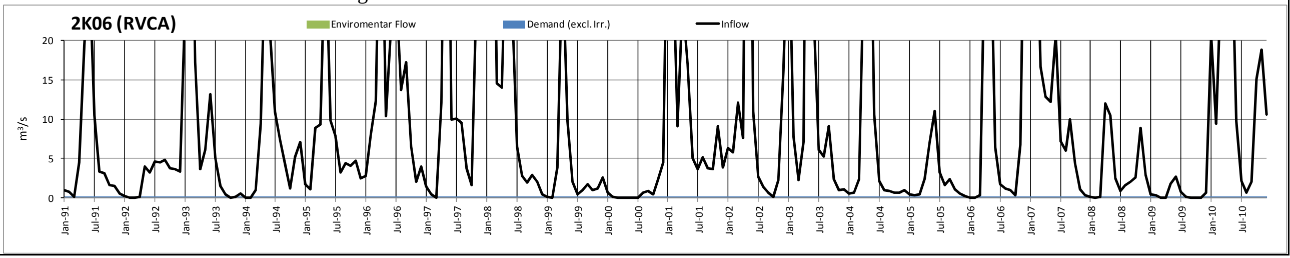


Source: JICA Study Team

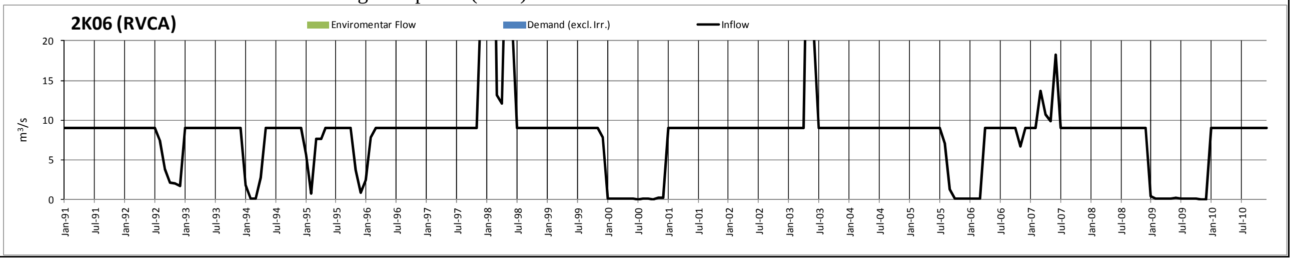
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.3 River Flow at Reference Point 2C16 under Present and Future Water Demands and Facilities Conditions (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Ewaso Ng'iro South River (RVCA)
Reference Point: 2K06

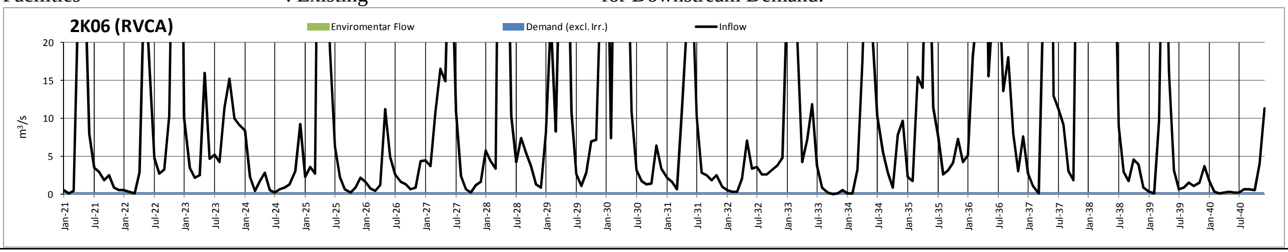
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



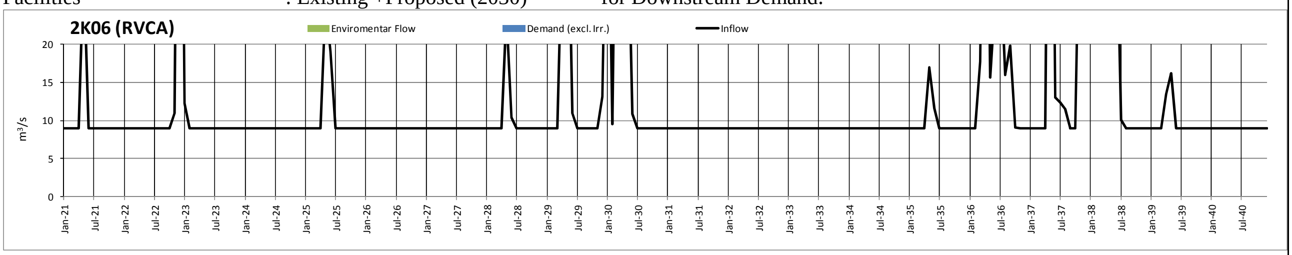
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.1	(m^3/s)



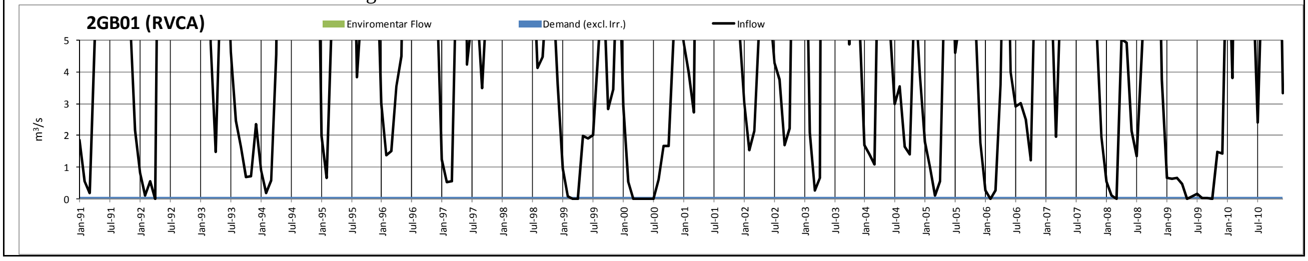
Note: Hydropower discharge is constant from the proposed Oletukat Dam.

