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 - VI SECTORAL REPORT (3/3)

OCTOBER 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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FINAL REPORT

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US$1.00 = KSh 85.24 = ¥79.98

as of November 1, 2012

Sectoral Report (K) Environmental and Social Considerations

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

FINAL REPORT
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K: ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

Abbreviation

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List of Abbreviations and Acronyms

ACA	:	Athi Catchment Area
BOD	:	Biochemical Oxygen Demand
BSAP	:	Biodiversity Strategy and Action Plan
BTS	:	Base Transceiver Station
CA	:	Catchment Area
CMS	:	Catchment Management Strategy
COD	:	Chemical Oxygen Demand
COL	:	Commissioner of Lands
DO	:	Dissolved Oxygen
EA	:	Environmental Audit
EAC	:	East African Community
EIA	:	Environmental Impact Assessment
EMCA	:	Environmental Management and Coordination Act
EMOP	:	Environmental Monitoring Plan for EIA
EMP	:	Environmental Management Plan for EIA
ENNCA	:	Ewaso Ng'iro North Catchment Area
GOK	:	Government of Kenya
IBA	:	Important Bird Area
IEE	:	Initial Environmental Evaluation
IRD	:	French Institute of Research for Development
IUCN	:	International Union for Conservation of Nature and Natural Resources
JICA	:	Japan International Cooperation Agency
KFRI	:	Kenya Forestry Research Institute
KEMWEB		Kenya Wetlands Biodiversity Research team
KenGen	:	Kenya Electric Generating Company
KENSUP	:	Kenya Slum Upgrading Project
KFS	:	Kenya Forest Service
KMFRI	:	Kenya Marine and Fisheries Research Institute
KWS	:	Kenya Wildlife Service
LVB	:	Lake Victoria Basin
LVNCA	:	Lake Victoria North Catchment Area
LVSCA	:	Lake Victoria South Catchment Area
MLIT	:	Ministry of Land, Infrastructure, Transport and Tourism
MOEMR	:	Ministry of Environment and Mineral Resources
MOFD	:	Ministry of fisheries Development
MOFW	:	Ministry of Forestry and Wildlife
MOL	:	Ministry of Lands
MRB	:	Mara River Basin
MWI	:	Ministry of Water and Irrigation
NEAP	:	National Environment Action Plan
NEAPC	:	National Environment Action Plan Committee
NEC	:	National Environment council
NEMA	:	National Environment Management Authority
NET	:	National Environment Tribunal

NETFUND	:	National Environment Trust Fund
NGO	:	Non-Governmental Organization
NWMP	:	National Water Master Plan
NWRMS	:	National Water Resources Management Strategy
O&M	:	Operation and Maintenance
OP	:	Operational Policy
PCC	:	Public complaints committee
RAP	:	Resettlement Action Plan
RVCA	:	Rift Valley Catchment Area
SEA	:	Strategic Environmental Assessment
SERC	:	Standards and Enforcement Review committee
SS	:	Suspended Solids
TCA	:	Tana Catchment Area
T-N	:	Total Nitrogen
T-P	:	Total Phosphorus
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
UN-HABITAT	:	United Nations Human Settlements Programme
WB	:	World Bank
WCA	:	water catchment areas
WRM		Water Resource Management
WRMA	:	Water Resource Management Authority
WRUA	:	Water Resources Users Association
WWF	:	World Wide Fund for Nature
WWF-ESARPO	:	World Wide Fund for Nature - Eastern and Southern Africa Region Programme Office

Abbreviations of Measures

Length

mm	=	millimetre
cm	=	centimetre
m	=	meter
km	=	kilometre

Area

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

Volume

1, lit	=	litter
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

NWMP 2030 proposes the direction of water development plan and water management plan in Kenya based on Vision, 2030 with water development projects to solve water scarcity of Kenya, which has been severe for a long time. However, since development projects cause negative environmental impacts on a certain level at times, environmental management plan is required to implement the NWMP 2030 to minimise such impacts.

This sectoral report on the environmental and social considerations presents the following; i) Current situation of environmental management in Kenya, ii) Proposed environmental management plan for NWMP 2030, iii) Cost estimate for the proposed management plan, and iv) Implementation Programme for the management plan. In addition, preliminary environmental review for the proposed development projects is shown in the last chapter.

Study flow for the preparation of the Environmental Management Plan is shown in Figure 1.1.1.

CHAPTER 2 CURRENT SITUATION OF ENVIRONMENTAL MANAGEMENT

2.1 Relevant Policies, Strategies and Legal Framework

Kenya has no comprehensive policy framework for environmental management. Despite of the existence of several policies, the lack of overall policy framework for the environmental sector hampers the effective environmental management of water resources environment. The draft environmental policy developed in 2008 has never been finalised and adopted. Policy related to environment is discussed in the Sessional Paper on Environment and Development (No. 6 of 1999). Other relevant policies, plans and strategies were prepared after 1992.

The legal basis for environmental management is clearly set out within the overarching framework legislation, the Environmental Management and Co-ordination Act (EMCA) of 1999. Under the EMCA, regulations to manage environment issues such as EIA for development project, water quality, waste management and biodiversity were established. In addition, Wildlife (Conservation and Management) Act, Wildlife Bill and Forest Act obligate development rules to manage various types of water resources.

2.1.1 Relevant Policies and Strategies

(1) Sessional Paper on Environment and Development (No. 6 of 1999), 1999

The aim of the policy is to harmonise environmental and developmental goals to ensure sustainability of natural environment utilisation. This paper provides comprehensive guidelines and strategies on environment and development for government action.

(2) National Policy on Water Resources Management and Development, 1999

While the National Policy on Water Resources Management and Development (1999) enhances a systematic development of water facilities in all sectors for promotion of the country's socio-economic progress, it also recognises the by-products of wastewater during this process. It therefore, calls for the development of appropriate sanitation systems to protect people's health and water resources from institutional pollution.

(3) Wetland Assessment and Monitoring Strategy for Kenya, 2012

The strategy is prepared by National Environmental Management Authorities (NEMA) to cover the requirements of Ramsar Conservation. The strategy proposed how to spearhead and sustain a wetland monitoring and assessment scheme using various methods and techniques that are compliant with the existing legislative and regulatory frameworks.

2.1.2 Relevant Legal Framework

(1) Environmental Management and Co-ordination Act No.8 of 1999 (EMCA)

EMCA (1999) provides for the establishment of an appropriate legal and institutional framework for the management of the environment and related matters. It is an environmental legislative framework that establishes appropriate legal and institutional mechanisms for the management of the environment.

Also, there are eight regulations (including draft versions) to obligate several sectors to implement regulations under EMCA. Five regulations related to water resources management and the Strategic Environmental Assessment (SEA) national guidelines are as follows:

1) Environmental Impact Assessment (EIA) and Environmental Audit Regulations, 2003 and Draft Environmental Guidelines and Administrative Procedures, 2008

The overall objective of EIA is to ensure that environmental concerns are integrated in all development activities in order to contribute to sustainable development. The main specific objective is to identify potential environmental impacts of the proposed projects, policies, plans, and programmes. According to the regulations and guidelines, the projects related to water resources development which are subject to EIA are specified by project types and activities. Water resources development activities which required EIA for its implementation are shown in Table 2.1.1.

2) Environmental Management and Co-ordination (Wetlands, River Banks, Lake Shore and Sea Shore Management) Regulations, 2009

The regulation defines a process of environmental management for wetlands, river banks, lake shore and sea shore. The regulation obligates all activities in wetlands to acquire a wetlands resource use permit or temporary permit which is required to be presented during emergencies and special investigations. Activities in river banks, lake shores, and sea shores are also required to acquire permits.

3) Environmental Management and Co-ordination (Water Quality) Regulations, 2006

The regulation defines standards for water diversion and effluent. Moreover, the regulation applies to drinking water, water used for industrial purposes, agricultural purposes, recreational purposes, fisheries and wildlife, and for any other purposes.

4) Environmental Management and Co-ordination (Waste Management) Regulations, 2006

The regulation obligates waste management including waste segregation, trash collection, reuse, recycling and disposition of waste. The type of waste under the regulation include: i) solid waste, ii) industrial waste, iii) hazardous waste, iv) agricultural chemicals and other hazardous substances, v) biological medical waste, and vi) radiological material.

5) Environmental Management and Co-ordination (Conservation of Biological Diversity and Resource, Access to Genetic Resources and Benefit Sharing) Regulations, 2006

The regulation defines the process of conservation, maintenance and monitoring of biological diversity and resource by NEMA. Specifically, NEMA prohibits or restricts the access and use of endangered species upon consultation with concerned authorities. Also, NEMA prepares biodiversity inventory in Kenya and monitors its current status. Moreover, the regulation indicates guidance on necessary processes for utilizing biological genetic resource for private purposes.

6) National Guidelines for Strategic Environmental Assessment (SEA) in Kenya, 2011

The SEA has been mentioned in EMCA and EIA regulations; however, NEMA only prepared the SEA guidelines on February 2011. SEA aims at guiding implementation of policies, plans and programmes as well as groups of projects which is mandatory under EMCA.

(2) The Wildlife (Conservation and Management) Act (Cap.376) (1985) Revised Edition, 2009

The Wildlife Act obligates wildlife protection, conservation and management in Kenya. The Act also designates national parks, national reserves, and local sanctuaries to facilitate wildlife conservation and management. Under the Act, the director of Kenya Wild Service (KWS) can establish agreement with authorities concerned to secure wildlife corridors and migratory routes.

(3) The Wildlife Bill, 2011

The Act applies to all wildlife resources on public, community and private land. The Act clarifies that nationally listed endangered and threatened ecosystems, critically endangered vulnerable, near threatened, protected species, and invasive species and list of national parks, national reserves, community conservation areas and sanctuaries.

(4) Water Act, 2002

The Act prohibits the pollution of water resources and controls the discharge of industrial and municipal effluents into rivers and lake. Pursuant to these provisions, MWI has established technical mechanisms (including laboratory facilities) for monitoring the quality of various water resources in Kenya.

This Act provided for the formation of a Water Resources Management Authority (WRMA), which is responsible for the management of lakes, aquifers and rivers, among other functions.

(5) Kenya Vision 2030

Kenya Vision 2030 states that Kenya’s current institutional framework to manage the environment is characterised by fragmentation. Various aspects of environmental policy cut across different institutions. Although EMCA was a major landmark, with the primary objective of improving coordination and management of the environment, legislation of relevant laws and regulations have not yet been completed.

In addition, Kenya Vision 2030 indicates that Kenya aims to be a nation that has a clean, secure and sustainable environment in 2030. Four strategic areas for government action are identified to help realise the national vision for the environmental sector. These include: i) conservation of natural resources, ii) pollution and waste management, iii) high-risk disaster zone management and iv) environmental planning and governance. Among four ‘flagship’ projects identified to be undertaken as priority actions for the environmental sector, the following three projects are related to NWMP 2030; i) water catchment management, ii) security of wildlife migratory routes, and iii) development of a national waste management system.

2.1.3 Relevant Master Plan

(1) Master Plan for the Conservation and Sustainable Management of Water Catchment Areas in Kenya, 2012

The Ministry of Environment and Mineral Resource (MOEMR) prepared the Master Plan for improved conservation and sustainable management of water resources in Kenya. The master plan analysed water catchment area information focusing on water conservation forest degradation and current governance framework for water catchment areas. As a result, the master plan proposed remedial actions for the challenges identified in their analysis. They proposed specific interventions for conservation and sustainable management of water catchment areas. The main interventions are: i) partnerships and participation of stakeholders, ii) governance of water catchment area, IV) capacity building, v) restoration and management of water catchment areas, vii) water resources conservation and management.

(2) National Environment Action Plan 2009-2013, 2009

The land-mark National Environmental Action Plan (NEAP) was published in 1994. The first generation of NEAP after EMCA (1999) was prepared for the period 2009-2013, which is the latest issue. It prioritises environmental activities for the country for implementation across the sector. NEAP reported the current status and proposed interventions for each current environmental issues. The general challenges and interventions almost covered almost all the recommended items in NWMP (1992). Most of the environmental challenges noted by the NEAP have been kept since 1992 until now without effectual solutions.

2.2 Relevant Organizations

There are several ministries responsible for various aspects of water resources environment, namely those responsible for wildlife, fisheries, and forestry. The key ministries related to environmental management include MOEMR and Ministry of Forestry and Wildlife (MOFW). MOEMR is composed of NEMA and NEMA's representative sections. NEMA is the main responsible authority for environmental management under EMCA, and their main function is to coordinate the environmental management activities undertaken by other government agencies, but does not carry out all the environmental functions. MOFW is composed of the Kenya Wildlife Service (KWS) and Kenya Forest Service (KFS). In addition, the Ministry of Fisheries Development (MOFD) concerns water resources environment pertaining to fisheries resource management side.

O ne of the key institutions related to social consideration is the Ministry of Lands (MOL), e which MOL is responsible for land acquisition. However, it is not clear which authorities control resettlement caused by development projects officially and constantly.

The outlines of key institution are described below:

(1) Ministry of Environment and Mineral Resources (MOEMR)

The mandates of the MOEMR are to monitor, protect, conserve, and manage the environment and natural resources through sustainable exploitation for socio-economic development. It aims at eradicating poverty, improving living standards, and ensuring that a clean environment is sustained now and in the future. Under MOEMR, seven authorities listed below are established by EMCA. The MOEMR organogram is shown in Figure 2.2.1.

- National Environment Management Authority (NEMA);
- National Environment Council (NEC);
- National Environment Tribunal (NET);
- National Environment Action Plan Committee (NEAPC);
- Standards and Enforcement Review Committee (SERC);
- Public Complaints Committee (PCC); and
- National Environment Trust Fund (NETFUND).

Among the seven authorities, NEMA is the most important in terms of environmental management. Therefore, the next subsection shows the detail information of NEMA.

(2) National Environmental Management Authority (NEMA)

NEMA is comprised of six departments based on the statutory functions mandated by EMCA and each is headed by a director. Compliance and enforcement department ensures compliance to environmental legislations. The department supervises all development projects through the EIA system. Also, the water quality section of NEMA is the implementation section for water quality investigation.

NEMA has multiple statutory functions and responsibilities for natural environmental management. However, its main function is to coordinate the environmental management activities undertaken by other government agencies, and should not to carry out all the environmental functions by itself.

NEMA has 43 offices in each county as shown in the table below. NEMA headquarters are transferring several authorities and duties to county offices, such as EIA reviews and effluent water permission reviews. In addition, NEMA required all counties to prepare an environmental action plan at county level based on the prepared planning manuals prepared by NEMA headquarters. These NEMA county offices will become the key authorities for environmental management in the local level.

NEMA County Office in Each Catchment Area

Catchment Areas	County Offices	Number
Lake Victoria North (LVNCA)	Kakamega, Bungoma, Busia, Uasin Gishu, Siaya, Trans Nzoia, Nandi, Vihiga, Marakwet, West Pokot, and Kisumu	11
Lake Victoria South (LVSCA)	Kisii, Bomet, Migori, Nyamira, Homa Bay, Narok, Kisumu, Kericho, Nakuru, Vihiga, Nandi, Siaya, Uasin Gishu, and Baringo	14
Rift Valley (RVCA)	Baringo, West Pokot, Turkana, Nakuru, Marakwet, Nyandarua, Narok, Kajiado, Samburu, Marsabit, Laikipia, Kiambu,Trans Nzoia, Uasin Gishu, Murango, Bungoma, Kericho, and Nyeri	18
Athi (ACA)	Kwale, Makueni, Taita Taveta, Kilifi, Machakos, Kajiado, Kiambu, Kitui, Nyandarua, and Tana River	10
Tana (TCA)	Kirinyaga, Lamu, Muranga, Tana River, Tharaka, Embu, Kitui, Nyeri, Garissa, Meru, Machakos, Kiambu, Kilifi, Isiolo, Nyandarua, and Laikipia	16
Ewaso Ng'iro North (ENNCA)	Mandera, Wajir, Isiolo, Laikipia, Marsabit, Samburu, Meru, Nyandarua, Garissa, Nyeri, Kirinyaga, Nakuru, Embu, and Tharaka	14

Source: JICA Study Team, based on information from NEMA.
Note: Jurisdiction area of NEMA county offices extends over the area of two or more catchment areas by WRMA.

(3) Ministry of Forestry and Wildlife (MOFW)

The mandate of the MOFW is to provide a conductive environment for the practice and promotion of sustainable and participatory management of forestry and wildlife resources to enhance socio-economic development of Kenyan**.** The authorities are established under the Ministry, namely: i) Kenya Wildlife Service (KWS), ii) Kenya Forest Service (KFS) and ii) Kenya Forestry Research Institute (KEFRI). Summarised information about the organisations is shown as follows:

1) Kenya Wildlife Service (KWS)

KWS was established under the provisions of the Wildlife (Conservation and Management) Act to formulate and implement policies for the conservation, management and utilisation of wildlife resources, national parks and reserves. KWS does not directly manage water resources; however, water environment and ecosystem should be managed by them.

2) Kenya Forest Service (KFS)

KFS is a state corporation established under the Forest Act 2005 to conserve, develop and sustainably manage forest resources for the socio-economic development. The overall mandate of KFS is to conserve, develop and sustainably manage gazetted forestry resources including Five Water Towers. The 'Five Water Towers' are the most important water conservation forests which consist of Mt. Kenya, the Aberdare Range, the Mau Complex forests, the Cherangani Hills, and the Mt. Elgon.

3) Kenya Forestry Research Institute (KEFRI)

KEFRI was established under the Science and Technology Act (Chapter 250) to carry out research in forestry and allied natural resources. The mandate is to conduct research in forestry, to disseminate research findings, and to co-operate with other research bodies carrying out similar research within and outside Kenya.

(4) Ministry of Fisheries Development (MOFD)

MOFD is mandated to facilitate the development and management of the fisheries sub-sector. Thus, the Ministry is a key authority involved in water resources environment. The Ministry has two main organisations as follows:

1) Department of Fisheries

The Department of Fisheries is mandated to provide leadership in the management and development of aquaculture and fisheries resources.

2) The Kenya Marine and Fisheries Research Institute (KMFRI)

KMFRI is a state corporation in the MOFD of the GOK. It is mandated to conduct aquatic research covering all the Kenyan waters and the corresponding riparian areas including the Kenyan's Exclusive Economic Zone (EEZ) in the Indian Ocean waters.

(5) Ministry of Lands (MOL)

The mandate of MOL is to formulate and implement land policy, undertake physical planning, register land transactions, undertake land surveys and mapping, land adjudication and settlement, land valuation and administration of state and trust land. MOL has the lands department. The head of the department is the Commissioner of Lands (COL). The compulsory land acquisition for the public work projects of Kenya is under the control of COL. GOK promotes the tide toward decentralization in MOL; however, COL which belongs to central government has exceptional total authority over compulsory land acquisition.

(6) Water Resources Management Authority (WRMA)

The authority is responsible for: (i) sustainable management of the nations water resources, (ii) implementation of policies and strategies relating to management of water resources, (iii) development of principles, guidelines and procedures for the allocation of water, (iv) development of catchment level management strategies including appointment of catchments area advisory committees, (v) regulation and protection of water resources quality from adverse impacts, and (vi) classification, monitoring and allocation of water resources.

2.3 Current Situation of Environmental Management

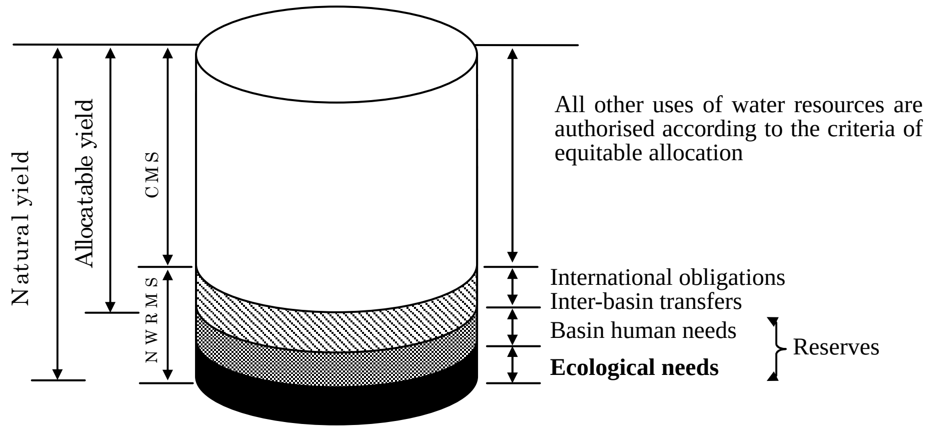
2.3.1 Overview

(1) Environmental Management for the Whole of Kenya

Kenya has various natural environmental resources such as forests, grasslands, wetlands, coral reefs and mangroves and a rich biodiversity supported by them. These natural environmental resources are very important which includes biological resources, and have brought huge benefits to Kenya as tourism resources. For the conservation of natural environmental resources, it is important to conserve the water bodies such as rivers, lakes, wetlands and other areas related to water. The water bodies produce water resources and are also habitats and water source for wildlife. However, the natural environmental resources are being degraded with the expansion of human settlement due to rapid population growth, illegal logging/ cultivation, and climate change.

Kenya has policies, legal and administrative frameworks for environmental management. The environmental management plans for national parks, reserves and specified areas have been developed. However, the environmental management plan for the whole of Kenya has not been developed yet. EMCA was enacted in 1999 and the EIA was required for development projects. NEMA is responsible for approval and issuance of environmental licence based on EIA process.

National parks, national reserves and sanctuaries are conserved and managed by KWS based on the



Source: Guidelines for Water Allocation (WRMA)

Definition of Water Resource under Guidelines for Water Allocation

Wildlife Act. KWS is obligated to prepare environmental management plan for each protected area. All reserved forests (including private forests) are protected and managed by KFS based on the Forest Act. The protected areas in the reserved forests such as Mt. Kenya National Park, Mt. Elgon National Park/ Reserve, and the Aberdare Range National Park are managed by KWS.

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

(2) Water Quantity and Quality Management

WRMA has “Guidelines for Water Allocation”, and which stipulate the requisite river flow as “Reserve”. The Reserve shall not be less than the flow value that exceeds 95% of the time as measured by naturalised flow duration curve at any point along the water course. The Reserve consists of basic human and ecological needs. The ecological needs are recognised as environmental river flow to protect the ecosystems of rivers and lakes.

WRMA monitors water quality and quantity of water bodies such as rivers, lakes, and springs, while NEMA issues licenses for effluent discharged by industries. The monitoring is not always for environmental conservation. From the viewpoint of environmental conservation, the water quantity and quality of major rivers and lakes should be continuously monitored to confirm impacts of water resources development projects for implementation.

Water quality regulation by NEMA and WRMA defines water quality standard for domestic water and effluent discharge from industrial and irrigation sectors. The regulation obliges all polluters / dischargers to apply for effluent discharge from EMCA. Although, according to the Water Quality Section of Water Compliance and Enforcement Department of NEMA, the section had received only 1,100 applications from all sectors (e.g. industrial factory, sewage treatment facilities, and large-scale flower farming) in the whole of Kenya. The number of currently received applications is smaller than the real number of polluters from all sectors. NEMA has a police unit that works with the inspectorate unit in their enforcement endeavours and have the court option to sue the offenders. However, this method of imposing compliance through court processes is burdensome and time consuming. Moreover, some polluters opted to pay penalty charge than to maintain proper wastewater treatment facilities. The reason is that penalty charge is cheaper than NEMA's licence fee and costs of wastewater treatment facilities.

Further, NEMA, WRMA headquarters, WRMA regional offices, MWI, and MOEMR have water quality data according to the status of each function. However, the data are kept by ministries and authorities internally. The absence of data sharing system among ministries and authorities is serious challenge. Moreover, some of the past data is kept on hard-copies only. In addition, some of the data were lost because if was saved in personal computers. According to WRMA regional officers, water quantity data management is one of the works that is highly prioritised. However, they have no adequate systems/procedures to manage and integrate all of the data in the local level. The current data management is undesirable to water resources management in future because the data will be utilised for effective and sustainable management of water resources as well as for environmental conservation.

There are many laws and regulations governing management of natural environmental resource related to water resources but no policy comprehensively address the water resources environment. On the other hand, the provisions have to be gleaned from these laws and regulations, some of which contradict each other. As a major example, there are functions on regulating water quality under the Water Act and EMCA. Based on both acts, the respective authorities have developed regulation, which set water quality standards and the need payment for permits for effluent discharge: Rules 87 and 104 of the Water Resources Regulations, and sections 74 and 75 of EMCA. Such conflicting legislations have led the authorities to difficulty in implementation, thereby reducing effectiveness in governance.

In addition, authorities related to environmental management such as NEMA, KFS, and their regional offices do not have enough capacity and manpower for adequate water quality management. Capacity building program and organization reinforcement projects are required.

(3) Wetlands Management

Wetlands in Kenya are recognised as important conservation areas as national parks, Ramsar sites, important bird areas and world heritage sites. Wetland management is considered as a very emergent work because many species of wildlife depend on the sensitive ecosystem in wetlands. NEMA prepared the Wetland Assessment and Monitoring Strategy for Kenya in February 2012.

Since 2010, the Kenya Wetlands Biodiversity Research Team (KENWEB) was established under the French Institute of Research for Development (IRD) program as a multi-disciplinary team of wetland experts. This is in relation to the high demand for expertise on wetlands from civil society and decision makers. The lead institution of the project is the National Museums of Kenya, and the main partners of the projects are IRD, KWS and the University of Nairobi.
The team is developing a rapid wetland assessment methodology to provide accurate and quick time valuation of wetland resources, ecosystem values and user strategies. In addition, the project priority focus is on the coastal Tana Delta and the inland Loboi Swamp in the Great Rift Valley.
As representative wetlands, five Ramsar sites are located in Kenya as shown in table below. All the Ramsar sites in Kenya are located in RVCA. GOK has already established regulations on environmental management for wetlands. However, due to lack of effective management mechanisms and proper appreciation of the regulations, wetlands have been continuously degraded due to unsustainable activities.

Summary of Ramsar Sites in Kenya

No.	Site	Designation Year	Elevation	Area	CA
1	Lake Nakuru	1990	1,750 – 2,070 m	18,800 ha	RVCA
2	Lake Naivasha	1995	1,890 m	30,000 ha	
3	Lake Bogoria	2001	900 - 963 m	10,700 ha	
4	Lake Baringo	2002	965 m	31,469 ha	
5	Lake Elementaita	2005	1,775 – 1,950 m	10,880 ha	

Source: JICA Study Team based on Ramsar Convention on Wetland website
(http://www.ramsar.org/cda/en/ramsar-junefrontpage/main/ramsar/)

(4) Management of Wildlife including aquatic ecosystems

1) National Protected Areas

National protected area includes national parks, national reserves, and sanctuaries. KWS manages 65 national protected areas (27 national parks, 34 national reserves, and four sanctuaries), and the total areas are equivalent to eight percent of the whole of Kenya. National park is managed by KWS in the national level. Human settlement or human activities in the park area are limited to the protection of nature and wildlife. Basically, economic activities (e.g. grazing and hunting) do not occur in the park area. If a development project is implemented in the area, the project should get a special permission by from the Minister of MOFW. On the other hand, national reserves are managed by the local authorities with the assistance of KWS. The purpose of the protected areas is the conservation of natural environment and wildlife without any changes similar to national parks. However, national reserves allow established interest such as human settlement and gazing by local people on some level. The purpose of sanctuaries is for the conservation of habitats of specific species. For example, the Kisumu Impala Sanctuary located in LVSCA. The ecosystem hosts leopards, hyena, olive baboons and vervet monkeys. It provides grazing lands for hippopotamus, habitat for numerous small mammals including the threatened Sitatunga, and supports a variety of reptiles and birds species.

The protected areas play major roles on the wildlife ecosystem of Kenya because valuable ecosystem and inhabitation for endemic species remain in these areas. Therefore, special care should be taken on water resources development so that protected areas will not be affected. In addition, Kenya Vision 2030 proposes the 'Secure Wildlife Migratory Routes' project as a flagship project of the environment sector. Wildlife is found along migratory routes between national parks and non-protected areas, and also between Kenya and other countries based on their behavior. If the main migratory route is located outside of the national protected area, the area should be expanded.

Locations of the protected areas are shown in Figure 2.3.1.

2) World Heritage Sites

Kenya has five world heritage sites; two of them are cultural heritage sites, and other three are natural sites. The latest convention area is the Kenya Lake System in the Great Rift Valley. The United Nations Educational, Scientific, and Cultural Organizations (UNESCO) evaluated the importance of the area as a natural property of outstanding beauty, comprised of three inter-linked relatively shallow lakes, namely, the Lake Bogoria, Lake Nakuru and Lake Elementaita.

Summary of World Heritage Convention in Kenya

Category	Name	CA	Date of Inscription	Property
Cultural	Lamu Old Town	TCA	2001	16 ha (Buffer zone:1,200 ha)
	Sacred Mijikenda Kaya Forests	TCA	2008	1,538 ha
Natural	Lake Turkana National Parks	RVCA	1997	161,485 ha
	Mount Kenya National Park/ Natural Forest	TCA, ENNCA	1997	142,020 ha
	Kenya Lake System in the Great Rift Valley	RVCA	2011	32,034 ha

Source: JICA Study Team based on UNESCO World heritage Centre website (http://whc.unesco.org/en/statesparties/ke)

3) International Bird Area (IBA)

IBAs are areas recognised as being globally important habitat for the conservation of bird populations. The program was developed and sites were identified by Bird Life International (IBAs).

In Kenya, 60 IBAs including 18 wetlands and six humid grasslands are identified and associated with Nature Kenya as natural NGOs. The representative IBAs of Kenya are; Arabuko-Sokoke Forest, Kakamega Forest, Kinangop grasslands, Kikuyu Escarpment Forest, Mukurweini Valleys and Lake Victoria Papyrus swamps. Detailed monitoring is conducted by KWS and NEMA in the six IBAs.

4) Biosphere Reserve

A biosphere reserve is an area of land or water is protected by law in order to support the conservation of ecosystems as well as the sustainability of mankind's impact on the environment. Biosphere reserves were created by UNESCO. Kenya has six biosphere reserves designated by UNESCO as shown in the table below. The areas except Mount Kulal were designated as national parks, national reserves by GOK.

Summary of Biosphere Reserve in Kenya

Name	Area ha	Date of Inscription	CA	Major Ecosystem Type
Mount Kenya	71,759	1978	RVCA, ACA, ENNCA	Mixed mountain and highland systems
Mount Kulal	700,000	1978	RVCA	Warm deserts and semi-deserts/lake systems
Malindi-Watamu	19,600	1979	TCA	Tropical coastal/marine zone
Kiunga	60,000	1980	ACA	Tropical coastal/marine zone including coral reefs
Amboseli	483,206	1991	TCA	Tropical grasslands and savanna
Mount Elgon	208,821	2003	LVNCA	Mixed mountain highland system Volcanic mountains and deep valleys and gorges

Source: JICA Study Team based on UNESCO World heritage Centre website (http://whc.unesco.org/en/statesparties/ke)

(5) Forest Management

Forests are major habitats of wildlife and one of the important features of the tourism industry. Forests also play a critical role in water catchment for the country. The 'Five Water Towers' of Kenya, namely, the Mt. Kenya, the Aberdare Range, the Mau Forest Complex, the Mt. Elgon, and the Cherangani Hills- are montage forests and the five largest forest blocks in the country. They are situated in the upper catchments of all the main rivers in Kenya (except the Tsavo River). However, the expansion of illegal farms into the indigenous forests and illegal logging poses the biggest threat to the indigenous forest conservation. KFS managed all gazetted forests including private forests.

Forest management information is also provided in the Sectoral Report H Water Resources Management.

(6) Waste Management

Vision 2030 proposes to develop national waste management system as one of the priority plans in environmental sector. The responsible authorities for waste management are the local governments. Waste collection is conducted by the local governments, or private companies that have licences from NEMA. Unfortunately, the local governments and private companies do not have enough ability to provide appropriate waste management to all residents, especially the poverty group. In addition, most of the rural authorities have no designated areas for disposal. Therefore, people continue dumping waste into the rivers and lakes or surrounding areas. Their illegal dumping causes a serious extent of water resources population.

(7) Current Challenges Related to Water Resources by Six Catchment

Six catchment areas have challenges related to water resources based on each environmental status. WRMA conducted mini-regional workshops (mini-WS) in WRMA regional offices from June to September 2011. The purposes of the mini-WS were to collect current information and confirm environmental challenges related to water resources in the regional level. The participants in the mini-WSs are WRMA regional officers, NEMA regional officers, KFS regional officers and other stakeholders. As the results, six regional offices face common serious challenges, namely, water scarcity, water pollution and poor waste management. The summary on the results of mini-WSs is shown in the following table.

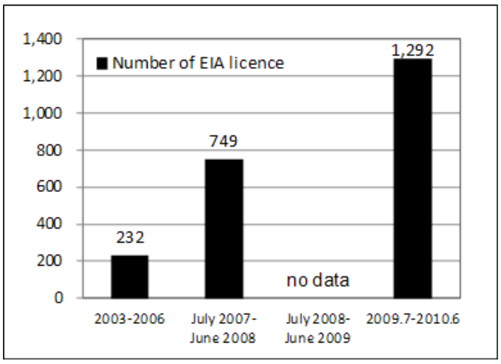
Current Significant Challenges in Each Catchment Area

Challenge \ CA	LVNCA	LVSCA	RVCA	ACA	TCA	ENNCA
Water scarcity	–	●	●	●	●	●
Water pollution	●	●	●	●	●	●
Wetland decrease	●	●	○	○	○	●
Uncontrollable of environmental river flow	–	○	●	○	○	●
Excessive use and pollution of groundwater	–	○	●	○	○	●
Conflict of water use	–	○	●	○	○	●
Poor waste management	●	●	●	●	●	●
Other challenges	–	- Poor farming, -Encroachment	- Climate type - Poor farming - Encroachment	- Sand harvesting -Encroachment	- Seawater intrusion - Inadequate water infrastructure	- Lack of harmonization among key stakeholders - Inadequate funds

Source: JICA Study Team, based on mini-workshop in this study.
Note: ●: Serious challenges, all sub-catchment areas have challenges.
○: Some of sub-catchment areas have challenges, but less serious than ● type.

(7) EIA Management

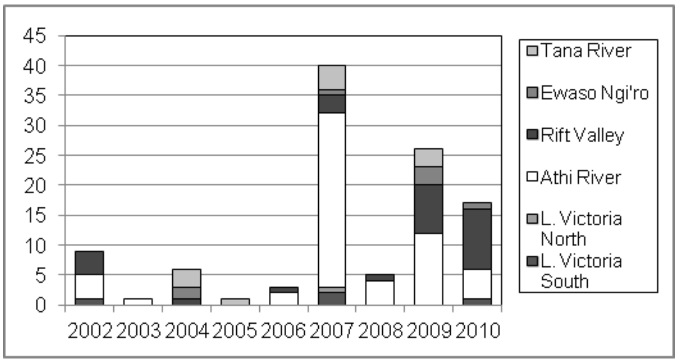
According to the Department of Compliance and Enforcement of NEMA, the trend in the number of EIA licences between 2003 and 2010 is shown in the right figure. As shown in the figure, the number of EIA licences is increasing yearly. The majority of projects for EIA licence are the base transceiver station (BTS) projects and borehole development projects.



Source: JICA Study Team based on information of NEMA

Number of EIA Licence

On another front, the numbers of EIA licences for the water resources development projects (boreholes, dams, waste water treatment plant, hydropower and small water supply projects) is decreasing as shown on the right figure. The maximum number of EIA licences for water resources development projects were 40 in 2007, whilst it decreased to 17 in 2010. A few number of water resources development projects except borehole projects have been implemented in recent years.



Source: JICA Study Team based on information of NEMA

Number of EIA Licences Related to Water Development Projects on Each Catchment Area

Region wise, the catchment for which the EIA licences have been obtained is mostly in ACA and the number of projects as 58 during past nine years because many borehole development projects have been conducted in ACA. The borehole projects were required to correspond to rapid population growth of large cities such as Nairobi City and surrounding area.

According to NEMA, the existing EIA process has following challenges, which are; i) time consuming procedures for EIA process, ii) EIA process is conducted only on paper, and iii) lack of adequate monitoring system. NEMA intends to overcome these challenges by revising EMCA and EIA/ EA regulations.

(8) Involuntary Resettlement to the Growth Development of Water Resources Development Project

Generally, water resources development projects, such as dam, large scale irrigation, and afforestation have caused involuntary resettlement in the past years. Some resettlement projects became significant problems because of inadequate Resettlement Action Plan (RAP). Land Acquisition Act Chapter 29 (Revised 2009 (1983)) manages land acquisition and resettlement which may be prepared during the EIA process. In addition, the project proponent is required by NEMA to submit the RAP report together with the EIA report in order to obtain the EIA approval if the project involves involuntary resettlement. When development projects need to prepare RAP, World Bank (WB) Operational Policy (OP) 4.12 Involuntary Resettlement is generally adopted in practice. Moreover, as for the approval of the RAP, it is confirmed that there is no official government authorities/ agencies which approve RAP in Kenya. RAP is commonly prepared in accordance with the donor requirements such as WB/ International Finance Cooperation. Moreover, it needs to be agreed amongst the project proponents and affected persons.

2.3.2 Lake Victoria North Catchment Area

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

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

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

There are three major categories of vegetation in LVNCA. Rain forest vegetation is distributed in the large area of the catchment, and most of the Nzoia River basin belongs to said vegetation. The middle reaches of the Yala River basin belong to evergreen bushland with wooded grassland vegetation. The upper reaches of the rivers, the Mt. Elgon, the Cherangani Hills, and the Mau Forest Complex are located in the area, situated in Mount forest vegetation. The three forests are the most important water conservation forests in Kenya. The forests have been destroyed by illegal logging/ encroachment due to population growth. The Mt. Elgon which is bisected by the border of Kenya and Uganda is a water source of the Nzoia River and is designated as a national park. The deforestation has affected water resources conservation.

Locations of the current natural resources and vegetation in LVNCA are shown in Figure 2.3.2.

Summary of Natural Environmental Resources (LVNCA)

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

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

2.3.3 Lake Victoria South Catchment Area

LVSCA faces the Winum Gulf of Lake Victoria. Six rivers in LVSCA are flowing into the gulf. Water pollution and eutrophication of the gulf are caused by hazardous substances of sewage and industrial wastewater from the rivers and Kisumu City, and nutrients from agricultural land in upper reaches. In particular, the Nyando and Sondu rivers regarded as main rivers of LVSCA transport large load to the gulf. In addition, Kisumu City, a central city of LVSCA has a population of over 400,000. Water pollution by urban and industrial wastes from the city is expected to increase with the future population and economic growth of the city and surrounding area.

The Masai-Mara National Reserve is located in the catchment area and bounds the Serengeti National Park of Tanzania. This reserve is an internationally important area for natural ecosystem such as gnu migratory over the borders. The Mara River is a main water source in the reserve. The River is a solitary example of an environmental river flow study by the World Wide Fund for Nature (WWF). The study is a good practice of water resources management considering both of rural people's life and wildlife. WWF-Eastern and Southern Africa Regional Program (WWF-ESARPO) was pursuing a strategy by using environmental flow study to determine appropriate water resources allocation in the Mara River basin for preparation of Biodiversity Strategy and Action Plan (BSAP) of this area.

However, conflicts between rural people and KWS caused by water shortage and excessive grasslands by drought have become a problem in recent years.

Vegetation of LVSCA is divided into three types, namely, evergreen bushland with wooded grassland, rain forest, and mountain forest vegetations. Lake front area, lower reaches of all rivers belong to evergreen bushland vegetation, while the middle reaches and belongs to rain forest vegetation. The Mau Forest Complex is located in the upper reaches and belongs to mountain forest vegetation. The forest has the largest forest area among the Five Water Towers. The forest is located in the northern part of the catchment and has the most serious forest degradation by illegal logging and encroachment among the Five Water Towers. The deforestation has become a factor for water resources degradation. Thus, strengthening of patrol activity and forestation by local people are conducted by KFS for the conservation of the forest. According to KFS, these mitigation measures are contributing to stop deforestation, but not enough.

Locations of current natural resources and vegetation in LVSCA are shown Figure 2.3.3.

Summary of Natural Environmental Resources (LVSCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Ndere Island N.P.	42 km^2	No information	Winum Gullf, Lake Victoria
2	Ruma N.P.	120 km^2	164	Suba District, Nyanza Province
National Reserve (N.R.)				
3	Masai Mara N.R.	1,510 km^2	205	Near the border between Tanzania
National Sanctuary (N.S.)				
4	Kisumu Impala N.S.	0.34 km^2	No information	Located near the Kisumu Town
5	Lake Simbi N.S.	41.7 ha	No information	Nyanza Gulf of Lake Victoria.
6	Ondago Swamp N.S	24.8 ha	No information	Besides Lake Victoria
Five Water Towers				
7	Mau Forest Complex	400,000 ha	No information	Central part of RVCA

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

2.3.4 Rift Valley Catchment Area

RVCA has poor freshwater resources since most of the rivers in RVCA area are seasonal or small. RVCA is an important catchment from the aspect of natural environmental resources since many wetlands, national parks and reserves are located in the surrounding areas of the lakes.

Main rivers are the Turkwel, Kerio, and Ewaso Ng'iro South rivers. The lower reaches of the Kerio and Ewaso Ng'iro South rivers have seasonal flow. The Kerio and Turkwel rivers are feeding Lake Turkana. The Lake Turkana is the largest saline lake in East Africa and the largest desert lake in the world. The area including the lake is now listed as a UNESCO World Natural Heritage Site in views of its rich biodiversity conservation and natural geographic characteristic. The lake also has important ecosystem for migratory birds and the world's biggest habitat of crocodile. However, the lake has been threatened by environmental degradation such as water pollution and drawdown of the lake’s water level. One of the reasons of the degradation is dam development projects in the Omo River which supplies 80% of the lake water. The Ewaso Ng'iro South River is feeding the Lake Natron, which is situated in Tanzania.

On the other hand, there are many well-known lakes and marshes such as the Lake Naivasha as fresh water lake and famous six saline lakes as important habitats of wild birds in RVCA. Among the saline lakes, the Lake Nakuru, Lake Bogoria and Lake Elementaita are listed as UNESCO World Natural Heritage Site in 2011. The area is habitat of 13 endangered bird species and an important breeding site for Pink Flamingo and Great White Pelican. The saline lakes which are characteristic natural resources of Kenya are concentrated in this catchment area. Though these lakes are not suitable for water source, they have important role as habitats of wild birds and large mammal such as Hippopotamus amphibious. These lake ecosystems are threatened by water pollution from inflow of human sewage, agricultural water, industrial wastewater and water shortage by excessive water abstraction in the upper reaches. The Lake Naivasha located near the town area, is also threatened by water pollution caused by sewage associated with population growth. Despite important water resources, water pollution of the Lake Naivasha caused by agricultural water and sewage has been accelerated. The lakes and surrounding wetlands should be officially protected as natural environment resources. It is required to consider adequate countermeasures based on periodic environmental monitoring to prevent any further environmental degradation.

Vegetation of the northern part of RVCA, deciduous bushland and thicket vegetation is distributed to a large range. The surrounding area of the Lake Turkana belongs to semi-desert grassland vegetation. In the southern part, evergreen bushland with wooded grassland vegetation is distributed in the Great Rift Valley area. The area of the Mau Forest Complex, the Cherangani Hills, and the Aberdare Range belong to mountain forest vegetation. The decrease of the water conservation forest areas affects water resources conservation similar to other catchments.

Locations of the current natural resources and vegetation in RVCA are shown Figure 2.3.4.