Source: JICA Study Team

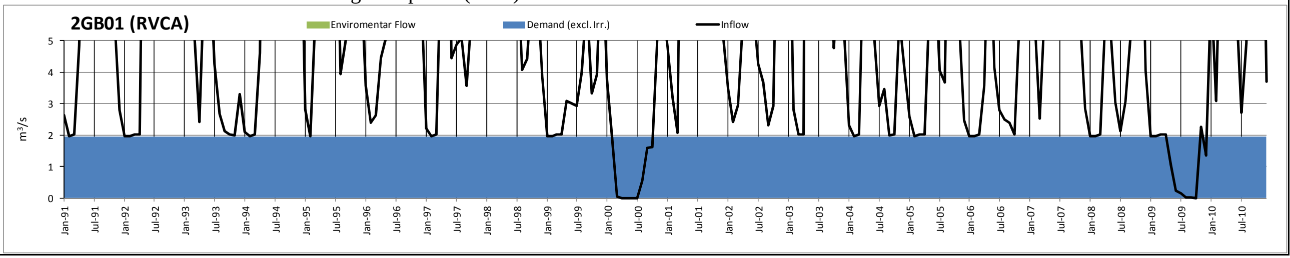
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.4**
JAPAN INTERNATIONAL COOPERATION AGENCY	**River Flow at Reference Point 2K06 under Present and Future Water Demands and Facilities Conditions (RVCA)**

River Name: Malewa River (RVCA)
Reference Point: 2GB01

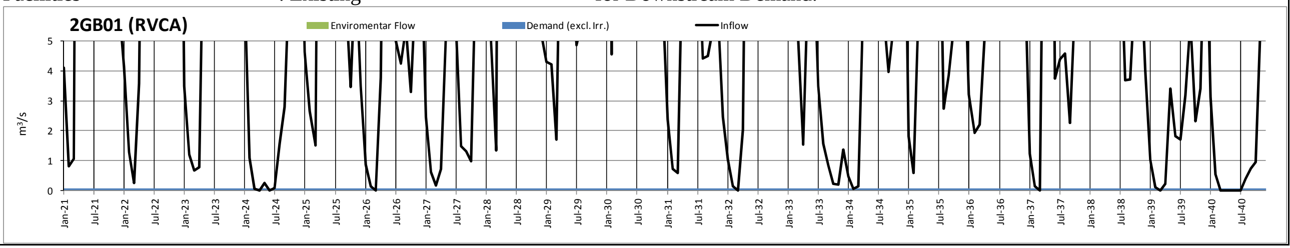
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



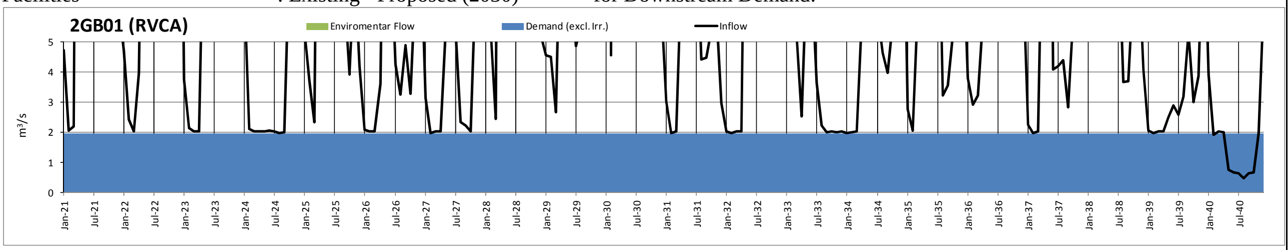
River Flow	: Present (1991-2010)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	2.0	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.1	(m^3/s)



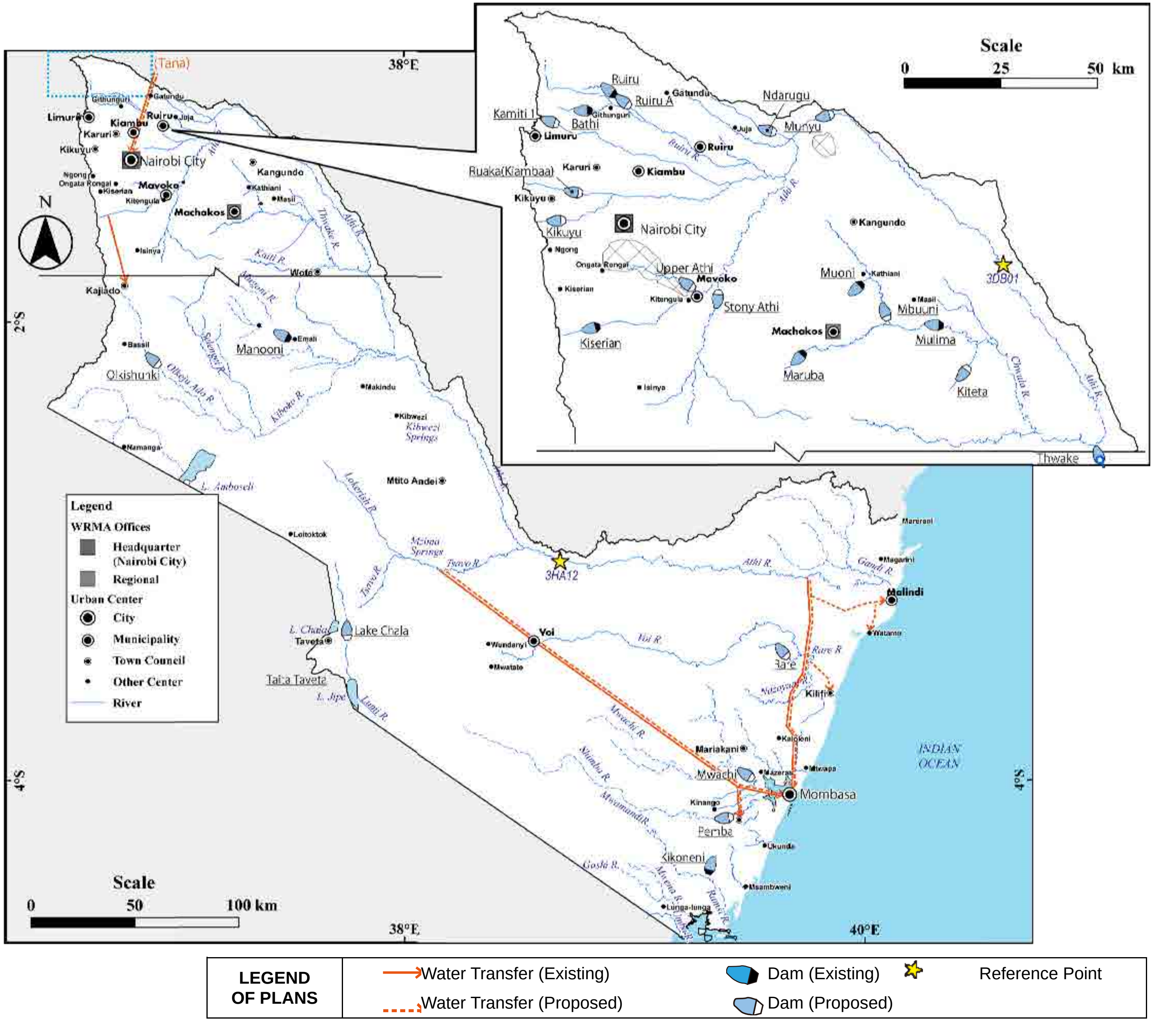
River Flow	: Future (2021-2040)	Reserve:	0.0	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	2.0	(m^3/s)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.6.5 River Flow at Reference Point 2GB01 under Present and Future Water Demands and Facilities Conditions (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