Summary of Natural Environmental Resources (RVCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Mt Longonot N.P	52 km^2	209	Naivasha District, Rift Valley Province
2	Saiwa Swamp N.P	2 km^2	No information	Trans- Nzoia District, Rift Valley Province
3	Central Island N.P	5 km^2	108	Within Lake Turkana
4	Hells Gate N.P	68 km^2	214	The south of Lake Naivasha
5	Lake Nakuru N.P	52 km^2	211	Nakuru District, Rift Valley Province
6	South Island N.P	39 km^2	109	Within Lake Turkana
7	Sibiloi N.P.	1,570 km^2	115	The north-eastern shore of Lake Turkana
National Reserve (N.R.)				
8	South Turkana N.R	1,109 km^2	160	Northern 125km from Lodwar
9	Nasalot N.R	194 km^2	160	Western of South Turkana N.R.
10	Kamnarok N.R	87.7 km^2	No information	Central of Rift Valley, next to Lake Kamnarok
11	Kerio Valley N.R	66 km^2	189	Between the Cherangani Hills and the Tugen Hills.
Five Water Towers				
13	Aberdare Range	250,000 ha	No information	Central Kenya, on the eastern edge of the RVCA
14	Cherangani Hills	120,000 ha	No information	Western ridge of the Great Rift Valley
15	Mau Forest Complex	400,000 ha	No information	Central of RVCA

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

2.3.5 Athi Catchment Area

The main river in ACA is the Athi River, the River and its tributaries are main water resources of ACA. WRMA is monitoring the river flow and water quality in the rivers. However, the current data is not enough to confirm the secular changes in water environment.

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

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

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

Most of ACA belongs to deciduous bushland and thicket vegetation. Evergreen bushland/ mountain forest vegetation are distributed in a patchy fashion in ACA. In lower reaches, coconut woodland, bushland, and tall savannah grasses vegetation while mangrove forest vegetation is located along coastal zone. Equatorial forest vegetation is situated partly within the coastal zone. The three vegetations are located only in ACA and TCA of Kenya.

Locations of the current natural resources and vegetation in ACA are shown Figure 2.3.5.

Summary of Natural Resources (ACA)

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

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

2.3.6 Tana Catchment Area

The Tana River is the main river of TCA. Many tributaries originating from the Aberdare Range and the Mt. Kenya are flowing into the upper reaches of the Tana River and rich water resources have been maintained.

There are 19 national parks/ reserves including Kiunga Marine National Reserve. There is concern that large scale development projects such as High Grand Falls Multipurpose Development Project in the upper reaches will affect the Kora and Meru national parks and the Mwingi, Bisanad and Rahole national reserves, which are situated directly below the projects. In addition, the Arawale and Tana River Primate national reserves are located in the middle reaches to lower reaches of the Tana River. Environmental monitoring for the natural resources is required in the middle reaches because negative impact by future population growth of Garissa town as main city of the area is expected. Tana Delta located near the river mouth is not designed as a national protected area; however, it is receiving attention as an important wetland ecosystem of Kenya. Tana Delta is the largest, most ecologically and socio-economically important wetlands in Kenya. The delta supports a gallery of ecosystems ranging from forests to swamps. KENWEB Project is conducting in the area to conserve and conduct sustainable use of the wetlands. Kiunga Marine National Reserve is designated as biosphere reserve by UNESCO. WWF-ESAPRO has conducted the Conservation and Development of the Kiunga Marine Reserve Area Programme in January, 2011. The purpose is to make a significant contribution to collaborative efforts for the sustainable conservation of the reserve's habitats and adjacent areas, and of its biodiversity as species, communities and ecological processes so that their productivity can benefit local livelihoods.

Most of ACA belongs to deciduous bushland and thicket vegetation. In the lower reaches, three peculiarity vegetations, namely, coconut woodland, mangrove forest, and equatorial forest vegetation are distributed along coastal zone. The upper reaches belong to evergreen bushland with wooded grassland and mountain forest vegetation. A part of the Mt. Kenya and the Aberdare Range belong to heath and moorland vegetation. The vegetation is only in the high mountain ranges.

Most of the area of the Mt. Kenya and the Aberdare Range of the Five Water Towers are located in TCA. Deforestation by illegal logging of the Aberdare Range is significant. Thus, urgent action is required to consider in sight of water resources management.

Locations of the current natural resources and vegetation in TCA are as shown Figure 2.3.6.

Summary of Natural Resources (TCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Tsavo East N.P	11,747 km^2	215	South Eastern Kenya, inland from the coast
2	Mt Kenya N.P	715 km^2	200	Eastern of Rift Valley
3	Meru N.P	870 km^2	141	Meru District, Eastern Province
4	Aberdare N.P	765.5 km^2	221	Aberdare Mountain Ranges of Central Kenya
National Reserve (N.R.)				
5	Arawale N.R	533 km^2	102	North Eastern Province
6	Kora N.R	1,787 km^2	115	North Eastern Province
7	Tana River Primate N.R	169 km^2	116	Tana River District, Coast Province.
8	Tsavo Road and Railway N.R	212 km^2	-	-
10	Bisanadi N.R	606 km^2	124	North-east boundary of Meru N.P.
11	Mwea N.R	68 km^2	154	Mbeere District, Eastern Province
12	Mt Kenya N.R	2,124 km^2	No information	East of the Rift Valley
13	Rahole N.R	1,270 km^2	104	Northeast of Kora N.P.
14	Boni N.R	1,339 km^2	109	Ijara district, North Eastern Province
15	Ngai Dethya N.R	212 km^2	No information	Next to Rahole N.R.
16	Dodori N.R	877 km^2	114	North east coast
17	South Kitui N.R	1,133 km^2	125	Northern area from Tsavo east N.P.
18	North Kitui N.R	745 km^2	114	Eastern Province
Marine Reserve				
19	Kiunga Marine N.R.	250 km^2	106	Lamu District, Coast Province
Five Water Towers				
20	Mt.Kenya	220,000 ha	No information	180km north of Nairobi
21	Aberdare Range	250,000 ha	No information	Central Kenya, on the eastern edge of the RVCA

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

2.3.7 Ewaso Ng'iro North Catchment Area

Most of ENNCA area belong ASAL area, and ENNCA has the poorest water resources among the six catchment areas. The main river of ENNCA is the Ewaso Ng'iro North River that takes its water from the Mt. Kenya. The Shaba National Park, the Buffalo Springs, Nyambene and Samburu national reserves in situated along the River. In addition, the River becomes underground flow from the lower reaches. Wetlands named Lorian Swamp and vegetation zones in a certain area are located along the groundwater vein of the River after underground flow. The Lorian Swamp is the largest wetlands in Kenya and is considered thought to be the important water resources for many of the large mammals which live in the ASAL area. Therefore, setting of adequate environmental flow rate and environmental monitoring are required for the River.

The Losai and Shaba national parks and Mt. Kenya national parks/ reserves are located in the south-western part of ENNCA. A large area of Mt. Kenya is designated as national parks/ reserves. The designated area is strictly protected by KWS from illegal logging/ encroachment. KWS activities are quite effective in protecting the area. However, KWS activities are facing strong oppositions from local people who have lived near the area for a long time.

In addition, some relatively-large gazetted forests are located in the western area. It is required to set appropriate environmental flow rate and to conduct environmental monitoring because the areas are important conservation targets in ENNCA.

Coconut woodland, bushland, tall savannah grasses and semi desert grasslands are distributed to large areas of ENNCA. Evergreen bushland with wooded grassland and mountain forest vegetation are located in Mt. Kenya and surrounding area.

Locations of the current natural resources and vegetation in ENNCA are shown Figure 2.3.7.

Summary of Natural Resources (ENNCA)

Protected Area		Total Area	Number of Wildlife Species	Location
National Park (N.P.)				
1	Marsabit N.P.	68 km^2	No information	Marsabit District, Eastern Province
2	Malka mari N.P.	876 km^2	No information	On the Kenya-Ethiopia border in the extreme north east of Kenya on the Mandera plateau
3	Mt Kenya N.P.	715 km^2	200	East of the Rift Valley
National Reserve (N.R.)				
4	Buffalo Springs N.R.	131 km^2	85	Isiolo district, Eastern Province
5	Losai N.R	1,806 km^2	126	Losai Mountains, northern Kenya
6	Samburu N.R.	165 km^2	145	The banks of the Ewaso Ng'iro River
7	Shaba N.R.	165 km^2	134	Ishiolo Distcict
8	Nyambene N.R.	640.6 km^2	No information	Meru North District
9	Marsabit N.R.	1,564 km^2	118	Marsabit District, Eastern Province
10	Laikipia N.R.	165 km^2	No information	Near Mt.Kenya
National Sanctuary (N.S.)				
11	Maralal N.S.	5 km^2	159	-
Five Water Towers				
12	Mt.Kenya	220,000 ha	No information	180km north of Nairobi
13	Aberdare Range	250,000 ha	No information	Central Kenya, on the eastern edge of the RVCA

Source: JICA Study Team, based on ProtectedPlanet.net (http://www.protectedplanet.net/about),Changes in Forest Cover in Kenya's Five water towers 2003-2005 and Wildlife Bill, 2011

2.4 On-going Projects and Existing Plans

On-going and existing (2011-2012) environmental projects related to water resources in a typical implementation are shown in the following table:

On-going Projects Related to Environmental Management Related to Water Resources

Plan / Project / Programme Name	Period	Lead Institutions	Funded by
Kenya Wetlands Biodiversity Research Team (KENWEB)	2012-	National Museums of Kenya	IRD
Lake Victoria Environmental Management Project II	2009-2013	LVB Organization	East African Community (EAC)
Lake Nakuru - Conservation and Development	1998-2011	WWF	WWF
Conservation and Development of the Kiunga Marine Reserve Area	1995-2011	WWF-ESAPRO	WWF
Kenya Slum Upgrading Project (KENSUP) :	2001-	Nairobi City Council	UN-HABITAT

Source: JICA Study Team, based on data from NEMA

2.5 Operation and Maintenance Issues

Operation and maintenance issues of environmental management are shortage of laboratories for water quality analysis. NEMA has over ten laboratories while WRMA has five laboratories in the regional level and one main laboratory in Nairobi City. Private companies related to environmental survey have their own laboratories for their works. However, the laboratories are not enough to cover water quality analysis for the whole of Kenya. In addition, according to NEMA water quality section and WRMA regional officers, analytical equipment of laboratories are not enough for performing adequate analysis and do not have test reagents on a regular analysis.

2.6 Challenges and Key Issues

Kenya faces many challenges and issues on environmental management including those related to water resources. MOEMR mentioned the challenges and key issues related to water resources in their web-site[1]. According to the web-site, current environmental issues of concern in Kenya are; a) water pollution due to urban and industrial wastewater, which affects major urban areas like Nairobi, Kisumu, and Mombasa, and has also caused decline of flamingos in the Lake Nakuru, b) water pollution due to increased use of pesticides and fertilizers, which affects the agricultural areas and disturbs the ecosystem of local water systems, e.g.. Lake Naivasha, c) over-growth of water hyacinth in the Lake Victoria, d) solid waste management and disposal as a major challenge for the major urban areas, and e) deforestation, desertification and soil erosion which are inter-related and are among the causes of climate changes and depletion of water in catchment areas.

On the other hand, the Master Plan for the Conservation and Sustainable Management of Water Catchment Areas in Kenya also states some challenges and issues on water catchment conservation, which are: a) weak institutional linkages and synergies, b) conflicting institutional mandates, c) lack of clear funding mechanisms for water catchment areas (WCA), d) lack of integrated WCA monitoring and evaluation systems, e) inadequate flow of information on WCAs, f) low levels of awareness and capacity of stakeholders, g) degraded WCA, h) land degradation (and soil erosion) in WCA, i) poor management of water resources, j) water insecurity, k) poor waste management, l) livelihood

[1] http://www.environment.go.ke/

insecurity, m) overdependence on biomass energy, and n) limited involvement of women and youth in WCA activities.

On the basis of above mentioned information, challenges of environmental management related to water resources can be categorised in five types. i.e., i) lack of water quality management, ii) lack of water quantity management, iii) lack of management system for water resources including institutions, legislations, and awareness, and vi) lack of watershed management as water conservation forest and soil erosion.

The environmental management plan of NWMP 2030 partially covers challenges categories i), ii), and iii). The environmental management is planned from the viewpoint of natural environment such as aquatic ecosystem, but not human needs. Water quality and quantity management for human needs and watershed management are covered by other sectors in the Water Resources Management Plan of NWMP 2030. This environmental management plan covers the following challenges: i) water quantity for natural ecosystem related to water resources and ii) water quality for natural ecosystem related to water resources.

The water resources development projects, which are proposed in NWMP 2030, will change river flow regime and may cause undesirable impacts on the ecosystems of rivers and lakes. The anticipated negative impacts should be monitored and managed adequately to avoid serious damage to the natural environment. EIA process will minimise the impact at project level. However, it is difficult to monitor multiple impacts by numerous projects and development for the current system. In addition, locations where significant environmental impacts on water bodies that have already been confirmed should be monitored and manage adequately. Under the current situation, there is no comprehensive system to resolve these challenges.

As described above, for environmental management related to water resources, it is necessary to confirm current ecological needs based on the natural ecosystem of each water resource. Moreover, it needs to conduct adequate management of river flow rate and environmental water level by each water resource. WRMA has “Guidelines for Water Allocation” and which stipulate the requisite river flow as “Reserve”. However, the definition is required for detailed analysis considering the following points:

- Firstly, the definition of the reserve is not based on each river status and ecosystem. Status of river flow is different in each river due to river regime, topography, rainfall and other factors as well as river environment.
- Secondly, environmental flow rate has not been clearly set in the guidelines because the ratio of basin human needs and ecological needs is not determined by the “Reserve” in the guidelines. Ecological needs and river environmental flow rate should be determined in consideration of the current status of each river. Thus, it is necessary to determine the environmental flow rate of major rivers and lakes through the ecosystem surveys.
- In order to do so, environmental flow rate by each water resources should be set based on scientific approach. In addition, regular environmental monitoring should be conducted to monitor changes in the natural environment related to water resources by development projects.

CHAPTER 3 ENVIRONMENTAL MANAGEMENT PLAN

3.1 General

Considering the relation of water resources development activities and environmental sustainability, the objective of environmental management in NWMP 2030 was set to minimise negative impacts on the natural environment by the water resources development activities. This chapter mentioned the overall environmental management concept and framework and proposed concrete environmental management plan for each catchment.

Besides, Strategic Environmental Assessment (SEA) on the proposed development projects is scheduled to be implemented by WRMA after the formulation of the master plan.

3.2 Overall Concept and Framework for Planning

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

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

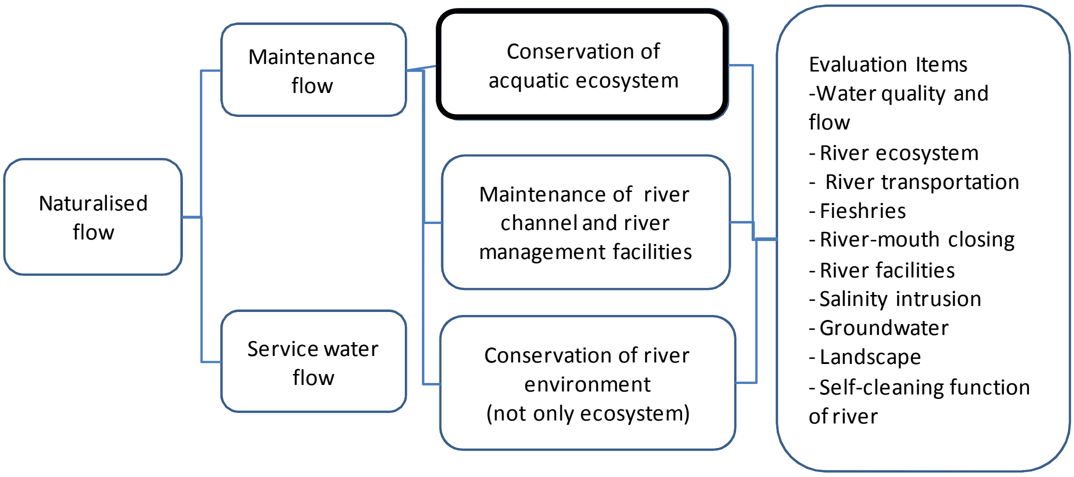
a) Setting of environmental flow rates at strategic points of major rivers and lakes through environmental surveys; and
b) Implementation of environmental monitoring at strategic points for major rivers and lakes.

Environmental flow rates mean the necessary river discharge for ecological needs of the river ecosystem. As for lakes, proper water level for conservation of aquatic ecosystem should be set based on the current environmental status.

3.2.1 Setting of Environmental Flow Rate

(1) Purpose of Environmental Flow Rate in NWMP 2030

The purpose of setting of environmental flow rate in NWMP 2030 is to secure the river flow and lake water level necessary for the conservation of aquatic ecosystems as mentioned above. The following figure indicates the definition of naturalised flow and maintenance flow, adopted by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in Japan. Maintenance flow includes flow rate for the conservation of aquatic ecosystem, for maintenance of river environment, and other factors.



Source: JICA Study Team based on the information from Ministry of Land, Infrastructure, Transport and Tourism in Japan

Definition of Naturalised Flow and Maintenance Flow

In river basin, a huge variety of habitat for the ecosystem is built based on river flow fluctuation from flood to drought. The river flow variation is an important factor for the conservation and restoration of habitat. In addition, decrease of the maintenance flow by large volume of water abstraction will cause degradation of aquatic ecosystem degradation seriously. As the environmental flow rate affects the water resources development planning, it should be properly determined based on the sufficient environmental survey.

(2) Setting Points of Environmental Flow Rate

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

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

(3) Environmental Survey for Setting of Environmental Flow Rate

The environmental flow rate should be determined based on the environmental surveys for each subject of ecosystem of rivers and lakes. The environmental survey aims to confirm aquatic ecosystem in the target rivers and lakes. The proposed contents of the environmental field survey are shown in the following table. The proposed environmental field survey should be conducted within one year. If the field survey could not get enough environmental information due to depend on several reasons such as abnormal climate and disaster, the field survey period could be extended. At the same time, past secondary information in target water bodies should be collected because it is an invaluable piece of material in the study of primary native ecosystem. Both the results from field survey and collected past environmental information are utilised in decision making for setting the environmental flow rate.

Proposed Contents of the Environmental Survey

Subject	Survey Item		Frequency
River	River Flow	Discharge at Fixed-point	Monthly
	Water Quality	Temperature, pH, DO, SS, BOD and Faecal Coliform	Monthly
	Ecosystem	Aquatic flora and fauna, Important habitat area and sediment	Semi-annually (Wet season / Dry season)
Lake	Water Level	Water Level at Fixed-point	Monthly
	Water Quality	Temperature, pH, DO, SS, COD and Faecal Coliform	Monthly
	Ecosystem	Aquatic flora and fauna including surrounding wetland area, Important habitat area and sediment	Semi-annually (Wet season / Dry season)

Source: JICA Study Team

(4) Setting Measure of Environmental Flow Rate

Essentially, environmental flow rate should be widely examined considering about flora and fauna as examination objects, because it does not only live in water bodies but it is also related to the aquatic ecosystem (MLIT, 2007)[2.]

In Japan, fish species are selected as examination objects among fish and shellfish species, benthos, and periphyton as close connection with river flow rate. The criteria are shown as follow:

a) Fish species are important wildlife in large-size and the highest on the food chain among river biota; and
b) Quantitative knowledge on hydraulic habitat status of fish species can be easily obtained in existing literature.

In Kenya, large mammals and reptiles such as hippopotamus and crocodiles live in rivers/ lakes which need large amount of water. Therefore, examination objects shall include large mammals and reptiles as necessary in setting environmental flow rate in Kenya.

Furthermore, environmental flow rate is set by the following general procedure by MLIT in Japan:

a) To collect baseline ecosystem information by field survey and secondary information study;
b) To select object fish species based on biological/ distribution characteristic among fish species which live in the target rivers;
c) To select representative fish species based on grouping of object fish species;
d) To calculate environmental flow rate based on necessary hydraulic condition (water depth, flow rate, and others) for representative fish species inhabitation;
e) To confirm necessary aquatic condition in view of the collective way of inhabitation; and
f) To confirm necessary aquatic condition of remarkable species.

The steps should be conducted through stake holder meeting which is explained in the following chapter.

(5) Stakeholder Meeting

The responsible authority for setting the environmental flow rate is MOEMR, since the Ministry is in charge of environmental ecosystem management for the whole Kenya. Based on the environmental

2 Draft manual of normal flow rate inquest (MLIT, Japan, 2007)

survey results and collected latest information about natural environment of the area, stakeholders should decide on the environmental flow rate in each river and lake through the stakeholder meeting in their specialised knowledge. The proposed stakeholders are MWI, MOFD, KWS, NEMA, KMFRI, universities, National museum, NGOs, WRUAs and WRMA. MOEMR takes the lead role on the setting of environmental flow rate in the stakeholder meeting.

In addition, MOEMR and WRMA should inform and share the new environmental flow rate among relevant authorities, namely, MWI, Water Service Board (WSB), National Irrigation Board (NIB), KenGen, and other water resources development authorities. The relevant authorities will refer the flow rate and pay attention to its importance when they organise new development plan in the same basin.

3.2.2 Environmental Monitoring for Major Rivers and Lakes

(1) Purpose of Environmental Monitoring in NWMP 2030

The purpose of environmental monitoring in NWMP 2030 is to monitor water quality and quantity of river/lake as well as confirmation of properness of the environmental flow rate for the conservation of aquatic ecosystem. If any environmental issue was observed, detailed field survey and inspection should be timely and properly implemented by the authorities in charge.

In addition, properness of the environmental flow rate should be confirmed based on the river/ lake environmental conditions. If any environmental issue was observed on the aquatic ecosystem by the monitoring, the environmental flow rate should be reviewed based on the field survey to be conducted by MOENR and WRMA. Furthermore, periodical ecosystem survey is recommended for confirmation of ecological change in the targeted water bodies every five years.

(2) Monitoring Points

The environmental monitoring should be implemented to confirm the latest conditions of quantities and qualities of river and lake water in view of environmental conservation. The environmental monitoring points were selected under the following criteria.

a) Representative point to monitor the river ecosystem;
b) Location where rare or characteristic ecosystem exists (ex. estuary area, closed basin);
c) Location where large city or town is located;
d) Location upstream from the protected area;
e) Major lakes in the catchment area; and
f) International rivers and lakes.

The environmental monitoring points are selected from the viewpoint of conservation of aquatic ecosystem and therefore they do not always coincide with the monitoring points for water resources management presented in Sectoral Report (H).

(3) Monitoring Items and Frequencies

Items and frequency of the environmental monitoring are tentatively proposed as shown in the table below. Such will be subject to change depending on the conditions based on the ecosystems survey.

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

Proposed Items and Frequencies of Environmental Monitoring

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

Source: JICA Study Team

1) River Flow and Water Level

River flow and water level of lakes are most important items for monitoring. The items should be monitored at fixed monitoring points throughout the year to monitor the validity of the environmental flow rate. Measuring method of river flow is mentioned in Sectoral Report (H) Water Resources Management, Chapter 2.3 Current Situation of Water Resources Management.

2) Water temperature

Water temperature affects feeding, reproduction, and metabolism of aquatic animals. High water temperature even only for a week or two weeks may create streams and other shallow water unsuitable for sensitive aquatic organisms, even though water temperatures are within tolerable levels throughout the rest of the year.

3) pH

The unit is measure of how acidic or basic (alkaline) the river or lake water is. In any given solution, some atoms of water dissociate to form hydrogen ions and hydroxyl ions. The pH is defined as the negative logarithm of the hydrogen ion concentration. This means that the concentration of hydrogen ions does not increase or decrease in a linear fashion.

4) Dissolved oxygen (DO)

DO is one of the most important indicators of the quality of water for aquatic life. It is essential for all plants and animals. Oxygen availability throughout the year is influenced by other chemicals present in the water, biological processes, and temperature.

5) Suspended Solids (SS)

The concentration of SS is important for both river and lake ecosystems for ecological and water quality reasons. SS usually enter the water as a result of soil erosion from disturbed land or can be traced to the inflow of effluent from sewage plants or industry.

6) Biochemical Oxygen Demand (BOD): only for Rivers

BOD refers to the amount of oxygen that would be consumed if all the organics in one litter of water were oxidised by bacteria and protozoa. The term also refers to a chemical procedure for determining this amount. The range of possible readings can vary considerably such as water from an exceptionally clear lake might show a BOD of less than two ml/L of water. Raw sewage may give readings in the hundreds and food processing wastes may be in the thousands.

6) Chemical Oxygen Demand (COD): only for Lakes

COD is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. The items are nearly similar to BOD; however, it is only applied to lake water.

7) Faecal Coliform

Faecal Coliform is found in the intestinal tracts of warm-blooded animals including humans. The presence of faecal coliform in drinking water or at swimming sites is evidence that human or animal waste has been or is present. Many diseases can spread through fecal transmission.

8) Total Nitrogen (T-N)/ Total Phosphorus (T-P): only for Lakes

The two nutrients cause eutrophication in lakes. The nutrient changes in aquatic flora and fauna composition.

9) Microorganism: only for Lake

Among aquatic ecosystem, microorganisms such as zooplankton and phytoplankton are highly sensitive and their dynamics can be seriously affected by environmental changes. Bacteria, phytoplankton and zooplankton have fast growth rates and therefore can provide meaningful and quantifiable indicators of ecological change in short timescales.

3.3 Environmental Management Plan for Lake Victoria North Catchment

3.3.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring points are proposed in main rivers and lakes in LVNCA.

The Nzoia and Yala rivers are the main rivers in the catchment and inflow to the Lake Victoria. In LVSCA, environmental flow rate setting points and environmental monitoring points are proposed in the two basins because water resources development plans proposed in NWMP 2030 are concentrated in the two river basins. In addition, environmental monitoring points are proposed in the Lake Victoria. Proposed projects will not directly affect the protected area and will not be located in the upstream of the protected area.
Based on the said situation, the management strategy of LVNCA is as follow:

a) Setting of environmental flow rate for the Nzoia and Yala rivers; and
b) Environmental monitoring in the Nzoia and Yala rivers and the Lake Victoria.

3.3.2 Proposed Environmental Management Plan

Based on the strategy, proposed environmental management plan of LVNCA is discussed below. Proposed locations of the environmental management plan are shown in Figure 3.3.1.

(1) Setting of Environmental Flow Rate

NWMP 2030 proposes setting of environmental flow rate and environmental survey of river ecosystem in the above-mentioned two rivers. The criteria of the proposed environmental flow rate setting points are as follow.

1) Nzoia River

The Nzoia River has many tributaries, especially in the upper and middle reaches. The river flow regime drastically changes in the upper, middle, and lower reaches caused by these tributaries. Vegetation along the river varies in three land types, namely, mountain forest in the upper reaches, rain forest in the middle reaches, and wetlands/ evergreen scrub forest in lower reaches. The setting is emergency work to maintain adequate river flow rate because five dams are proposed in the upper and middle reaches of the River. Thus, environmental flow setting points are proposed in three locations, in each reaches of the River.

2) Yala River

In the Yala Basin, the Nandi Forest Dam is proposed in the upper reaches. The dam has attracted attention over the years because the location of the dam is close to the gazetted forest, and large environmental impact is expected. Environmental monitoring point is proposed at one location in the lower reaches to confirm water quality inflow into the Lake Victoria and to monitor impact to the Yala Swamp.

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

Environmental Flow Rate Setting Points (LVNCA)

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

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

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

(2) Environmental Monitoring

Environmental monitoring points of LVNCA are set at five points and the criteria of each point are follows:

1) Nzoia River

Environmental monitoring points are proposed in two locations, i.e., i) representative point of the river ecosystem, and ii) lower reaches point, to confirm water quality inflow into the Lake Victoria and to monitor the impacts to Saiwa Swamp National Park and a protected wetland within the Nzoia River basin.

2) Yala River

Environmental monitoring points are proposed in an entrance point of the Yala Swamp. The Swamp is one of the most important riparian and floodplain wetlands around the lake. It has very important ecosystem as habitats of birds and endangered fish species.

3) Lake Victoria

Environmental monitoring points are proposed close to river mouths of the inflow river in order to confirm impact level caused by any change of the inflow river.

Environmental Monitoring Points (LVNCA)

Target	Monitoring Point		Reserve (m^3/s)	Monitoring Point of WRM	Selection Criteria
Nzoia River	LVN-M1	Lower reaches of the Nzoia River	34.1	1EE01	d) Upstream points from the protected area
	LVN-M2	Reference point (Webuye Town)	15.9	1DA02	a) Representative point to monitor the river ecosystem
Yala River	LVN-M3	Yala Swamp	-	1FG03	b) Points where rare or characteristic ecosystem exists (Yala Swamp) d) Upstream points from the protected area
Lake Victoria	LVN-M4	Near river mouth of the Nzoia River	-	-	e) Major lakes in the catchment area, and f) International rivers and lakes.
	LVN-M5	Near river mouth of the Yala River	-	-	

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

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

3.4 Environmental Management Plan for Lake Victoria South Catchment

3.4.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring points are proposed in the main rivers and lakes in LVSCA.

Proposed water resources development projects by NWMP 2030 are concentrated on Nyando, Sondu, and Gucha-Migori rivers as main rivers of LVSCA. Therefore, setting points of environmental flow rate and environmental monitoring are proposed in the three rivers. In addition, setting of environmental flow rate and environmental monitoring points are also proposed in the Mara River because the Masai-Mara National Reserve has biological importance.

Environmental monitoring points are also proposed in the Winum Gulf of the Lake Victoria. In addition, Kisumu City and Homa Bay Town are targeted for environmental monitoring because increasing sewage/ industrial wastewater amount might occur in connection with future population growth of the cities and towns.

Three dam projects are proposed in the Mau Forest Complex forest area. However, the project will not directly change the forest area. In addition, KFS manages the forests under their management roles. Thus, the area is not included in the environmental monitoring targets.

Based on the situation, the management strategy of LVSCA is as follow:

a) Setting of environmental flow rate for the Nyando, Sondu, Gucha-Migori, and Mara rivers: and
b) Environmental monitoring in the Nyando, Sondu, Gucha-Migori, and Mara rivers and Lake Victoria

3.4.2 Proposed Environmental Management Plan

Based on the strategies, the proposed environmental management plan of LVSCA is shown as discussed below. Proposed locations of the environmental management plan are shown in Figure 3.4.1.

(1) Setting of environmental flow rate in the Nyando, Sondu, Gucha-Migori and Mara rivers

NWMP 2030 proposes setting of environmental flow rate and environmental survey of the river ecosystem in the above-mentioned five rivers. The criteria of the proposed environmental flow rate setting points are as follows:

1) Nyando River

Major tributary of the Nyando River inflows the middle reaches of the Aunamutua River. The River is the largest tributary of the Nyando River, thus, Nyando River regime changes at the confluence point with the Aunamutua River. Therefore, environmental flow rate setting points are proposed in two locations: i) upper reaches, and ii) lower reaches of the points.

2) Sondu River

The Itare River which is the largest tributary of the Sondu River inflows the middle reaches of the River. Thus, Sondu River regime changes from the confluence point with the tributary. Therefore, environmental flow rate setting points are proposed in two locations: i) upper reaches and ii) lower reaches of the point

3) Gucha-Migori River

The Gucha-Migori Rivers consists of two tributaries. One tributary is the Gucha River: the River has no large tributary and belongs to evergreen bushland vegetation. Another tributary is the Migori River, the River has no large tributary and most of the basin belongs to rain forest vegetation. Therefore, environmental flow rate setting point is proposed in three locations : i) reference point of the upper reaches in the Gucha River , ii) reference point of the upper reaches in the Migori River near Migori Town, and iii) in the lower point of confluence point of both two rivers.

4) Mara River

The points in the Mara River basin is different from that of the other rivers because it is a trans-boundary river and environmental flow rate has been set in the latest studies by WWF-ESARPO (2001, IUCN). Environmental study for the setting point of the River has been conducted by them. Thus, the setting flow should check the current status of the environmental river flow by hearing and collection of secondary data from related authorities to confirm the validity based on environmental monitoring. The setting point is the proposed entrance point of the Mara River inflow to Masai-Mara National Reserve because it is the main water resources for the reserve.

Environmental Flow Rate Setting Points (LVSCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Nyando River	LVS-F1	Reference point (Ahero Town)	Nyando(Koru) and Londiani dams, Kano Plain Irrigation	Evergreen bushland with wooded grassland	1.7	1GD03
	LVS-F2	Near Muhoroni Town		Rain forest	1.9	1GD07
Sondu River	LVS-F3	Reference point (Upstream of Sondu Dam)	Magwagwa and Itare dams	Rain Forest	10.5	1JG05
	LVS-F4	Confluence point with the Itare River		Mountain Forest	3.7	1JF08
Gucha - Migori River	LVS-F5	Confluence point of both rivers	Bunyunyu, Ilooiterre and Katieno dams, and Lower Kuja Irrigation	Evergreen bushland with wooded grassland	2.4	1KB05
	LVS-F6	Reference point (Gucha River)			0.4	1KB03
	LVS-F7	Reference point (Migori River)			1.5	1KC03
Mara River	LVS-F8	Reference point (Upstream of the Masai-Mara National Park)	Amala Dam	Evergreen bushland with wooded grassland	4.3	1LA04

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

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

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

(2) Environmental monitoring in the Nyando, Sondu, Gucha-Migori and Mara rivers and Lake Victoria

Environmental monitoring points of LVSCA are set at 13 points and the criteria of each point are as follow:

1) Nyando River

Environmental monitoring points are proposed at two locations similar to the environmental flow rate setting points: i) representative point of river ecosystem, and ii) upper reaches points, to confirm the impact level by the Londiani and Nyando dams.

2) Sondu River

Environmental monitoring points are proposed in two locations similar to the environmental flow rate setting points: i) representative point of the river ecosystem, and ii) upper reaches point, to monitor river changes by the Magwagwa Dam in the future.

3) Gucha-Migori River

Environmental monitoring points are proposed at the same point of the environmental flow rate setting points as representative environmental point in the River.

4) Mara River

Environmental monitoring points are proposed in the same point of the environmental flow rate setting points. The point is set at the entrance point of the Masai-Mara National Reserve to confirm changes in the river environmental condition.

5) Lake Victoria

Environmental monitoring points are proposed close to three river mouths in order to confirm the impact level caused by any change in the inflow river.

6) Kisumu City and Homa Bay Town

Kisumu City and Homa Bay Town are located next to the Lake Victoria. Environmental monitoring points are proposed at the lowest point of effluent water from the towns in order to monitor and evaluate the impact level.

Environmental Monitoring Points (LVSCA)

River	Monitoring point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Nyando River	LVS-M1	Reference point (Ahero Town)	1.7	1GD03	a) Representative point to monitor the river ecosystem
	LVS-M2	Near Muhoroni Town	1.9	1GD07	b) Points where rare or characteristic ecosystem exists (Mau Forest Complex)
Sondu River	LVS-M3	Reference point (Upstreams of Sondu Dam)	10.5	1JG05	a) Representative point to monitor the river ecosystem
	LVS-M4	Confluence point with the Itare River	3.7	1JF08	b) Points where rare or characteristic ecosystem exists (Mau Forest Complex)
Gucha - Migori River	LVS-M5	Confluence point of both rivers	2.4	1KB05	b) Points where rare or characteristic ecosystem exists
	LVS-M6	Reference point (Gucha River)	0.4	1KB03	a) Representative point to monitor the river ecosystem
	LVS-M7	Reference point (Migori River)	1.5	1KC03	a) Representative point to monitor the river ecosystem
Mara River	LVS-M8	Reference point (Upstream of the Masai-Mara National Park)	4.3	1LA04	d) Upstream points from the protected area, and f) International rivers and lakes.

River	Monitoring point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Lake Victoria	LVS-M9	Near river mouth of the Nyando River	-	-	e) Major lakes in the catchment area, and f) International rivers and lakes.
	LVS-M10	Near river mouth of the Sondu River	-	-	
	LVS-M11	Near river mouth of the Gucha River	-	-	
Kisumu City and Homa Bay Town	LVS-M12	Kisumu City (Main discharge point) (Lower reaches of the Kibos River)	-	-	c) Points where large city or town is located, and d) Upstream points from the protected area.
	LVS-M13	Homa bay Town (Main discharge point)	-	-	

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

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

3.5 Environmental Management Plan for Rift Valley Catchment

3.5.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring points are proposed in the main rivers and lakes in RVCA.

Proposed water resources development projects by NWMP 2030 are concentrated on the Turkwel, Kerio, and Ewaso Ng'iro South rivers as main rivers of RVCA. Therefore, setting of environmental flow rate and environmental monitoring points are proposed in the three rivers. Similarly, setting of environmental water level and environmental monitoring points are proposed in six saline lakes which are of high importance as habitats for large mammals, amphibians and bird species and in the Lake Naivasha as an important freshwater lake.

In addition, environmental monitoring targets Nakuru City and Naivahsa Town which are located in nearby the Lake Nakuru and Lake Naivasha because water pollution have occurred in the two cities and future population growth might aggravate the pollution.

Based on the situation, the management strategy of RVCA follows:

a) Setting of environmental flow rate for the Turkwel, Kerio, and Ewaso Ng'iro South rivers, Lake Turkana, Lake Bogoria, Lake Baringo, Lake Elementaita, Lake Nakuru, Lake Naivasha, and Lake Magadi; and
b) Environmental monitoring in i) Turkwel, Kerio and Ewaso Ng'iro South rivers, and ii) Lake Turkana, Lake Bogoria, Lake Baringo, Lake Elementaita, Lake Nakuru, Lake Naivasha, and Lake Magadi.

3.5.2 Proposed Environmental Management Plan

Based on the strategy, proposed environmental management plan of RVCA is as follows:

Proposed locations of the environmental management plan are shown in Figure 3.5.1.

(1) Setting of environmental flow in the Turkwel, Kerio, and Ewaso Ng'iro South rivers, Lake Turkana, Lake Bogoria, Lake Baringo, Lake Elementaita, Lake Nakuru, Lake Naivasha, and Lake Magadi

NWMP 2030 proposes environmental flow rate/ environmental water level setting points and environmental survey of the ecosystem in above mentioned three rivers and seven lakes. The criteria of proposed environmental flow rate/ environmental water level setting points are as follow.

1) Turkwel River

The Turkwel River has one tributary named the Suam River, which has the Turkwel Dam. According to WRMA regional staff, the Turkwel Dam has never been managed adequately. Currently, the down reaches of the Suam River does not receive enough water because the dam stem up most of river water in the upper reaches. To monitor the impacts of the dam, environmental flow rate setting points should be set based on the environmental survey and the latest secondary environmental information before the dam construction. Furthermore, in the main regime of the Turkwel River, the setting point is proposed in the reference point near Lodwar Town.

2) Kerio River

The Kerio River regime has no large tributary in the whole basin. Therefore, a reference point as environmental flow rate setting point is proposed in the upper reaches.

3) Ewaso Ng'iro South River

Four dam projects are concentrated in the upper reaches of the Ewaso Ng'iro South River. These developments might affect river regime in the lower reaches of the River. Environmental flow rate setting point is proposed in the upper reaches as reference point is proposed at the lower reaches to confirm impacts of the development in the upper reaches.

4) Lake Turkana

The Lake Turkana is the largest saline lake in the world and international lake over Kenya and Ethiopia. The water level fell by ten meters between 1975 and 1993, and currently, have fallen even further. Rapid decrease of water level might affect the lake ecosystem. Therefore, environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

The Lake is larger than other saline lakes. If one or two more setting point is needed as agreed in the stakeholder meeting to manage the lake ecosystem, adequate number and location should be proposed in the meeting.

5) Lake Baringo

The Lake is important to the communities in the basin as water resources for domestic use and livestock consumption. For sustainable use, setting of environmental water level should be conducted in the representative point. Therefore, environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

6) Lake Bogoria

The Waseges Dam is planned in the upper reaches in the inflow river of the Lake named as the Waseges River. In addition, the lake is at Ramsar site, and the Lake Bogoria National Reserve has been protected and designated as national reserve since 1973. For conservation of the lake ecosystem, environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

7) Lake Nakuru

The Lake Nakuru is designated as Ramsar wetland and located in the Lake Nakuru National Park. For conservation of the lake ecosystem, environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

8) Lake Elementaita

The Lake Elementaita is designated as a registered wetland under the Ramsar Convention and is important habitats for birds. For conservation of the lake ecosystem, environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

9) Lake Naivasha

The Lake Naivasha has been an important water resource for the surrounding area. The lake has been set as an adequate lake water level standard in the Lake Naivasha Management Plan. Therefore, NWMP 2030 proposed to examine the standard for lake ecosystems and monitor water quality and level by environmental monitoring.

10) Lake Magadi

The Lake Magadi is a lake with strong acidity and the lake ecosystem is poorer than others due to its specific environment. However, the lake is an important habitat for flamingos and other birds. The habitat status is dependent largely on water level/quality of the Lake. Therefore, adequate environmental water level should be set at the representative point of the lake. The representative point represents the natural environmental status of the lake ecosystem. In addition, accessibility and safety should be considered for sustainable monitoring.

Environmental Flow Rate / Water Level Setting Points (RVCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Turkwel River	RV-F1	Reference point (Lodwar Town)	Embobut Dam and Turkwel Irrigation	Semi-desert grassland	0.0	2B21
	RV-F2	Confluence point with the Suam River (Downstream of Turkwel Dam)		Deciduous bushland and thicket	0.0	2B33
Kerio River	RV-F3	Reference point (Downstream of confluence with the Arror River)	Arror, Murung-Sebit and Kimwarer dams	Deciduous bushland and thicket	0.0	2C16
Ewaso Ng'iro South River	RV-F4	Reference point (Narok Town)	Upper Narok, Oletukat, Leshota, and Ololorko dams	Evergreen bush land with wooded grassland	0.0	2K06
Lake Turkana	RV-F5	Representative point	-	Semi-desert grassland	-	2B13
Lake Baringo	RV-F6	Representative point	-	Deciduous bushland and thicket	-	2EH1
Lake Bogoria	RV-F7	Representative point	Waseges Dam	Evergreen bush land with wooded grassland	-	2EB10
Lake Nakuru	RV-F8	Representative point	-	Evergreen bush land with wooded grassland	-	2FC04
Lake Elementaita	RV-F9	Representative point	-	Evergreen bush land with wooded grassland	-	2FA08
Lake Naivahsa	RV-F10	Representative point	Malewa Dam	Evergreen bush land with wooded grassland	-	2GD06
Lake Magadi	RV-F11	Representative point	-	Deciduous bushland and thicket	-	New

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

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

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

(2) Environmental Monitoring in the Turkwel, Kerio, and Ewaso Ng'iro South rivers, Lake Turkana, Lake Bogoria, Lake Baringo, Lake Elementaita, Lake Nakuru, Lake Naivasha, and Lake Magadi

Environmental monitoring points of RVCA are set at 13 points and the criteria of each point are follows:

1) Turkwel River

Environmental monitoring points are proposed in two locations similar to the environmental flow rate setting points.

2) Kerio River

The Kerio river regime has no large variation. However, vegetation along the river changes drastically from rain forest to semi-desert grassland and thicket. River ecosystem largely depends on onshore vegetation and climate. Therefore, a reference point as environmental monitoring point is proposed in the upper reaches similar to the environmental flow rate and additional point is proposed in the lower reaches of the semi-desert vegetation.

3) Ewaso Ng'iro South River

Four proposed dam projects are concentrated in the upper reaches of the Ewaso Ng'iro South River. The developments might affect river regime in the lower reaches of the River. In addition, the Lake Natron of Tanzania is fed by the River and might also be affected by the developments. Therefore, environmental monitoring point is proposed at the lower reaches to confirm the river regime and ecosystem changes by all of the proposed projects in the upper reaches.

4) Lake Turkana

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

5) Lake Baringo

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

6) Lake Bogoria

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

7) Lake Nakuru

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

8) Lake Elementaita

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

9) Lake Naivasha

The Lake Naivasha is an important water resource for the surrounding area. The lake has been set as an adequate water level standard in the Lake Naivasha Management Plan. Therefore, the master plan will examine the standard and monitor water quality and level by the monitoring.