JAPAN INTERNATIONAL COOPERATION AGENCY

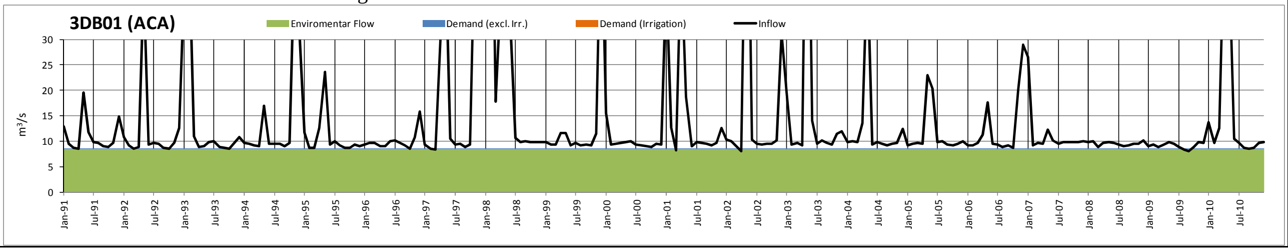


Source: JICA Study Team

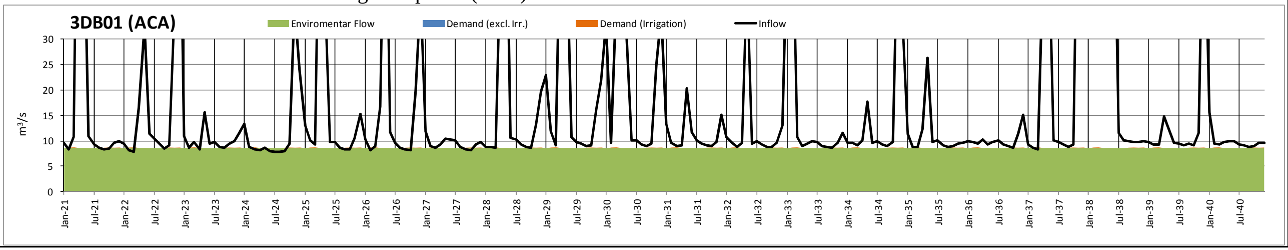
Figure 4.7.1
Proposed Development Plans for Dams and Water Transfers (ACA)

River Name: Athi River (middle) (ACA)
Reference Point: 3DB01

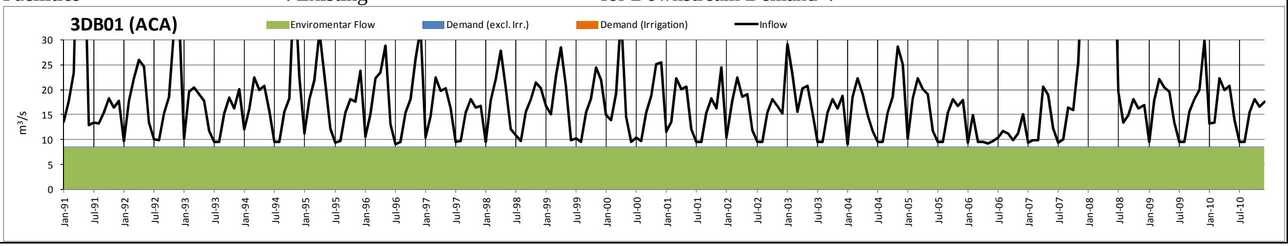
River Flow	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand*:	0.1	(m^3/s)



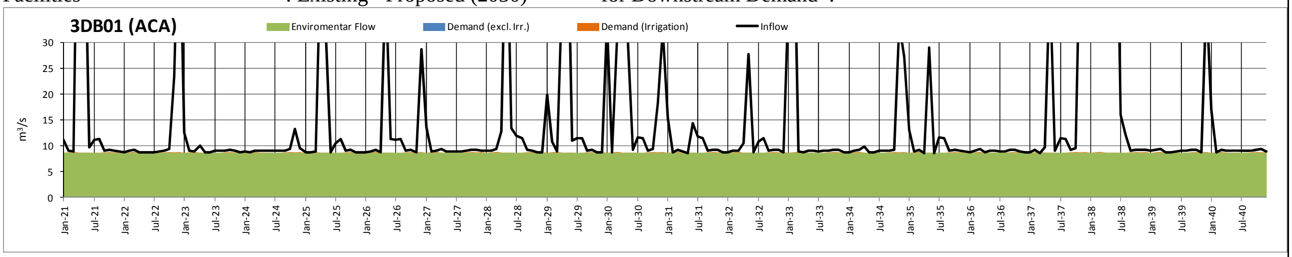
River Flow	: Present (1991-2010)	Reserve:	8.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand*:	0.1	(m^3/s)



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)



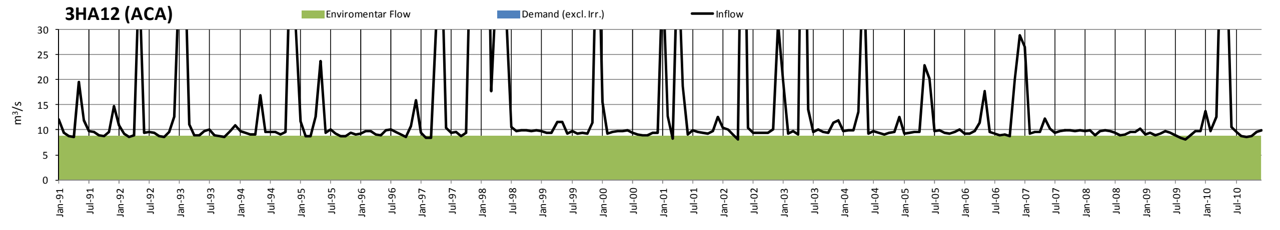
Note: * Irrigation water demand is the average irrigation water demand during April, May, and June.