10) Lake Magadi

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

11) Nakuru City and Naivasha Town

Nakuru City and Naivasha Town are located next to the Lake Nakuru and Lake Naivasha, respectively. Environmental monitoring points are proposed in the lowest point of effluent water from these towns in order to monitor and evaluate the impact level from the towns.

Environmental Monitoring Points (RVCA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Turkwel River	RV-M1	Reference point (Lodwar Town)	0.0	2B21	a) Representative point to monitor the river ecosystem
	RV-M2	Confluence point with the Suam River (Downstream of the Turkwel Dam)	0.0	2B33	b) Points where rare or characteristic ecosystem exists (To monitor existing Turkwel Dam)
Kerio River	RV-M3	Downstream of the South Turkana National Reserve	-	-	b) Points where rare or characteristic ecosystem exists (Semi-Arid Area)
	RV-M4	Reference point (Downstream of confluence with the Arror River)	0.0	2C16	a) Representative point to monitor the river ecosystem
Ewaso Ng'iro South River	RV-M5	Reference point	0.0	2K04	a) Representative point to monitor the river ecosystem f) International rivers and lakes
Lake Turkana	RV-M6	Representative point	-	2B13	e) Major lakes in the catchment area, and f) International rivers and lakes
Lake Baringo	RV-M7	Representative point	-	2EH1	e) Major lakes in the catchment area
Lake Bogoria	RV-M8	Representative point	-	2EB10	e) Major lakes in the catchment area
Lake Nakuru	RV-M9	Representative point	-	2FC04	d) Points upstream from the protected area, and e) Major lakes in the catchment area
Lake Elementaita	RV-M10	Representative point	-	2FA08	e) Major lakes in the catchment area
Lake Naivasha	RV-M11	Representative point	-	2GD06	e) Major lakes in the catchment area
Lake Magadi	RV-M12	Representative point	-	New	e) Major lakes in the catchment area
Nakuru and Naivasha towns	RV-M13	Nakuru Town (Main discharge point)	-	-	c) Points where large city or town is located, and d) Points upstream from the protected area
	RV-M14	Naivasha Town (Main discharge point)	-	-	

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

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

3.6 Environmental Management Plan for the Athi Catchment

3.6.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring are proposed in main rivers and lakes in ACA.

Proposed water resources development projects of ACA are proposed in the Athi, Nairobi, Lumi River, Mwachi, and Kaiti and other several rivers. Appropriate environmental flow rate should be set for all these rivers in the future. As a first step, NWMP 2030 proposes setting of environmental flow rate and environmental monitoring in the Athi and Lumi rivers regard as representative rivers among the rivers. The Lake Chala and Lake Jipe are also proposed setting of environmental water level and environmental monitoring because these are international lakes and have important ecosystem. In addition, the Lake Amboseli is proposed for environmental monitoring because it maintains important natural resources.

Sewage and industrial wastewater from Nairobi and Mombasa cities which are the two largest cities, have already affected the surrounding environment. Therefore, environmental monitoring targets the two cities and the Nairobi River which is directly affected by Nairobi City.

Based on the situation, the management strategy for ACA is shown below;

a) Setting of environmental flow rate for the Athi and Lumi rivers, Lake Chala, and Lake Jipe
b) Environmental monitoring in the Athi, Nairobi and Lumi rivers, Lake Amboseli, Lake Chala, Lake Jipe, Nairobi and Mombasa cities

3.6.2 Proposed Environmental Management Plan

Based on the strategy, the proposed environmental management plan of ACA is discussed below. Proposed locations of the environmental management plan are shown in Figure 3.6.1.

(1) Setting of environmental flow in the Athi and Lumi rivers, Lake Chala, and Lake Jipe

NWMP 2030 proposes setting of environmental flow rate and environmental survey of the ecosystem in the Athi and Lumi rivers, Lake Chala and Lake Jipe. The criteria of the proposed environmental flow rate/ environmental water level setting points are as follows:

1) Athi River

Athi River is the main river in ACA. The River has two large tributaries, namely, the Tsavo and Kiboko rivers. Thus, the Athi River regime changes drastically at the confluence points. Therefore, environmental flow rate setting points are proposed three locations; i) reference point (upper reaches), ii) lower reaches in the confluence point of the Kiboko River, and iii) lower reaches in the confluence point of the Tsavo River.

2) Lumi River

The Lumi River recharges water to the Lake Jipe. Lake Chala Dam project is planned in the upper reaches of the river and affects the Lake Jipe and Tanzanian side. The setting point is proposed in the upper reaches of the River as reference point.

3) Lake Chala

The Lake Chala is located between Kenya and Tanzania. The Lake is fed by groundwater, and not by rivers. Water level has been lowered in recent years. Thus, setting of adequate water level should be conducted in the lake to manage its sustainable use.

4) Lake Jipe

The Lake Jipe is an important trans-boundary wetland ecosystem stretching across the Kenya and Tanzania boarder, and is important to the local communities. Thus, setting of adequate water level should be conducted in the Lake to manage its sustainable use.

Environmental Flow Rate / Water Level Setting Points (ACA)

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

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

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

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality and river ecosystem) shall be conducted in the Athi and Lumi rivers, the Lake Chala and the Lake Jipe. The Lake Amboseli is also targeted in the environmental survey. However, the Lake does not set environmental water level because the water level change drastically in the dry season and wet season. Thus, environmental survey should be conducted only to confirm the river ecosystem of the Lake.

(2) Environmental Monitoring in the Athi, Nairobi, and Lumi rivers, Lake Chala, Lake Jipe, Lake Amboseli, Nairobi and Mombasa cities

Environmental monitoring points of ACA are set at ten points and the criteria of each point are discussed as follows:

1) Athi River

Environmental monitoring points are proposed at three points similar to the environmental flow rate setting points because the river regime change points might cause river ecosystem changes.

2) Lumi River

Environmental monitoring points are proposed at a point of the environmental flow rate setting. The point is in the lower reaches of the Lumi River to confirm impact caused by the development projects in the upper reaches.

3) Lake Chala

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

4) Lake Jipe

Environmental monitoring point is proposed at a location of the environmental water level setting point which represents of the lake ecosystem.

5) Lake Amboseli

Setting of an environmental water level for the lake is difficult because it is a seasonal lake with high alkaline water, usually dry and extremely dusty. However, the lake has rich ecosystem at the Amboseli National Park, and is an important water resource for the surrounding area during wet season. In addition, it serves as an important water resource of the Amboseli National Park during wet season. Therefore, environmental monitoring point is proposed at the Lake as one reference point.

6) Nairobi and Mombasa Cities

These two cities are located next to water bodies. Environmental monitoring points are proposed in the lowest point of effluent water from these towns in order to monitor and evaluate impact levels.

Environmental Monitoring Points (ACA)

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

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

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

3.7 Environmental Management Plan for Tana Catchment

3.7.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring points are proposed in main rivers and lakes in TCA.

Proposed water resources development projects by NWMP 2030 are concentrated in the upper reaches of the Tana River. Therefore, setting of environmental flow rate and environmental monitoring are proposed in the Tana River and the Chania River which is a tributary of the Tana River. Moreover, a project involving water transfer from the river to the ACA is proposed.

Based on the situation, the management strategy of TCA is as follows:

a) Setting of environmental flow rate for the Tana and Chania rivers: and
b) Environmental monitoring in the Tana and Chania rivers

3.7.2 Proposed Environmental Management Plan

Based on the strategy, the proposed environmental management plan for TCA is shown is discussed as follows:

Proposed locations of the environmental management plan are shown in Figure 3.7.1.

(1) Setting of environmental flow rate for the Tana and China rivers

NWMP 2030 proposes setting of environmental flow points and environmental survey of river ecosystem in the Tana and Chania rivers. The criteria of the proposed environmental flow rate setting points are as follows:

1) Tana River

The Tana River is the longest river in Kenya with many tributaries. The tributaries flowing into the lower reaches from Garissa Town are seasonal rivers. River regime does not change drastically from Garissa Town. Therefore, environmental flow rate setting points were proposed in three locations: i) Reference point in the upper reaches from Masinga Dam as representative point of the area, ii) point located in the lower reaches of High Grand Falls Dam to monitor the impact caused by the dam to lower four national parks and reserves and, iii) reference point in Garissa Town to manage lower river flow rate from the town.

2) Chania River

The Chania River is one of the tributaries of the upper reaches of the Tana River. Two dam projects are planned in the upper reaches of the river to transfer water from TCA to Nairobi area in other catchments. Water transfer between the catchments might affect the river ecosystem in the lower reaches of the river. Therefore, environmental flow rate setting point is proposed in the lower reaches of the River.

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Tana and Chania rivers.

Environmental Flow Rate Setting Points (TCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Tana River	TCA-F1	Reference point (Downstream of Garissa Town)	Maragua 4, Thiba, and High Grand Falls dams, Masalani and Tana Delta irrigations	Deciduous bushland and thicket	53.5	4G01
	TCA-F2	Upstream of the Meru National Park		Deciduous bushland and thicket	52.1	4F13
	TCA-F3	Reference point (Upstream of Masinga Dam)		Evergreen bush land with wooded grassland	1.5	4BE01
Chania River	TCA-F4	Reference point (Downstream of Thika Town)	Ndiara, Karimenu 2, Thika 3A, Chania-B and Yatta dams	Evergreen bush land with wooded grassland	8.5	4CC03

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

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

(2) Environmental Monitoring in the Tana and Chinia rivers

Environmental monitoring points of TCA are set at six points, and the criteria of each point are shown as follows:

1) Tana River

Environmental monitoring points are proposed similar to the environmental flow rate setting points at three points and two additional points located in the lower reaches. The additional points are: i) entrance of the Tana River Primate National Reserve, the point is to monitor maintenance of water quality and quantity for the reserve area, and ii) point in the Tana Delta to monitor river and wetland ecosystem changes caused by the development.

2) Chania River

The Chania River is one of the tributaries in the upper reaches of the Tana River. Two dam projects are planned in the upper reaches of the river to transfer water from TCA to Nairobi area in other catchments. Water transfer between the catchments might affect the river ecosystem in the lower reaches of the River. Therefore, an environmental monitoring point is proposed in the lower reaches of the River.

Environmental Monitoring Point (TCA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Tana River	TCA-M1	Tana Delta	42.7	4G02	b) Points where rare or characteristic ecosystem exists (Tana Delta) d) Upstream points from the protected area
	TCA-M2	Upstream of the Tana River Primate National Reserve	-	-	d) Points upstream from the protected area
	TCA-M3	Reference point (Downstream of Garissa Town)	53.5	4G01	a) Representative point to monitor the river ecosystem, b) Points where large city or town is located, and, d) Upstream points from the protected area
	TCA-M4	Upstream of the Meru National Park	52.1	4F13	d) Points upstream from the protected area
	TCA-M5	Reference point (Upstream of Masinga Dam)	1.5	4BE01	a) Representative point to monitor the river ecosystem
Chania River	TCA-M6	Reference point (Downstream of Thika Town)	8.5	4CC03	a) Representative point to monitor the river ecosystem

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

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

3.8 Environmental Management Plan for Ewaso Ng'iro North Catchment

3.8.1 Management Strategy

Based on the overall concept and framework mentioned in Section 3.2, setting of environmental flow rate and environmental monitoring points are proposed in main rivers and lakes in ENNCA.

Proposed water resources development projects by NWMP 2030 are concentrated in the upper reaches of the Ewaso Ng'iro North River and its tributaries such as the Ewaso Narok and S.R.uguoi rivers. Therefore, setting of environmental flow rate and environmental monitoring are proposed in the Ewaso Ng'iro North River as the main river of ENNCA.

Based on the situation, the management strategy of ENNCA is as follows:

a) Setting of environmental flow rate for the Ewaso Ng'iro North River; and
b) Environmental monitoring in the Ewaso Ng'iro North River.

3.8.2 Proposed Environmental Management Plan

Based on the strategy, the proposed environmental management plan of ENNCA is discussed as follows:

Proposed locations of the environmental management plan are shown in Figure 3.8.1.

(1) Setting of environmental flow rate for the Ewaso Ng'iro North River

NWMP 2030 proposes setting of environmental flow points in the Ewaso Ng'iro North River, and environmental survey of the river ecosystem. Environmental flow rate setting points are proposed at two locations; i) reference point of the river to confirm main river change, and ii) confluence point of the Ewaso Narok River because the upper reaches of the Ewaso Ng'iro North River has many tributaries.

Environmental flow rate setting points are shown in the following table.

Environmental Flow Rate Setting Points (ENNCA)

Target	Environmental Flow Setting Point		Proposed Major Development Projects	Vegetation	Reserve* (m^3/s)	Monitoring Point of WRM
Ewaso Ng'iro North River	ENN-F1	Reference point (Archer's Post Town)	Archer's Post, Isiolo, Kihoto, Rumuruti, and Nyahururu dams	Deciduous bushland and thicket	0.0	5ED01
	ENN-F2	Downstream of confluence point with the Ewaso Narok River		Evergreen bush land with wooded grassland	1.3	5DC02

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

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

In addition, environmental survey for setting of environmental flow rate (current river flow rate, water quality, and river ecosystem) shall be conducted in the Ewaso Ng'iro North River.

(2) Environmental monitoring in the Ewaso Ng'iro North River

Environmental monitoring points of ENNCA are proposed at two locations similar to the environmental flow rate setting points as shown in the following table.

Environmental Monitoring Points (ENNCA)

Target	Monitoring Point		Reserve* (m^3/s)	Monitoring Point of WRM	Selection Criteria
Ewaso Ng'iro North River	ENN-M1	Reference point (Archer's Post Town)	0.0	5ED01	a) Representative point to monitor the river ecosystem b) Points where rare or characteristic ecosystem exists (National parks and reserves) d) Points upstream from the protected area
	ENN-M2	Downstream of confluence point with the Ewaso Narok River	1.3	5DC02	a) Representative point to monitor the river ecosystem (including the Ewaso Narok River)

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

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

CHAPTER 4 COST ESTIMATE

4.1 Basic Conditions for Cost Estimate

Cost estimates for the environmental management plan were categorised into two types, namely, i) recurrent cost and ii) development cost.

Basic conditions for the cost estimate are as follows:

a) Unit cost of environmental experts based on the hearings of environmental experts in Kenya:
b) Unit cost of field survey team, consisting of environmental experts, survey assistants, and others, for the setting of environmental flow rate is assumed at KSh 130,000 / day:
c) Necessary days for field survey are assumed at one day/ 10 km of river length, 10 days/lake (Lake Turkana is assumed to be 20 days):
d) Personnel costs for data analysis of field survey are assumed at KSh 2,000,000 for one water body (Tana and Athi rivers are KSh 4,000,000):
e) Overhead cost of field survey, including transportation, accommodation, survey tool, and others, is assumed at 30% of direct personnel costs:
f) Cost for stakeholder meeting for setting of environmental flow rate is assumed at KSh 200,000 / time (three times for one setting point):
g) Cost for latest data collection and analysis for setting of environmental flow rate is assumed at KSh 200,000 / setting point: and
h) Environmental monitoring cost is assumed at KSh 150,000/time/one point.

4.2 Cost Estimates for Proposed Plans

4.2.1 Development Cost

Development cost consists of: i) environmental survey for setting of environmental flow rate, and ii) setting of environmental flow rate. The surveys will be conducted in short term because the setting should be conducted before water resources development of the objected rivers. Summary of the cost by each catchment is shown in the following table. Development cost will be required only during short term. However, cost for the setting of environmental flow rate should be revised based on the environmental monitoring information to confirm the validity of rate. If environmental challenges are confirmed in the natural ecosystem, environmental survey should be re-conducted not only for water quality and quantity, but also for aquatic ecosystem. The re-survey cost is not included in the current cost estimate.

Summary of Development Cost

(Unit: million Ksh)

Term / CA	Short Term (2013-2017)	Middle Term (2018-2022)	Long Term (2023-2030)	Total
LVNCA	35.4	0.0	0.0	35.4
LVSCA	48.7	0.0	0.0	48.7
RVCA	98.8	0.0	0.0	98.8
ACA	66.6	0.0	0.0	66.6
TCA	62.0	0.0	0.0	62.0
ENNCA	13.5	0.0	0.0	13.5
Total	325.0	0.0	0.0	325.0

Source: JICA Study Team

(1) Environmental Survey for the Setting of Environmental Flow Rate

It is assumed that the survey team consists of four experts on aquatic flora and fauna, three survey assistants, driver and one support staff from WRUAs or WRMA. The survey will be conducted in the dry season and wet season within one year to confirm baseline environmental information. If the survey cannot get enough environmental information on aquatic ecosystem due to unexpected reason, the survey should be re-conducted in the following year.

(2) Setting of Environmental Flow Rate

The contents include: i) data collection survey of latest environmental information by each river and lake, ii) proposal for adequate environmental flow rate based on analysis of the above environmental survey and latest environmental information, and iii) holding stakeholder meeting for setting of the rate.

4.2.2 Recurrent Cost

Recurrent cost of the plan is the environmental monitoring cost from 2013 to 2030. The cost does not include survey cost in common point with water resources monitoring station by WRMA. However, it includes survey cost for the monitoring points of the Lake Victoria and Lake Amboseli, one Point of Kerio River, and the lower reaches of Kisumu, Nakuru, Nairobi, and Mombasa cities and Homa Bay and Naivasha towns, and also includes operation and maintenance costs. The monitoring will start from 2013, and its frequency is quarterly every year. Summary of the cost for each catchment is shown in the following table.

Summary of Recurrent Cost

(Unit: million Ksh)

Term / CA	Short Term (2013-2017)	Middle Term (2018-2022)	Long Term (2023-2030)	Total
LVNCA	4.0	4.0	6.4	14.4
LVSCA	12.0	12.0	19.2	43.2
RVCA	6.0	8.0	12.8	26.8
ACA	8.0	8.0	12.8	28.8
TCA	0.0	0.0	0.0	0.0
ENNCA	0.0	0.0	0.0	0.0
Total	30.0	32.0	51.2	113.2

Source: JICA Study Team

CHAPTER 5 IMPLEMENTATION PROGRAMME

5.1 General

The chapter describes the implementation program for environmental management plan, which considers developments and water resources management sector. The implementation program is prepared for 18 years from 2013 to 2030 by dividing the term into three, namely; i) short term (five years from 2013 to 2017), ii) middle term (five years from 2018 to 2022) and iii) long term (eight years from 2023 to 2030).

WRMA is recommended as implementation agency for the monitoring. WRMA should monitor water quantity and quality of water resource not only water resource management aspect but also environmental aspect. If environmental changes are observed by the monitoring, WRAM should inform the issues to MOEMR/NEMA and request detailed environmental survey for analysis of the cause and comprehending environmental impacts.

5.2 Criteria for Prioritization for Implementation

For formulation of Implementation Program for the proposed management plan for each catchment, the following criteria were referred,

a) Setting of environmental flow rate and environmental survey will be conducted in short term:
b) Environmental monitoring will start in medium term to confirm a viability of the setting of environmental flow rate:
c) Priority basins were decided referring to implementation schedule of development projects, especially dams: and
d) Environmental monitoring for the Lake Victoria, Lake Amboseli, and Lake Chala will start in short term because the water bodies were not included in current water resources monitoring network of WRMA.

5.3 Implementation Programmes of Proposed Plans

Based on the criteria mentioned in the preceding section, the implementation programme is formulated as shown in Figure 5.3.1.

5.4 Recommendations for Further Surveys, Studies, and Actions for NWMP2030

In the course of formulation of the environmental management 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) Earlier Implementation of Environmental Survey

The proposed environmental management plan of NWMP 2030 includes setting of environmental river flow rates and water level in main rivers/ lakes and environmental monitoring of strategic points. However, the required information and data were not sufficient, so the environmental survey (river discharge, water level, water quality, aquatic flora and fauna, habitats etc.) was also proposed. It is recommended to implement the environmental survey as early as possible since the environmental river flow rates largely affect the water resources development and management in the catchment area.

(2) EIA for Development Projects

In order to achieve the Kenya Vision 2030, it is required to implement various development projects as proposed in NWMP 2030. Moreover, negative impacts on the natural and social environments by those development projects are expected. EIA at the stage of the project implementation is essential for protection of the natural and social environments. The environmental management plan of NWMP 2030 does not include the EIA process for each project, but it is understood that all development projects are subject to the current EIA.

(3) Establishment of Environmental Database

For environmental management on the water resources, basic data and information on the water resources such as water quantity, water quality and aquatic ecosystem are essential. Currently, WRMA manages water quantity and water quality, while KWS and KEMFRI manage aquatic ecosystem and NEMA manages effluent discharges of polluters. On the other hand, MOENR is in charge of environmental management planning. To make the environmental management more effective, it is recommended to establish an environmental database for sharing of basic data and information among relevant organisations.

(4) Introduction of Environmental Education Program into Elementary and Secondary Education

The population of Kenya is expected to grow rapidly and volume of wastes will increase according to population growth. Urban population will significantly increase. The water resources might be polluted by illegal damping in rivers, lakes and wetlands unless wastes are properly managed. It is recommended that an environmental education should be introduced in elementary and secondary curricula to avoid such circumstances.

(5) Care for Involuntary Resettlement by Development Projects

As mentioned above, many development projects are required to achieve the Kenya Vision 2030. For smooth implementation of the projects, smooth land acquisition and resettlement are essential. It is recommended to enhance the system on land acquisition and resettlement in the government for smooth operation. It will include decision making through stakeholder meetings, proper compensation, training of specialists for land acquisition and resettlement, establishment of permanent organisation in charge, etc.

(6) Actions for Water Pollution Control

Water pollution caused by industrial effluent is a threat not only to aquatic ecosystem but also to human life. The lake ecosystem with closed basin is seriously damaged by water pollution. The evaluation of effluent licences issued to polluters by NEMA should be strictly managed and penalties for offenders should be strengthened e.g. cancellation of licence. In addition, effluent discharge plans prepared by polluters and submitted to WRMA should be strictly controlled to prevent pollution of water resources.

CHAPTER 6 INITIAL ENVIRONMENTAL EVALUATION OF PROPOSED PROJECT

6.1 General

This chapter presents the results of the preliminary environmental review of the proposed development projects; dam projects: large scale irrigation, and water supply and sanitation in the NWMP 2030. Currently, detailed project designs and conditions for most of the proposed projects are not prepared yet. Thus, this study conducted Initial Environmental Evaluation (IEE) under limited status such as project type, proposed location, proposed scale and others. The chapter describes i) IEE of selected water development projects with reference to environmental scoping criteria contents by JICA, and ii) major anticipated environmental impacts by each catchment.

6.2 Environmental Scoping Criteria

6.2.1 Selected Proposed Projects for Preliminary Environmental Review

Under the EMCA, most of the water development projects must follow the EIA procedures to minimise negative impact on natural and social environment due to project implementation. However, since current plans for proposed development projects in NWMP 2030 are not detailed at current stage, preliminary environmental review was carried out by adopting the following approaches for each type of development project:

a) Dam project: All proposed projects because dam projects might cause large impact to surrounding environment and most dam projects include other water development plans such as water supply and water transmission:.
b) Large scale irrigation: Proposed projects where F/S or Pre-F/S have already been conducted, particularly those that have no specific information and plan such as scale and location: and
c) Water supply and sanitation project: Proposed projects which completely undergone official EIA process, and with EIA reports that can be downloaded from NEMA website.

Consequently, total of 49 dam projects, 18 large-scale irrigation projects, and five water supply projects/ sanitation projects were selected for the initial environmental examination.

In addition, the SEA study of NWMP 2030 by WRMA has already started in 2011 to comply with NEMA's request and is currently on-going to be finished in 2013.

6.2.2 Environmental Scoping Criteria

Upon comparing "JICA Guidelines for Environmental and Social Considerations" (hereinafter called as "the JICA guidelines") with Environmental (Impact Assessment and Audit) Regulations of GoK (hereinafter called as "the Kenya EIA regulations"), it was found that the latter meet the JICA guidelines in principle. Therefore, the screening items (check list for environmental impacts identification) were prepared based on the JICA guidelines. The screening matrix (IEE in the JICA guideline) is designed for the assessment of proposed development projects in NWMP 2030. The three main categories examined are socio-economic environment, natural environment, and pollution. Major impacts are shown in the following table.

Major Environmental Scoping Items

Contents	Scoping Items
Pollution	1. Air pollution, 2. Water pollution, 3. Soil contamination, 4. Waste, 5. Noise and vibration, 6. Ground subsidence, 7. Offensive odour, 8. Bottom sediment and 9. Disaster
Natural Environment	10. Topography and geographical features, 11. Soil erosion, 12. Groundwater, 13. Hydrological situation, 14. Coastal zone, 15. Flora, fauna and biodiversity, 16. Meteorology, 17. Landscape, and 18. Global warming
Socio-economic Environment	19. Involuntary resettlement, 20. Local economy such as employment and livelihood, etc., 21. (Surrounding) Land use and utilization of local resources, 22. Social institutions (including regional severance), 23. Existing social infrastructures and services, 24. Socially vulnerable groups such as the poor, indigenous and ethnic people (including gender matter), 25. Misdistribution of benefit and damage, 26. Historical and cultural heritage (including religious matters), 27. Water usage or water rights and rights of common, 28. Local conflict of interests, 29. Sanitation, 30. Hazardous (risk) infectious diseases such as HIV/AIDS, and 31. Accident

Source: JICA Study Team based on JICA environmental guidelines (2010)

The screenings for environmental and social considerations were conducted on the proposed development projects of NWMP 2030 based on preliminary information to identify environmental and social impacts. The following table shows the screening (assessment) criteria to be adopted. Both negative and positive impacts with four levels were assessed. Since current information is very limited, the criteria are used only as reference.

Criteria for Environmental Scoping

Negative Impact	Positive Impact
A- ; Significant B- ; Minor C- ; Negligible D ; Unknown	A+ ; Significant B+ ; Minor C+ ; Negligible D ; Unknown

Note: Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

6.3 Lake Victoria North Catchment Area

6.3.1 Scoping Result of Major Proposed Projects

Based on the above criteria, seven dam projects, two large scale irrigation projects and three water supply and sanitation projects were selected for IEE in LVNCA. Selected proposed projects are shown in the following table. Table 6.3.1 shows a summary of negative and positive impacts for the 13 proposed projects in LVNCA.

Selected Proposed Project (LVNCA)

Dam Projects		Large Scale Irrigation Projects	Water Supply & Sanitation Projects
1. Siyoi 2. Moi's Bridge 3. Nzoia (34B) 4. Kibolo	5. Teremi 6. Nzoia (42A) 7. Nandi Forest	8. Lower Nzoia Irrigation 9. Yala Swamp Irrigation (Stage-1) 10. Lower Sio Irrigation	11. Bondo and Siaya Towns Water Supply Project 12. Bond Town Sanitation Project 13. Maraba Waste Stabilization Pond

Source: JICA Study Team

6.3.2 Major Anticipated Environmental Impact Factors (LVNCA)

Major anticipated environmental impact factors of LVNCA are i) dam projects in and around the Five Water Towers, ii) large scale irrigation projects in the Yala Swamp and other wetlands, and iii) water supply and sanitation projects around Lake Victoria.

The proposed dam projects in LVNCA are located in the upper regime of the Nzoia River. The area has rich water and water conservation forest such as Mt. Elagaon, Cherangani Hills and other gazetted forests. Watershed management is one of the important challenges for Kenyan environment because water conservation forests have decreased rapidly in recent years. Kenya Vision 2030 also proposed adequate watershed management and forest recovery as priority projects. The Mau Forest Complex, one of the Five Water Towers, had been damaged by many causes such as illegal logging, encroachments and development projects. Most of the existing dams in LVNCA are located in and surrounding Mau Forest Complex. These dams also might have had a significant negative impact on the water conservation forest. Similarly, the proposed Nandi Forest Dam in the upper regime of the Yala River will be constructed in gazetted forest area. All proposed dam projects should pay attention to the preservation of water conservation forest from planning phase.

In the Yala River basin, large-scale irrigation projects such as the Yala Swamp irrigation project is proposed in the river mouth. The area is called 'Yala Swamp', which harbour endangered fish species *Oreochromis esculentus* and *Oreochromis variabilis* that have disappeared from the Lake Victoria. The critically endangered *Sitatunga Antelope* (*Tragecephalus spekii*) lives in the swamps. Birdlife International classifies the swamp among Kenya’s 60 Important Bird Areas (IBAs). River mouth areas which are the same as swamps are unique and important ecosystem, especially surrounding the Lake Victoria. The Yala Swamp irrigation project should consider mitigation methods for aquatic ecosystem to minimise their negative impact. Other large-scale irrigation projects of LVNCA are also proposed in Lower Sio and Lower Nzoia. The negative impacts caused by irrigation project will include pumping or draining of water for irrigation farmland, as well as poor land use practices that increase influx of sediment, fertilizers and pesticides to the down reaches. The proposed irrigation projects of NWMP 2030 include the water saving irrigation projects to avoid such large impact to rhe surrounding areas.

Since LVNCA has rich water resources, the population of the area will increase rapidly in near the future. Population growth may cause significant negative impact on natural environment in various aspects. In particular, untreated sewage water will cause water pollution of river and lake water. For example, the Lake Victoria has already been polluted by inflowing sewage, irrigation water, and industrial water from the surrounding areas. There are urgent need to conduct sanitation project for large cities and towns. Sanitation projects have a beneficial impact to surrounding water environment because the type of project contributes to improvement of water quality. However, if only water supply project is implemented, negative impacts to surrounding water environment by the increase of untreated domestic wastewater will be a concern. Therefore, water supply project should be implemented with water sanitation project.

Figure 6.3.1 shows locations of development projects proposed in NWMP 2030 (not limited to selected 12 projects) and natural environmental resources in LVNCA.

6.4 Lake Victoria South Catchment Area

6.4.1 Scoping Result of Major Proposed Projects

Based on the above criteria, ten dam projects, one large-scale irrigation project and one water supply project were selected for the IEE in LVSCA. Selected proposed projects are shown in the following table. Table 6.4.1 shows a summary of negative and positive screenings for 15 proposed projects in LVSCA.

Selected Proposed Project (LVSCA)

Dam Projects		Large-scale Irrigation Projects	Water Supply and Sanitation Projects
1. Londiani 2. Nyando (Koru) 3. Kibos 4. Itare 5. Magwagwa	6. Bunyunyu 7. Katieno 8. Ilooiterre 9. Sand River (Naikara) 10. Amala	11. Ahero and West Kano Irrigation 12. Kano Plain Irrigation 13. Lower Kuja Irrigation (Stage-1) 14. Nandi Forest Irrigation	15. Migori Water Supply and Sanitation Project

Source: JICA Study Team

6.4.2 Major Anticipated Environmental Impact Factors (LVSCA)

Major anticipated environmental impact factors of LVSCA are: i) water pollution of the Winum Gulf, ii) dam projects in the Five Water Towers, iii) water transfer project for RVCA and iv) proposed projects in the upper reaches of Masai-Mara National Reserve.

The proposed development projects in LVSCA should consider the Winum Gulf and Lake Victoria. Especially, projects in the Nyando, Sondu and Nyamesani rivers must consider inflow river water quality and quantity because the three rivers inflow the Gulf directly. Water quality of the Winum Gulf has already been worsened by discharge water from industry, agriculture and households. Mitigation methods should be considered to prevent any further pollution.

LVSCA has four new proposed dams, namely, the Londuani, Itare, Amala, and Nyando dams in and surrounding the Mau Forest Complex, one of the Five Water Towers. The Mau Forest Complex is the largest of the Five Water Towers with a total forest cover of 403,775 ha. However, a large area of the forest has already been deforested or degraded. KFS, MOEMR, and relevant authorities should sternly protect the forest to prevent any further degradation. All proposed dam projects should pay attention to the preservation of water conservation forest from planning phase and follow the rule on forests management.

The proposed Itare (including Londuani) and Amala dams function to transport water to RVCA. Water transportation between two catchment areas threatens native aquatic ecosystems. Attention should be paid to water discharge and water treatment in the receiving catchment area to protect fragility of ecosystem.

The Masai-Mara National Reserve is one of the most popular national protected areas in Kenya. The Reserve is contiguous to the Serengeti National Park in Tanzania. Thus, natural ecosystem management of the Masai-Mara National Reserve is very important and has influence on both Kenya and Tanzania. All water in the reserve serves as sources for the Kenyan side. Therefore, the upper reaches development projects in the Mara and Longaianiet rivers should examine down reaches ecosystem, including the Tanzanian side.

Figure 6.4.1 shows locations of development projects proposed in the NWMP 2030 (not only limited to the selected 12 projects) and natural environmental resources in LVSCA.

6.5 Rift Valley Catchment Area

6.5.1 Scoping Result of Major Proposed Projects

Based on the above criteria, ten dam projects, and five large scale irrigation projects were selected for IEE in RVCA. Selected proposed projects are shown in the following table. Table 6.5.1 shows a summary of negative and positive screenings for 15 proposed projects in RVCA.

Selected Proposed Projects (RVCA)

Dam Projects		Large-scale Irrigation Projects	Water Supply and Sanitation Projects
1. Murung-Sebit	6. Malewa	11. Arror Dam Irrigation	None
2. Kimwarer	7. Upper Narok	12. Lower Ewaso Ng'iro Irrigation	
3. Arror	8. Oletukat	13. Norera Irrigation	
4. Embobut	9. Leshota	14. Perkera Irrigation Extension	
5. Waseges	10. Oldorko	15. Turkwel Irrigation	

Source: JICA Study Team

6.5.2 Major Anticipated Environmental Impact Factors (RVCA)

Major anticipated environmental impact factors of RVCA are: i) proposed projects on important natural resources such as Ramsar site and international river and ii) water pollution on closed basins, especially areas near large cities.

RVCA has rich ecosystem and natural environmental resources such as natural world heritage, Ramsar site wetlands, and national protected area. On the other hand, the catchment has poor freshwater resources because most of the lakes have saline water and most of the rivers are seasonal rivers in RVCA. There are three main rivers in RVCA, namely, such as the Turkwel, Kerio, and Ewaso Ng'iro South rivers.

Four dam projects are proposed in the upper reaches of the Ewaso Ng'iro South River. Development projects in the area should consider not only its impact on the river ecosystem conservation but also the impact to other project. Furthermore, the River is also feeding the Lake Natron, which is located in Tanzania. Thus, development projects for the River should pay attention to the lake ecosystem in the EIA phase.

The Waseges Dam which is proposed in the upper basin of the Lake Bogoria have potential to negatively affect the lake ecosystem. Similarly, the Marewa Dam is proposed in the upper basin of the Lake Nakuru. The two lakes are closed basins, which have inflow rate only and has no outflow. Furthermore, the aquatic ecosystem of the lakes are easily influenced from outside. The two development projects should examine the lake and surrounding ecosystems, and prepare adequate Environmental Management Plan and Environmental Monitoring Plan (EMP&EMOP) through EIA process.

There is an urgent need to set up sanitation facility for Nakuru and Naivasha towns because both are located in important water resources such as the Lake Nakuru and Lake Naivasha. Population of the area will rapidly increase toward the future, and the population growth will affect the closed basins. Construction of sanitation facilities could mitigate the negative impact of the population growth.

Figure 6.5.1 shows locations of proposed development projects by NWMP 2030 (not only limited to the selected 15 projects) and natural environmental resources in RVCA.

6.6 Athi Catchment Area

6.6.1 Scoping Result of Major Proposed Projects

Based on the above criteria, 16 dam projects, one large scale irrigation project and one water supply project were selected for the IEE in ACA. Selected proposed projects are shown in the following table. Table 6.6.1 shows a summary of negative and positive impacts on 18 proposed projects in ACA.

Selected Proposed Project (ACA)

Dam Projects		Large-scale Irrigation Projects	Water Supply and Sanitation Projects
1. Upper Athi 2. Stony Athi 3. Kikuyu 4. Puaka (Kiambaa) 5. Kamiti 1 6. Ruiru-A (Riuru2) 7. Ndarugu 8. Munyu	9. Mbuuni 10. Kiteta 11. Thwake 12. Olkishunki 13. Pemba 14. Lake Chala 15. Rare 16. Mwachi	17. Taita Taveta Irrigation	18. Umanyi-Mtito Anddei Water Supply Project

Source: JICA Study Team

6.6.2 Major Anticipated Environmental Impact Factors in ACA

Major anticipated environmental impact factors of ACA are: i) water pollution caused by Nairobi City and ii) proposed project on Tsavo national parks, iii) dam projects on coastal zone, and iv) dam projects on international lakes such as Lake Chala and Jipe.

Nairobi City, which is the largest city of Kenya, is located in the upper reaches of the Athi River and needs large volume of drinking, irrigation, and industrial water. Most of the proposed development projects in ACA are planned in the upper reaches of the Athi River for Nairobi's demand. Development projects in the area should examine not only its impacts but also the impact of other project in the river ecosystem.

The Tsavo West and Tsavo East national parks are the largest protected areas in Kenya. Important water resources for the protected area are the Athi and Tsavo rivers and the Mzima Spring. The Mzima Spring is an important water resources in the protected area. Water transmission project from the Spring to Mombasa is a very important project in ACA. The project should pay attention for the setting to conserve aquatic ecosystem of the water resources and surrounding terrestrial ecosystem including wildlife in the protected area.

In the coastal zone of ACA, three dam projects, namely, the Mwach, Rare and Pemba dams are proposed near the river mouth. The river mouth area has unique and characteristic aquatic ecosystem such as estuarine basin, mangrove forests, and wetlands. The aquatic ecosystem is a very sensitive environment. Development projects in the upper reaches near the river mouth present a credible threat to negatively affect the unique ecosystem in the aspects of sedimentation, water regime change, and water pollution in especially. To avoid such consequence, adequate mitigation and monitoring plans for conservation of the area should be included in the three dam projects.

The Lake Chala Dam project is proposed in the upper reaches of the Lake Jipe and the Lumi River, which are both international water bodies in Tanzania. Therefore, the Lake Chala Dam project should consider environmental impacts for the two countries.

Figure 6.6.1 shows locations of the proposed development projects by NWMP 2030 (not only limited to the selected 18 projects) and natural environmental resources in ACA.

6.7 Tana Catchment Area

6.7.1 Scoping Result of Major Proposed Projects

Based on the above criteria, 11 dam projects and three large-scale irrigation projects were selected for IEE in TCA. Selected proposed projects are shown in the following table. Table 6.7.1 shows a summary of negative and positive screenings for 14 proposed projects in TCA.

Selected Proposed Project (TCA)

Dam Projects		Large-scale Irrigation Projects	Water Supply and Sanitation Projects
1. Maragua 4 2. Ndiara 3. Chania-B 4. Karimenu 2 5. Thika 3A 6. Yatta	7. Thiba 8. High Grand Falls 9. Mutuni 10. Kitimui 11. Kora	12. High Grand Falls Irrigation 13. Hola Irrigation Expansion 14. Hola Irrigation Greater Extension	None

Source: JICA Study Team

6.7.2 Major Anticipated Environmental Impact Factors (TCA)

Major anticipated environmental impact factors of TCA are the proposed projects in upper reaches of the Tana River.

Most of the proposed development projects in TCA are planned in the upper reaches of the Tana River. Development projects in the area should consider not only its impacts on the river ecosystem but also the impact of other projects. From the middle reaches to the lower reaches, some large-scale irrigation schemes (excluding the above selected projects) are proposed along the Tana River basin.

Many national protected areas such as the Meru and Kora national parks and the Bisanadi, Rahole, and Mwingi national reserves are situated in the upper reaches of the River. The Arawel and Tana River Primate national reserves are located in middle to the lower river basin. In particular, the river is flowing through the Tana River Primate National Reserve. The reserve was gazetted to protect the

Lower Tana riverine forests and the above two endangered primate species. During the EIA phase, each project should examine the protected areas to avoid negative damage caused by the projects.

Figure 6.7.1 shows locations of the development projects proposed in NWMP 2030 (not only limited to the selected 17 projects) and natural environmental resources in TCA.

6.8 Ewaso Ng'iro North Catchment Area

6.8.1 Scoping Result of the Major Proposed Projects

Based on the above criteria, five dam projects, and two large-scale irrigation projects were selected for IEE in ENNCA. The selected proposed projects are shown in the following table. Table 6.8.1 shows a summary of the negative and positive impacts of the proposed seven projects in ENNCA.

Selected Proposed Project (ENNCA)

Dam Projects	Large-scale Irrigation Projects	Water Supply and Sanitation Projects
1. Nyahururu 2. Rumuruti 3. Kihoto 4. Isiolo 5. Archer's Post	6. Kieni Irrigation 7. Wajir Irrigation	None

Source: JICA Study Team

6.8.2 Major Anticipated Environmental Impact Factor (ENNCA)

Major anticipated environmental impact factors of ENNCA are the proposed projects in the upper reaches of the Ewaso Ng'iro North River.

All of the projects in ENNCA proposed by NWMP 2030 are located in the area surrounding the Mt. Kenya and the Aberdare Range, southwest area of ENNCA. Five dams are proposed and planned in the upper reaches of the Ewaso Ng'iro North River and its tributaries. Therefore, the multiple impacts caused by these projects should be analysed in the project planning phase. In addition, two national parks and five national reserves are located in the same area. These protected areas also rely on the Ewaso Ng'iro North River and its tributaries. Thus, water resources development projects must pay attention to these lower environmental resources.

Figure 6.8.1 shows locations of proposed development projects by NWMP 2030 (not only limited to the selected six projects) and natural environmental resources in ENNCA.

Tables

Table 2.2.1 Water Resources Development Activities which require EIA Implementation by EMCA

Proposed Project Type of NWMP 2030	Activities which are Required by Second Schedule of EMCA
All Projects	1. General (a) An activity out of character with its surrounding; (b) Any structure of a scale not in keeping with its surrounding; (c) Major changes in land use. (d) Shopping centres and complexes.
	12. Natural conservation areas including: (a) Creation of national parks, game reserves and buffer zones; (b) Establishment of wilderness areas; (c) Formulation or modification of forest management policies; (d) Formulation or modification of water catchment management policies; (e) Policies for the management of ecosystems, especially by use of fire; (f) Commercial exploitation of natural fauna and flora;
Dams	4. Dams, rivers and water resources including: (a) Storage dams, barrages and piers; (b) River diversions and water transfer between catchments; (c) Flood control schemes; (d) Drilling for the purpose of utilizing ground water resources including geothermal energy.
Irrigations	7. Agriculture including: (a) Large-scale agriculture; (b) Use of pesticide; (c) Use of fertilizers; (d) Irrigation.
Water Supply and Sanitations	3. Transportation including- (a) Water transport;
	11. Waste disposal including –sites for solid waste disposal; (a) Sites for hazardous waste disposal; (b) Sewage disposal works; (c) Works involving major atmospheric emissions; (d) Works emitting offensive odors.
Afforestation	6. Mining, including quarrying and open-cast extraction of: (a) Reforestation and afforestation.