Source: JICA Study Team

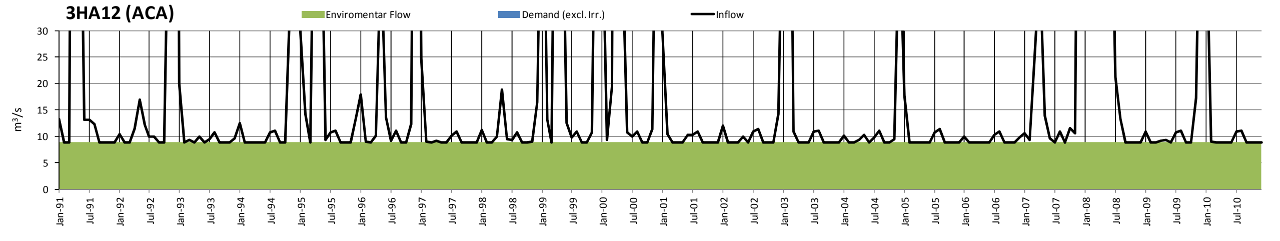
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.7.2 River Flow at Reference Point 3DB01 under Present and Future Water Demands and Facilities Conditions (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

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

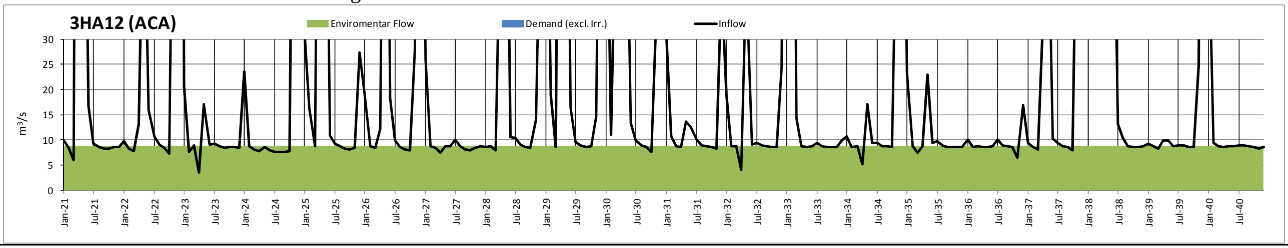
River Flow	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



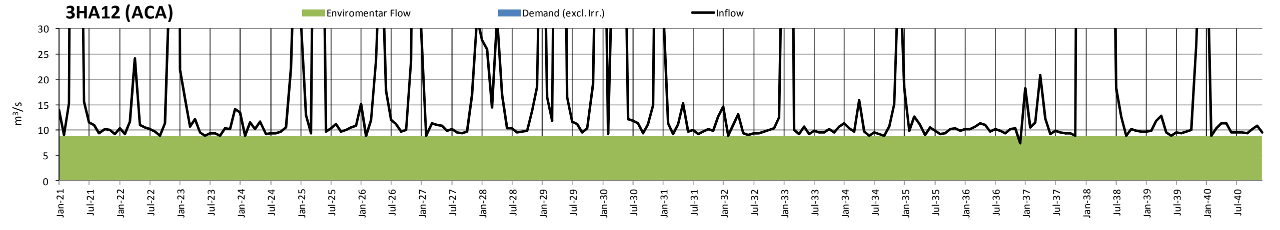
River Flow	: Present (1991-2010)	Reserve:	8.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	8.9	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	8.9	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	0.1	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



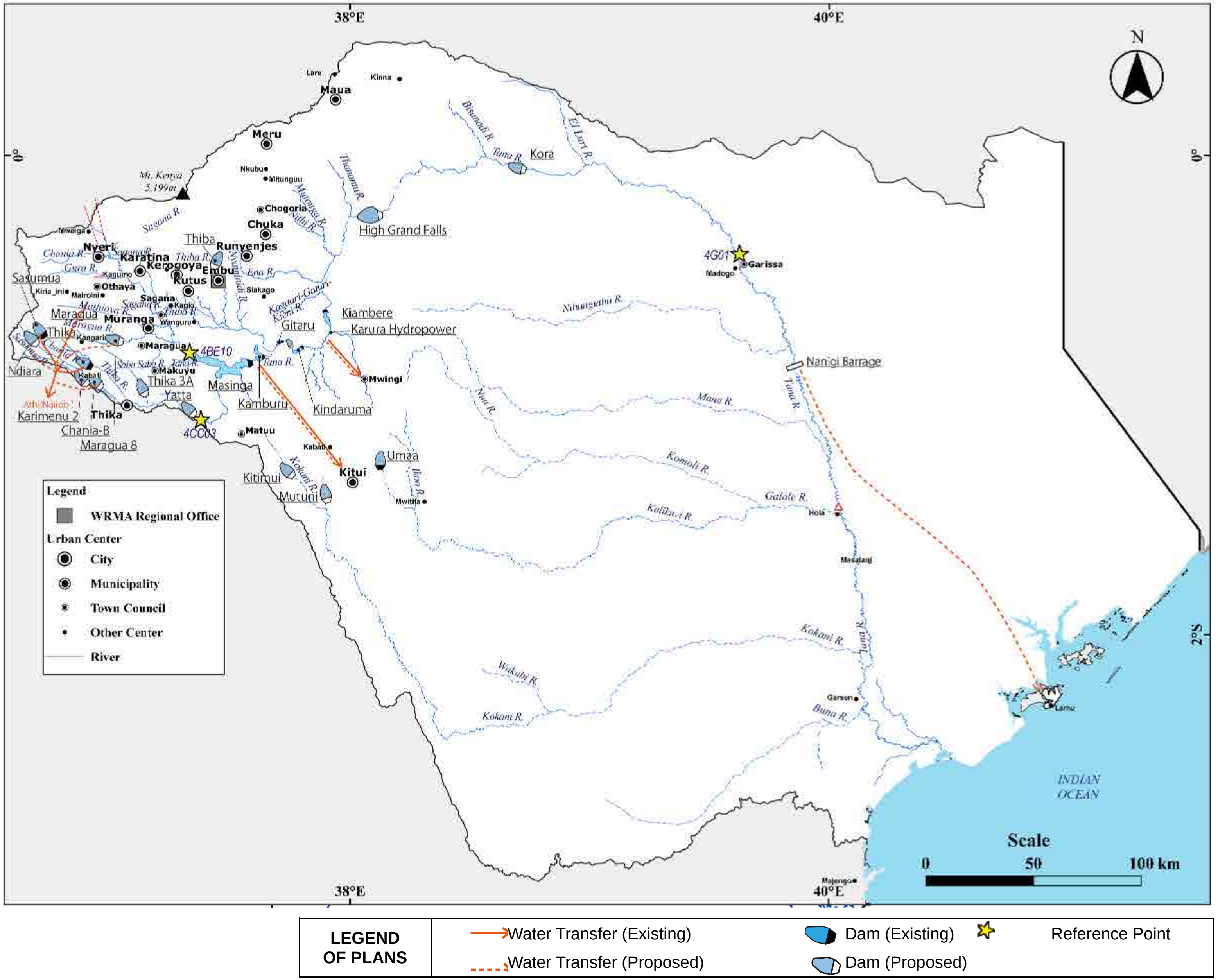
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.7.3** **River Flow at Reference Point 3HA12 under Present and Future Water Demands and Facilities Conditions (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

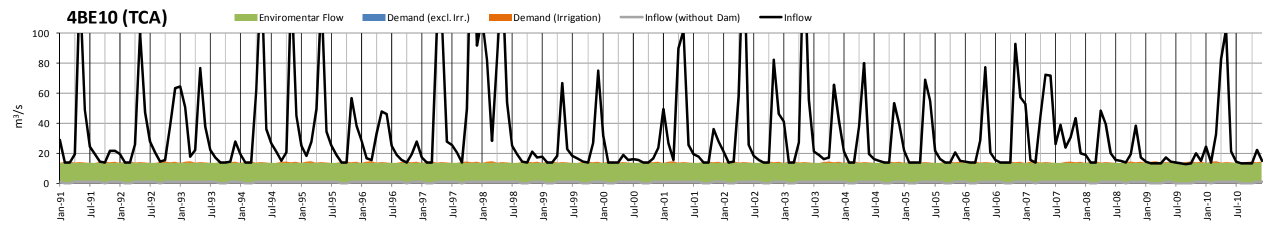
Figure 4.8.1
Proposed Development Plans for Dams and Water Transfers (TCA)



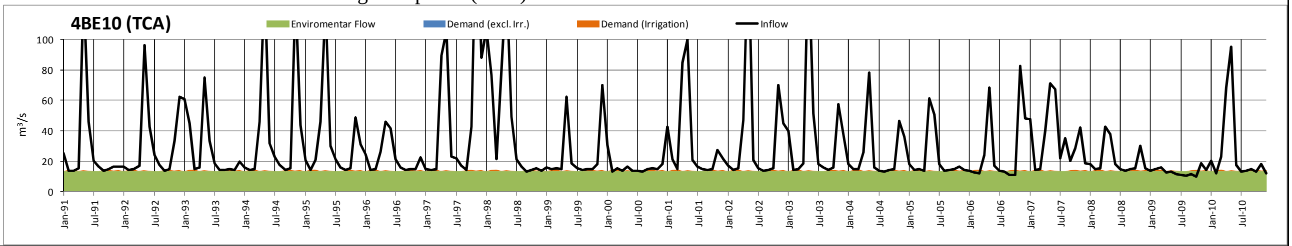
Source: JICA Study Team

River Name: Tana River (upper) (TCA)
Reference Point: 4BE10

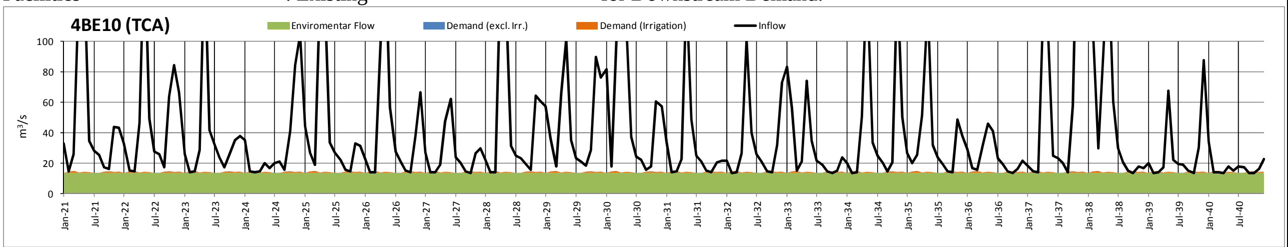
River Flow	: Present (1991-2010)	Reserve:	13.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.7	(m^3/s)



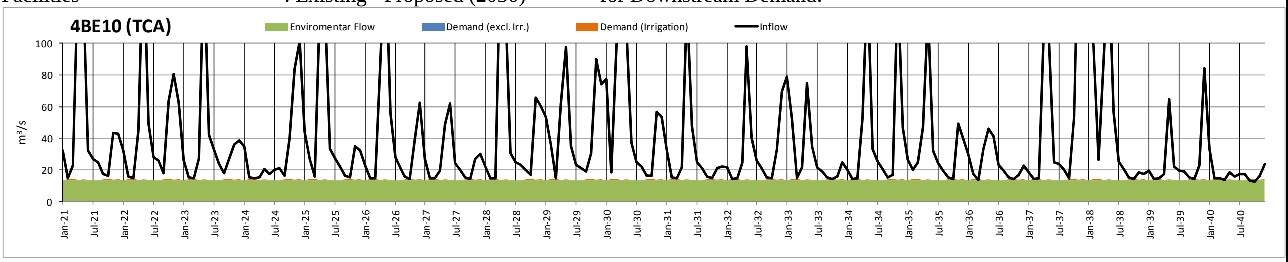
River Flow	: Present (1991-2010)	Reserve:	13.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.9	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	13.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained		
Facilities	: Existing	for Downstream Demand:	0.7	(m^3/s)



River Flow	: Future (2021-2040)	Reserve:	13.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained		
Facilities	: Existing +Proposed (2030)	for Downstream Demand:	0.9	(m^3/s)



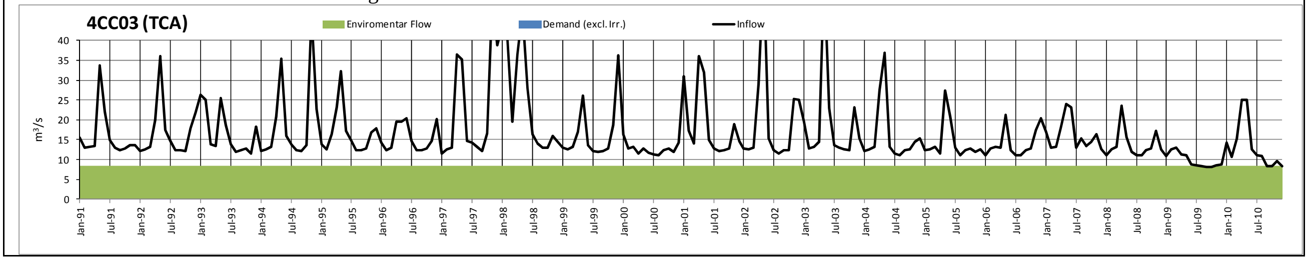
Note: * Irrigation water demand is the average irrigation water demand during March, April, and May.