Source: Prepared by JICA Study Team based on Second Schedule of EMCA 1999

Table 6.3.1 Scoping Results (LVNCA)

Name of Project / Scorping Items		Dams							Irrigation			Water supply & Sanitation		
		Siyoi	Moi's Bridge	Nzoia (34B)	Kibolo	Teremi	Nzoia (42A)	Nandi Forest	Lower Nzoia Irrigation	Lower Sio Irrigation	Yala Swamp Irrigation	Bondo and Siaya Towns Water Supply Project	Bond Town Sanitation Project	Maraba Waste Stabilization Pond
		1	2	3	4	5	6	7	8	9	10	11	12	13
Pollution Control														
1	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	A-	A-	A-
5	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	A-	A-	A-
6	Ground subsidence	D	D	D	D	D	D	D	C-	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-	B-
9	Disaster	B+	B+	A+	B+	B+	A+	B+	D	D	D	D	D	D
Natural Environment														
10	Topography and geographical features	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-	A-
11	Soil erosion	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-
12	Groundwater	D	D	D	D	D	D	D	B-	B-	B-	D	D	D
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-
14	Coastal zone	D	D	D	D	D	D	D	D	D	D	D	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-	B-	B-	A-	A-	A-	A-
16	Meteorology	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	C-	C-	C-
18	Global warming	B+	B+	A+	B+	B+	A+	A+	D	D	D	D	D	D
Social Environment														
19	Involuntary resettlement	B-	A-	A-	B-	B-	A-	A-	B-	B-	B-	D	D	D
20	Local economy	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	A+	A+	A+
21	Land use and utilization of local resources	B-	A-	A-	B-	B-	A-	A-	B-	B-	B-	B-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-	C-
23	Existing social infrastructures and services	B+/B-	B+/B-	B+/B-	B+/B-	B+/B-	B+/B-	B+/B-	C-	C-	C-	C-	C-	C-
24	Socially vulnerable groups (including gender matter)	B+/B-	A+/A-	A+/A-	B+/B-	B+/B-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	B+	B+	B+
25	Misdistribution of benefit and damage	B+/B-	A+/A-	A+/A-	B+/B-	B+/B-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	A+	A+	A+
26	Historical and cultural heritage	D	D	D	D	D	D	D	D	D	D	C-	C-	C-
27	Water usage or water rights	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+	A+	A+
28	Local conflict of interests	B-	A-	A-	B-	B-	A-	A-	B-	B-	B-	B-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+	A+	A+
30	Hazardous (risk) infectious diseases(HIV/AIDS)	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	B-	B-	B-
31	Accident	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

Table 6.4.1 Scoping Results (LVSCA)

Scoping Items \ Name of Project		Dams										Irrigation				Water supply & Sanitation
		Londiani	Nyando (Koru)	Kibos	Itare	Magwagwa	Bunyunyu	Katieno	Ilooiterre	Sand River (Naikara)	Amala	Ahero and West Kano Irrigation	Kano Plain Irrigation	Lower Kuja Irrigation (Phase I)	Nandi Forest Dam Irrigation	Migori Water Supply and Sanitation Project
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pollution Control																
1	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	A-
5	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	A-
6	Ground subsidence	C-	C-	C-	C-	C-	C-	C-	D	D	D	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-
9	Disaster	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	D	D	D	D	D
Natural Environment																
10	Topography and geographical features	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	A-
11	Soil erosion	B-	B-	B-	B-	B-	B-	B-	A-	A-	A-	A-	A-	A-	A-	C-
12	Groundwater	D	D	D	D	D	D	D	D	D	D	B-	B-	B-	B-	D
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-
14	Coastal zone	C-	C-	C-	C-	C-	C-	C-	D	D	D	D	D	D	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	A-
16	Meteorology	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	C-	C-	C-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	C-	C-
18	Global warming	B+	A+	B+	B+	A+	B+	B+	A+	B+	B+	D	D	D	D	D
Social Environment																
19	Involuntary resettlement	B-	B-	B-	B-	A-	B-	A-	B-	B-	A-	B-	B-	B-	B-	D
20	Local economy	A-	A-	A-	A-	A-	A-	A-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	A+/B-	A+
21	Land use and utilization of local resources	B-	B-	B-	B-	A-	B-	A-	B-	B-	A-	B-	B-	B-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-
23	Existing social infrastructures and services	B-	B-	B-	B-	B-	B-	B-	B+/B-	B+/B-	B+/B-	C-	C-	C-	C-	C-
24	Socially vulnerable groups (including gender matter)	B+/B-	B+/B-	B+/B-	B+/B-	A+/A-	B+/B-	A+/A-	B+/B-	B+/B-	A+/A-	A+/B-	A+/B-	A+/B-	A+/B-	B+
25	Misdistribution of benefit and damage	B-	B-	B-	B-	B-	B-	B-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	A+/B-	A+
26	Historical and cultural heritage	D	D	D	D	D	D	D	D	D	D	D	D	D	D	C-
27	Water usage or water rights	A+	A+	A+	A+	A+	A+	A+	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+
28	Local conflict of interests	B-	B-	B-	B-	A-	B-	A-	B-	B-	A-	B-	B-	B-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+
30	Hazardous (risk) infectious diseases(HIV/AIDS)	B-	B-	B-	B-	B-	B-	B-	A-	A-	A-	C-	C-	C-	C-	B-
31	Accident	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

Table 6.5.1 Scoping Results (RVCA)

Scoping Items \ Name of Project		Dams										Irrigation				
		Murung-Sebit	Kimwarer	Arror	Embobut	Waseges	Malewa	Upper Narok	Oletukat	Leshota	Oldorko	Arror Dam Irrigation	Lower Ewaso Ngiro River Basin Integrated	Norera Irrigation	Perkera Irrigation Extention	Turkwel Dam Irrigation
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Pollution Control																
1	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-
5	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-
6	Ground subsidence	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-
9	Disaster	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	D	D	D	D	D
Natural Environment																
10	Topography and geographical features	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-	B-	B-
11	Soil erosion	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A-	A-	A-	A-	A-
12	Groundwater	D	D	D	D	D	D	D	D	D	D	B-	B-	B-	B-	B-
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
14	Coastal zone	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	D	D	D	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
16	Meteorology	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-	C-	C-
18	Global warming	B+	A+	A+	A+	B+	B+	B+	A+	A+	A+	D	D	D	D	D
Social Environment																
19	Involuntary resettlement	B-	B-	B-	B-	B-	B-	B-	A-	B-	B-	B-	B-	B-	B-	B-
20	Local economy	B-	B-	B-	B-	B-	B-	B-	A-	B-	B-	A+/B-	A+/B-	A+/B-	A+/B-	A+/B-
21	Land use and utilization of local resources	B-	B-	B-	B-	B-	B-	B-	A-	B-	B-	B-	B-	B-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-
23	Existing social infrastructures and services	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-
24	Socially vulnerable groups (including gender matter)	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-	A+/B-	A+/B-
25	Misdistribution of benefit and damage	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+/B-	A+/B-	A+/B-	A+/B-	A+/B-
26	Historical and cultural heritage	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
27	Water usage or water rights	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-
28	Local conflict of interests	B-	B-	B-	B-	B-	B-	B-	A-	B-	B-	B-	B-	B-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
30	Hazardous (risk) infectious diseases(HIV/AIDS)	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-	C-	C-
31	Accident	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

Table 6.6.1 Scoping Results (ACA)

Scoping Items \ Name of Project		Dams																Irrigation	WS&S
		Upper Athi	Stony Athi	Kikuyu	Puaka (Kiambaa)	Kamiti 1	Ruiru-A (Riuru2)	Ndarugu	Munyu	Mbuuni	Kiteta	Thwake	Olkishunki	Pemba	Lake Chala	Rare	Mwachi	Taita Taveta Irrigation	Umanyi-Mtito Anddei Water Supply Project
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pollution Control																			
1	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	A-
5	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	A-
6	Ground subsidence	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-
9	Disaster	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	D	D
Natural Environment																			
10	Topography and geographical features	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	A-
11	Soil erosion	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A-	C-
12	Groundwater	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	B-	D
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-
14	Coastal zone	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
16	Meteorology	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-
18	Global warming	B+	B+	B+	B+	B+	B+	B+	A+	B+	B+	A+	B+	B+	B+	B+	B+	D	D
Social Environment																			
19	Involuntary resettlement	B-	B-	B-	B-	B-	B-	A-	A-	B-	B-	A-	B-	B-	B-	B-	B-	B-	D
20	Local economy	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A+/B-	A+
21	Land use and utilization of local resources	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-
23	Existing social infrastructures and services	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-
24	Socially vulnerable groups (including gender matter)	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/B-	B+
25	Misdistribution of benefit and damage	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+/B-	A+
26	Historical and cultural heritage	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	C-
27	Water usage or water rights	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+/A-	A+
28	Local conflict of interests	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+
30	Hazardous (risk) infectious diseases(HIV/AIDS)	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	B-
31	Accident	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

Table 6.7.1 Scoping Results (TCA)

Scoping Items \ Name of Project		Dams											Irrigation		
		Maragua 4	Ndiara	Chania-B	Karimenu 2	Thika 3A	Yatta	Thiba	High Grand Falls	Mutuni	Kitimui	Kora	High Grand Falls Dam Irrigation	Hola Pump Irrigation Extention	Hola Irrigation Greater Extension
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pollution Control															
1	Air pollution	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-
5	Noise and vibration	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-
6	Ground subsidence	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-
9	Disaster	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	B+	D	D	D
Natural Environment															
10	Topography and geographical features	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-
11	Soil erosion	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A-	A-	A-
12	Groundwater	D	D	D	D	D	D	D	D	D	D	D	B-	B-	B-
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
14	Coastal zone	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	C-	D	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-
16	Meteorology	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	C-	C-	C-
18	Global warming	B+	B+	B+	B+	B+	B+	B+	A+	B+	B+	B+	D	D	D
Social Environment															
19	Involuntary resettlement	B-	B-	B-	B-	B-	B-	B-	A-	B-	B-	B-	B-	B-	B-
20	Local economy	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A+/B-	A+/B-	A+/B-
21	Land use and utilization of local resources	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-
23	Existing social infrastructures and services	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-
24	Socially vulnerable groups (including gender matter)	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-	A+/B-
25	Misdistribution of benefit and damage	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	A+/B-	A+/B-	A+/B-
26	Historical and cultural heritage	D	D	D	D	D	D	D	D	D	D	D	D	D	D
27	Water usage or water rights	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+	A+/A-	A+/A-	A+/A-
28	Local conflict of interests	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	A-	B-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-
30	Hazardous (risk) infectious diseases(HIV/AIDS)	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	C-	C-	C-
31	Accident	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

Source: JICA Study Team

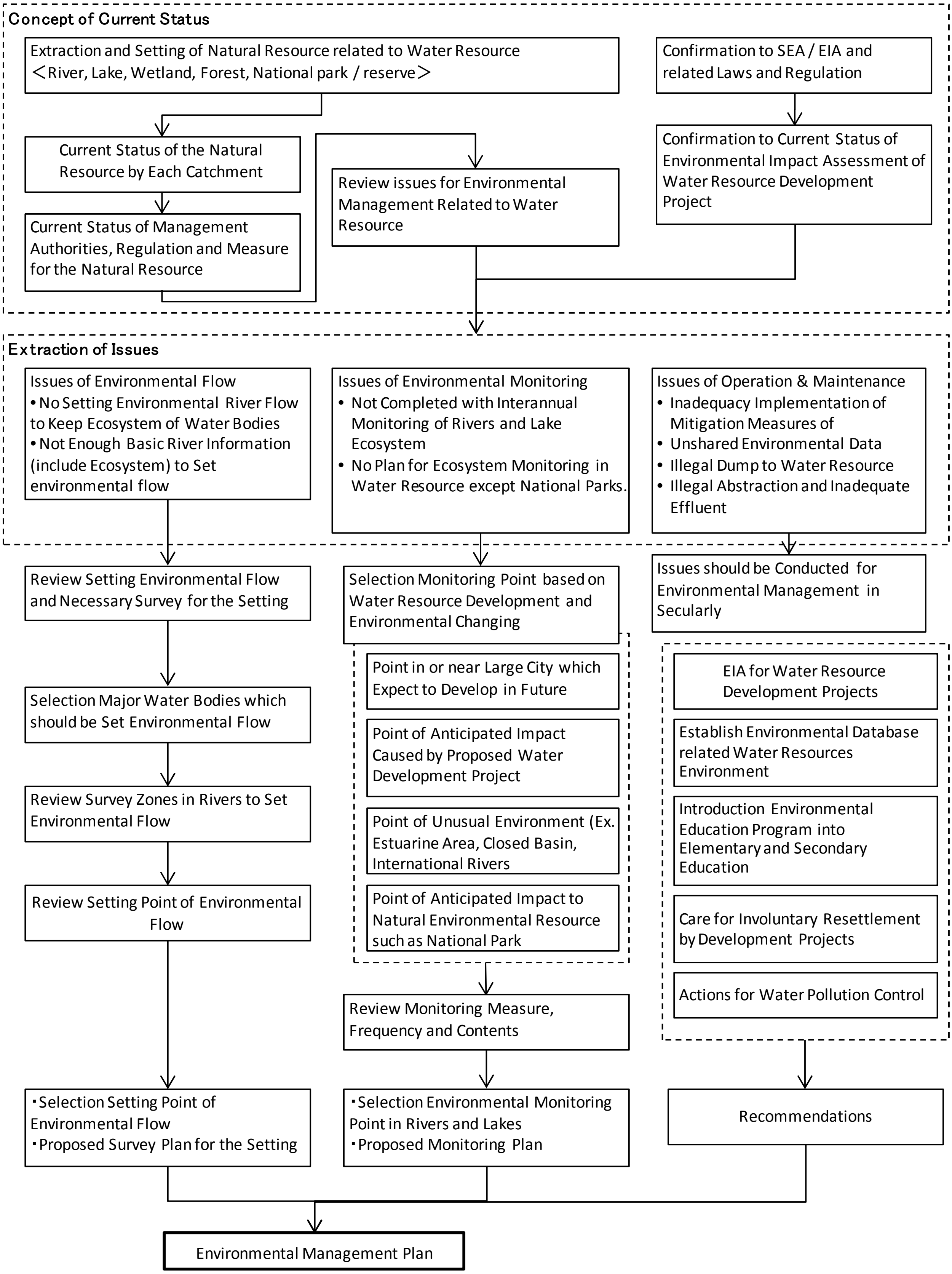
Table 6.8.1 Scoping Results (ENNCA)

Scoping Items		Name of Project: Dams					Irrigation	
		1 Nyahururu	2 Rumuruti	3 Kihoto	4 Isiolo	5 Archer's Post	6 Kieni Irrigation	6 Wajir Irrigation
Pollution Control								
1	Air pollution	B-	B-	B-	B-	B-	B-	B-
2	Water pollution	A-	A-	A-	A-	A-	A-	A-
3	Soil contamination	B-	B-	B-	B-	B-	B-	B-
4	Waste	A-	A-	A-	A-	A-	B-	B-
5	Noise and vibration	B-	B-	B-	B-	B-	C-	C-
6	Ground subsidence	C-	C-	C-	C-	C-	C-	C-
7	Offensive odor	C-	C-	C-	C-	C-	C-	C-
8	Bottom sediment	A-	A-	A-	A-	A-	B-	B-
9	Disaster	B+	B+	B+	B+	B+	D	D
Natural Environment								
10	Topography and geographical features	A-	A-	A-	A-	A-	B-	B-
11	Soil erosion	B-	B-	B-	B-	B-	A-	A-
12	Groundwater	D	D	D	D	D	B-	B-
13	Hydrological situation	A-	A-	A-	A-	A-	A-	A-
14	Coastal zone	C-	C-	C-	C-	C-	D	D
15	Flora, fauna and biodiversity	A-	A-	A-	A-	A-	A-	A-
16	Meteorology	A-	A-	A-	A-	A-	C-	C-
17	Landscape	A-	A-	A-	A-	A-	C-	C-
18	Global warming	B+	B+	B+	B+	B+	D	D
Social Environment								
19	Involuntary resettlement	B-	B-	A-	B-	A-	B-	B-
20	Local economy	A-	A-	A-	A-	A-	A+/B-	A+/B-
21	Land use and utilization of local resources	A-	A-	A-	A-	A-	B-	B-
22	Social institutions	B-	B-	B-	B-	B-	C-	C-
23	Existing social infrastructures and services	B-	B-	B-	B-	B-	C-	C-
24	Socially vulnerable groups (including gender matter)	A+/A-	A+/A-	A+/A-	A+/A-	A+/A-	A+/B-	A+/B-
25	Misdistribution of benefit and damage	B-	B-	B-	B-	B-	A+/B-	A+/B-
26	Historical and cultural heritage	D	D	D	D	D	D	D
27	Water usage or water rights	A+	A+	A+	A+	A+	A+/A-	A+/A-
28	Local conflict of interests	A-	A-	A-	A-	A-	B-	B-
29	Sanitation	B-	B-	B-	B-	B-	B-	B-
30	Hazardous (risk) infectious diseases(HIV/AIDS)	B-	B-	B-	B-	B-	C-	C-
31	Accident	B-	B-	B-	B-	B-	B-	B-

Note : The criteria of environmental scoping are ; A: Significant, B: Minor, C: Negligible and D: Unknown. Positive Impact is indicated with "+" and negative impact is indicated with "-".

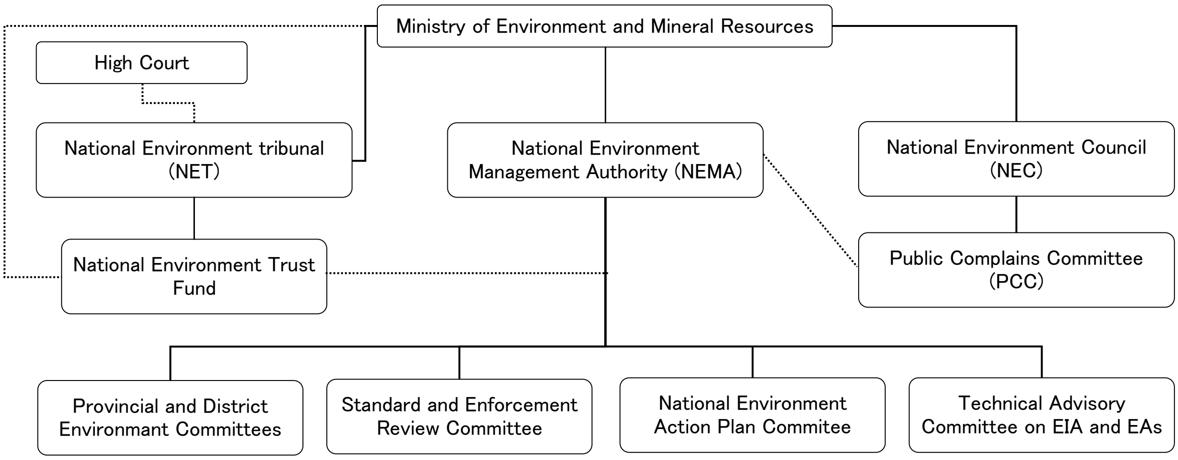
Source: JICA Study Team

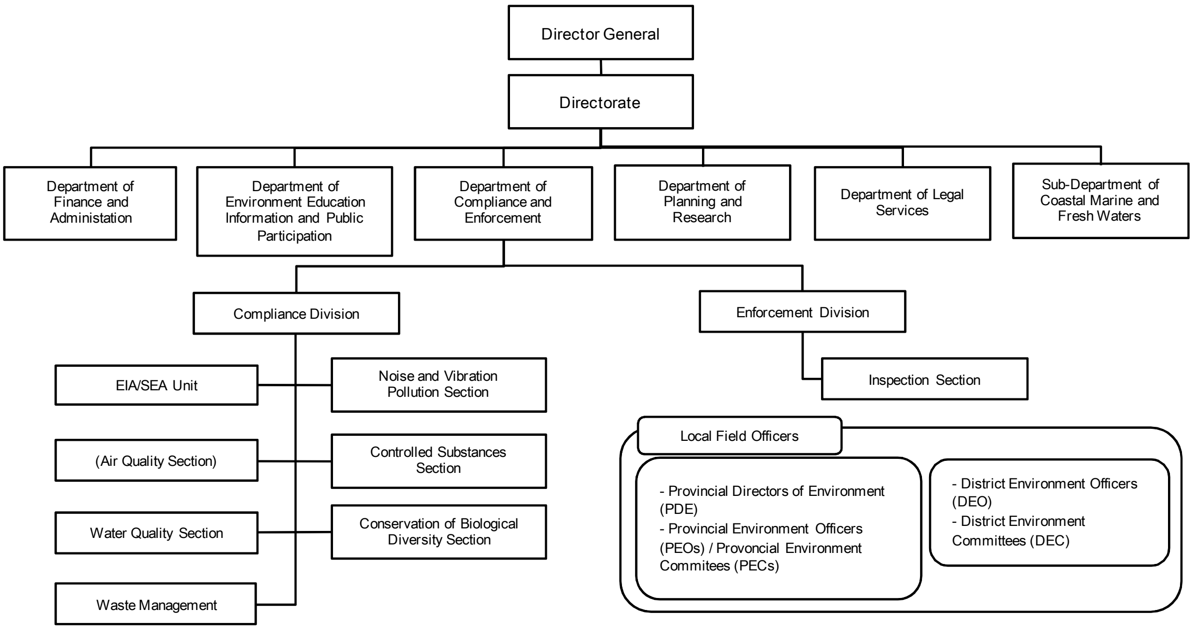
Figures



Source: JICA Study Team

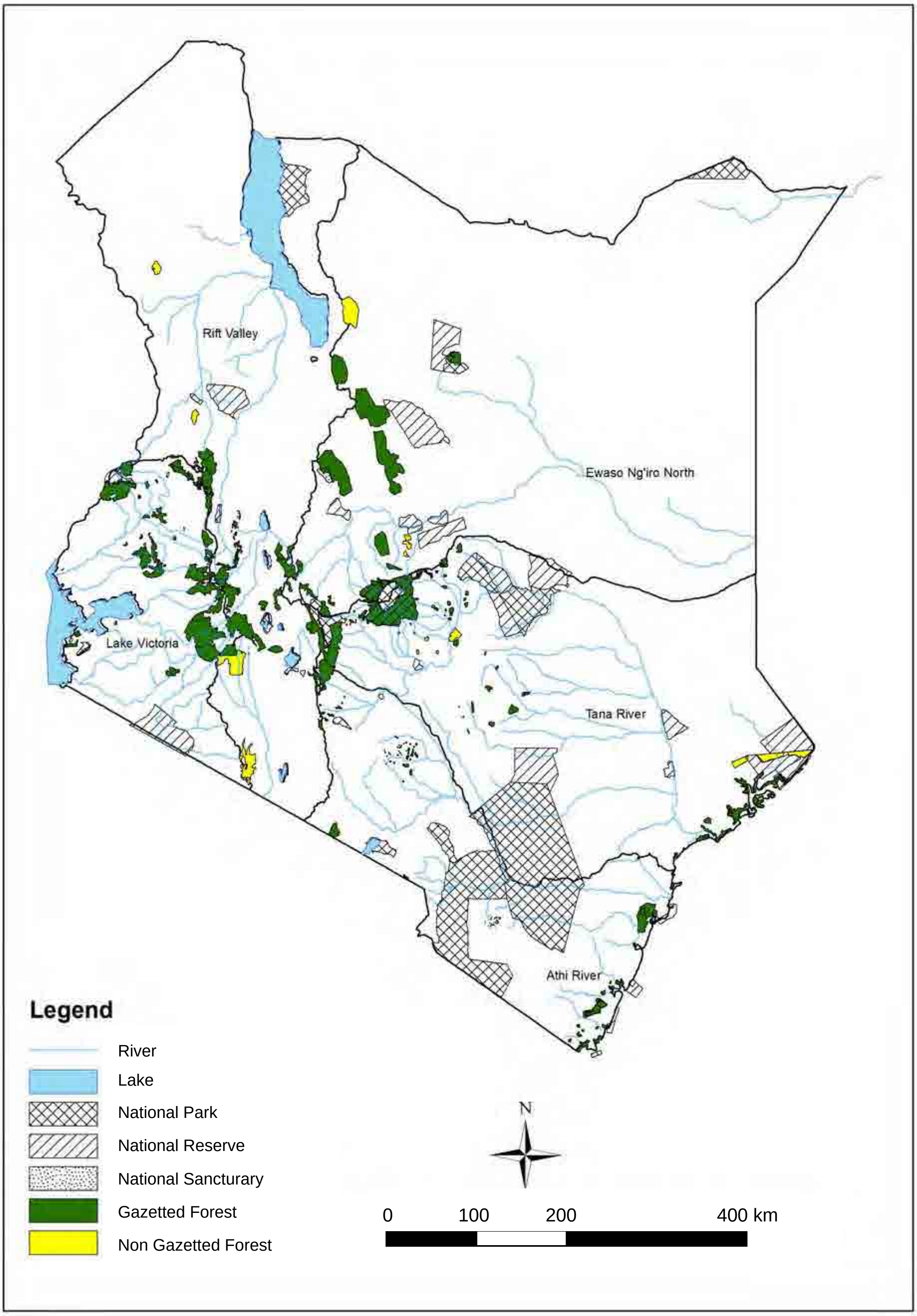
THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 1.1.1 Work Flow of Environmental Management Planning**
JAPAN INTERNATIONAL COOPERATION AGENCY	





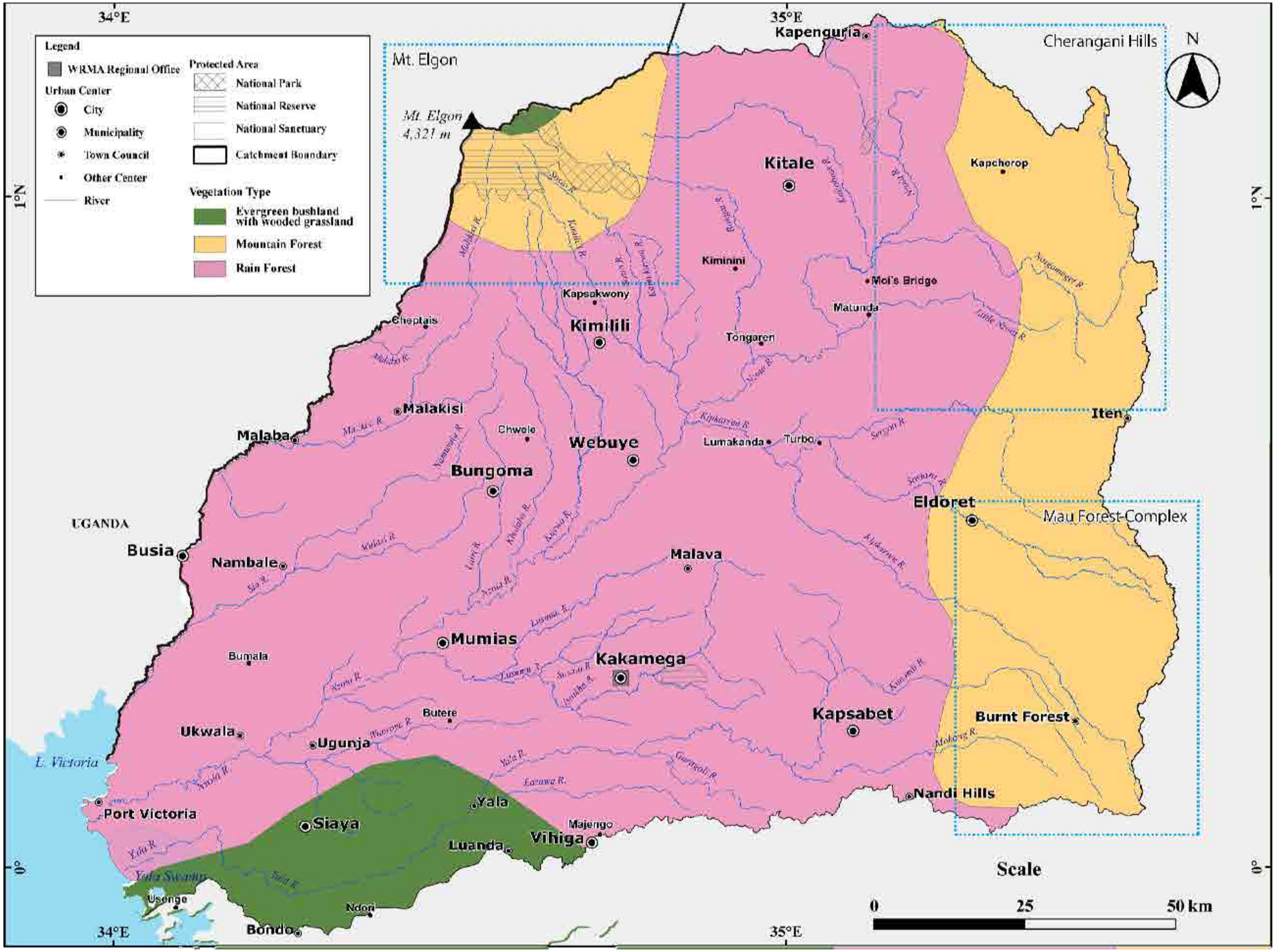
Source: JICA Study Team (As of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.2.1 Institutional Framework of MOEMR and NEMA**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team based on KWS information

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.1** **Protected Area in Kenya**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team based on UNESCO Vegetation Map of Africa

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Figure 2.3.2
Current Natural Resources and Vegetation (LVNCA)

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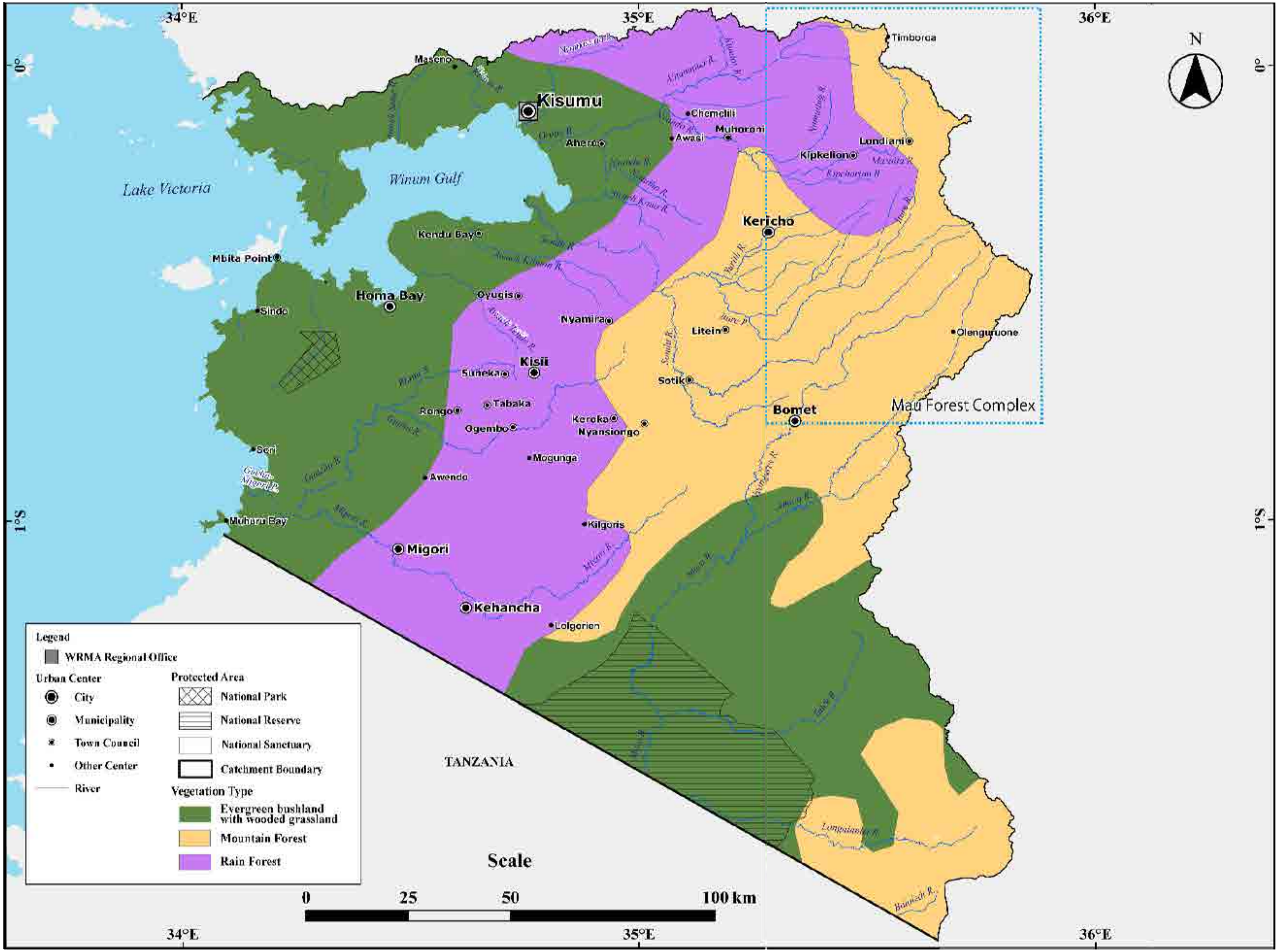
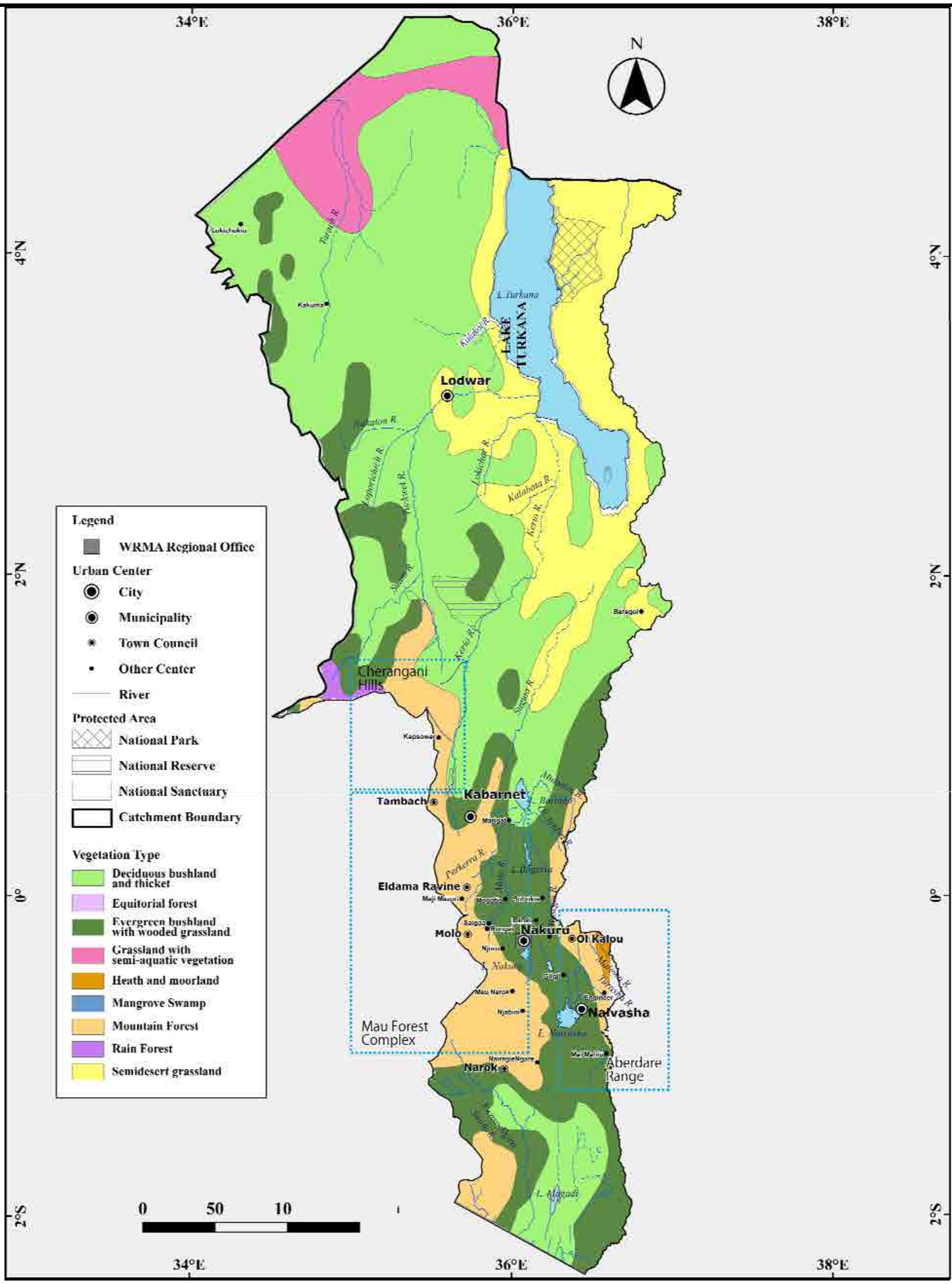
Figure 2.3.3
Current Natural Resources and Vegetation (LVSCA)

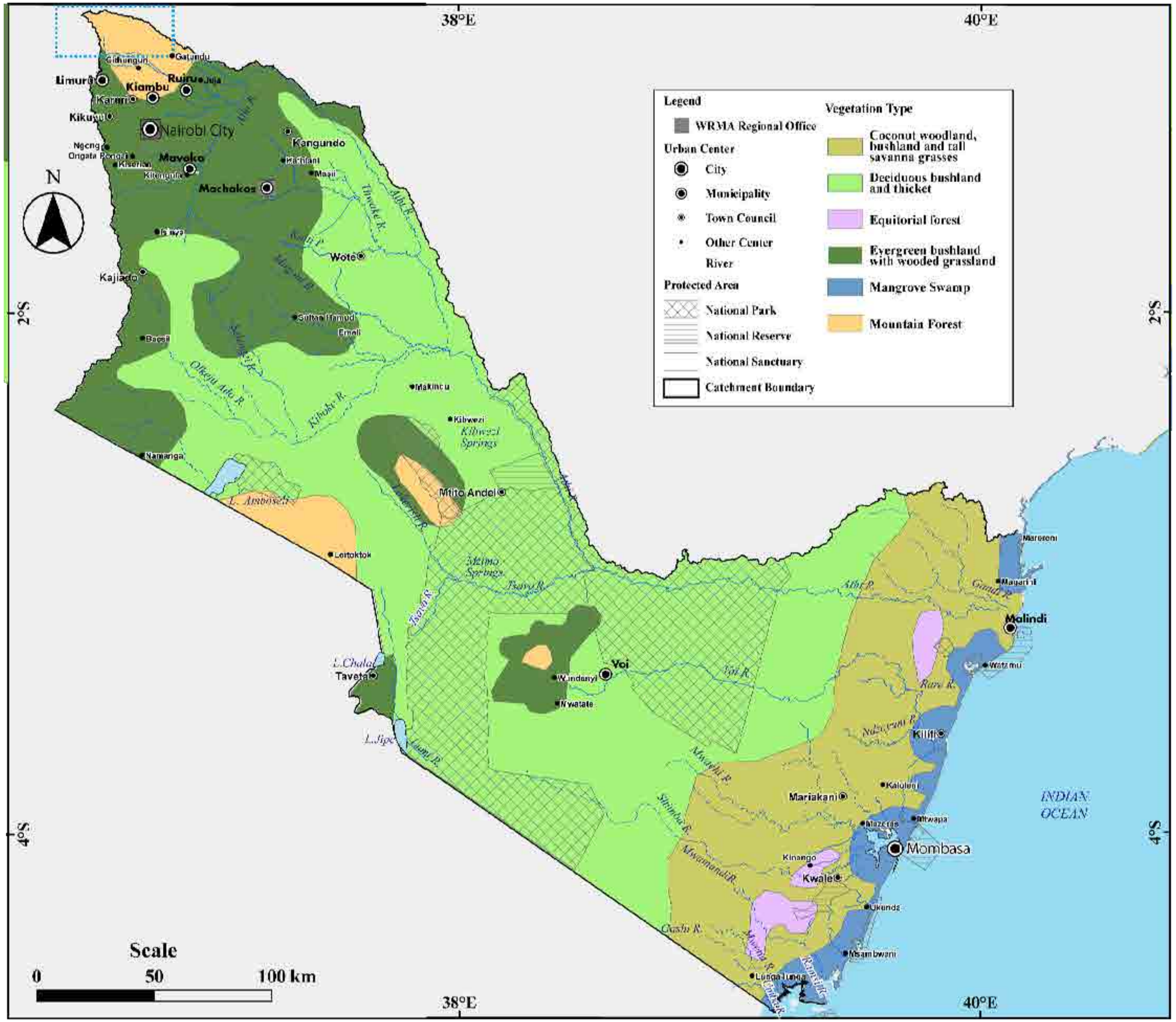
Source: JICA Study Team based on UNESCO Vegetation Map of Africa





Source: JICA Study Team based on UNESCO Vegetation Map of Africa

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.3.4** **Current Natural Resources and Vegetation (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team based on UNESCO Vegetation Map of Africa

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JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.3.5
Current Natural Resources and Vegetation (ACA)

Source: JICA Study Team based on UNESCO Vegetation Map of Africa

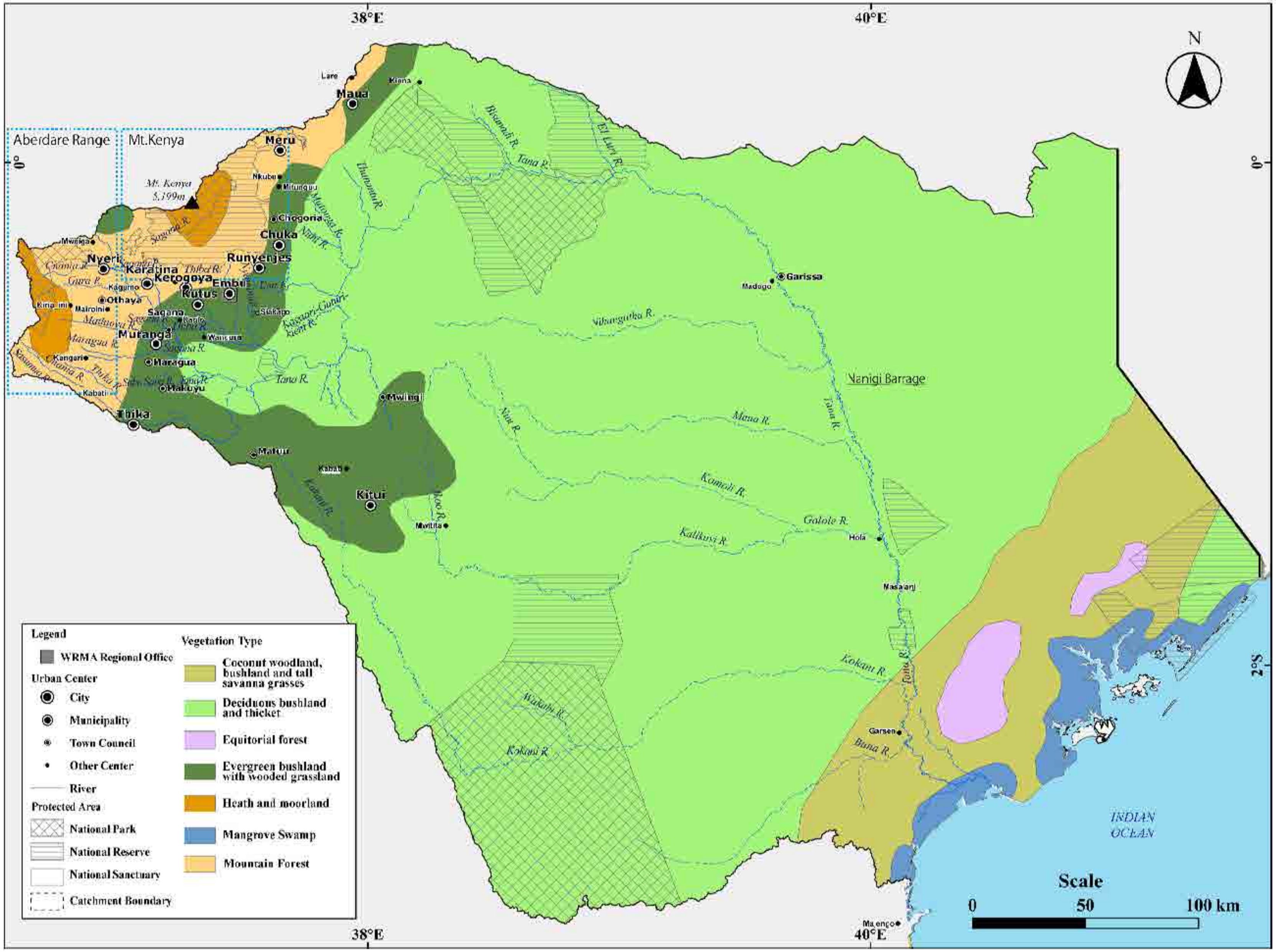

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Figure 2.3.6
Current Natural Resources and Vegetation (TCA)