Source: JICA Study Team

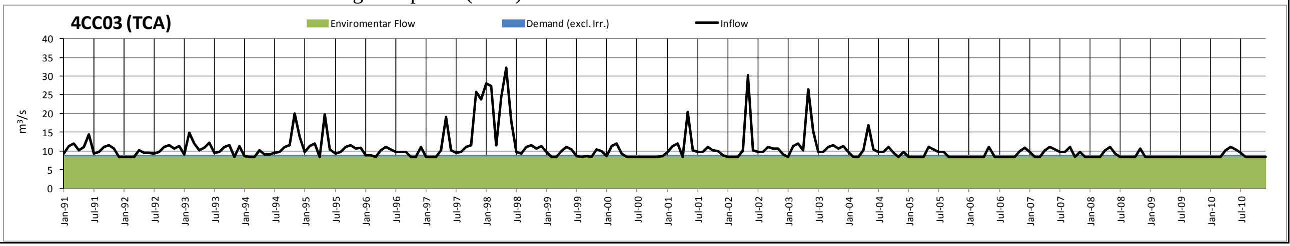
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.8.2 River Flow at Reference Point 4BE10 under Present and Future Water Demands and Facilities Conditions (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Thika River (TCA)
Reference Point: 4CC03

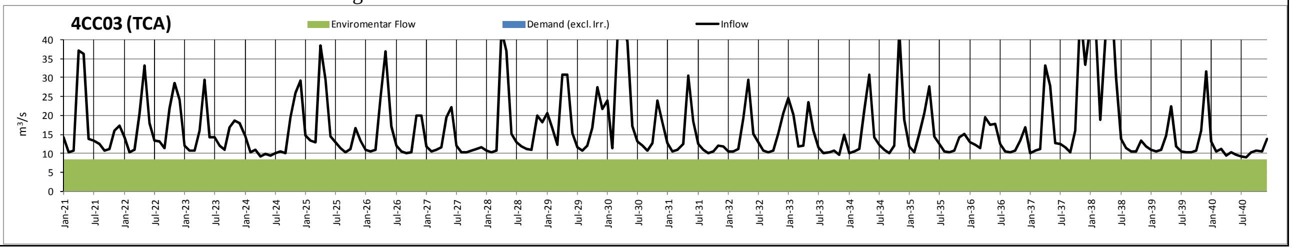
River Flow	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand:	1.4	(m^3/s)
Facilities	: Existing			



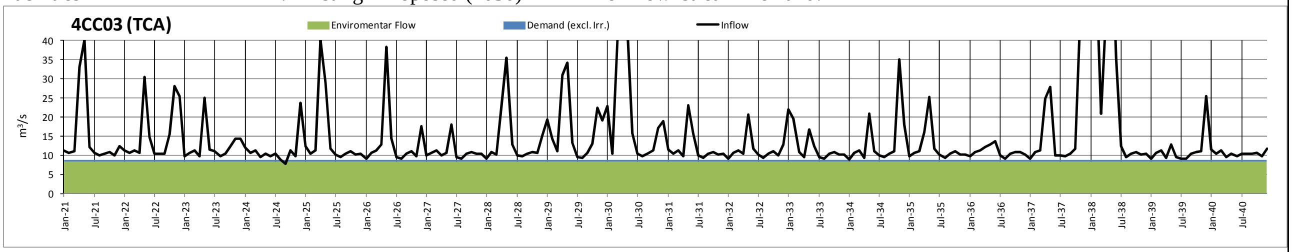
River Flow	: Present (1991-2010)	Reserve:	8.4	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand:	1.7	(m^3/s)
Facilities	: Existing +Proposed (2030)			



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)			

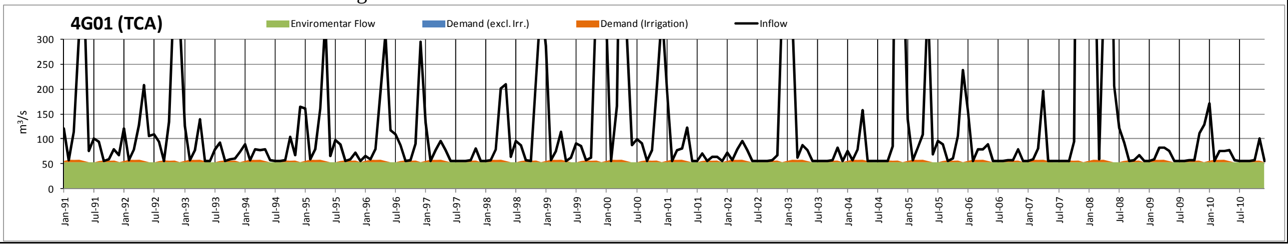


Source: JICA Study Team

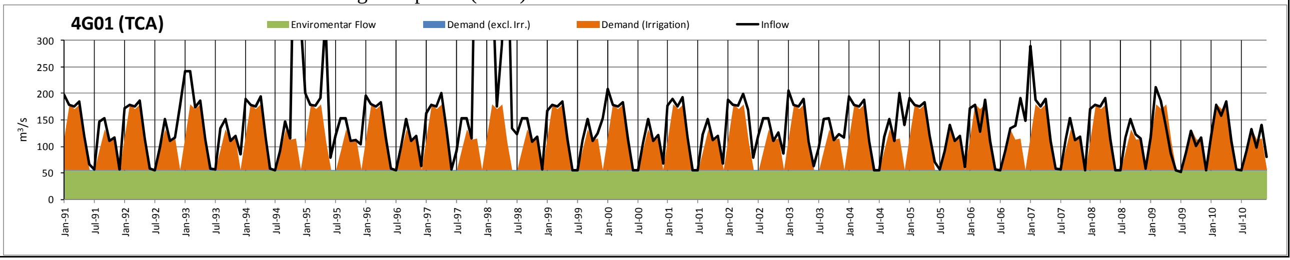
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.8.3 River Flow at Reference Point 4CC03 under Present and Future Water Demands and Facilities Conditions (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

River Name: Tana River (lower) (TCA)
Reference Point: 4G01

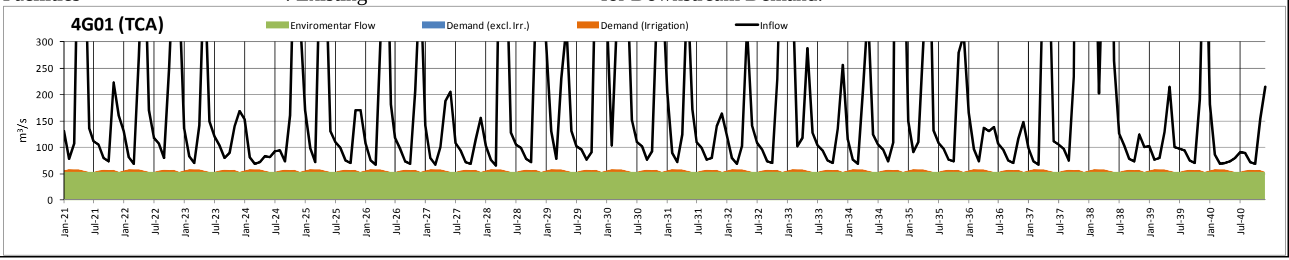
River Flow	: Present (1991-2010)	Reserve:	53.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	3.5	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