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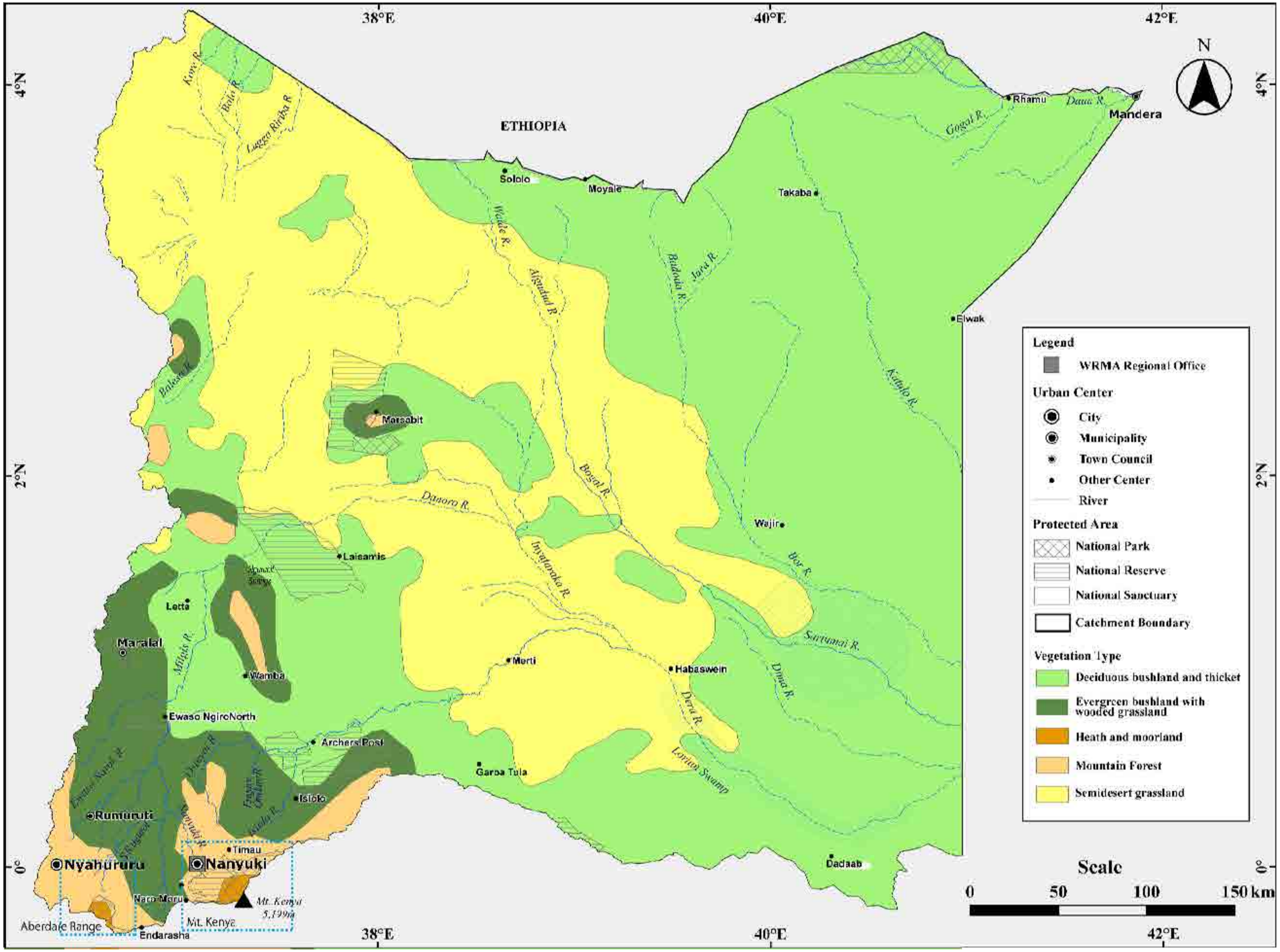

Figure 2.3.7
Current Natural Resources and
Vegetation (ENNCA)

Source: JICA Study Team based on UNESCO Vegetation Map of Africa

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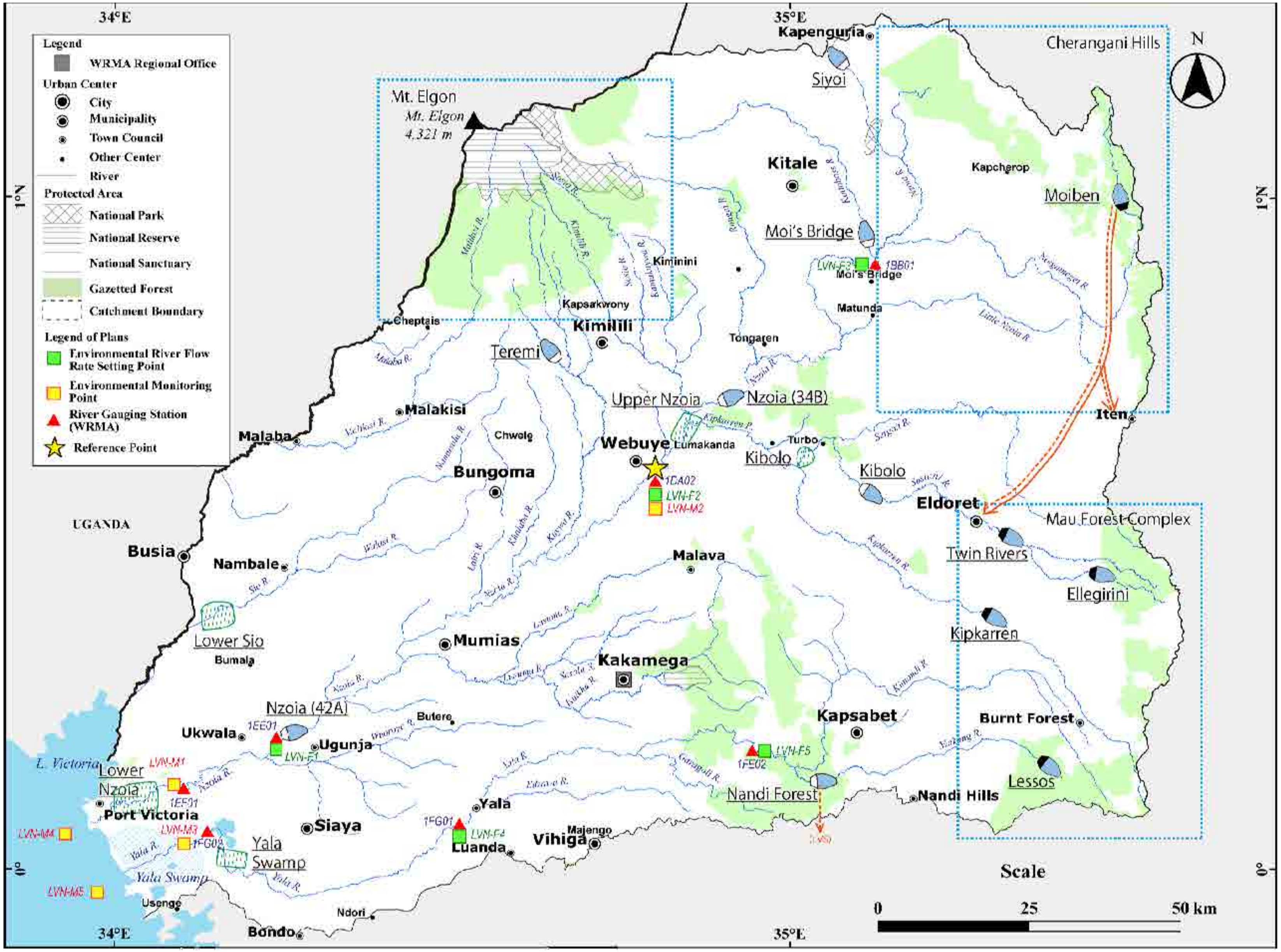
Figure 3.3.1
Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (LVNCA)

Source: JICA Study Team

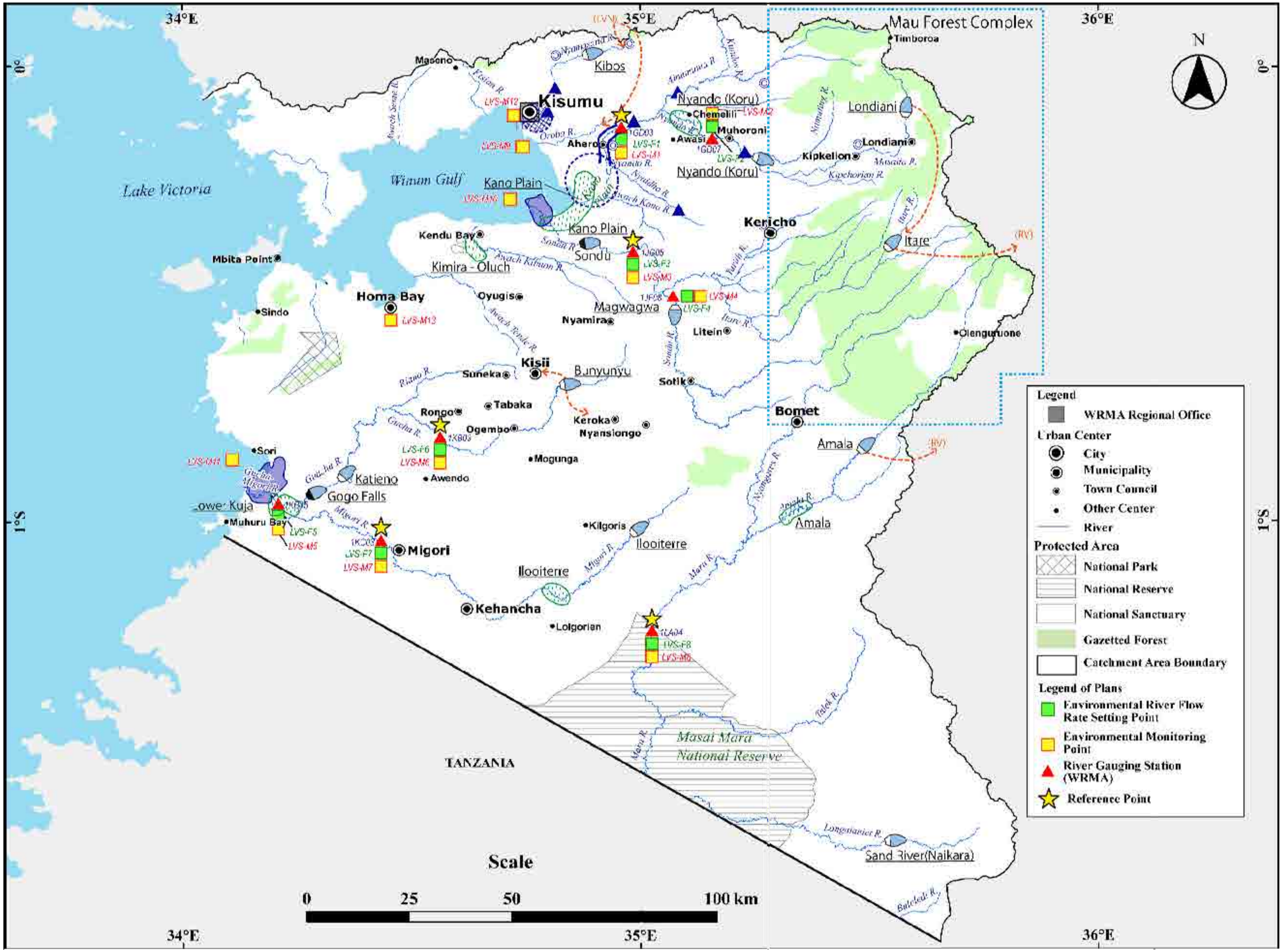


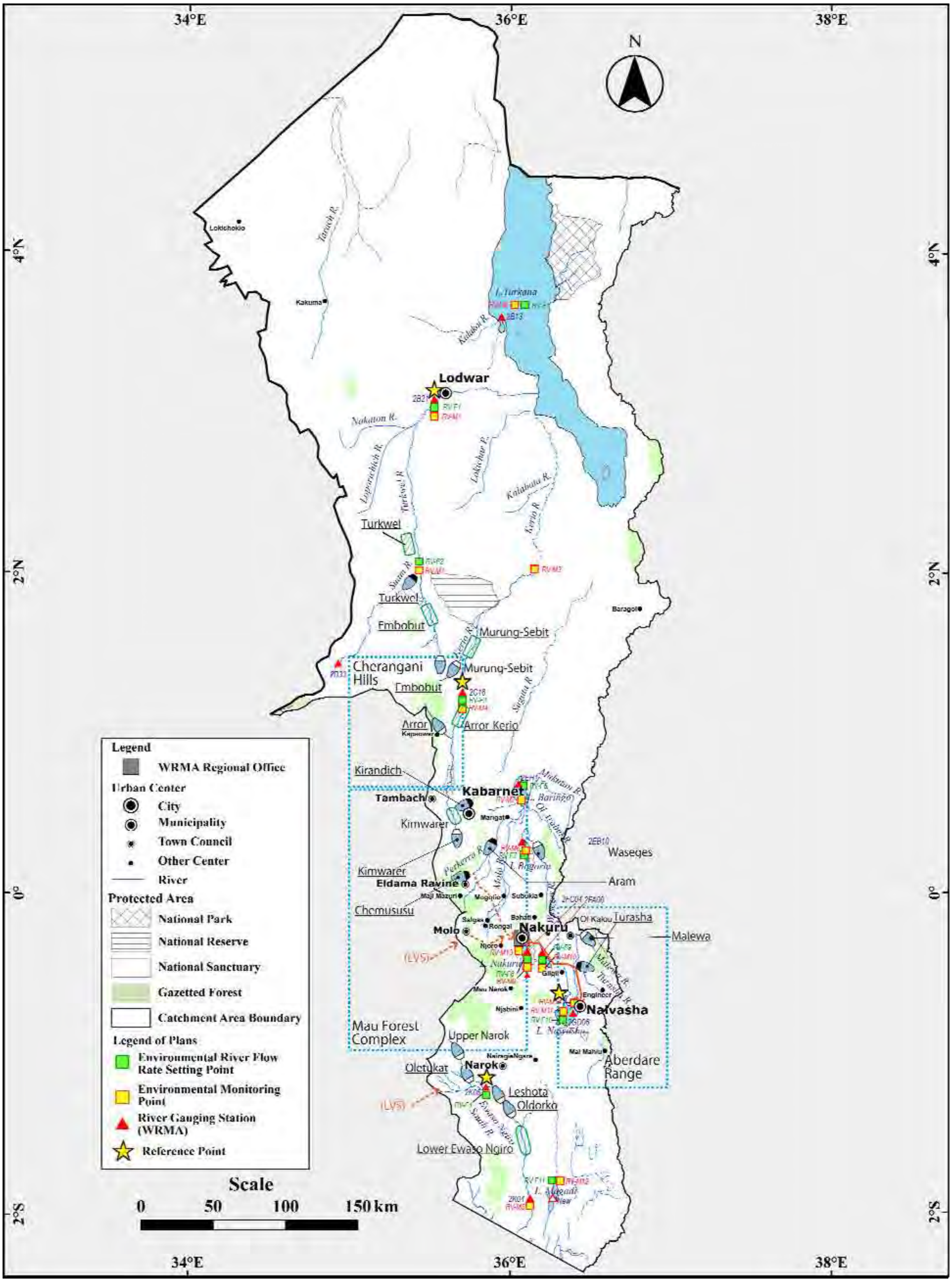
JAPAN INTERNATIONAL COOPERATION AGENCY

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

Figure 3.4.1
Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (LVSCA)

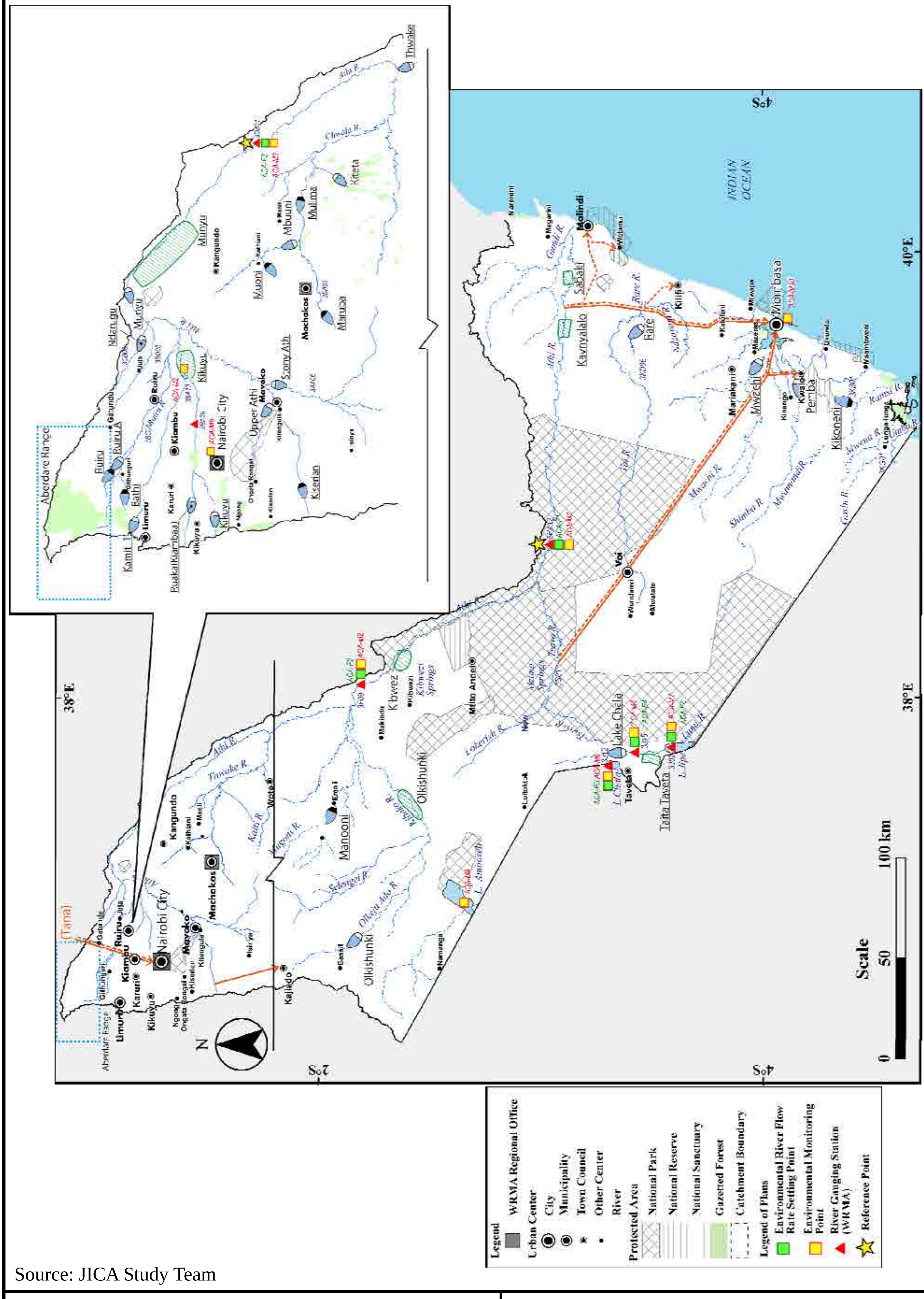
Source: JICA Study Team





Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.5.1** **Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (RVCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.6.1** **Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (ACA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

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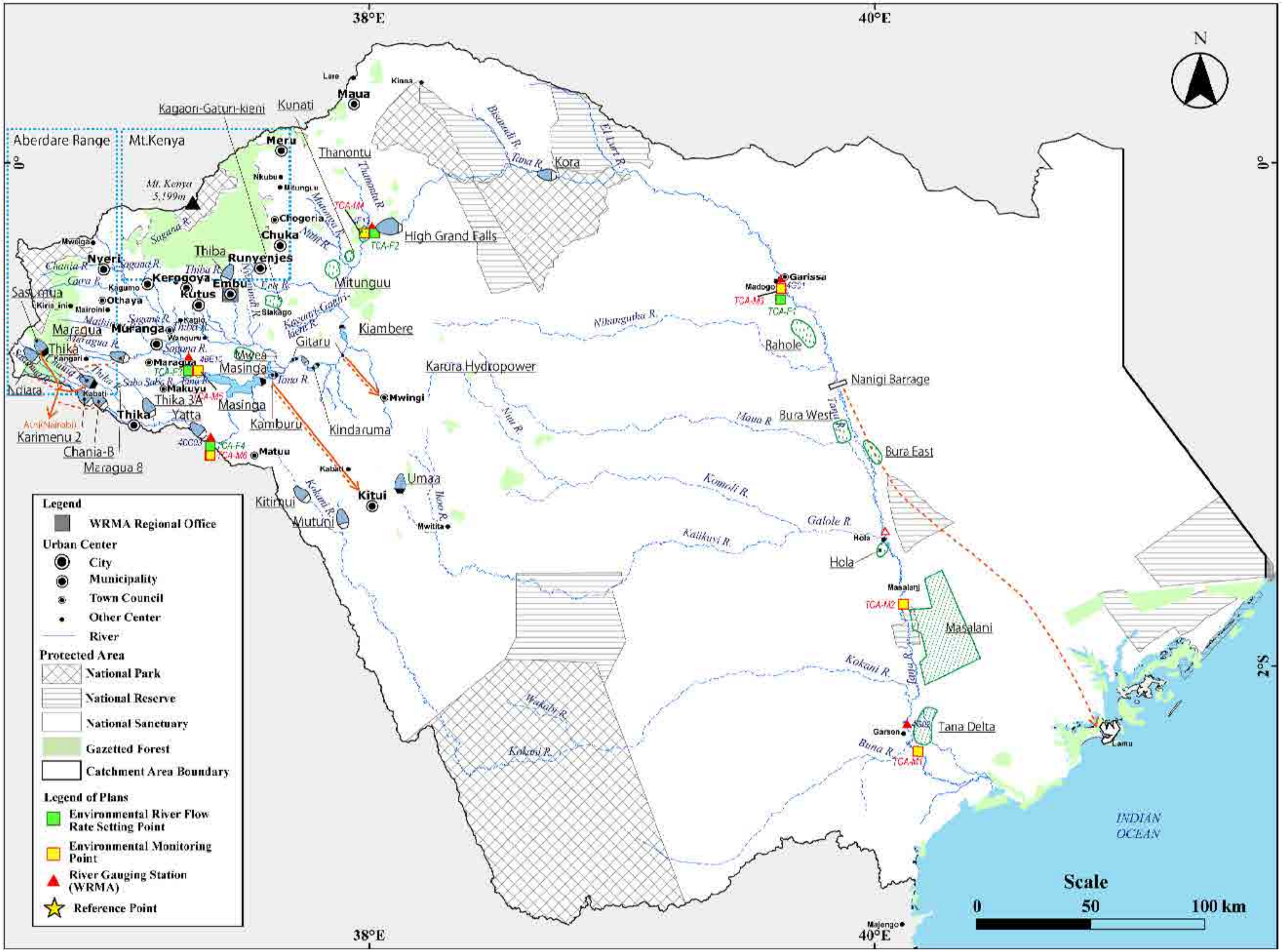
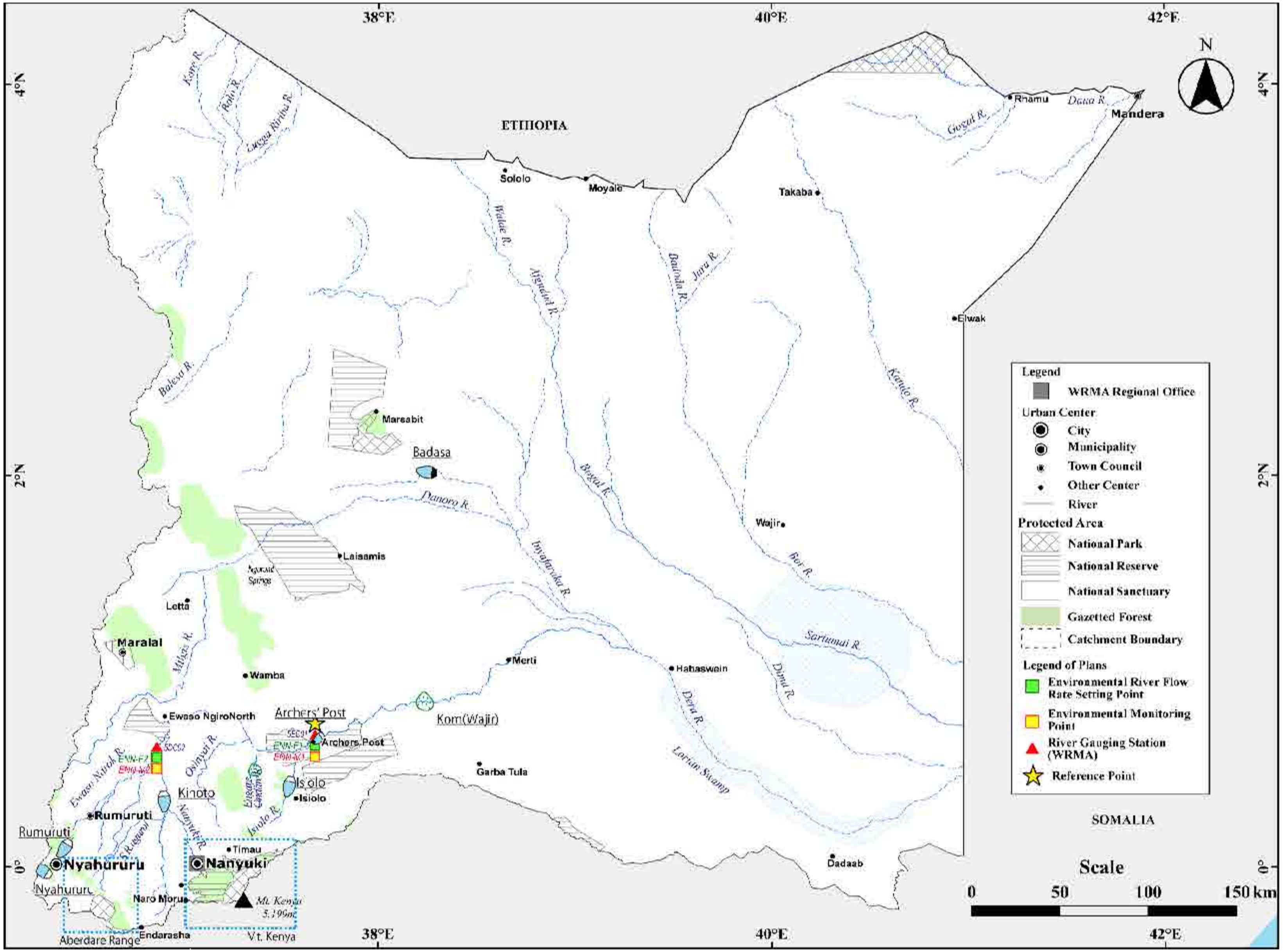
Figure 3.7.1
Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (TCA)

Source: JICA Study Team





Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

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Figure 3.8.1
Locations of Proposed Environmental River Flow Rate Setting Points and Environmental Monitoring Points (ENNCA)

WRMA Catchment	No.	Name of Project	Target	Related Project (Dams and Irrigation)	Implementation Schedule																	
					Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
LVN	1	Setting of Environmental Flow	Nzoia River	Nandi Forest Dam		Set																
LVN	1	Setting of Environmental Flow	Yala River	Siyoi, Nzoia (34B), Nzoia (42B), Moi's Bridge, Kibolo, and Teremi Dams				Set														
LVN	2	Environmental Monitoring	Nzoia River	Nandi Forest Dam																		
LVN	2	Environmental Monitoring	Yala River	Siyoi, Nzoia (34B), Nzoia (42B), Moi's Bridge, Kibolo, and Teremi Dams																		
LVN	2	Environmental Monitoring	L. Victoria	-																		
LVS	1	Setting of Environmental Flow	Nyando River	Nyando and Londiani Dams				Set														
LVS	1	Setting of Environmental Flow	Sondu River	Magwagwa and Itare Dams		Set																
LVS	1	Setting of Environmental Flow	Gucha River	Bunyunyu and Katieno Dams			Set															
LVS	1	Setting of Environmental Flow	Migori River	Ilooiterre Dam					Set													
LVS	1	Setting of Environmental Flow	Mara River	Amala Dam	Set	(Confirmation of current status only)																
LVS	2	Environmental Monitoring	Nyando River	Nyando and Londiani Dams																		
LVS	2	Environmental Monitoring	Sondu River	Magwagwa and Itare Dams																		
LVS	2	Environmental Monitoring	Gucha River	Bunyunyu and Katieno Dams																		
LVS	2	Environmental Monitoring	Migori River	Ilooiterre Dam																		
LVS	2	Environmental Monitoring	Mara River	Amala Dam																		
LVS	2	Environmental Monitoring	L. Victoria	-																		
LVS	2	Environmental Monitoring	Kisumu Town	-																		
LVS	2	Environmental Monitoring	Homa Bay Town	-																		
RV	1	Setting of Environmental Flow	Kerio River	Arror and Kimwarer Dams		Set																
RV	1	Setting of Environmental Flow	Turkwel River	Embobut Dam					Set													
RV	1	Setting of Environmental Flow	Ewaso Ng'iro South River	Upper Narok, Oletukat, Leshota, and Oldorko Dams			Set															
RV	1	Setting of Environmental Flow	L.Turkana	-		Set																
RV	1	Setting of Environmental Flow	L. Baringo	Waseges Dam				Set														
RV	1	Setting of Environmental Flow	L. Bogoria	Ratata Dam				Set														
RV	1	Setting of Environmental Flow	L. Nakuru	-		Set																
RV	1	Setting of Environmental Flow	L. Elementaita	-					Set													
RV	1	Setting of Environmental Flow	L. Naivasha	-		Set	(Confirmation of current status only)															
RV	1	Setting of Environmental Flow	L. Magadi	-					Set													

Environmental Survey for Setting Environmental Flow

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

Environmental Monitoring (including Planning)

Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 5.3.1 Implementation Programme (1/2)**
JAPAN INTERNATIONAL COOPERATION AGENCY	

WRMA Catchment	No.	Name of Project	Target	Related Project (Dams and Irrigation)	Implementation Schedule																	
					Short Term					Medium Term					Long Term							
					2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
					13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30	30/31
	2	Environmental Monitoring	Kerio River	Arror, Mutung-Sebit and Kimwarer Dams																		
			Turkwel River	Embobut Dam																		
			Ewaso Ngiro South River	Upper Narok, Oletukat, Leshota, and Oldorko Dams																		
			L.Turkana	-																		
			L. Baringo	Waseges Dam																		
			L. Bogoria	Ratata Dam																		
			L. Nakuru	-																		
			L. Elementaita	-																		
			L. Naivasha	-																		
			L. Magadi	-																		
			Nakuru Town	-																		
			Naivasha Town	-																		
Athi	1	Setting of Environmental Flow	Ahti River	Ruiru-A, Thwake, Kikuyu, Kiambaa, Upper Athi, Munyu, Kiteta, Mbuuni, Olkishunki, and Ndarugu Dams			Set															
			Lumi River	Lake Chala Dam				Set														
			L. Jipe	Lake Chala Dam					Set													
	2	Environmental Monitoring	Athi River	Ruiru-A, Thwake, Kikuyu, Kiambaa, Upper Athi, Munyu, Kiteta, Mbuuni, Olkishunki, and Ndarugu Dams																		
			Nairobi River	-																		
			Lumi River	Lake Chala Dam																		
			L. Chala	-																		
			L. Jipe	Lake Chala Dam																		
			Nairobi City	-																		
			Mombasa City	-																		
Tana	1	Setting of Environmental Flow	Tana River	High Grand Falls, Thiba, Marauga, Yatta, Ndiara, and Kitimui Dams				Set														
			Chania River	Chania-B					Set													
	2	Environmental Monitoring	Tana River	High Grand Falls, Thiba, Marauga, Yatta, Ndiara, and Kitimui Dams																		
			Chania River	Chania-B																		
ENN	1	Setting of Environmental Flow	Ewaso Ng'iro North River	Isiolo, Archers' Post and Kihoto Dams		Set																
	2	Environmental Monitoring	Ewaso Ng'iro North River																			

Environmental Survey for Setting Environmental Flow

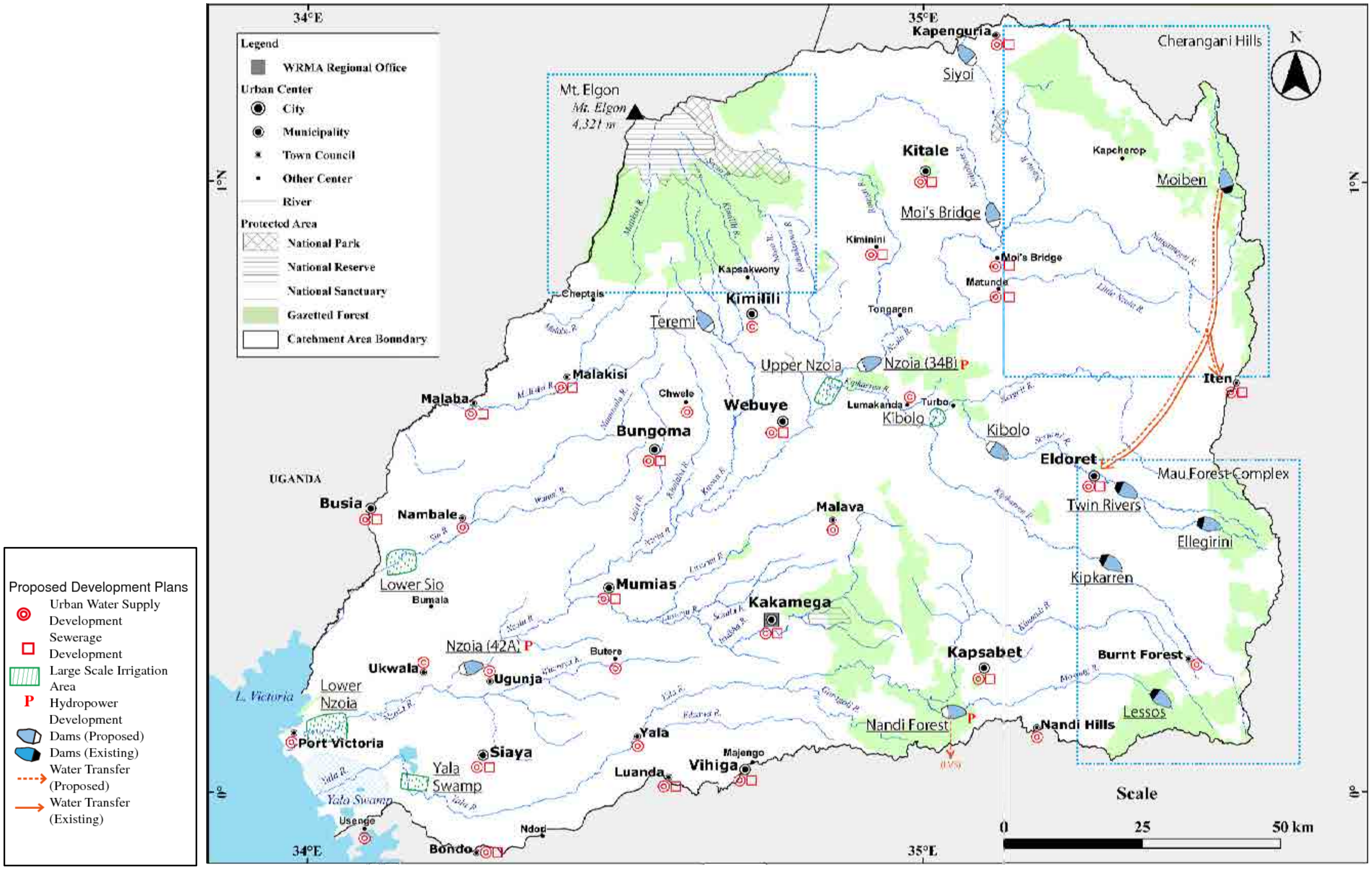
Set — Setting of Environmental Flow (including Key Stakeholder Meeting)

Environmental Monitoring (including Planning)

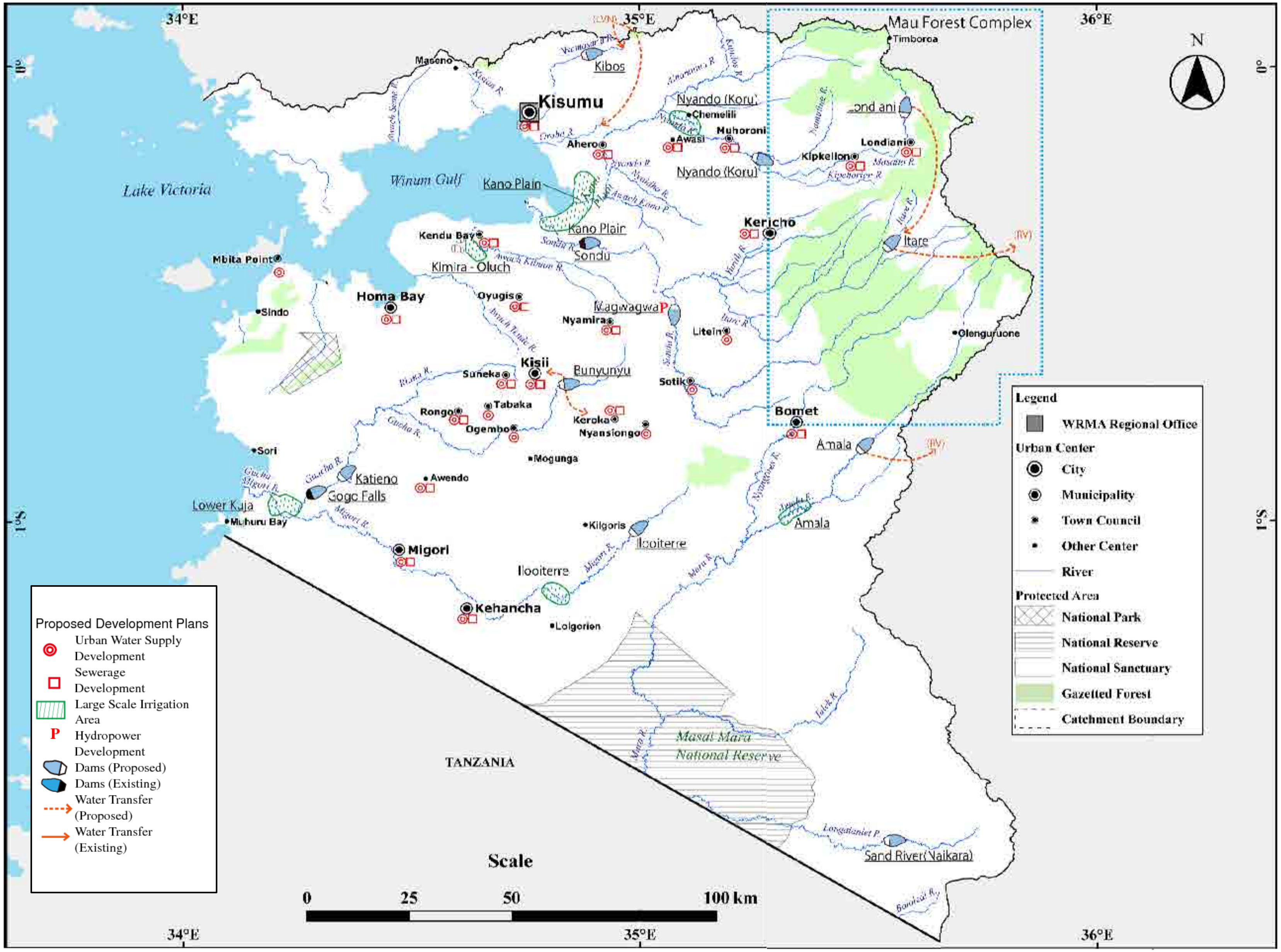
Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 5.3.1 Implementation Programme (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

Figure 6.3.1
Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (LVNCA)