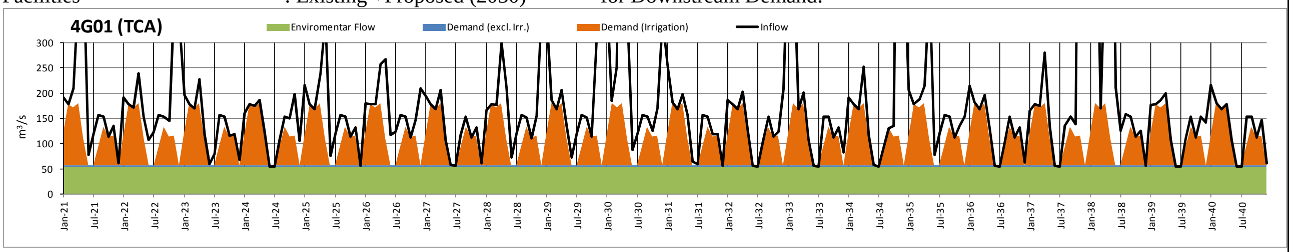
River Flow	: Present (1991-2010)	Reserve:	53.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	99.7	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	53.5	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained	3.5	(m^3/s)
Facilities	: Existing	for Downstream Demand:		



River Flow	: Future (2021-2040)	Reserve:	53.5	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained	99.7	(m^3/s)
Facilities	: Existing +Proposed (2030)	for Downstream Demand:		



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

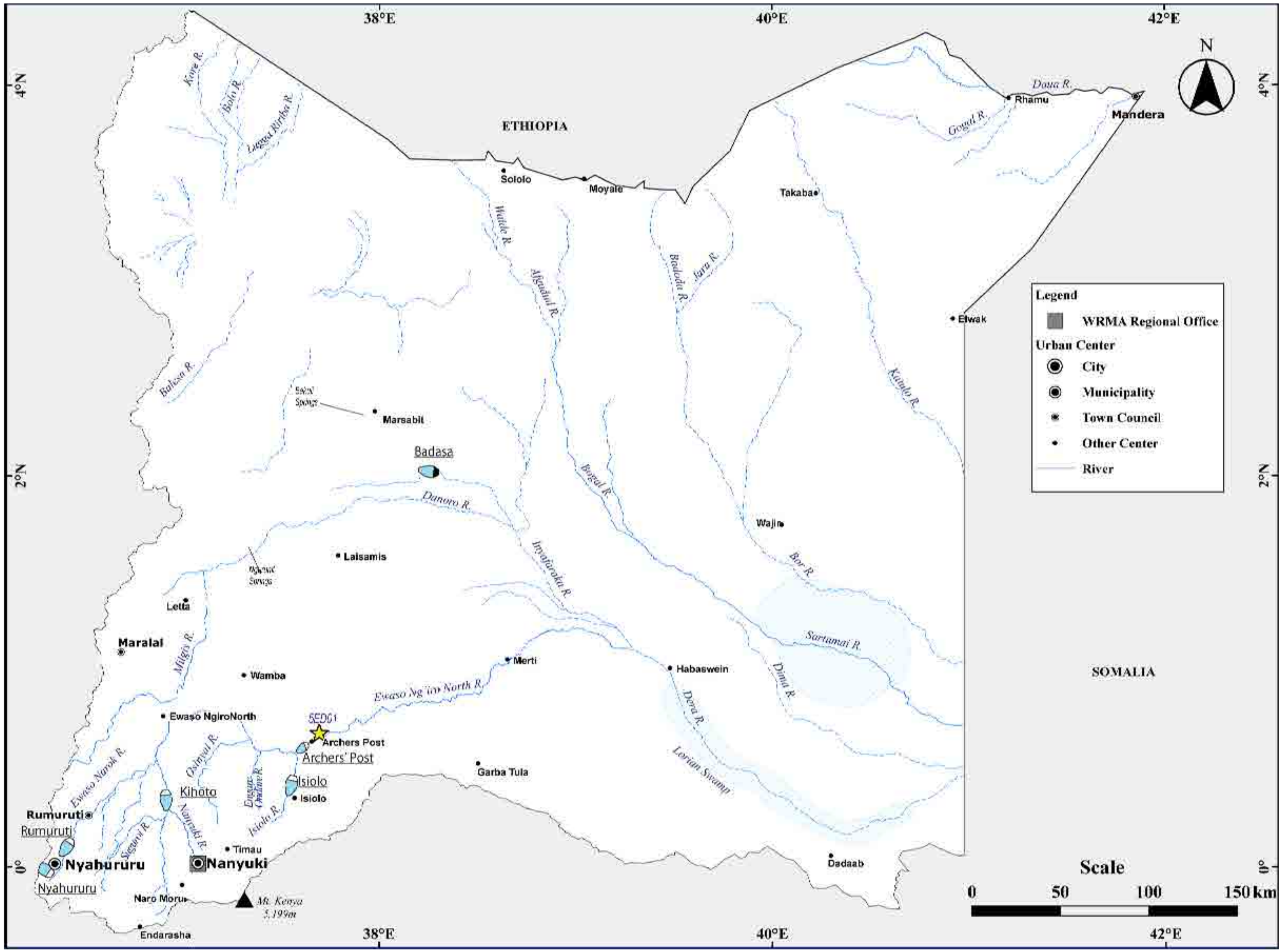
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 4.8.4 River Flow at Reference Point 4G01 under Present and Future Water Demands and Facilities Conditions (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.9.1
Proposed Development Plans for Dams (ENNCA)

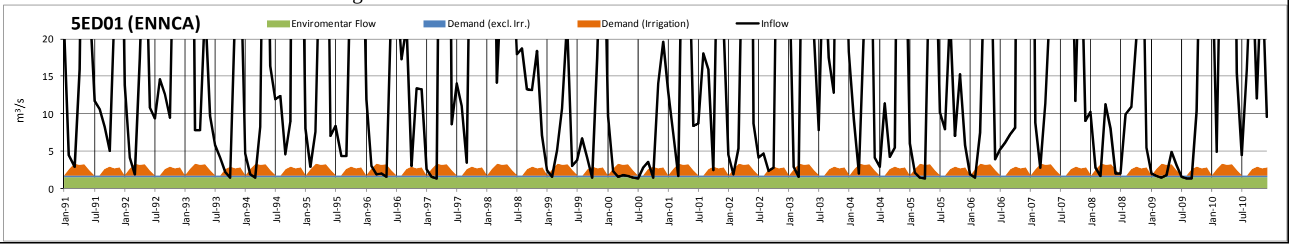
Source: JICA Study Team



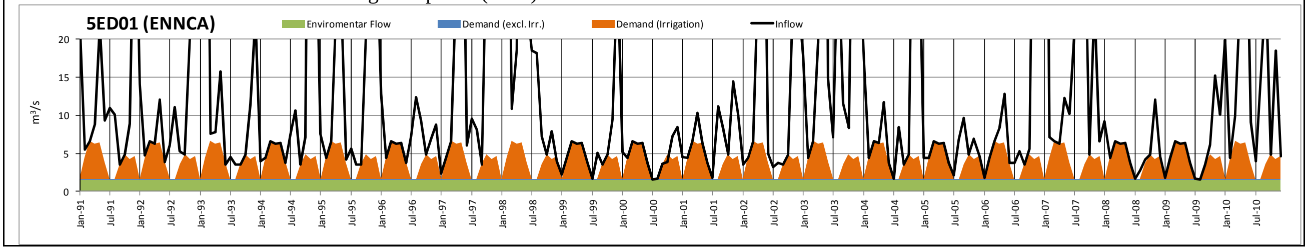
LEGEND OF PLANS		
	Water Transfer (Existing)	Dam (Existing)	Reference Point
	Water Transfer (Proposed)	Dam (Proposed)	

River Name: Ewaso Ng'iro North River (ENNCA)
Reference Point: 5ED01

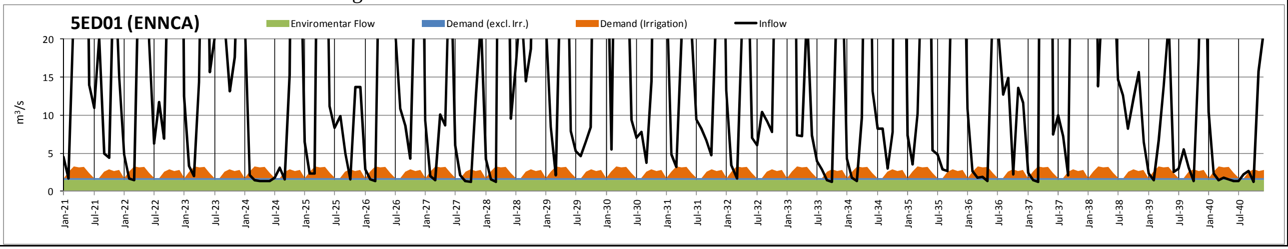
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	1.4	(m^3/s)
Facilities	: Existing			



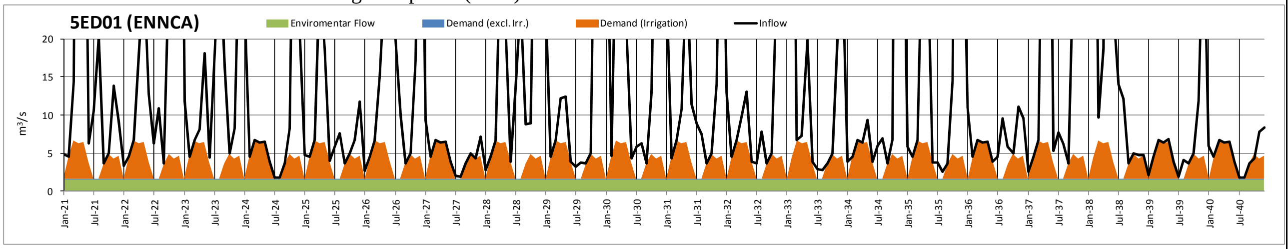
River Flow	: Present (1991-2010)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.9	(m^3/s)
Facilities	: Existing +Proposed (2030)			



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2010	Required Discharge to be maintained for Downstream Demand*:	1.4	(m^3/s)
Facilities	: Existing			



River Flow	: Future (2021-2040)	Reserve:	1.6	(m^3/s)
Water Demand	: 2030	Required Discharge to be maintained for Downstream Demand*:	4.9	(m^3/s)
Facilities	: Existing +Proposed (2030)			



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

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.9.2
River Flow at Reference Point 5ED01 under Present and Future Water Demands and Facilities Conditions (ENNCA)

WRMA Catchment	No.	Name of Project	Purpose	Effective Storage Volume (MCM)	Project Status	Implementation Schedule																	
						Short Term					Medium Term					Long Term							
						2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
						13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
LVN	1	Nandi Forest Dam	W, I, P	220	D/D done		P																
	2	Siyoi Dam	W	4	Flagship D/D ongoing			P															
	3	Nzoia (34B) Dam	I, P, F	204	Flagship D/D ongoing					P													
	4	Nzoia (42A) Dam	I, P, F	395	Flagship D/D ongoing							P											
	5	Moi's Bridge Dam	W, I	214											P								
	6	Kibolo Dam	W, I	40													P						
	7	Teremi Dam	W	3															P				
LVS	1	Magwagwa Dam	W, I, P, F	445	D/D done																		
	2	Itare Dam	W	20	Flagship			P															
	3	Nyando (Koru) Dam	W, I, F	87	Flagship P/D ongoing					P													
	4	Bunyunyu Dam	W	6	Flagship D/D done				P														
	5	Katieno Dam	I	201	Pre-F/S done					P													
	6	Londiani Dam	W	25	Flagship Pre-F/S done								P										
	7	Kibos Dam	W, F	26											P								
	8	Amala Dam	W, I	175													P						
	9	Sand River (Naikara) Dam	W	1														P					
	10	Ilooiterre Dam	W, I	14	Pre-F/S done														P				
RV	1	Upper Narok Dam	W, I, F	29	Flagship			P															
	2	Arror Dam	W, I, P, F	62	D/D done		P																
	3	Oletukat Dam	W, P	300	D/D ongoing				P														
	4	Leshota Dam	W, P	33	D/D ongoing					P													
	5	Oldorko Dam	W, I, P	20	D/D ongoing						P												
	6	Kimwarer Dam	W, I, P	107	Pre-F/S done										P								
	7	Embobut Dam	W, I, P	30	Pre-F/S done										P								
	8	Malewa Dam	W	34													P						
	9	Waseges Dam	W	4														P					
	10	Murung-Sebit Dam	I, F	40															P				

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

Source: JICA Study Team

Figure 7.3.1
Implementation Schedule of Proposed Water Resources Development Plan (1/2)

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	█	█	█	█
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	█	█	█	█
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	**Figure 7.3.1 Implementation Schedule of Proposed Dam Water Resources Development Plan (2/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	