Source: JICA Study Team

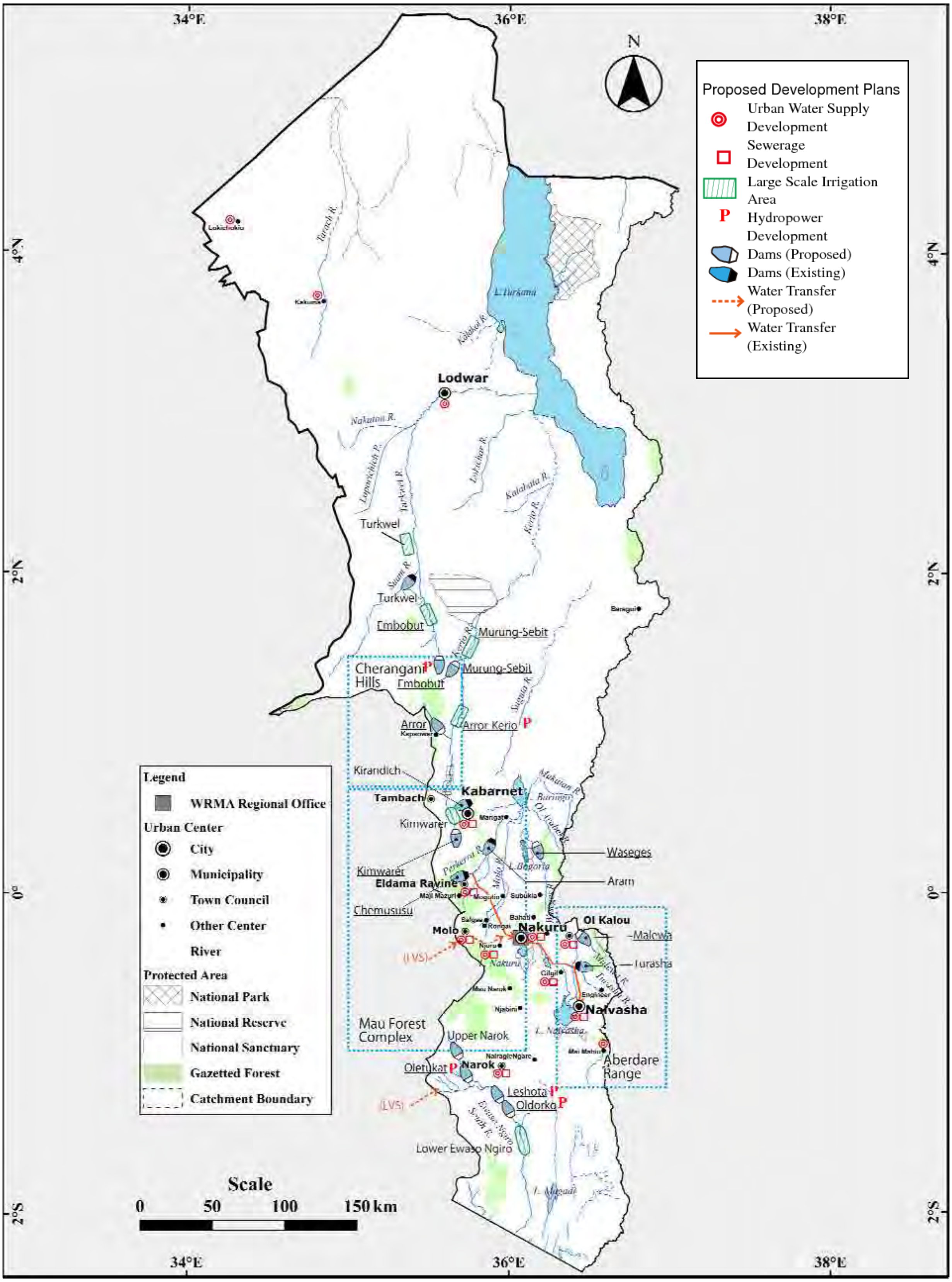


Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030

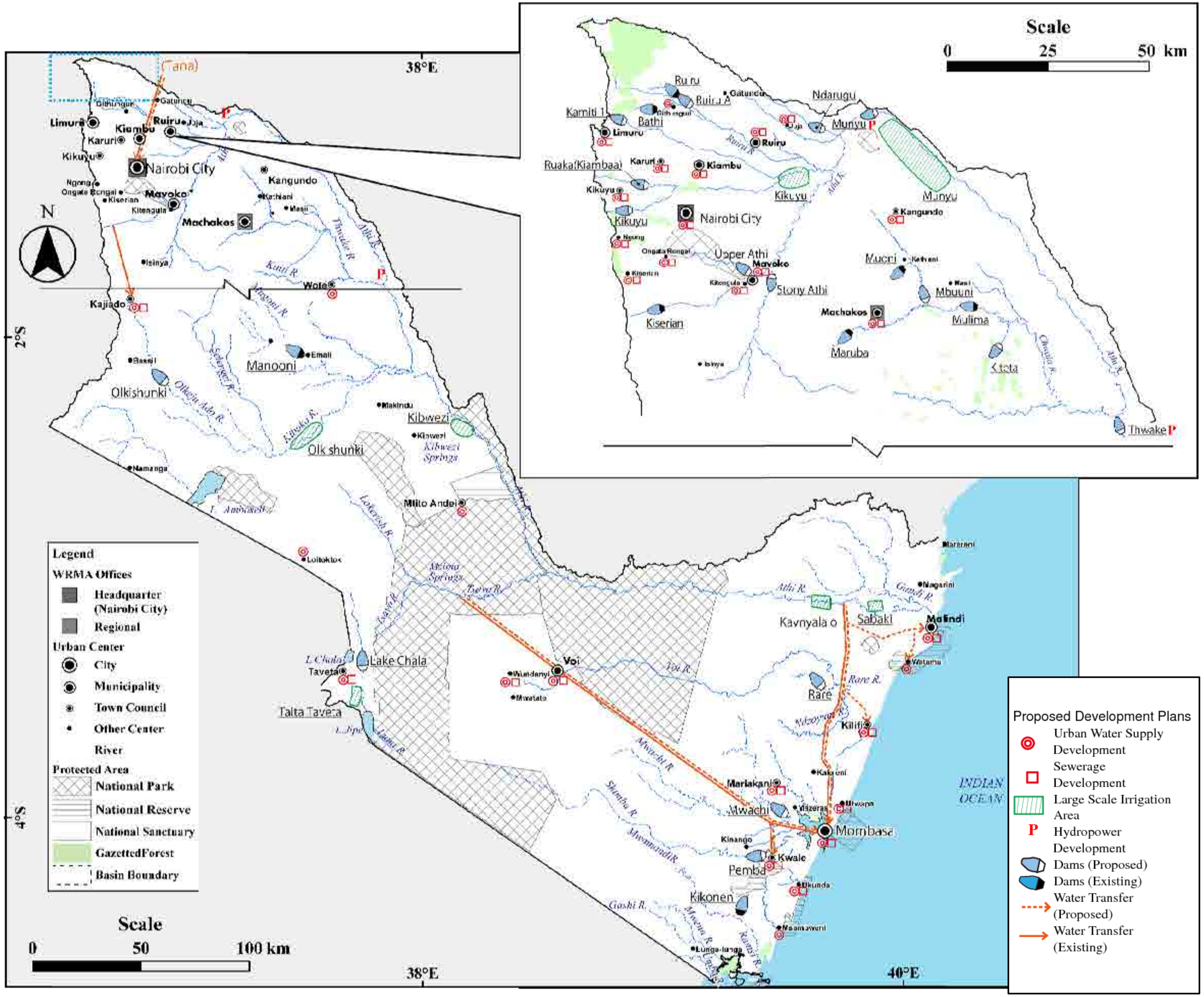
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 6.4.1 Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (LVSCA)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 6.5.1 Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (RVCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	

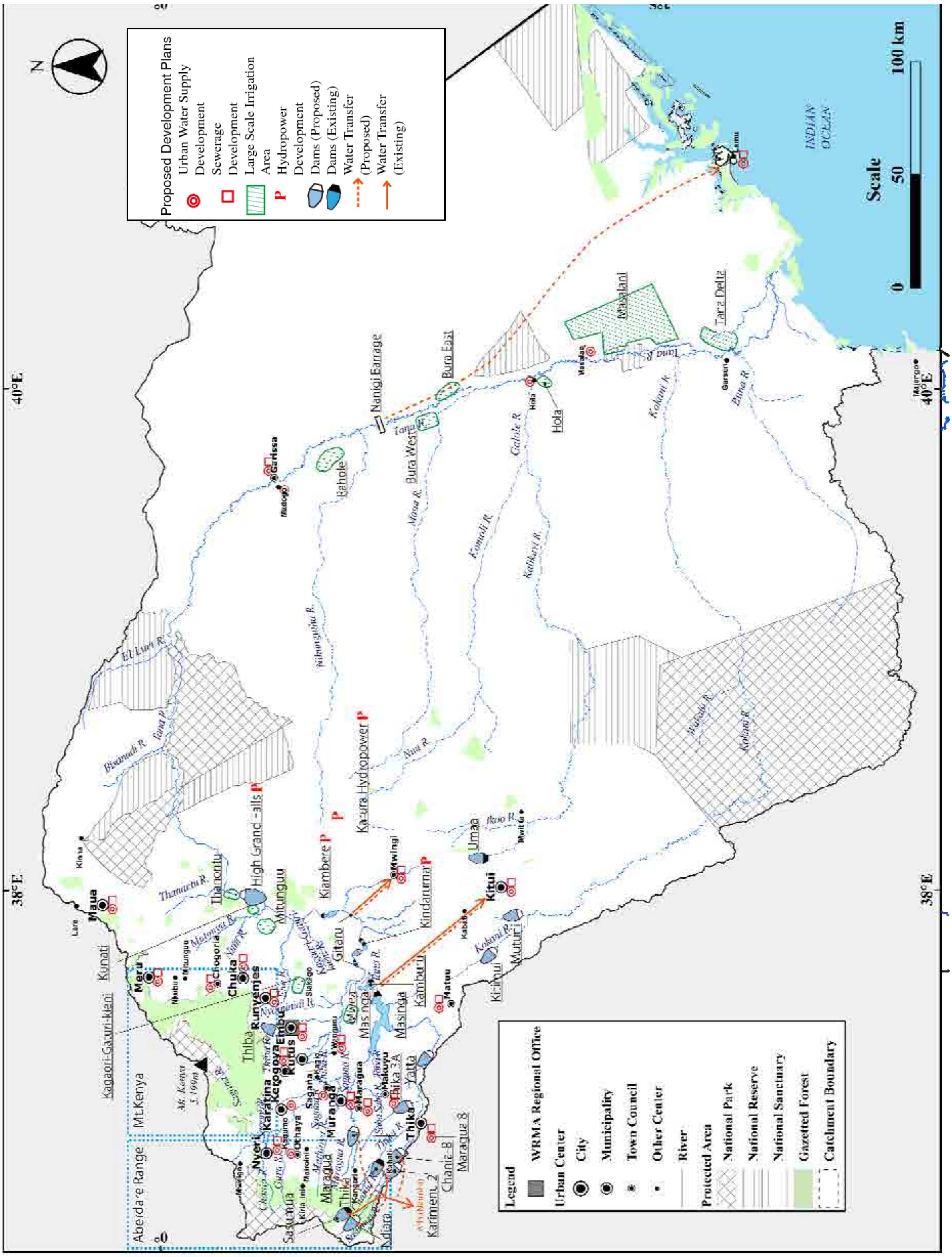


Source: JICA Study Team

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

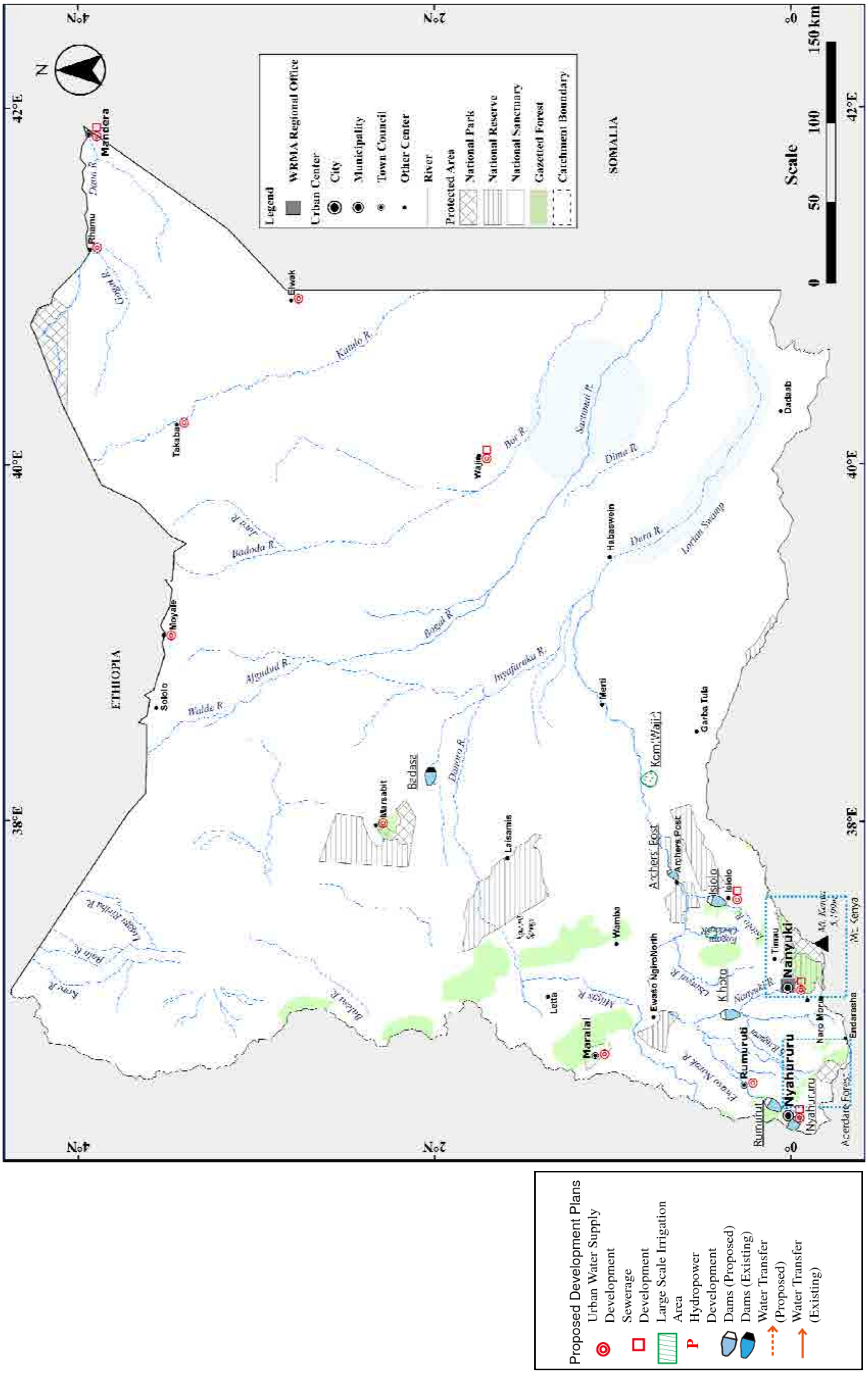
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 6.6.1
Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (ACA)



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 6.7.1** **Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (TCA)**
JAPAN INTERNATIONAL COOPERATION AGENCY	



Source: JICA Study Team

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	Figure 6.8.1 Locations of Proposed Development Projects by NWMP 2030 and Natural Environmental Resources (ENNCA)
JAPAN INTERNATIONAL COOPERATION AGENCY	

Sectoral Report (L) Institution

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

FINAL REPORT
VOLUME – VI SECTORAL REPORT (3/3)

L: INSTITUTION

Abbreviation

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Appendix 2.1 The Issues and Possible Solutions for Institutional Organization in Water Resources Management

List of Abbreviations and Acronyms

ALDEF	:	African Land and Development Organization
BWRB	:	Basin Water Resources Board
CAAC	:	Catchment Areas Advisory Committee
CB	:	Catchment Board
CoK	:	Constitution of Kenya
EMCA	:	Environmental Management and Coordination Act
GOK	:	Government of Kenya
IWRM	:	Integrated Water Resources Management
IWUA	:	Irrigation Water Users Association
JICA	:	Japan International Cooperation Agency
KEWI	:	Kenya Water Institute
MNR	:	Ministry of Natural Resources
MOA	:	Ministry of Agriculture
MOE	:	Ministry of Environment
MOWD	:	Ministry of Water Development
MWI	:	Ministry of Water and Irrigation
NCPC	:	National Conservation and Pipeline Corporation
NEMA	:	National Environment Management Authority
NIB	:	National Irrigation Board
NWCPC	:	National Water Conservation and Pipeline Corporation
NWMP	:	National Water Master Plan
NWRDP	:	National Policy on Water Resources Management and Development
NWRMS	:	National Water Resources Management Strategy
RBO	:	River Basin Organization
RWC	:	Regional Water Committee
SCMP	:	Sub-catchment Management Plan
WAB	:	Water Appointment Board
WAB	:	Water Appeal Board
WASREB	:	Water Services Regulatory Board
WDD	:	Water Development Department
WRA	:	Water Resources Authority
WRM	:	Water Resources Management
WRMA	:	Water Resources Management Authority
WRRA	:	Water Resources Regulatory Authority
WRUA	:	Water Resources Users Association
WSB	:	Water Service Board
WSP	:	Water Service Provider
WSRB	:	Water Service Regulatory Board
WSTF	:	Water Services Trust Fund

Abbreviations of Measures

Length

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

Area

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

Volume

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 Objective of Institutional Strengthening for Water Resources Management

The objective of institutional development is to strengthen the organizational and institutional capacity on water resources management (WRM) at the national and regional levels based on the national water resources development and management policy. This will ensure the implementation of the action plan up to the year 2022 of the National Water Master Plan (NWMP) to achieve the goals of the Kenya Vision 2030 as illustrated in the figure below.

The nation's present WRM was reviewed by addressing the following: i) legal aspects, ii) organizational aspects, and iii) financial aspects. The Study identified the present and future issues to be addressed so as to achieve the objectives of NWMP 2030.

Source: JICA Study Team

Objective of Institutional Development

1.2 Background on Reform of Water Resources Management

1.2.1 Reform of National Agencies for Water Resources Management Before 2002

Until 1964, the hydraulic branch of the Ministry of Public Works was responsible for water and sewerage development in the urban areas. Rural water development was one of the responsibilities of the African Land and Development Organization (ALDEF) of the Ministry of Agriculture (MOA). In 1964, the two organizations were amalgamated under the Ministry of Natural Resources (MNR) as the Water Development Department (WDD). The department was transferred to MOA in January 1968 and was then demoted as the Water Development Division (WDD) of the ministry. In 1974, the WDD was upgraded to become the Ministry of Water Development (MOWD) by taking over the responsibility of the Water Resource Authority in addition to other functions of the water department.

The three key institutions assigned to water resources development and management in the Water Act revised in 1972 were the Minister of MOWD, the Water Resources Authority (WRA), and the Water Apportionment Board (WAB) together with the Catchment Board (CB). The authority of the minister was to execute construction works according to the plans recommended by WRA. On the other hand, WRA had the mandate to execute planning and investigation of water resources of the nation with the support of the Regional Water Committee (RWC) under WRA. The WAB executed permission for water use and its construction works, monitoring water and riparian works. The authority of WRA did not function because the minister actually executed the duty of WRA. The MOWD exercised the development, conservation, and control of water until the enactment of the Water Act in 2002.

1.2.2 Revision of Water Act

The Water Ordinance had been enforced since 1927. The Water Act, which is the supreme law on water, was initiated in 1951 and was revised once more in 1972. The MOWD has recognised various deficiencies, contradictions, and constraints in implementing the act in actual undertaking of water development due to changes in the situations surrounding water development and use. The draft revision on the Water Act 1972 had been discussed with the Attorney General's chambers and the Cabinet in May 1992 when the draft final report of the study on NWMP was edited. The Sessional Paper No. 1 1999 on the National Policy on Water Resources Management and Development (April 29 1999) was enacted based on NWMP (1992). The Sessional Paper No. 1 1999 was the base law to enact the Water Act 2002 and to establish new organizations required for the specified water sector reform. The Water Act 2002 was enacted in October 2002. Its implementing rules, namely the Water Resources Management Rules 2007 was issued five year later.

CHAPTER 2 CURRENT SITUATION OF THE INSTITUTION

2.1 Existing Laws for Water Resources Management

2.1.1 Hierarchy of Laws in Kenya

The hierarchy of Kenyan laws starts with the Constitution, followed by Acts of the Parliament, rules and regulations, gazette notices, circulars, and by-laws.

Hierarchy of Laws

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

Source: JICA Study Team

2.1.2 Constitution and Acts Related with Water Resources Management

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

The Water Act 2002 provides principles and mandates for the regulation and management of water resources in the country. The Water Resources Management Rules 2007 provides detailed implementing rules of the Water Act. The key institutions established in the act are the minister of the Ministry of Water and Irrigation (MWI), the Water Resources Management Authority (WRMA), the Catchment Area Advisory Committee (CAAC), the Water Service Regulatory Board (WASRB), the Water Service Board (WSB), the Water Appeal Board (WAB) and the Water Services Trust Fund (WSTF). Main sections of the act are outlined as follows:

Section 3: Every water resources is vested in the state, subject to any rights of user granted by or under this act or any other written law;

Section 4: The minister of MWI shall have and may exercise control over every water resource in accordance with this Act assisted in discharge of his duties by Director of Water;

Section 7: The Water Resources Management Authority (WRMA) shall be a body with perpetual succession and a common seal and shall power in exercise and performance its power and functions,

Section 8: The WRMA shall have ten items of power and functions including: to develop principles, guidelines and procedures for the allocation of water resources; to monitor the national water resources strategy; and to regulate and protect water resources quality from adverse impacts;

Section 15: The WRMA shall formulate a Catchment Management Strategy for the management, use, development, conservation, protection and control of water resources within each catchment area;

Section 16: The WRMA shall, in consultation with the minister, appoint a Catchment Area Advisory Committee (CAAC) of not more than 15 members in respect of each catchment area;

Section 47: The Water Service Regulatory Board (WASREB) shall have 18 items of powers and functions including: to issue licences for the provision of water services; and to determine standards for provision of water services to consumers;

Section 49: The minister shall formulate, a National Water Service Strategy;

Section 55: A Water Service Board (WSB) may arrange for the exercise and performance of its power and functions under the licence of one or more agents as water service providers;

Section 83: Establish the Water Service Trust Fund to assist in financing the provision of water services to areas of Kenya which are without adequate water services; and

Section 85: Establish the Water Appeal Board (WAB) for the suit of any person having a right or proprietary interest and to hear and determine disputes.

Refer to the contents of the Constitution, the act and the water resources management rules in the section below.

The other acts related with the three main legal documents are the Agriculture Act, Forest Act, Land Act, Environmental Management and Coordination Act, Irrigation Act, Lakes and Rivers Act, Electric Power Act, Mining Act, Wildlife Act, Land Planning Act, Local Government Act, Fisheries Act, Public Health Act, Tana and Athi River Development Authority Act. Table 2.1.1 lists the water related acts, orders, and rules while Table 2.1.2 lists the water related policies and strategies in Kenya.

2.1.3 Composition of the Constitution, the Water Act, and the Management Rule

The composition of the Constitution, the Water Act, and the Management Rule is briefly discussed below.

<u>The Constitution</u>

The Constitution of Kenya is composed of a preamble containing 18 chapters, with 264 articles, and six schedules:

PREAMBLE	
Chapter One	Sovereignty of the People and Supremacy of this Constitution
Chapter Two	The Republic
Chapter Three	Citizenship

Chapter Four	Bill of Rights
	Part 1-General provisions relating to the Bill of Rights
	Part 2-Rights and fundamental freedoms
	Part 3-Specific application of rights
	Part 4-State of emergency
	Part 5-Kenya National Human Rights and Equity Commission
Chapter Five	Land and Environment
	Part 1-Land
	Part 2-Environment and natural resources
Chapter Six	Leadership and Integrity
Chapter Seven	Representation of the People
Chapter Eight	The Legislature
Chapter Nine	The Executive
Chapter Ten	Judiciary
Chapter Eleven	Devolved Government
	Part 1-Objects and principles of devolved government
	Part 2-County governments
	Part 3-Functions and powers of county governments
	Part 4-The boundaries of counties
	Part 5-Relations between governments
	Part 6-Suspension of county governments
	Part 7-General
Chapter Twelve	Public Finance
Chapter Thirteen	The Public Service
Chapter Fourteen	National Security
Chapter Fifteen	Commissions and Independent Offices
Chapter Sixteen	Amendment of this Constitution
Chapter Seventeen	Transitional and Consequential Provision
First Schedule	Counties
Second Schedule	National symbols
Third Schedule	National oaths and affirmations
Fourth Schedule	Distribution of functions between national and the county governments
Fifth Schedule	Legislation to be enacted by the parliament
Sixth Schedule	Transitional and consequential provisions

<u>The Water Act 2002</u>

The Water Act No.8 of 2002 was assented on October 17, 2002. It is an act of parliament to provide for the management, conservation, use and control of water resources and the acquisition and regulation of rights to use water; to provide for the regulation and management of water supply and sewerage services; to repeal the Water Act (Cap 372) and certain provisions of the Local Government Act; and for other related purposes. The act is composed of six parts with 114 sections and five schedules:

Part I- Preliminary- Section 1	
Part I- Introductory- Section 2	
Part II- Ownership and Control of Water- Sections 3 to 6	
Part III- Water Resources Management	
	The Water Resources Management Authority- Sections 7 to 10
	Water Resources Management Strategies- Sections 10 to 18
	Public Works for Water Use- Sections 19 to 24
	Water Rights and Works- Sections 25 to 43
	Ground Water- Sections 44 to 45
Part IV- Water Supply and Sewerage	
	Water Services Regulatory Board- Sections 46 to 48
	Water Supply and Sewerage Strategies- Sections 49 to 50
	Water Service Boards and Water Service Providers- Sections 51 to 55
	Provision of Water Services- Sections 56 to 69
	Power and Duties of Licensees- Sections 70 to 78
Part V- Financial Provisions- Sections 79 to 83	
Part VI- General and Supplemental	
	The Water Appeal Board- Sections 84 to 88
	Entry on to Land- Sections 89 to 93
	Miscellaneous- Sections 94 to 110
	Repeals, Savings and Transitional Provisions- Sections 111 to 114
First Schedule	Membership and Procedure of Boards and Committees
Second Schedule	Conditions Relating to Construction of Works
Third Schedule	Easements
Fourth Schedule	Abstraction of Groundwater
Fifth Schedule	Membership and Procedure of Water Appeal Board

The Water Resources Management Rules, 2007

The minister for water and irrigation made the Water Resources Management Rules 2007, Legal Notice No. 171, which is conferred by Section 110 of the Water Act 2002. The management rule is composed of thirteen parts, with 154 rules and twelve schedules.

Part I- Preliminary- Sections 1 to 15
Part II- Approval, Authorization and Permit- Sections 16 to 48
Part III- Surface Water- Sections 49 to 71
Part IV- Groundwater- Sections 72 to 80
Part V- Water Quality Monitoring and Effluent Discharge- Sections 81 to 92
Part VI- Works- Sections 93 to 95
Part VII- Conditions of Authorization, Permits and Approved Water Uses- Sections 96 to 103
Part VIII- Water Used Charges- Sections 104 to 115
Part IX- Conservation of Riparian and Catchment Areas- Sections 116 to 120
Part X- Catchment Management Strategies- Sections 121 to 122
Part XI- Protected Areas and Groundwater Conservation Areas- Sections 123 to 126
Part XII-The Reserve- Sections 127 to 129
Part XIII: Miscellaneous- Sections 130 to 154

First Schedule	Fees and Charges (Rules 13, 26, 37, 45, 70, 80, 90, 104, 135, and 144)
Second Schedule	Technical Reports (Rules 27, 64, 66, 68, 72, 85, 120, and 121)
Third Schedule	Guideline Standard for Effluent Discharge (Rule 81)
Fourth Schedule	Details of Storage Dams (Rules 56, 57, 58, 59, and 61)
Fifth Schedule	Water Use and Permit Details (Rules 16, 22, 24, 42, and 77)
Sixth Schedule	Protection and Conservation of Riparian and Catchment Areas (Rules 118, 120, and 123)
Seventh Schedule	Response to Violation of the Reserve (Rule 129)
Eighth Schedule	Qualified Water Resources Professionals and Qualified Contractors (Rules 130 and 141)
Ninth Schedule	Emergency Orders (Rule 151)
Tenth Schedule	Format for Report on Complaints (Rule 5)
Eleventh Schedule	Water Quality Sampling Procedures (Rule 91)
Twelfth Schedule	List of Forms and Registers

2.2 Existing Institutional Framework in Water Sector

2.2.1 Institutional Framework Under Water Act 2002

The existing representation of the institutional framework of the water sector under MWI is illustrated in Figure 2.2.1. Under the Water Act 2002, the water resources management comprises two pillars: the regulation of water resources, and the regulation of water supply and sewerage services. The regulation of water resources is mainly the allocation and enforcement of water rights, while the regulation of water supply and sanitation is mainly the regulation and monitoring of water supply service providers. The MWI is composed of departments of water services, namely; Department of Irrigation, Drainage and Water Storage; Department of Land Reclamation and Head of Donor Coordination; and Department of Water Resources. The organogram of MWI is shown in Figure 2.2.2.

The roles and responsibilities of the MWI include the following: development of legislation, policy formulation, sector coordination and guidance, monitoring and evaluation. The WRMA, which comprises the head office and its regional offices, is a regulatory body for the planning, regulation and management of water resources, and contribution to policy formulation at the national and regional levels. The WRMA is under the jurisdiction of MWI. The CAAC is an advisory body to WRMA for the regulation of water resources issues at the regional level. The sub-regional offices of WRMA provide WRM services at catchment level under the regional offices of WRMA. The functional organization structure of WRMA is shown in Figure 2.2.3. The functional organizational structure of WRMA at the regional level is shown in Figure 2.2.4. The water resources user’s associations (WRUAs) are local bodies set up by water resources users to enable communities and water users/consumers to participate in water resources management.

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

The Water Service Trust Fund (WSTF) is a financing provision of water supply and sanitation to disadvantaged groups. The Water Appeal Board (WAB) is a resolution body for the arbitration of water-related disputes and conflict. The National Water Conservation and Pipeline Corporation (NWCPC) is responsible for the construction of dams and drilling of boreholes. The Kenya Water Institute (KEWI) is responsible for the water-related training and researches. The National Irrigation Board (NIB) is a regulatory body for the development of irrigation infrastructure. In Figure 2.2.1, the relationship among NIB, irrigation services provision at the regional and local level and Irrigation Water User Associations (IWUAs) is not included.

The roles and responsibilities of the WRMA, WASREB, WSBs, and WRUAs are compared in the following table:

Roles and Responsibilities of Regulatory Bodies

WRMA	WASREB
• Planning, management, protection, and conservation of water resources • Planning, allocation, apportionment, assessment, and monitoring of water resources • Issuance of water permits • Water rights and enforcement of permit conditions • Regulation of conservation and abstraction structures • Catchment and water quality management • Regulation and control of water use • Coordination of the IWRM Plan	• Regulation and monitoring of Water Service Boards (WSBs) • Issuance of licenses to WSBs • Setting standards for the provision of water services • Developing guidelines for water tariffs
WRUAs	WSBs
• Involvement in decision making process to identify and register water users • Collaboration in water allocation and catchments management • Assisting in water monitoring and information gathering • Conflict resolution and cooperative management of water resources	• Responsible for efficient and economical provision of water services • Developing water supply facilities • Applying regulations on water services and tariffs • Procuring and leasing of water supply and sewerage facilities • Contracting WSPs

Source: Adopted from Section 2 (pp 13-14) of National Water Resources Strategy 2007-2009, MWI

2.2.2 WRMA Roles and Functions

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

The role and functions of the WRMA are to:

- Regulate and protect water resources from adverse impacts;
- Delineate catchment areas for gazettement;
- Identify with stakeholders protected areas for gazettement;
- Liaise with other bodies for better management and regulation of water bodies;
- Monitor and enforce conditions attached to water permits and water use;
- Regulate water infrastructure, use, and effluent discharge;
- Develop principles, guidelines and procedures for the allocation of water;

- Manage and protect water catchments;
- Formulate catchment management strategies;
- Manage and conserve water resources;
- Declare state and community schemes;
- Coordination with other bodies for early warning, preparedness, and mitigation measures against water related disasters such as floods and droughts;
- Advise the minister with respect to water resources management;
- Determine and collect charges for water use;
- Seek legal address with consent of the attorney general in case of contraventions;
- Constitute CAACs and support WRUAs;
- Establish water resources monitoring networks;
- Collect, analyse, collate, and disseminate water resources information; and
- Encourage stakeholder participation in water resources management including resilience to water related disasters such as floods and droughts.

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

The roles and functions are not the same as the table shown in Section 2.2(1).

2.3 Key Issues in National and Regional Institutional Framework

2.3.1 Direction of Reform

The main thrust of the reform is to separate WRM and development from water services delivery. This would focus MWI's role on policy formulation, implementation and monitoring while leaving the detailed regulation to a number of parastatal bodies who report to boards that represent the different stakeholder interests (refer to Section 4 of the National Water Resources Management Strategy 2007-2009, MWI, and Section 2.2 of Strategic Plan 2012-2017, WRMA 2012). The provision of water services by water service providers, both from the private and NGO sectors, must be market-oriented.

In 2011, the weight of the WRM and water supply services delivery shifted from the national government to the county governments based on the Constitution. The WRMA regional offices, sub-regional offices, and WRUAs will play more significant roles in each catchment in the WRM. A unified and consistent legal and institutional framework of the state is the basis of executing the national and local policies and strategies.

2.3.2 Existing Issues Identified by Interview Survey

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

1) Low level of implementation of water resources management,
2) Low enforcement of law,
3) Serious deficiency in legal provisions,

4) Insufficient functions of organizations concerned,
5) Insufficient amount of financial and human resources, and
6) In adequate allocation of financial and human resources at national and regional level.

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

In the Republic of Kenya mandates and responsibilities of the national government and sector agencies are governed by laws and regulations. However, the authority and responsibility for sector policymaking, planning, regulating, implementing and monitoring of projects are severely fragmented, spreading across different government tiers and various national government agencies. This issue might be related with the issue items 2, 3 and 4. The fragmentation might be partly induced by frequent rationalization or reform of the water sector, the policy of decentralization and severe shortage of government funds and other resources.

The results of the interview survey are presented as common problems and needs faced at the regional and sub-regional levels. Actual response records of the six regional offices are shown in Appendix 2.1.

<u>Legal Issues</u>

a) How to clarify the conflicting roles of regulators, service providers, and water users.
b) How to harmonise the conflicting acts in their operations with Water Act 2002 which include the Agriculture Act, Forest Act, Land Act, and EMCA 1999, where the conflicting mandates of those acts were never repealed.
c) How to strengthen the capacity to enforce the regulations where prosecution capacity is a key to enforcement.
d) How to facilitate the role of counties to be accommodated in the regions in terms of representation in CAAC to assist conflict management between counties.
e) How to facilitate the law to effectively recognise the representatives of WRUAs as catchment forums with mandates for policy and coordination of catchment issues like flood, drought and conservation.
f) How to implement the projects at the strategic storage sites to regulate water flow all year round, where strengthening of the mandate of WRMA to determine water storage (both the state and private) is necessary.
g) How to exercise water resources assessment and water rights to manage demand which must be addressed, where there is no direct incentive for water users to legalise water use.
h) How to clarify the function of water quality management, where management conflict prevails between the National Environmental Management Authority (NEMA) and WRMA.
i) How to further clarify the mandates, roles, and responsibilities for all levels established in law without conflicting with other laws, where there is no need for reorganization.
j) How to setup the legal position for catchment forum, where:
    i) WRMA-Tana considers it as an umbrella forum for WRUAs, which the envisaged function is to determine policy direction and coordination, mobilization and

allocation of resources at the regional level for conflict and disaster management; and

ii) There is a need for the forum to have two or more catchments to discuss inter-basin transfer, then share information and experiences, e.g., Tana and Athi.

<u>Organizational Issues</u>

a) How to increase the number of the sub-regional offices for effectiveness exercise, where:
   i) The current level of organizations is adequate as long as the mandates of WRUAs are fully established by law; and
   ii) WRUAs are keys in water resources management, and must be facilitated and empowered to undertake their mandates.

b) How to empower the present organization of WRMA, which includes the headquarters for policy and regulation, regional offices for coordination, sub-regional offices for implementation, and WRUAs to assist in the implementation, where:
   i) Human resource allocation should ensure that the majority of technical staff are at the sub-regional level and, if possible, technical assistance availed;
   ii) Inter-regional coordination is insufficient at present. The catchment forum set at the regional level may function as a basis for an inter-regional forum. It will assist CAACs in their mandates; and
   iii) Coordination among stakeholders (the national government, local governments, national sector agencies, and other stakeholders) is not functioning well in which different mandates and programs of the national agencies overlap.

<u>Financial Issues</u>

a) How to allocate water resources management budget for the implementation of conservation activities, information gathering and sharing, and training of staff of WRUAs, where the operation and maintenance budget of the regional offices is insufficient.

b) How to diversify the sources of funds for WRMA directly from government revenues, donor funds and beneficiary contributions, other than funding based on the WRMA revenue only.

c) How to ensure the timely release of budget funds.

2.3.3 Key Issues for the Future

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

Isssue-1: How to set up Comprehensive Water Resources Management Institution

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

a) How to clarify conflicting role of regulators, service providers and water users at both the national and regional (catchment) level,

b) How to harmonise the conflicting Acts in their operations with Water Act of 2002 which include Agriculture Act, Irrigation Act, Forest Act, Land Act, and EMCA 1999 where the conflicting mandates of those Acts were never repealed,

c) How to strengthen the capacity to enforce the regulations where prosecution capacity is a key to enforcement,

d) How to facilitate the law to effectively recognise the representatives of Water Resources Users Associations (WRUAs) as catchment fora (forums) with mandates for policy and coordination of catchment issues like water uses, flood and conservation.

e) How to clarify the function of water quality management, where management conflict prevails between National Environmental Management Authority (NEMA) and WRMA,

f) How to make clearer the mandates, roles and responsibilities for all levels established in law without conflicting with other laws, where there is no need of reorganization,

Issue-2: How to Regulate Inter-national, Inter-catchment and Multi-sector Issues

The CoK 2010 allocates the function of the use of international waters and water resources to the National Government (The Fifth Schedule of item 2 of Part 1- National Government). However the following mandates of water resources administrator (the Minister in charge) are not well defined in Water Act 2002.

a) Administration and regulation of water uses in the international/shared rivers,

b) Regulation of inter-catchment and inter-sub-catchment water transfer (inter-catchment water rights regulation),

c) Inter-sector/ministerial coordination (multi-sector water uses, flood control, water environment, multi-purpose dams),

d) Regulation of water uses and development from both supply side and demand side management, and

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

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

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

Issue-3: How to set up Quantitative Water Rights Allocation and Regulation

Grant of new surface water rights will require construction of many new dams in the water stress areas in the future to avoid significant reduction of water supply security/guarantee level. There is no quantitative water rights management system considering regional water supply security level which is widely adopted in advanced industrialised countries. The present institution also does not require formulation of scientific and quantitative Basin Water Resources Development Plans. Scientific and quantitative Basin Water Resources Development Plans will be required soon to achieve credible, transparent and accountable regulation and enforcement of water rights. The existing six Catchment Area Water Resources Management Strategies does not include any scientific and quantitative Basin Water Resources Development Plan. WRMA has no experience to formulate scientific and quantitative basin water resources development plans.

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

Issue-4: How to achieve Transparent and Scientific Management of Water Resources

Present data bases of the WRMA Regional offices are not sufficient to implement quantitative management of water rights. How to use effectively the present three components of regulation, monitoring, and data and information management system for grant of water use permits, monitoring of discharge and abstraction records, and regulation of water rights.

Issue-5: How to set up Water Saving Society and Economic Structure for the Future

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

Issue-6: How to Strengthen Capacity of WRMA Regional Offices as RBOs

The WRMA Regional Offices, which correspond to River Basin Organizations (RBOs), are facing at increasing water resources management issues on site, provided with limited personnel and technical capacity. The prevailing issues include:

a) How to increase the number of the sub-regional offices for effectiveness exercise, where

- Current level of organizations are adequate as long as the mandates of WRUAs is fully baked by law, and
- WRUAs are a key in water resources management and must be facilitated and empowered to undertake their mandates,

b) How to capacitate the present organization of WRMA which includes headquarters for policy and regulation, regional offices for coordination, sub-regional offices for implementation and WRUAs to participate in the implementation, where

- Human resource allocation should ensure majority of technical staff are at the sub-regional level with appropriate technical assistance,
- Catchment forum set at regional level may function as basis for an inter-regional forum, where inter-regional coordination is not sufficient at present, and
- Coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) is not functioning well where different mandates and programs of national agencies overlap.

Issue-7: How to Consolidate Legal Position of WRUAs

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

How to setup the legal position for catchment forum, where there is need for the forum for two or more catchments to discuss inter-basin transfer then share information and experiences e.g. Tana and Athi.

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

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

a) How to allocate water resources management budget for implementation of conservation activities, information gathering and sharing and training of staff of WRUAs, where the operation and maintenance budget of the regional offices is not sufficient,

b) How to diversify sources of funds for WRMA direct from the government revenue, donor funds and beneficiaries contribution other than funding based on WRMA revenue only, and

c) How to ensure the budget funds are released timely.

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

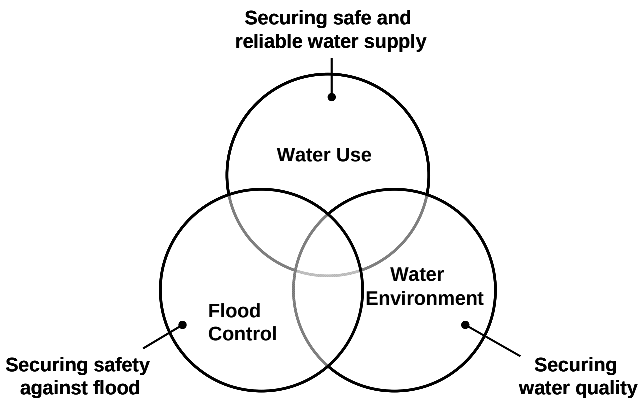
CHAPTER 3 INSTITUTIONAL STRENGTHENING PLAN

3.1 Framework of Water Resources Management

3.1.1 Mission of IWRM

The mission of Integrated Water Resources Management (IWRM) adopted in Agenda 21 (Chapter 18) aimed mainly to manage the whole water environment by a river basin unit, and to develop relevant water codes and concerned administrative organizations. The mission that covers the three attributes; water use, flood control, and water environment illustrated in the figure below has been widely acknowledged both in developed and developing countries.

The key management elements of IWRM are: i) securing safe water supply to various uses; ii) securing water quality for sanitation and ecology (effluent control and wastewater treatment); and iii) securing safety against flood (flood control). The mission aims to integrate the three key interactive elements, water, land, and environment, in forming a broad aspect of sustainable development for the long-term. Its key management elements also cover soil erosion, compound pollution, preservation of watersheds and habitats, irrigation and drainage issues. In Kenya, of which lands are mostly in arid and semi-arid, the water resources management is still at the stage of covering the key interactive water elements: surface water and groundwater for water use, water quantity and water quality. Flood control is still at its starting point.



Source: JICA Study Team

Mission of Integrated Water Resources Management

The IWRM concept at any level is made functional, providing it with an essential support system of monitoring and database systems for scientific and equitable coordination and management.

3.1.2 Principles of WRM

The JICA Study Team takes into consideration the three principles of WRM defined by the Japan Water Forum, as follows:

a) To take the nature into consideration together: by integration of water resources, land, water quantity and quality, surface and groundwater from all aspects of the hydrological cycle;

b) To take various water-related sectors into consideration together: by integration of various management institutions of water uses (domestic water supply, sewerage, agricultural water, industrial water, fishery, hydropower, navigation, tourism, environmental/ecological water, etc.); and

c) To accommodate participation of various stakeholders: by participatory approach of all levels of stakeholders (national and local governments, private sector, residents, NGOs, etc.) with consideration of gender and socially disadvantaged groups

3.1.3 Sector Framework of WRM and Policy Measures

Though water use management is the main trunk, a comprehensive approach of WRM has been envisaged in the Republic of Kenya. Among the three key management components of WRM, the MWI and WRMA exercise its jurisdiction over water use and flood control. NEMA exercises its jurisdiction over the management of water environment (water quality and aquatic ecology), including watershed management under the Ministry of Environment (MoE). The jurisdiction of flood control by MWI or WRMA is not clear under the Water Act 2002. Catchment protection is under WRMA according to the Water Act 2002, but it is not clear if the protection includes flood control. Meanwhile, watershed management is part of catchment protection.

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

The WRM framework will take into consideration the present and future needs of various water-related sectors, the policy and non-policy measures and requirement, alternative measures, and appropriate balance of policies and measures. WRM covers drought regulation and flood management, but it excludes drought and flood disaster management. The Study drafted approximately the water sector framework as illustrated in Figure 3.1.1 because the present sector framework is not clear at various management components.

3.1.4 Supply Side and Demand Side Water Resources Management

The development of huge amounts of new surface and ground water sources will be required to achieve the goal of the Kenya Vision 2030. In particular, the expansion policy of irrigation areas will require the construction of large-scale dams, inter-catchment surface water transfer, and development of groundwater; but these might induce conflicts due to water rights allocation. Water shortage issues will not be resolved by the supply-side management (development of new water sources) only. This will also require appropriate demand-side management (water saving, recycle, reduction of loss, etc).

Alternative policies and planning measures in the WRM are illustrated in the following table (upper) for agricultural water use, and in the following table (lower) for domestic and industrial water use, as an example. The appropriate combination of supply-side management and demand-side management is envisaged in water use management particularly for irrigation, and domestic and industrial water supply. Alternative measures of the supply-side and demand-side are also listed for review and discussion in the upper table for agriculture, and the lower table for domestic and industrial water.

Alternative Policy and Planning Measures for Agricultural Use

Agricultural Water Use			
Needs of Water Uses	Policy Measures and Requirement	Supply Side Measures	Demand Side Measures
Effective use of agricultural lands and higher agricultural production with water requirement	Water resources allocation for agricultural use with harmony among all the water-related sectors	Structural Measures S1: Dam Option (large and small) S2: Non-dam Option -Natural river water by weirs, intakes and pumping stations -Groundwater pumping -Desalination of seawater	Structural Measures D1: Improvement of water conveyance facilities (lined canals, earth canals, and pipelines) D2: Improvement of water diversion facilities (turnouts with and without measuring device, and check gates) D3: Improvement of water use efficiency (drip irrigation, water saving farming, green house, etc.)
Target agricultural water demand (m^3)	Improvement of water management skills so as to operate within the allocated future amount	Non-Structural Measures S3: Proper operation of water source facilities for efficient supply	Non-structural measures D4: Institution for water use rights, pricing of irrigation water, and provision of incentives for water saving farming D5: Improvement of water management practices (water saving, and training of operation and farming)

Source: JICA Study Team

Alternative Policy and Planning Measures for Domestic and Industrial Water Supply

Domestic and Industrial Water Use			
Needs of Water Uses	Policy Measures and Requirement	Supply Side Measures	Demand Side Measures
Water use and supply plan at the target years	Achievement of the target service coverage (%), and supply security Q90 for domestic water and Q80 for irrigation water. Water use priority for domestic water is higher than irrigation.	Structural Measures S1:Dam Option (large/small) S2: Non-dam Option -Natural river water by weirs, intakes and pumping stations -Groundwater pumping -Rain water use -Desalination of seawater	Structural Measures D1: Improvement of water conveyance facilities (ducts and pipelines) for leakage reduction D2: Reduction of leakage in distribution pipeline networks D3: Improvement and rehabilitation of treatment facilities
		Non-structural Measures S3: Proper operation of water source facilities for efficient supply	Non-Structural Measures D4: Efficient unaccounted for water (UFW) reduction D5: Improvement of water pricing D6: Water saving (recycling and water saving consciousness) D7: Institution for re-allocation of water rights between agricultural and other uses
Safe and reliable bulk water for domestic and industrial water use (quantity and quality)	Assure the sufficient safe water for people as human right	Structural Measures S4: Rehabilitation of existing facilities and construction of new facilities S5: Provision of domestic sanitation and sewerage facilities	Non-structural Measures D8: Regulation and enforcement of effluent discharges D9: Enhancement of zero-effluent production factories D10: Provision of watershed preservation measures

Source: JICA Study Team

3.1.5 Lessons Learned from Experiences in Past Water Sector Reform

NWMP 1992 had been considered to be a policy guide and milestone for the implementation of comprehensive water resources development in the Republic of Kenya. However, it is reported that majority of the water sector projects proposed in NWMP 1992 have not yet been materialised, mainly due to financial constraints and partly due to institutional weakness of the Government of Kenya (GOK).

NWMP 1992 identified that the low level of implementation and enforcement of the law had been the primary issues, rather than any serious deficiencies in the legal provisions with reference to the Study and National Programming of Community and Rural Water Supply, Sewerage and Water Pollution Control; Report No.6-Water Legislation, 1973.

3.2 Strategy of Institutional Strengthening

3.2.1 Progress of Aligning Water Act 2002 with Constitution of Kenya

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

Schedule of the Water Act Bill is delayed though the revision should have been completed within 18 months according to the Fifth Schedule, Legislation on Land (Article 68 of CoK). Water resources are part of land (river, lakes and other water bodies) in CoK 2010[1].

The key three documents required for the revision are as follows:

i) New National Water Policy 2012;
ii) Draft Water Bill 2012 (new Water Act); and
iii) Concept Paper for Aligning Water Act 2002 by Task Force (Chairman Professor Mumma).

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

The content of the final draft proposal of the concept paper by the task force was simplified and focused on the articles of revision which are required by CoK. The contents of the Draft Water Bill 2012 (updated last March 2012) covers also an extensive reform not directly related to the required alignment by CoK 2010. The concrete power and functions of the organizations for WRM have not been consolidated yet.

The main revision of the Draft Water Bill 2012 covered briefly the following:

- Focus on reform of water supply and sanitation service;

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

- The power and functions of present organizations are transferred to new organizations. For example, the WRMA to the Water Resources Regulatory Authority (WRRA); the WRMA Regional Offices to the Basin Water Resources Boards (BWRBs); the National Water Conservation and Pipeline Corporation to the National Water Storage Authority; the Water Services Regulatory Board to the Water Services Regulatory Commission; the Water Service Trust Fund to Water Sector Trust Fund Authority; the Water Services Boards to the Water Works Development Boards; the Water Service Providers to the County or the Cross-County Water Service Providers; and Water Appeals Board to the Water Tribunal;
- The power and functions of the national government to regulate water resources as the national assets are clarified: the relation of the power and functions of national apex body of water resources (the WRRA), and the power and functions of the regional river basin organizations (BWRBs) are well defined; and
- Comprehensive WRM is not well defined; for example, irrigation water use is not well delineated under WRRA.

Facilitation and operation of WRUAs as fora in conflict resolution and co-operative management of water resources in catchment areas (Article 15 (5) of the Water Act 2012) is not well reproduced in the Draft Water Bill 2012, Article 16.

The power and functions of flood management by the national and county governments are not well defined, such as the planning and implementation of flood control (design, construct and operate and maintain flood control facilities).

The draft of the National Water Policy 2012 was also subjected to further elaboration by the end of January 2013.

3.2.2 Strategy

(1) Assumption

Strategy of the institutional strengthening on WRM is drafted based on the following assumptions:

- Sessional Paper No.1 on National Policy on Water Resources Management and Development 1999 (NWRDP 1999) is effective as of end of January 2013; and
- The WRM framework stipulated in the Water Act 2002 is effective as of end of January 2012.

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

(2) Strategy

Strategy components are formulated at the national level for each of the key issues identified in Section 2.3.3 as follows:

1) Clarify the integrated framework of WRM at both the national and regional (catchment) levels in terms of regulation, service provision, and water users;
2) Establish monopolistic and unified regulatory functions of water resources at the national level (WRMA) and regional level (WRMA regional offices) for the regulation of inter-basin and sub-basin water transfer, equitable and sustainable allocation of water rights in terms of national and regional interests;

3) Establish unitary management of water rights and basin water resources development plans in line with grant of water use permit;
4) Establish scientific and quantitative WRM to achieve credible, transparent, and accountable regulation as well as the enforcement of water rights;
5) Enhance both supply and demand management to achieve the target of water supply security, and efficient, beneficial and sustainable water uses;
6) Strengthen the capacity of WRMA regional offices for scientific and quantitative water rights regulation at site being consistent with the national level regulation and enforcement. The WRMA regional offices correspond with different river basin organizations (RBOs);
7) Enhance the establishment of WRUAs and strengthen the capacity of WRUAs as fora in conflict resolution and cooperative management of water resources in catchment areas; and
8) Improve the financial capacity for water resources management institution at national and regional levels trough effective government financing.

3.3 Strategic Actions

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

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

The Water Act 2002 distinctively reflects on the historic and political background of water supply services in Kenya, where large water users such as irrigation and hydropower are still at the starting stage. The concept of IWRM is at initial level. Functions stipulated in the Water, Land, Irrigation, and Environmental Management and Coordination Acts, etc., are still duplicated or inconsistent.

Therefore, the WRM framework is still not comprehensive.

For example, the regulation on irrigation water services is not included in the present sector framework of WRM in Kenya because it is regulated by the Irrigation Act. Regulation of irrigation and drainage services is one of the main pillars of WRM. In reality, irrigation water services will be conducted as illustrated in Figure 3.3.1.

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

(2) Strategic Action-2: Establish A Monopolistic and Unified Regulation of Water Resources at National and Regional Levels

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

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

The natural resources including water resources are assets of the state under the Constitution of Kenya 2010 and the Water Act 2002. The two laws indemnify the national government to manage the water resources both at the national and regional levels under one unified rule, which is a very valuable institution. There is no inconsistency with the Constitution with respect to executing unitary regulation of water resources both at the national and county levels from policy-making to coordination.

Some countries such as Malaysia and Australia have not yet achieved the unitary management of water resources by the national government despite their historic efforts.

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

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

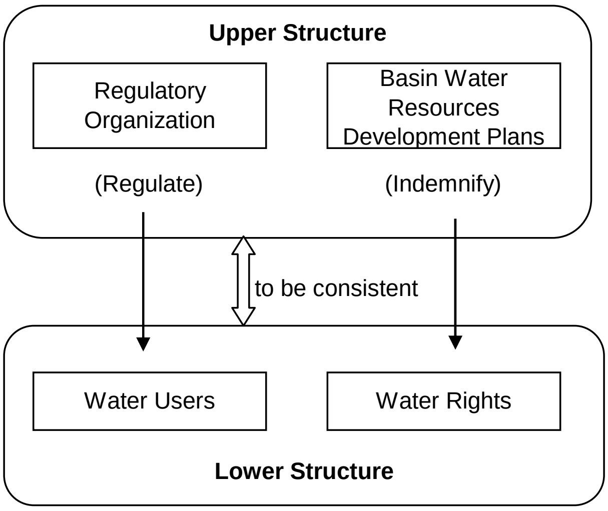
Strategic Action-3 proposes the establishment of unitary regulation and enforcement of water rights, which links the grant of all water permits with river basin water resources development plans which are widely adopted in advanced industrialised countries. The water permit registers all water abstraction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

Water rights regulation is a conflict management and resolution between human rights and equity (personal and regional). Equal opportunity to access safe water as a basic human need is the domestic water supply commitment to the poor and socially weak. It is also concerned with equal access and poverty orientation of the Millennium Development Goal. Regional equity requires the nation to re-allocate safe water not equally distributed geographically and to address the conflict between national and regional interests relating to regional income disparity.

Water rights institution is composed of the upper and lower structures as illustrated in the figure below. The upper structure is composed of regulatory organizations and river basin water resources development plans. The lower structure is composed of water users and water rights. The apex regulatory organization manages both the upper and lower structures and water uses. The river basin water resources development plans to guarantee water rights and also support regulation of water users together with the water rights. The upper structure is deliberately and generally under the jurisdiction of the national and regional governments[2].

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

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



Source: Sambongi (2005)

Upper and Lower Structure for Water Rights Regulation

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

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

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

1) Grant of water use permits and their monitoring records of database;
2) Monitoring of discharge and abstraction records and their database; and
3) Regulation of water rights and drought regulation linked with the relevant Basin Water Resources Development Plan and their database.

Strategic Action-3 and Strategic Action-4 provide basis for Strategic Action-2 in establishing a monopolistic and unified regulation of water resources at the national and regional levels.

Strategic Action-4 would be implemented in two stages:

Stage-1:

Each WRMA regional office, with consultation from the WRMA head office, executes the scientific and quantitative WRM. This integrates the foregoing components of regulation, monitoring and corresponding data system as a trial by the use of each of the six Catchment Water Resources Development Plans of NWMP 2030 which is scheduled to be completed by the Study in the first quarter of 2013. The six Catchment Water Resources Development and Management Plans of NWMP 2030 were all prepared based on the scientific and quantitative water demand and supply balance models. Hot spots of water demand and supply sites are modeled in each quantitative river and sub-river basin system diagrams. The NWMP 2030 nationwide policy models and plans are rather macroscopic, but can be applied as trial operation models for the basin and sub-basin water rights allocation with moderate accuracy.

During the trial period, an extensive capacity development will be necessary to the respective staff of the WRMA regional and sub-catchment offices.

Before this trial, national strategic catchment areas or river basins shall be identified, and the trial program shall be executed to the selected strategic catchment areas or river basins with the highest priority.

Stage-2;

After the capacities of the WRMA and the selected WRMA regional offices have been assessed to be sufficient enough to execute the specified scientific and quantitative WRM, the stage will be shifted to prototype WRM. This process will formulate the prototype of the river basin water resources development plans.

The water demand and supply balance models and the river basin system diagrams prepared for NWMP 2030 will be upgraded by the use of updated and more detailed data as required covering demand, hydrological, environmental, etc.

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

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

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

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

These laws mentioned above triggered the development of large scale water resources in Japan just after 1945, resolving the shortage of water resources and public funds. These laws also provided appropriate incentives to irrigation service providers, water supply service providers, hydropower development companies, etc.

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

Strategic Action-6 proposes to execute capacity development for the WRMA regional offices as a lower structure of WRMA. Technical capacity development of the WRMA regional offices shall be executed as an integrated program with Strategic Actions-2, 3, 4 and 7. In particular, the increase in staff number of the sub-catchment offices and their technical capacity development is a basic requirement.

Capacity development of the WRMA regional offices is the first priority rather than reform of MWI. The shortage of staff and technical capacity of sub-catchment offices is crucial. The present staff number and technical capacity of the sub-catchment offices will be reinforced in order to activate WRM at site together with WRUAs.

(7) Strategic Action-7: Enhance the Establishment of and Strengthen Water Resources Users Associations

Strategic Action-7 proposes to enhance the establishment of Water Resources Users Associations (WRUAs) and strengthen their capacity in conflict resolution and co-operative management of water resources in catchment areas (Article 15 (5) of Water Act 2002). The WRUAs are representatives of their respective water users such as IWUAs, county water supply providers, government, private enterprise, and individual domestic water users. The WRUAs shall remain as water users and service providers, but not as regulators (refer to upper and lower structure for water rights regulation in Section 3.3 (3)). The objectives of capacity development of WRUAs shall be planned well based on the role of WRUAs as stipulated in the Water Act 2002.

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

Strategic Action-8 proposes the improvement of the financial capacity for the WRM institution at the national and regional levels to secure smooth implementation of water resources management activities through effective government financing, while the Water Sector Trust Fund finances WRUA activities.

3.4 Institutional Strengthening Action Plan

The eight strategic actions are the core institutional strengthening of WRM required to materialise the NWMP 2030. It is recommended to be implemented all together as soon as possible to avoid prevailing water rights conflicts.

3.5 Further Studies

(1) Organization for Flood Control Management

It is too early to establish independent flood management sections inside the WRMA regional offices due to the following present situations:

- The role of the WRMA regional offices is not clear since the Draft Water Bill 2012 which aligns the Water Act 2002 with CoK 2010 is still pending.
- The study on the financial sustainability of WRMA (October 2012) recommended the separation of the present WRMA head office and its regional offices. It also recommended the abolishment of the WRMA regional offices due to shortage in government funds, although a question remains on who will take charge of the WRM of the river basins.
- Under the present legal basis, it is difficult to allocate new functions of flood control management to the WRMA and its regional offices. In order to operate flood control management, the functions of basin flood control planning, design and implementation of flood control projects (structural and non-structural measures), and operation and maintenance of flood control facilities (structural and non-structural) must be well-defined and allocated to relevant organizations with provisions of adequate funds.

(2) Trial Study for Strategic Actions 3 and 4

It is recommended to execute a trial study of the Strategic Action-3 and Strategic Action-4 as part of institutional strengthening of the head and regional offices of WRMA. The trial can be started by the use of the catchment water resources development and management plan of NWMP 2030 of the strategic river basins. For example, the trial would be implemented in two stages: first, a trial by use of the outputs of NWMP 2030, and second, to formulate prototype basin water resources development plans after the capacity of the WRMA regional offices have been well developed.

Tables

Table 2.1.1 Water Sector Laws (1/2)

National Legislation	Purpose/Salient Provision
The Constitution, 2010	
The Water Act revised in 1972	Revision of the Water Act, 1951
The Water Act, 2002 (No. 8 of 2002)	Provide for the management, conservation, use and control of water resources and the acquisition and regulation of rights to use water; Provide for the regulation and management of water supply ad sewerage services; Repeal the Water Act, 1972 (Cap 372)
The Water Resources Management Rules, 2007, Legal Notice No. 171, the Water Act (No. 8 of 2002)	The Rules made by the Minister to exercise of the powers conferred by Section 110 of the Water Act, 2002
The Agriculture Act (Cap 318) (as amended by Act No. 11 of 1993 and No.2 of 2002)	Promote agricultural development and stress the need for conservation of soil and its fertility and the development of agricultural land
The Irrigation Act	The establishment, constitution and functions of the National Irrigation Board which is responsible for the development, control and improvement of national irrigation schemes in the areas designated by the Minister
The Forest Act, 2005 (repeal of Cap 385)	Provide for the establishment, control and regulation of central forest, other forests and forest areas in Nairobi area and on unalineated Government land, and encourage conservation an maintenance of vegetative cover in all lands
The Government Lands Act (Cap 280), 1970, Revised 1984	Provide for regulation of leasing and other disposal of Government lands, and for other purposes
The Land (Group Representatives) Act (Cap 287), Revised 1970	Provides for the incorporation of representatives of groups who have been recorded as owners of land under the Land Adjudication Act and other connected purposes.
The Trust Land Act (Cap 288), 1962, Revised 1970	Act of parliament to make provision for the Trust Land on setting apart of land, exclusions, miscellaneous powers, and extinguishment of rights
The Land Acquisition Act (Cap 295), 1970, Revised 1983	Act of parliament to make provision for the compulsory acquisition of and for the public benefit
The Registered Land Act (Cap 300)	An Act of Parliament to make further and better provision for the registration of title to land, and for the regulation of dealings
The Land Control Act (Cap 302), 1981, Revised 1989	Act of parliament to provide for controlling transactions in agricultural land
The Land Planning Act (Cap 303), Revised 1970	Act of parliament to make provision for planning the use and development of land.
The Physical Planning Act, 1996 (N0.6 of 1996)	Act of parliament to make further and better provision for the registration of title to land, and for the regulation of dealings in registered land
The Environmental Management and Co-ordination Act (EMCA No.8 of 1999)	Co-ordinate the various environmental management activities being undertaken by the lead agencies integration of environmental considerations into development policies and plans.
The Lakes and Rivers Act (Cap 409), 1962, Revised 1983	Regulates dredging and the use of streams on certain lakes and rivers
The Electric Power Act	Facilitates and regulates the generation, transmission, distribution, supply and use of electric energy
The Mining Act	Provisions for mining activities licensed by the Act, including those related to soil conservation and water management
The Wildlife Act	Provide for the protection, conservation, and management of wildlife
The Local Government Act (Cap 265), 1986, Revised 1998	Provides for the establishment of authorities for local government, defining their functions and providing for other related matters
The Territorial Waters Act (Cap 371, Laws of Kenya)	Provisions for the delimitation of the territorial waters in the sea
The Kenya Ports Authority Act	Establishment of the Kenya Port Authority

Table 2.1.1 Water Sector Laws (2/2)

National Legislation	Purpose/Salient Provision
The Government Fisheries Protection Act	Prevent the depletion of certain species, for example, pearls or shellfish, beche-de-mer, etc.
The Fisheries Act (Cap 378) (Caps. 378, 379, 380 repealed)	An Act of Parliament to provide for the development, management, exploitation, utilisation and conservation of fisheries
The Public Health Act (Cap 242)	Provisions for securing and maintaining health and the importance of water from the health point of view, to define responsibility of the local authority for taking necessary measures
The Malaria Prevention Act (Cap 243)	Enables health authorities to make measures for the prevention of Malaria by drainage, etc.
The Kerio Valley Development Authority Act and The Lake Basin Development Authority Act (Cap 441)	Provide for the establishment of an authority to plan and co-ordinate the implementation of development projects in each catchment area
The Lake Basin Development Authority Act (Cap 442)	An Act of Parliament to provide for the establishment of an authority to plan and co-ordinate the implementation of development projects in the Lake Victoria catchment area and for matters connected
The Tana and Athi River Development Authority Act (Cap 443)	Provide for the establishment of an authority to advise on the institution and co-ordination of development projects in the basin
The Agricultural Development Corporation Act (Cap 444)	Act of Parliament to provide for the establishment of the Agricultural Development Corporation
The State Corporations Act (Cap 446) (KEPHIS, NTZDC)	Act of Parliament to make provision for the establishment of state corporations: for control and regulation of state corporations; and for connected purposes
The Ewaso Ngiro South River Development Act (Cap 447)	Provides for the establishment of an Authority to plan and co-ordinate the implementation of development projects in Ewaso Ngiro South River basin and its catchment areas.
The Ewaso Ngiro North River Development Act (Cap 448)	Provides for the establishment of an Authority to plan and co-ordinate the implementation of development projects in Ewaso Ngiro North River basin and its catchment areas.
The Mombasa Pipeline Board Act	Provide for the establishment of the Board, its constitution and vesting of assets, its powers and functions, price charged by Board
The National Water Conservation and Pipeline Corporation Order, 1988	Exercise of power conferred by the State Corporation Act, the establishment of the corporation (NWCPC)
The Legal Notice No. 270 of June 24, 1988	Official establishment of the NWCP

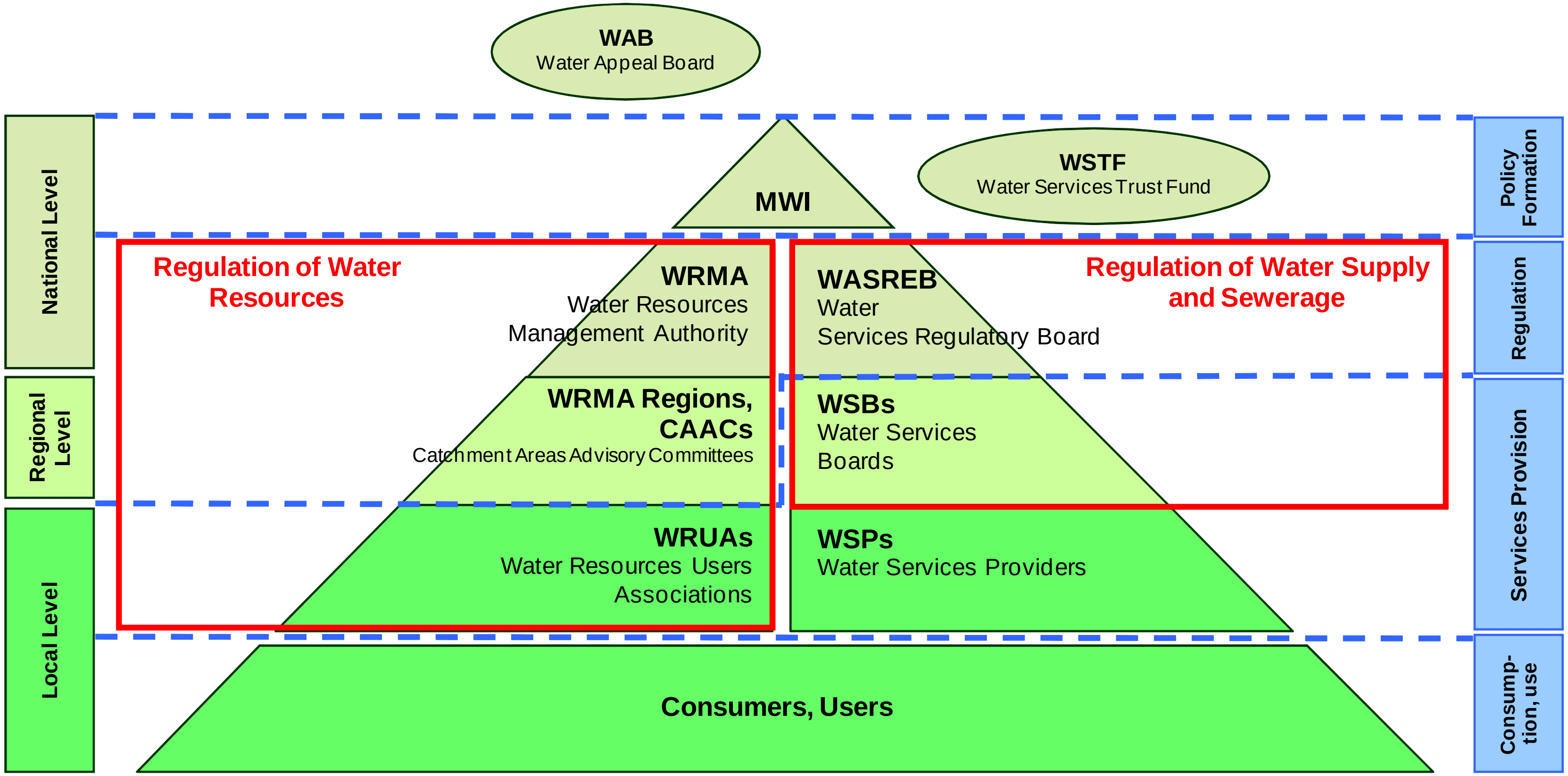
Source: JICA Study Team

Table 2.1.2 Water Sector Policies and Strategies

Policies/Strategies	Agency	Purpose and Salient Provision
National Water Policy on Water resources Management and Development 1999 (sessional Paper Number 1 of 1999).	MWI	Provides policy direction in addressing the national challenges which include: Treating water as a social and economic good. Preservation, conservation and protection of water resources. Sustainable allocation of water resources. Supplying adequate and quality water. Ensuring save disposal of wastewater for environmental protection. Developing a sustainable financial system for the water sector.
National Policy on Irrigation and Drainage development (June 2007).	MWI	Stimulate irrigation and drainage through targeted technical support; intensified investment in the sector; improved research and extension services; and capacity building in farmer organizations to ensure full integration of smallholder farmers in irrigation and drainage development.
National Water Storage Policy (March 2009)	MWI	Provides a guide on how water storage and its infrastructure development can be achieved and managed to meet the water demand.
National Irrigation and Drainage Policy (March 2009)	MWI	The National Irrigation and Drainage Policy presents a concise set of principles and guidelines designed to facilitate an orderly and rapid development and improved performance of the irrigation sector in Kenya.
National Water Harvesting and Storage Management Policy (May 2010)	MWI	Provides a guide for sustainable national water harvesting, storage and flood control to support livelihoods and prevent disasters, while involving the stakeholders.
nal Water Resources gement Strategy 2007- (January 2007)	MWI	Provides a road map for Assessing, Maintaining, Developing and Managing national water resources Sustainably, using an Integrated approach.
National Water Services Strategy 2007- 2015 (June2009)	MWI	Provides a clear, accountable and transparent road map to implement sector policy in order to improve health, jobs, and wealth for all Kenyans.
Flood Mitigation Strategy (June 2009)	MWI	Provides a guide on integrated flood interventions in the water basins while involving the stakeholders.
Catchment Management Strategy – Lake Victoria South (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Lake Victoria North (June 2007)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Ewaso Ng'iro North (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Athi (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Tana (June 2007)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.
Catchment Management Strategy – Rift Valley (June 2008)	WRMA	Providing a guide for assessment, maintaining, developing and managing the water resource in the catchment through conservation, protection and sustainable use while involving stakeholders.

Source: JICA Study Team

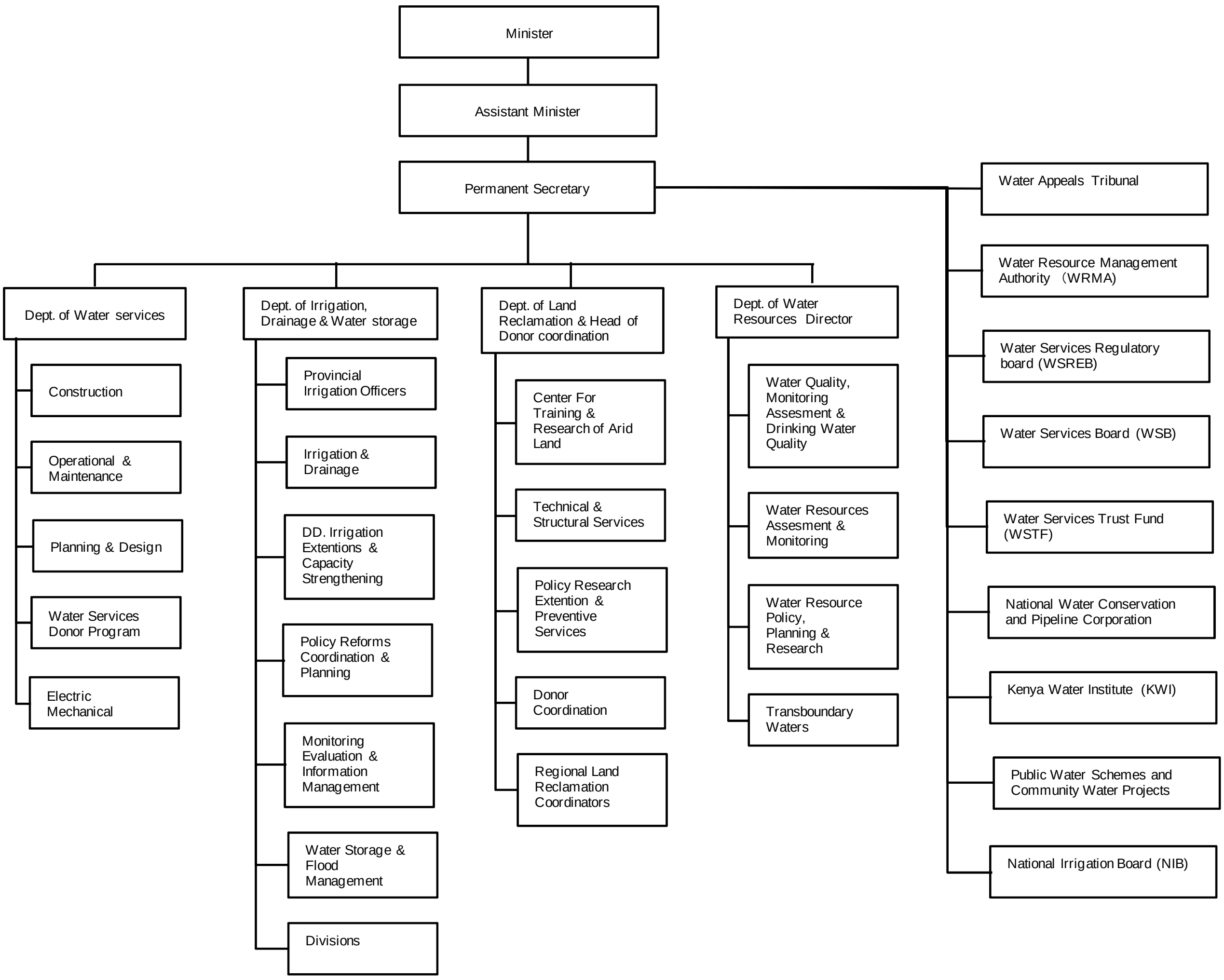
Figures



Source: WRMA modified by JICA Study Team (As of November 2012)

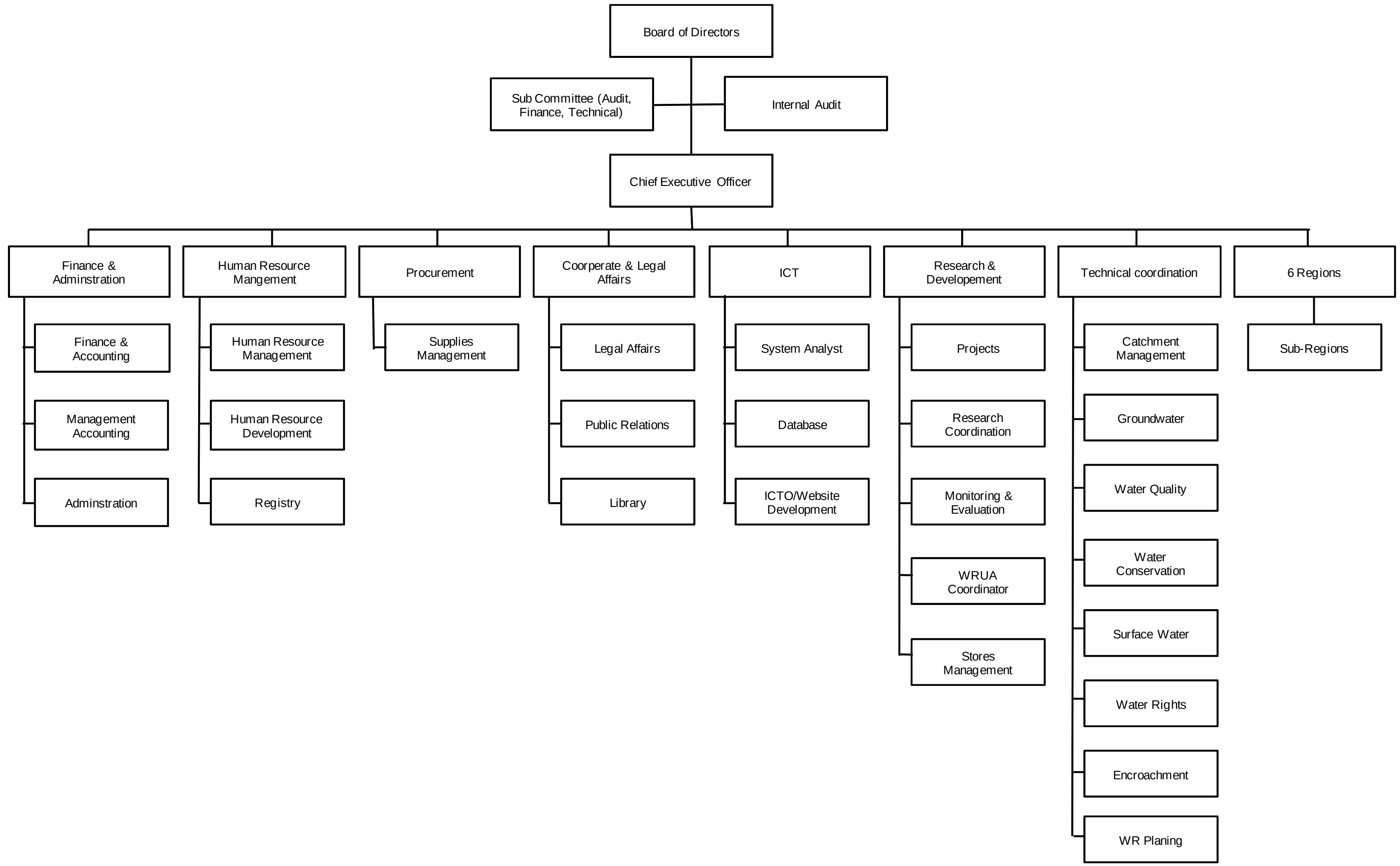
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.2.1
Existing Representation of Institutional Framework of Water Sector under MWI



Source: MWI (As of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030 JAPAN INTERNATIONAL COOPERATION AGENCY	**Figure 2.2.2** **Organogram of Ministry of Water and Irrigation, as of April 2010**

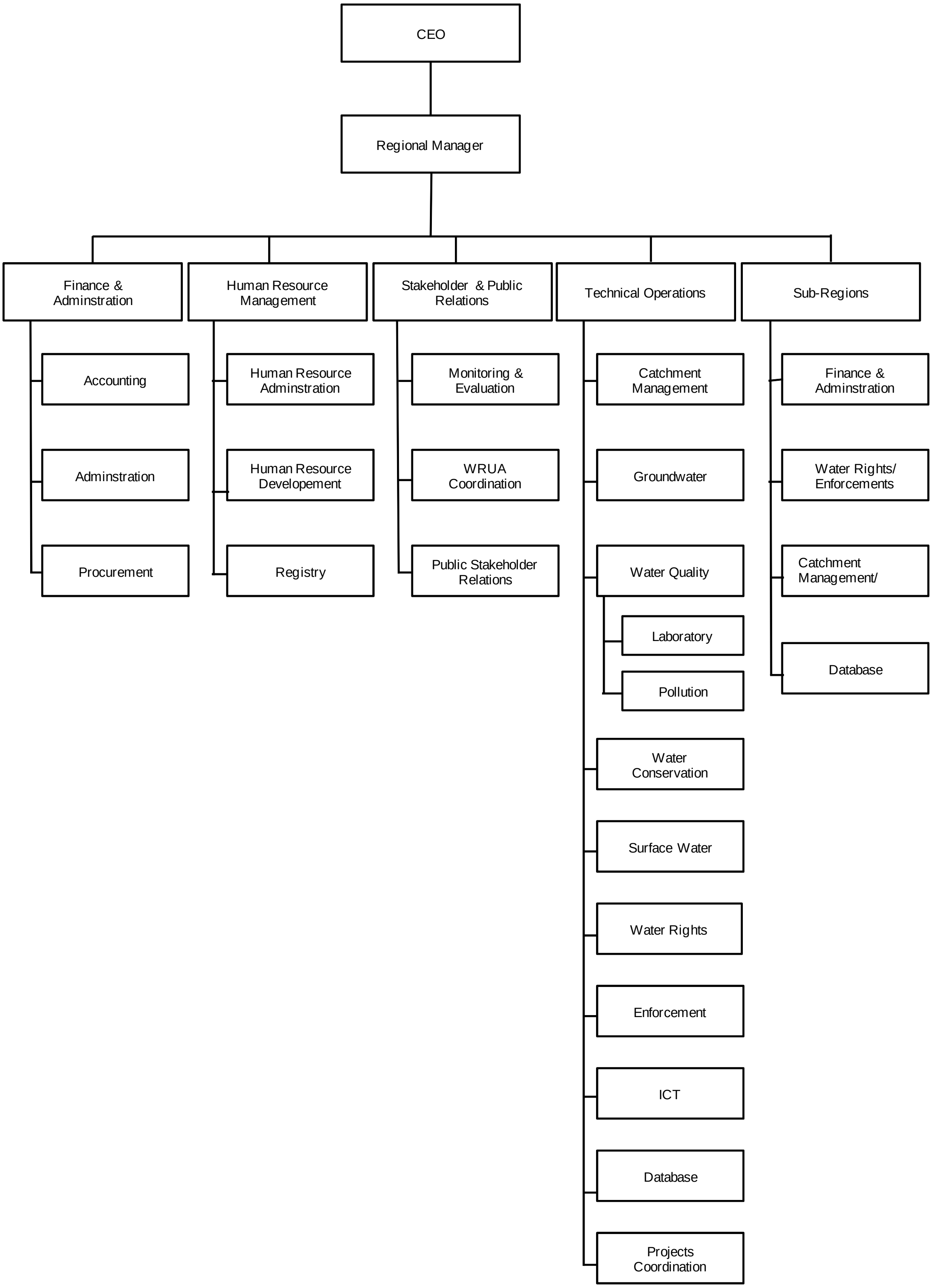


Source: WRMA (As of November 2012)

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.2.3
Functional Organization Structure of WRMA

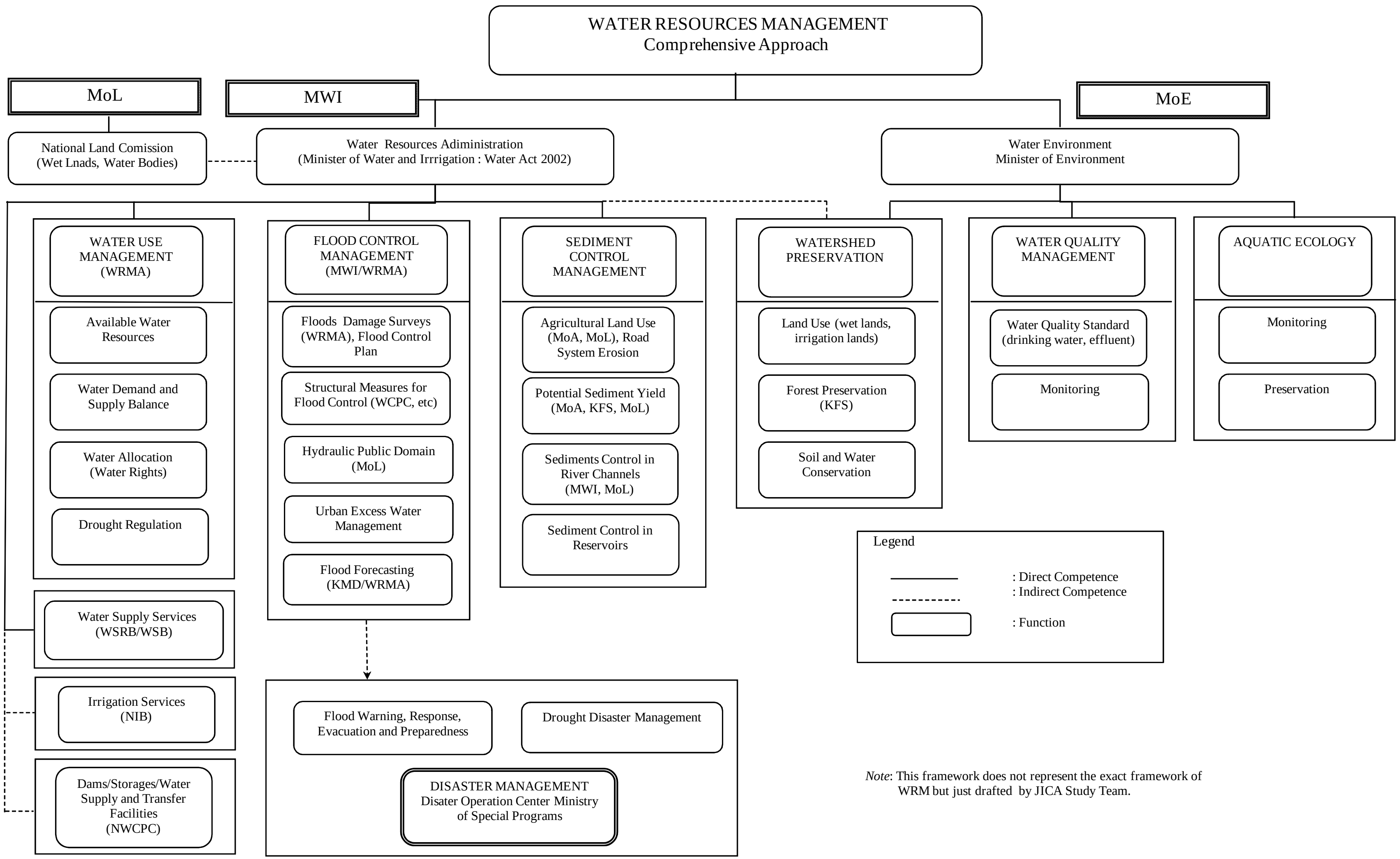


Source: WRMA (As of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 2.2.4** **Functional Organization Structure of WRMA at Regional Level**
JAPAN INTERNATIONAL COOPERATION AGENCY	

JAPAN INTERNATIONAL COOPERATION AGENCY

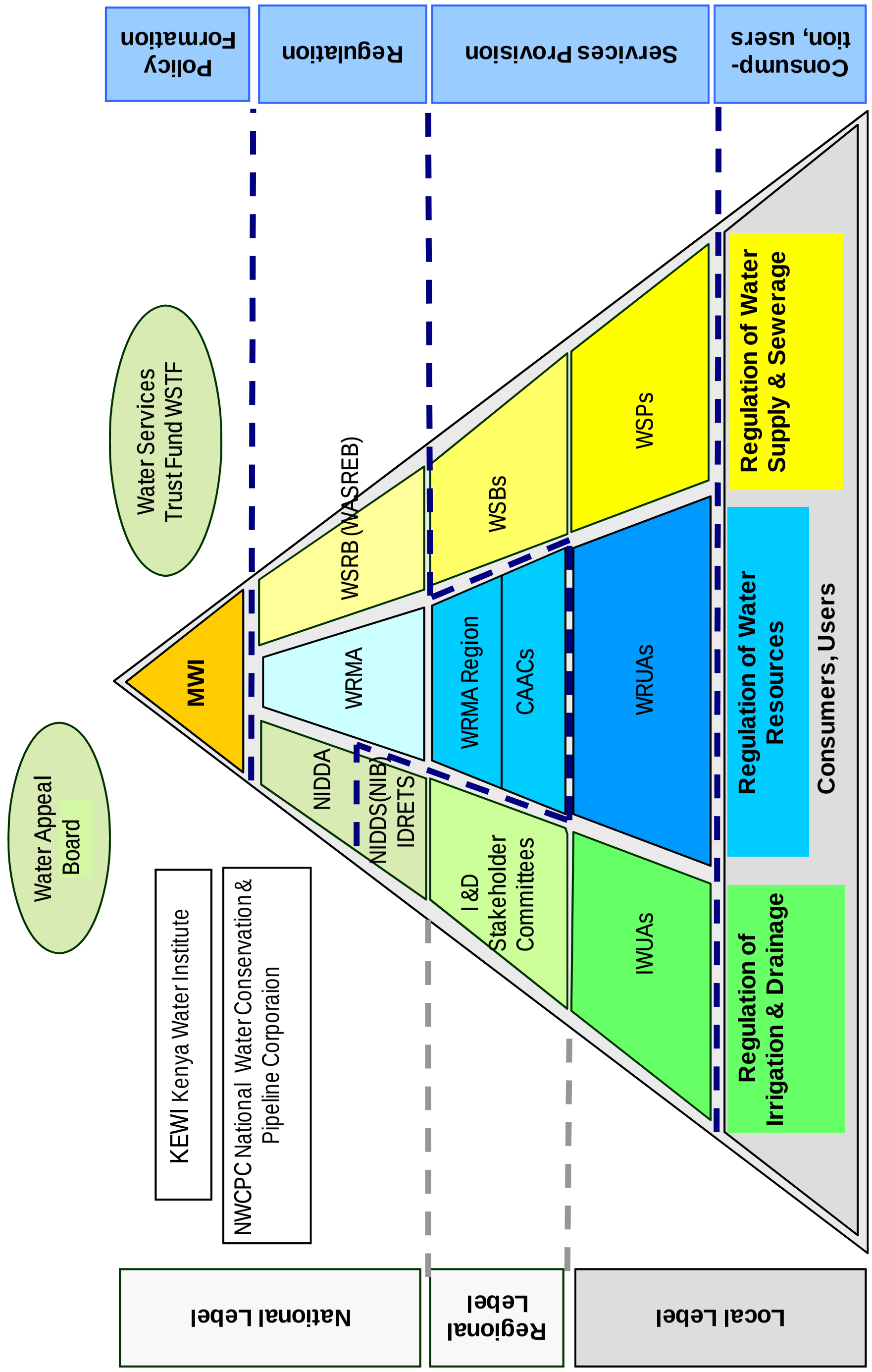
THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030



Note: This framework does not represent the exact framework of WRM but just drafted by JICA Study Team.

Note: JICA Study Team (As of November 2012)

Figure 3.1.1
Existing Sector Framework of Water Resources Management in Kenya



Note 1: NIDDA: National Irrigation and Drainage Authority
NIDDS: National Irrigation and Drainage Development Services
NIB: National Irrigation Board
IDRETS: Irrigation and Drainage Research, Extension and Training Service
I&D: Irrigation and Drainage

Note 2: The Draft Water Bill 2012 (version of March 2012) transfers the existing functions; from WRMA to Water Resources Regulatory Authority (WRRA), from WRMA Regional Offices to Basin Water Resources Boards (BWRBs), from NWCPC to National Water Storage Authority, from WSRB to Water Services Regulatory Commission, WSBs to Water Works Development Boards, from WSPs to County or Cross-County Water Service Providers, from Water Appeal Board to Water Tribunal, from WSTF to Water Sector Trust fund Authority.

Source: Trans boundary Water (As of November 2012)

THE DEVELOPMENT OF THE NATIONAL WATER MASTER PLAN 2030	**Figure 3.3.1** **Actual Institutional Set-up of Ministry of Water and Irrigation**
JAPAN INTERNATIONAL COOPERATION AGENCY	

Appendixes

APPENDIX 2.1

THE ISSUES AND POSSIBLE SOLUTIONS FOR INSTITUTIONAL ORGANIZATION IN WATER RESOURCES MANAGEMENT

THE OBJECTIVE OF INTERVIEW

The project on the Development of the National Water Master Plan 2030 (NWMP2030) has the following objectives:

(1) To assess and evaluate availability, reliability, quality, and vulnerability of country's water resources up to around 2050 taking into consideration of climate change,
(2) To renew the National Water Master Plan towards the year 2030 taking into consideration of climate change,
(3) To formulate action plan up to the year 2022, and
(4) To strengthen capacity of water resources management.

Among the objectives is the strengthening of the capacity of Water Resources Management (WRM) through the institutional development at the national and regional levels based on the decentralisation policy. This will ensure the implementation of the action plan up to the year 2022 of the NWMP to achieve the goals of the National Vision 2030.

The capacity in WRM can be strengthened by addressing:

i) Legal aspects
ii) Organisational aspects
iii) Financial aspects

The team had to find out the present and future problems plus issues to address so as to achieve the objectives of NWMP2030. A questionnaire on the aspects to be addressed was developed and subjected to discussion with the officers at regional level.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Tana Regional Office

Interviewee: Mr. Bonface Mwaniki, Regional Manager
Date of interview: January 26, 2011

The Regional manager gave a background of the institutional aspect in Tana and the following are the issues raised:

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- The constitution in the fourth schedule classifies the functions on water resources as national function while the catchment water resources management at site requires involvement of WRUAs.

- The Region feels that the role of Counties to be accommodated in the regions in terms of representation in Catchment Area Advisory Committee (CAAC) to assist conflict management between the counties. Ten counties have all or bigger portion of their area in Tana Catchment.

- There are conflicting acts in their operations with Water Act 2002 which include Agriculture Act, Forest Act, Land Act, and EMCA 1999 where the conflicting mandates of those Acts were never repealed.

  a) There is conflict in areas of river management in the farms and in the forest. For example, effluent management and licensing effluent is reflected in both EMCA1999 and Water Act 2002 and conflicts in the operations of WRMA and NEMA as concerns effluent management.
  b) Water supply and sewerage service is at present by Water Service Bard (WSB) through Water Service Providers (WSPs) based on counties.

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- Capacity to enforce the regulations is weak and need for capacity building and empowerment.

  a) For example Nairobi Water Company refuse to pay the water use fee (WUF) but WRMA-Tana cannot enforce. Non payment of WUF is more serious by the government side than by private side.

  b) Water resources are a national asset but land on which rivers flow is managed at county level. Management of water in the rivers crossing over many counties faces difficulties. Issues are scarce water which is a revenue source while equitable allocation is challenge.

  c) Align counties with WRMA in water resources management in accordance with Constitution and Water Act 2002.

- The issue of prosecution is a key to enforcement therefore the need to strengthen and empower the officers legally to build strong cases and prosecute effectively.

- Need for the law to recognise the representatives of Water Resources Users Associations (WRUAs) as catchment forums with mandates for policy and coordination of catchment issues like flood, draught and conservation.

- However the rules and regulation currently are adequate though issues of meters should be clearer on who fixes them.

  b) WRMA can not enforce because it is not very clear who fixes the meter and users do not like the metering concept (fixed rate preferred).

  c) Data on demand estimate and number of water users (irrigation, domestic and industrial water supply, hydropower, etc) are not available. Those data are basis for regulation and enforcement.

  d) There is no law on who will take the responsibility of damages in case of collapse of dams.

Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?

- The current law does not accommodate the cost sharing rule. The concept of participation by stakeholders/water users and cost sharing by beneficiaries/stakeholders is welcomed.

- The concept of cost sharing rule of multipurpose dams is a good concept if adopted and backed by law.

Question 4 Are any other legal arrangements necessary?

- WRUAs need more powers to operate and implement their activities for they are a very key in the catchment management.

- The reservoir water in the Masinga dam belongs to the State but owner of the dam is TARDA. WRMA has the mandate of allocation of water resources in the reservoir to users (irrigation, hydropower, municipal water supply, etc) but there is a regulatory conflict with TARDA during dry season. Adequate legal arrangement is necessary to avoid conflicting interest in the reservoir operation, water uses and land.

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- The sub-regional offices should be increased to 10 in Tana for effectiveness.

  a) Current organizations are adequate as long as the mandates of WRUAs is fully baked by law.

  b) WRUAs are a key in water resources management and must be facilitated and empowered to undertake their mandates.

  c) The Water Users Associations (WUAs) existed and were for water supply consumers. The WRUAs are for all water resources users including irrigators and power companies, etc.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- Present organisation of WRMA includes Headquarter- for policy and regulation, Regional office for coordination, Sub-regional offices for implementation and WRUAs to assist in the implementation.

  a) Majority of the technical resources (professional staff) shall be allocated to Sub-region level.

  b) Role and responsibility of the four levels of WRMA should be made clearer to allocate resources efficiently.

- The NWMP 2030 should clarify functions of all the institutions involved in WRM including WRUAs.

Question 3 What personnel capacity is necessary to strengthen?

- Human resource allocation should ensure majority of technical staff are at the Sub-Regional level and if possible technical assistance availed.

  a) A technical assistance to Tana Region and Sub-regions is ongoing well by gtz (GIZ) for community mobilization including partly backup of GIS.

  b) Expected professional capacity development includes - GIS experts for resource management maps - experts for water resources data collection, process and analysis - experts in preparing information, booklets, brochure, film for public relation and information, and - environmental specialists for conservation and protection.

c) The current number of Catchment Area Advisory Committees (CAACs) is 14. Therefore each of 9 counties can be represented: making 9 from general public and remaining 5/6 from institutions. The maximum number stipulated in Water Act 2002 (Art. 16) is 15.

Question 4 Is inter-regional coordination sufficient?

- Inter-regional coordination is not sufficient now. Catchment Forum set at regional level may function as basis for an inter-regional forum. It will assist CAACs in their mandates. The function includes dissemination, sharing information and technical transfer.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Coordination is not functioning well. Different mandates and programs of national agencies overlap.

  a) There is a conflict between Ministry of Agriculture (MoA) and WRMA. MoA plans to increase irrigation areas while according to WRMA assessment there is no water for new irrigation schemes. This leads to a waste of national resources.

- Regional Office-Tana intends to give the public more opportunity of participation in implementation. Community based organizational structure may be necessary to be incorporated in WRMA organization structure.

- WRMA-Tana wishes that governors in counties who are representatives of the public including communities are involved in Catchment Forum.

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- Put more emphasize on implementing projects at the strategic storage sites to regulate water flow all the year around.

- Strengthening of the mandate of WRMA to determine water storage (both the State and private) is necessary.

  a) The Tana River is water scarce. However its water is transferred away to Nairobi which is in other catchments. This cause for a more serious need to create storage.

- There is no direct incentive for water users to legalize water use. For Tana, challenges are water resources assessment and water rights to manage demand which must be addressed.

- The function of water quality management should be clarified. There is management conflict between Ministry of Environmental Management (MEM) and WRMA.

  a) For example, it is not possible to control all effluent sources (both on lands and in water body) by NEMA while implementation of monitoring the quality, enforcement of laws and conservation of the water body is by WRMA.

Question 7 Is River Basin reorganization necessary?

- A Report proposed WRMA be organized into two functional levels: regulatory function and implementation function.

- The spirit of the proposed restructuring of WRMA by the report is basically wrong.

  a) WRMA-Tana disagrees with the proposal to setup River Commission.

  b) WRMA-Tana has not read the final report yet.

- There is no need of reorganisation, but mandates, roles and responsibilities for all levels established should be clear in law without conflicting with other laws.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- Yes it is necessary. There is no legal position for Catchment Forum now. WRMA-Tana considers it as an umbrella forum for WRUAs.

- The envisaged function of the forum is to determine policy direction and coordination, mobilization and allocation of resources in the region for conflict and disaster management.

- Membership of Catchment Forum is subject to discussion. However, county level representative, CAACs, representatives of major water users, NGOs, farmers, hydropower, water supply service providers, WRUAs and other government agencies need to be involved.

- Catchment Forum shall be at Regional level, where the 10 counties will be involved.

  a) Potential number of WRUAs is estimate at about 800 within Tana Catchment administration. Current number of WRUAs is about 140 and the target for this time is 200 to manage the catchment more effectively.

- There is need for the Forum for two or more catchments to discuss inter-basin transfer then share information and experiences e.g. Tana and Athi.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- The operation and maintenance budget of the Regional office is not sufficient. More of WRMA budget should be allocated to implementation.

- WRMA should be funded direct from the Government revenue other than funding based on WRMA revenue only.

- The budget fund should be provided timely.

Question 2 Is budgetary arrangement sufficient?

- Amount of budget is not sufficient.

- Financial allocation for development should be more at the sub regional level (may be 75%) with the balance shared by Headquarter and Regional office at 10% and 15% respectively.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- More financing is required to implement Catchment Management Plans.
- Finance for implementation at sub-region and regional level covers the facilitation to WRUAs and communities to implement their sub-catchemnt management plans. This shall change to have specific funds for each level.

Remarks

- ✓ There is need to revise the catchment management strategy.
- ✓ Upper Tana has stakeholder’s forum through the NRM project.
- ✓ Two Sub-Regional Offices were reconstructed under the on-going program for capacity building of water resources management financed by the World Bank through Natural Resources Management project.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Athi Regional Office

Interviewee: Mr. John Masila Ngilu Regional Surface Water Officer, Representing for Regional Manager
Ms. Margaret Waturu Regional Water Quality Officer, Representing for Regional Technical Manager
Date of interview: January 27, 2011

The officers gave a background of the institutional aspect in Athi and the following are the issues raised:

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- The New constitution allows water resources to be managed at national levels because the catchment boundaries do not follow administrative boundaries.

- To ensure that counties are taken into account, sub regions should be such that WRMA can be represented in each county.

  a) The county issue is too early to discuss. Its discussion should come after the start of new parliament.

- The existing laws are not harmonized: inconsistent provisions among the existing acts such as Water Act (2002), Agricultural Act, Environmental Management and coordination Act (1999), Land Act, etc.

- Land Act does not recognise the river channel and the land it operates on. Ownership of land is up to the centre of the river or the whole channel.

  a) Sand harvesting is a key issue in river management and land ownership poses a challenge especially enforcement.

  b) Kinze dam which is a strategic storage dam in Mbooni could not be done due to land ownership problems because the community never wanted the project to be implemented.

  c) Installation and monitoring of WRMA gauzing stations in the river channel requires approval of the land owner. The procedure requires to inform to owner, to install stations, to negotiate how to read gauzing (manually or automatically, amount of access fee to read).

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- IRR is generally good but enforcement and regulation is not clear. Revision of water use (threshold of water use rights) clauses is necessary due to climate change.

- WRUAs be given their mandate in details through the Water Act because they are very key in the implementation of the WRM.

Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?

- The cost sharing rule is not applied or backed by any law but a good idea for it could solve some of the problems like development and operations of multipurpose dams e.g. Kinze dam.

- Multipurpose dam will be a political issue involved in various problems including lands in reservoir areas, donor's preference, less capacity of cost sharing.

  a) Present dams were government funded for purely public use without cost sharing by water users.

  b) Donors prefer a single institution handles a large dam financed by loan implying multi-agencies problems.

  c) Irrigation and environmental conservation is under the mandates of the government where managers discuss prospective issues after completion of projects.

  d) Irrigation water users have no capacity to share the cost except labour in particular at semi and arid areas, thus preferred community based small storages.

Question 4 Are any other legal arrangements necessary

- There should law ensuring river channels and the riparian land are owned by the state just like the water.

- The EMCA 1999 conflicts with Water Act (2002) especially on effluent management by allowing NEMA to collect fees while they do not directly manage the water bodies receiving the effluent. This should be properly spelled in law and total mandate given to WRMA.

  a) The majorities of factories do not install treatment facilities but pay effluent discharge fee to NEMA resulting in serious degradation of water quality. WRMA regulates the effluent discharge in the water course under Water Act (2002). Kenya Bureau of Standard (KBS) cross check the condition.

- There should clarify deficiencies in the mandates in sand harvesting between WRMA and NEMA (EMCA) to avoid management conflict. NEMA is a coordination body of licensing sand scooping under EMCA.

  a) Sand deposition in the reservoir and degradation of the riverbed is an issue in the seasonal Rivers.

- Involvement of riparian communities as WRUAs is important in implementation but the legal mandate of WRUAs is not clear.

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- Staffing levels in every sub-region should be based on workload.

- More specialised personnel at the sub-region to ensure effective monitoring, enforcement and conservation where the present four levels of WRMA organization is adequate.

- Capacity of the monitoring network is not sufficient in terms of data and enforcement capacity: namely, rainfall, evaporation, discharge, water quality, and conservation ability of WRUAs and no budget for WRUAs.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- Specialised professionals are required at regional and sub-regional level.

  a) The number of staff should be increased at monitoring groundwater and water quality, and enforcement in particular in Mombasa and Nairobi.

Question 3 What personnel capacity is necessary to strengthen?

- Capacity needs improvement through training and technical assistance: data processing and analysis, enforcement how to prosecute effectively (for sub-regional officers).

  a) Athi Region is very busy with a lot of day to day tasks.

- Need to train on the use of the current equipment especially on water quality.

  a) No technical assistance program from the donor organizations.

  b) A potential solution is how to coordinate with the Kenya Water Institution- a way to meet the demand of consumers.

  c) Procurement of new equipment should be made including the components of installation plus training on operation and maintenance.

Question 4 Is inter-regional coordination sufficient?

- Inter-regional activities/exercises needs to be encouraged and practised for sharing of experiences.

  a) For example, the major water supply source to Nairobi is from the reservoirs in Tana Catchment, and pollution/sewerage/effluent discharges from Nairobi into the Athi River.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Stakeholder coordination is not done well. Consumers and institutions have different interests.

- The catchment forum concept is good and welcome as a venue for stakeholders to discuss issues, but the representatives should be zone based due to unique challenges in each zone: Upstream (water resources), Middle reach (sand harvesting), Downstream (water quality).

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- Need for power to prosecute to improve on enforcement.

- Athi region urgently needs publicity for stakeholders to be informed about the region.

- Athi region is home to two cities (Nairobi & Mombasa) and faces challenges of enforcement on ground water.

- Official procedure of sand harvesting issues is necessary including establishment of an environmental court.

Question 7 Is River Basin reorganization necessary?

- No need of reorganising the region but the catchment forum should be put in place.

  a) The team for reorganization of WRMA did not conduct interview at the Athi offices.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- Yes it is necessary. There is no legal position for Catchment Forum now. WRMA-Athi considers it as an umbrella forum.

- Currently there are 97 WRUAs but no projection of the optimum number.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- Regional Office-Athi collects 30% of the potential revenue because government institutions are not willing to pay including the Water Regulating Service Board.

  a) Present potential revenue source is the ground water users who generally pay the permit fee.

  b) Surface water is available in Kiambu Sub-region only but its potential is low.

- The operation and maintenance budget of the Regional office is not sufficient.

- The budget fund should be provided timely.

- The Trust Fund allocation is done for WRUAs by WRMA Head Quarter.

Question 2 Is budgetary arrangement sufficient?

- Distribution of funds to Regional Offices is equal now, but allocation of funds should be work load based other than per office.

- There should be incentive by ploughing back a portion or percentage of the revenue.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- More allocation for monitoring and conservation is needed. Staff salary is paid by the tax revenue.

- Inadequate finding is a challenge.

Remarks

- ✓ Need to revise the thresholds (ceiling of water use) due to ongoing drought.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Lake Victoria North Regional Office

Interviewee: Mr. Enoch Wanyonyi, Regional Manager
Date of interview: February 16, 2011

The officers gave a background of the institutional aspect in Lake Victoria North and remarked that the 1992 NWMP is out dated in some areas because some of the items identified are non existence e.g. some wetlands identified are today farmlands. This justifies the urgent need for the revision of the NWMP.

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- Involvement of CAACs in Water Resources Management (WRM) as advisory while their legal basis is loose (advisory). The CAACs have been requesting to be an entity just like the WSBs

- The WRUAs mandate and their responsibility and their relationship with WRMA which should be very strong are not effectively backed by law. WRUAs are very key in implementation of WRM, and no way of managing the catchment without the owners of the land being involved.

- The WRMA needs to facilitate information to WRUAs where the data base is not shared with the public yet: for example, groundwater information (distance between the existing bore holes, quantity and quality of water, legal status, etc.).

- WRM includes improvement of quality and quantity of water hence the importance of storage for use. The WRMA should therefore be legally involved in planning and implementation of storage so as to manage the excess for use during deficit, as WRMA has no effective link with storage facilities at present.

- The issues on trans-boundary water sources and downstream/ upstream management of water is not clear in law. Example is the situation of Sio River where catchments are shared by two countries and the current problems on use of the dam supplying water to Eldoret town.

- Too many actors in water and even levying on water leads to duplication: e.g. Water use fee by WRMA through Water Act, Storage fee by KFS (also fee for intakes and pipelines) through Forest Act, Effluent discharge fee by NEMA through EMCA Act.

- Harmonization of the existing acts with EMCA 1999 is necessary since the EMCA is superior in controlling related laws.

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- Enforcement of the riparian land as per WRM rules for conservation activities is a problem because of the Land Act.

- Water Act is not effective on conservation and management for some wetlands: e.g. already identified wetlands are farm lands like the Yala swamp which is now rice fields.

    a) Municipal and County Councils manipulate the wet land (trust land) and effect issuance of title deed.

    b) Wet land functions as habitat for bio-diversity and water filtering.

- Enforcement on abstraction levels is not effective because either the meters are not fixed or not working. In law, there should be clear provisions on the best way to handle this issue, where inspection and assessment of the master meter is user's responsibility at present.

Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?

- There is no law covering cost sharing of multipurpose dams. In the past, the Government has been putting the bill alone without involving other stakeholders.

- The concept is good and communities/stakeholders should own their rightful share. WRUAs can be some of the stakeholders while countries can be the stakeholders on trans- boundary water projects.

    a) Example: the multipurpose dam on Nzoia, project identified in the Yala multipurpose study and the multipurpose study of Sio, Malaba and Malakisi.

- Expected issues on the multipurpose dams include involvement of stakeholder participation (public and private) in implementation, land ownership and resettlements as a social issue, and water transfer outside the basin and wetland conservation in wet season as normal and natural.

Question 4 Are any other legal arrangements necessary?

- The current law is adequate only that it needs to be more superior than other laws as concerns water.

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- Representation at local levels especially with the new constitution so as to accommodate counties in CAACs and WRUAs especially in sub-catchments managed by a WRUA but cuts across more than one county.

- The region has 3 sub-regions at present and needs 2 extra.

    a) The current Eldoret takes care of upper Yala, Kitale takes care of upper Nzoia, while Siaya takes care of lower Yala and lower Nzoia. The new sub-region should cover Yala and Nzoia at the middle while the other one covers Sio, Malaba and Malakisi.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- For complete management of the Hydrological/ water cycle WRMA should be mandated to handle storage so as to design for the competing users like irrigation, flood control etc.

- Need to embrace Information and Communication Technology (ICT) for communication and implementation.

- WRMA and WRUAs to play a major role in early warning system in terms of data collection through WRUAs, data analysis and forecasting for floods.

- Need for stronger sector linkage between relevant organisations for sharing data, information and implementation of projects be backed by law.

  a) For example, gabion installation may involve the community forest associations (CFAs), environmental associations, WRUAs, local governments, etc.

- Need for law to strengthen the WRUAs as an institution.

Question 3 What personnel capacity is necessary to strengthen?

- Need for training to ensure qualified and effective personnel to perform all functions within the mandate of WRMA.

  a) Supervision of dam construction needs a dam engineer.
  b) Stakeholder relations officer needs a trained public relations person while pollution control services are required at sub-regional level for effective water quality management.
  c) Personnel in financial sector.
  d) Enforcement officer on effective prosecution because police men have not sufficient knowledge on water matters which are different form criminal cases (attorney/court) on public prosecution. Need for environment court.
  e) Personnel in water quality sector.
  f) Effective training of WRUA members: e.g. the auditor requires a clear cash book but some WRUAs can not prepare.

Question 4 Is inter-regional coordination sufficient?

- It is not sufficient. Need to strengthen inter-regional coordination so as to know the potential water transfer and deficit of the neighbouring catchment during draught and plan way forward together to optimise the use of the available resource. Fair to note that irrigation is minimal in the region because 9 out of 12 months are wet/ rainy.

- Inter-basin transfer within the Nile basin is a national policy bound by the Nile Basin initiative.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Coordination is not sufficient. Water as a social and economic good and should be managed in participatory and integrated manner with sharing data and information, like road runoff leads to gulley erosion especially downstream of the culvert leading to silt in rivers and reservoirs.

- Need for awareness creation among stakeholders possibly within WRUAs to come together in a forum to discuss and plan the catchment conservation, by agreeing on how to implement activities like wetland restoration, on farm activities like woodlots etc.

  a) Need stakeholder forum periodically to define the role to be played by stakeholders.

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- It is important to plough back the earned profits by investing the same in the catchment e.g. giving incentive from the money raised from water users to stakeholders doing conservation work.

Question 7 Is River Basin reorganization necessary?

- There is need to restructure to ensure each region becomes an entity especially for resource mobilisation then there can be a regulator on top of the regions.

  a) The international treaty of 1997 on shared water resources affects the region because of the river Nile Basin.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- Yes it is necessary. There is no legal position for Catchment Forum now.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- Resource mobilisation should be diversified to avoid relying on donors only. Let the community, councils etc contribute.

  a) Donor’s fund flow is not continuous and, thus casing the discontinuity of data collection.

- Resource allocation including budget delivery, timing and amounts should target work plans and their time schedules.

- Resources monitoring to ensure impact on the ground such that projects should accompany any soft ware activity like awareness creation and training of communities on conservation without component of livelihood project.

Question 2 Is budgetary arrangement sufficient?

- Not sufficient, enough or timely. The arrangement is poor and needs improvement.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- WRUAs develop Strategic Catchment Management Plan (SCMP) and cost of implementing the SCMP will be the cost of implementing the plan of the catchment.

- Currently there are 50 WRUAs and the ultimate number could be 100 each covering an area of 200 km^2 in the total area of 9,800 km^2.

- In the multipurpose studies, WRUAs have their activities to undertake like conservation while GOK and WRMA do the others.

Remarks

- ✓ To draw a budget, the national and regional strategies are taken into account to identify activities which are put into work plans and cost calculated for each activity.
- ✓ WRUA activities are drawn from SCMP.
- ✓ There is Feasibility Studies and Final Design Preparation of Flood Control Structures within Nzoia River Basin, by BRL Ingenierie, and the World Bank. This is shopping basket where ranking and selected 4 out of 49 potential sites are targeted for implementation.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Lake Victoria South Regional Office

Interviewee: Mr. Phytalis Opango, Ag. Regional Technical Manager and the team.
Date of interview: February 17, 2011

The officer gave a background of the institutional aspect in Lake Victoria South and the following are the issues raised:

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- The sub-catchments should be defined in the Water Act or the WRM rules.
- Conflict with other acts like EMCA 1999 which has its superior water Quality standard (Regulation No.8) on water while WRMA has different standards. The gap should be filled. The Agriculture and Land Acts have their conflict with water especially on riparian land demarcation.
- Inability to enforce the WRMA rules like where a dam has been fenced off denying access to water and putting up structure in wetlands.
- How to address capacity of legal personnel in number and capability with appropriate power based on knowledge?
  a) Regional enforcement officers rely on the only one person in the legal department of the national WRMA office, and thus slow decision process in the national office.
  b) Is an environmental court necessary?
- Need for legal provision to take care of trans-boundary WRUAs cutting across areas outside the Catchment. The region had such a case and had to call it a water users FORUM other than WRUA. a) A river flows from Kenya through Tanazana and then flows into the Lake Victoria.

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- The issue is not IRR but is insufficient implementation capacity, especially pollution control in the rivers (markets, factories) and it has been difficult to enforce where NEMA has issued effluent discharge licence.
- There should be improvement in numbers and capacity to enforce at sub-regional level; now only one enforcement officer for three sub-regional offices and only one water right officer.
- The penalties imposed those contravening the water act are not effective and should be improved to higher levels like the EMCA and Public Health Acts.
- WRM rules and Water Act should allow for precautionary action other than a process; e.g. close a factory which is polluting other than the process of taking samples and waiting for the laboratory test results so as to close.

- There should be special security arrangements for WRMA to enforce effectively; e.g. an arrangement of special police unit for hiring.

- The law should be clear on how to manage trans-boundary waters in catchments; a guideline on involvement in the trans-boundary water users is necessary plus how to manage the trans-boundary water permit.

- WRUAs response in the area has been affected by the way NGOs organise their functions for they usually give hand out to participants. WRMA's actions are for long-term basis while NGO's actions for short-term basis.

Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?

- The idea of sharing cost is good for it will allow each stakeholder will take their share of benefits, cost of implementation and allocation of water rights based reservoir operations ensuring effective economic and social use of the water, flood control downstream, and ecological function.

- Currently no law takes care of the multipurpose dam cost sharing concept.

Question 4 Are any other legal arrangements necessary

- The legal arrangements are so far enough but there is need for precautionary action by WRMA for effective enforcement.

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- The current WRMA structure is of 3 levels handling the policy and quality control, coordination and supervision, and implementation.

- It should be made clearer on the mandates (definition of rules, functions and responsibilities) at each level though projects size and nature will dictate on who to implement.

- For effective management, 3 more sub-regions are needed to increase to 6 which should be distributed to cover Mara, Sondu, Gucha, Nyando, Southern and Northern shoreline.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- There is no groundwater resource assessment yet while assessment of surface water was done.

- Need to strengthen capacity in groundwater and surface water sector to assist in data collection and be able to have realistic water balance figures through comprehensive River Gauging Station (RGS) rehabilitation and effective operations and maintenance including provision of enough equipment.

- Need for good abstraction survey for credible permit data base and equitable allocation plans to ensure environmental flow is available.

- Catchment degradation and wetland encroachment are main challenges and the process of handling them is long and tedious.

- Delinking of the personnel may be a key to ensuring sustainable empowerment and capacity building.

Question 3 What personnel capacity is necessary to strengthen?

- Capacity building in specific component/ sector includes GIS (maps for watershed and wetland), basic training for community mobilization, computer skills for data management and storage, etc especially at sub-regional level is very important.

- For proper implementation of the NWMP it is necessary to provide adequate tools, vehicles and equipment, and to ensure ability to use the same for effective and efficient data collection and analysis particularly water quality monitoring.

Question 4 Is inter-regional coordination sufficient?

- Not sufficient.
- There is need for two or more regions to meet to share experiences and information like how to operate the new and modern equipment while measuring the river flow.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Coordination is not sufficient because of different sector interests like irrigation planning alone without involving water.

- Need of coordination of internal stakeholder like WRMA, Irrigation, WSB, WSPs, DWOs, etc while reaching out to others like Technical Advisory Committee of Mara and Nyando river flood management forum, etc.

a) The Nyndo River flood management forum might collapse if JICA withdraw after the project because it was not established with suitable outlook.

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- To increase storage should be one of the key functions of WRMA enhance the mandate of storage should be given to WRMA.

a) Water rights allocation should be all under WRMA in particular water balance and allocation at intake sites.

Question 7 Is River Basin reorganization necessary?

- Not necessary to reorganise the river basins because the current structure has not been in operations long enough to test the effectiveness otherwise there are many gains so far. The main issue is not organizational structure. The current structure needs to be facilitated with enforcement power for effective regulation and operations. Duplication of functions and rules among agencies should be shortened out.

- Need to have WRMA involved in the Trans-boundary waters functions/ operations.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- A good concept and the forum can be used to discuss issues of upstream and downstream conflicts.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- Amount is not enough because the full budget proposal was never receive; e.g. the approved is only 50% of the proposed.
- The release of funds is usually late; e.g. allocated in the last two months in a financial year and the allocated amount can not be used timely.
- Donor funds are sometimes not reliable.

Question 2 Is budgetary arrangement sufficient?

- Budgetary allocations should target specific activities especially taking into account the number of sub-regions.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- Adequate and timely flow of funds is a key to proper implementation of WRM.

  a) Allocation of 80% for development and 20% for recurrent.

- Diversification of fund sources is preferred consisting of the government funds, water permit revenue, fund from donors, African water facility fund, etc.
- The revenue from the WRMA should be used for conservation activities.

Remarks

✓ Need to harmonise the thresholds (ceiling of water use) for all water sources to be at same level by creating storage in areas of deficit.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Rift Valley Regional Office

Interviewee: Mr. David Mutai Regional Technical Manager
Date of interview: February 22, 2011

The officers gave a background of the institutional aspect in Rift Valley and the following are the issues raised:

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- Water resources are linked with land and due to land tenure and ownership, a problem in control and management of water resource is experienced.
- Land use affect water quality and quantity and sometimes conflict of Water Act and Agriculture Act especially land use along rivers.
- Competing demands have strained the available water leading to different thresh holds which is impacting badly among the water users of the water from different sources.
- Water quality is an indicator of the prevailing environmental conditions, and Lake Nakuru conditions (flamingos gone) is an indicator of the conflicts of EMCA with Land, Agriculture, Forest (destruction of plantation, water friendly species) and Water Acts leading to very bad condition of the catchment.

  a) Chemususu dam in the forest had problems with Forest Service/Forest Department though later the problems were solved.

  b) The water levels of the three rivers around Nakuru town have gone down such that 72% of water to the town is from boreholes.

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- The rules are fairly sufficient but enforcement capacity is a challenge. First priority is domestic water and then environmental flow to be maintained.

a) Example is enforcing irrigators to have storage for 3 months dry season for their own irrigation.

- The mandate on storage should have been fully with WRMA so as to manage the excess to create stock for sharing.

Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?

- There is no law supporting the cost sharing of multi purpose dams. Cost sharing rule is necessary to reduce conflicts and enhance sustainability.

Question 4 Are any other legal arrangements necessary?

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- The ministry personnel in WRMA need to be delinked from the ministry to ensure total commitment.
- The region has 5 sub regions. To ensure effective management of the region, the sub-regions are river basin based, hence 2 more sub-regions need to be established.
- The region covers 7 counties and it is expected that all counties will be WRUA members in their respective areas. Since CAACs can be representatives of WRUAs, the county governments can be represented in CAACs through WRUAs.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- Mainstreaming the stakeholder participatory approach will ensure information sharing which is a key to the management of the catchment.
- The WRUAs needs to be strengthened with capacity building while sub-regional offices need more personnel with relevant number and qualification because these two institutions are keys in implementations.

Question 3 What personnel capacity is necessary to strengthen?

- Due to the challenge in enforcement, the enforcement officers and water rights officers should be trained and gazetted to prosecute to ensure effectiveness in enforcement.
- The sub-regional personnel should de all round water resources managers to be in a position to address issues on water quality and quantity.

Question 4 Is inter-regional coordination sufficient?

- Inter linkage between regions is not common except on cross cutting issues like security, health etc.
- There is need for two or three regions to meet to share experiences and information.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Stakeholder coordination is not sufficient due to sector mandates and work plans.
- NEMA is willing to work with the other sectors but it lacks capacity to implement the action plans (one or two persons per office).

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- WRMA should be a key member on decisions for change on change of land use especially in water catchment areas.

Question 7 Is River Basin reorganization necessary?

- No need to reorganise the river basin.
- There is need to strengthen the existing structure especially the sub-regions to cover each river basin or for the larger rivers to have upstream and downstream management.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- Very necessary for it will assist the stake holders to exchange ideas, information and experiences.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- Funds available not adequate as per the proposed budget.
- Budget approved is very low compared to the proposed one while the disbursed is also lower than the approved.
- WRMA should be financed directly from the Government revenue other than being donor or WRMA revenue based.

Question 2 Is budgetary arrangement sufficient?

- Since the original budget is activity based, there is need to approve the budgets ensuring that activities are done to a level to create a positive impact taking into account the long term plans.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- Recurrent budget is small.
- More money should be for development.
- Monitoring, protection and enforcement funds need to be increase to ensure the effectiveness of the catchment management.

THE RESPONSE TO THE QUESTIONNAIRE

WRMA Ewaso Ng'iro North Regional Office

nterviewee: Mr. Simon Wangombe Regional Manager
Date of interview: February 28, 2011

The Regional manager gave a background of the institutional aspect in Ewaso Ng'iro North and the following are the issues raised:

Legal Issues

Question 1 What are the top three significant issues from the legal aspect?

- Lack of capacity to enforce because the staff is not trained and gazetted to prosecute.
- Lack of cooperation and knowledge on water issues by other law enforcing agents like the police and the courts.
- Most issues in the region are illegal irrigation intake of water during draught: typical process, 1) the downstream users complain to WRMA that no water in the river channel, 2) WRMA patrol/normal surveillance to inspect, 3) WRMA requests the administrative police to arrest the illegal person, 4) the regular police determine to file (when, how) in court or release, 5) go to the court if case filed.
- The court cases take long to be determined and the fines (the maximum is only ksh 50, 000, normally less than ksh 10,000) are too small to be effective.
- Overlapping roles with EMCA, Agriculture Act and Land Act bring implementation challenges especially on management of riparian land and effluent discharge.
- Need for a police unit and courts for WRMA and other natural resources agencies to be used for enforcement.

Question 2 Implementing Rules and Regulations (IRR) for the Water Act 2002 are sufficient to operate the regional water resources management?

- The rules are adequate but the fines (too small) need be revised upwards for effectiveness.
- Question 3 Cost sharing rule of multipurpose dams among stakeholders are legally necessary to enhance multipurpose dam projects?
- There are dams in the region which are individually owned, mostly by the large farms. Communities have pans which never last even 2 months of the dry period. However there are about 7 sites ready for development.
- The cost sharing idea is good for all will own and ensure sustainability. Though no legal provisions available, MOUs and agreements can be used before legislation is developed.

Question 4 Are any other legal arrangements necessary?

- Water crimes are treated/ regarded as petty crimes as per penal code though upstream and downstream conflicts lead to loose of life (a security issue). The some of the water crimes should be categorised as serious criminal offences.

Organizational Issues

Question 1 What are the top three significant issues from the organizational aspect?

- Inadequate office space and in appropriate plus inadequate transport both at the region and some sub-regions.

- Inadequate relevant personnel at the sub-regional offices for implementation.

- Need for 2 extra sub-regions for effective management of the catchment.

Question 2 What functions are necessary to strengthen the existing organization in order to materialize the water master plan for the respective catchment, in line with the respective Catchment Strategy and NWRMS?

- The function of creating storage should be with WRMA so that the excess water can be stored for use during the low flows.

Question 3 What personnel capacity is necessary to strengthen?

- Prosecution personnel need the capacity to be built to a level where they can prosecute in a court of law.

- Personnel on storage structures designs and supervision needs to be in place.

- All need to be re trained in their respective area of specialisation and others area like ICT, community mobilisation, management skills etc.

Question 4 Is inter-regional coordination sufficient?

- Not sufficient but there is need for inter regional meetings to share ideas and experiences.

Question 5 Is coordination among stakeholders (national government, local governments, national sector agencies, stakeholders) sufficient?

- Not sufficient because even within water sector agencies, no coordination at all levels. There is need for the stakeholders to meet. The WRUAs in the region are in the process of forming Ewaso Ng’iro North WRUA forum targeting the 57 WRUAs where majority are in the upper part of the catchment.

  a) WRUR Forum was initiated by active WRUAs in December 2010, the second meeting was held in January 2011, and the meeting for preparation of its constitution is planned in March 2011.

  b) It will be financed by WRMA and Centre for Training and Research in Arid Districts, MWI (CETRAD). Fund raising is also planned.

Question 6 Are there any missing functions at present to achieve sustainability of water resources management?

- WRMA should be the leader in storage and conservation of water catchments.

Question 7 Is River Basin reorganization necessary?

- No need of reorganising the river basins. What is required is adequate facilitation with resources of the current structures.

Question 8 Is Catchment Forum tested by JICA necessary (as a pilot program)?

- It is necessary to have a forum for exchanging ideas and experiences.

Financial Issues

Question 1 What are the top three significant issues from the financial aspect?

- Proposed budget usually not approved, and what is approved is not released timely and in total.

Question 2 Is budgetary arrangement sufficient?

- Cutting down proposed budget by 50% in not fair.
- Funds not released on time and sometimes unreliable.
- The fund should target 80% to sub-regions then the rest to the region.
- There should be fund for public awareness, storage, development of recharge areas, demonstration of good water management practices, etc.

Question 3 What financial capacity is necessary to materialize the water master plan for the respective catchment?

- Personnel in accounts at regional and sub-regional levels need to be increased and trained especially on accounting software.
- Information decemination/ education of the public rights shall be financed or subsidised.
- Funds for catchment protection, construction of storages and water tanks are necessary.
- WRUAs need to be trained on accounting so that they can account for the money they receive.
- Funds for WRUAs activities (e.g. transportation cost) are necessary. The WRUAs need some office to keep their records and be a meeting place for them.

Remarks

- ✓ The catchment is 210,000 km^2 with the challenges which include diminishing water and illegal abstractions.
- ✓ Ground water is the major source of water and drought is the biggest challenge.
- ✓ KWS is CAAC member while CFA are WRUA member and WRUAs are CFAs members.
- ✓ The region intents to raise fund through Harambee for the WRUA forum expenses.

Sectoral Report (M)
Database and GIS

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

FINAL REPORT
VOLUME – VI SECTORAL REPORT (3/3)

M: DATABASE AND GIS

Abbreviation

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List of Abbreviations and Acronyms

DHI	:	Danish Hydraulics Institute
GIS	:	geographic information system
GTZ	:	Deutsche Gesellschaft fur Internationale Zusammenarabeit
ICT	:	Information and Communication Technology
IT	:	Information Technology
KWSP	:	Kenya Water Sanitation Programme
LAN	:	Local Area Network
MB-TAE	:	MIKE Basin - Temporal Analyst Enterprise
MWI	:	Ministry of Water and Irrigation
NIB	:	National Irrigation Board
NWMP	:	National Water Master Plan
SQL	:	Structured Query Language
WAN	:	Wide Area Network
WISC	:	Water Information System Centre
WQ	:	Water Quality
WRAP	:	Water Resources Assessment and Planning
WRMA	:	Water Resource Management Authority
HQ	:	Headquarter
WRMIS	:	Water Resources Management Information System
WSB	:	Water Service Board

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

Water resources data are critically important to both operations and long-term planning of Kenya. Although the data on water resources are collected by the Ministry of Water and Irrigation (MWI) and Water Resources Management Authority (WRMA), most informational needs relating to water studies and planning had not been met. Water resource management is inherently geographical, with activities that require the handling of multiple forms of spatial data. Various combinations of geographic information system (GIS) and simulation models will be required to improve further knowledge in these areas. GIS offers powerful new tools for the collection, storage, management, and display of map related information; whereas simulation models can provide decision-makers with interactive analysis tools to understand the physical system and judge how management actions might affect that system. Powerful GIS tools require strong database management. Without a strong foundation and well organized database, it will be difficult to manage water resources effectively or to adequately plan for the future.

A field survey has been conducted to MWI, WRMA headquarters, and all WRMA regional offices in order to understand the current situation of the database and GIS sections. The survey shall also identify key issues for future improvement to meet the increasing demand of a well organized database. This sectoral report evaluates the database and GIS sections located in all the organizations mentioned above, which is divided into three main chapters, as follows:

(1) Chapter 1 provides a brief background of the importance of GIS and database to water resources management, and gives an introduction to this report.

(2) Chapter 2 explains the current situation of GIS and database in the country, the relevant organizations involved in this survey, relevant polices and strategies, operation and maintenance issues, and the challenges and key issues.

(3) Chapter 3 suggests a proposal to strengthen the GIS and database in the relevant organizations for a more effective database management.

CHAPTER 2 CURRENT SITUATION OF DATABASE AND GIS

2.1 Relevant Organizations

The organizations concerned in this study are mainly those related to water resources management specifically: MWI, WRMA headquarters, WRMA regional offices, and WRMA sub-regional offices. Figure 2.1.1 shows the database flow from the WRMA sub-regional offices to WRMA headquarters. The flow chart illustrates that the database sections of MWI and WRMA are separate and they do not have one common database section. This is attributed to the Water Act 2002 which caused the formation of WRMA as an implementation agency for water resources management. Consequently, database management should be executed by WRMA as well as all its regional and sub-regional offices located in various municipalities and town councils in Kenya.

2.2 Relevant Policies and Strategies

The MWI and WRMA headquarters do not have a clear policy for database management. This is one of the main key issues that should be taken into consideration in the future. There is a draft report prepared by MWI on June 2010, which is "Draft Guidelines on Water Resources Data and Information Management". The guideline covers a wide range of database, such as rainfall, water level, river gauging, water quality, and sediment data. However, the guideline did not cover the policy for the database. Presenting a well defined policy for handling and managing water resources database will be more effective. Through this policy, a specific annual budget can be identified, the proper number of personnel can be addressed, and necessary capacity building can be organized in a suitable and regular way.

2.3 Current Situation of Database and GIS

2.3.1 Database and GIS in MWI

The development of the National Water Policy of 1999 and Water Act 2002 caused the reform of the water sector. The Water Act 2002 provided a legal framework that guided the creation of institutions to manage water resources and provide water services. This act limits the MWI role to policy formulation namely; overseeing the implementation of the policies and resource mobilization. Also through this act, the WRMA was established in 2003, and started its operation in 2005. The main responsibility of WRMA is the planning, regulation and management of water resources, as well as contributing to the formulation of water policies. As a result of the reformation, the entire water-related database was transferred from MWI to WRMA.

The current conditions of the Water Resources Database Section of MWI after the reformation were noted as follows:

(1) Database Section

1) Computers

i) The computers in the database room are very old and are in an unorganized condition. The latest personal computer (PC) model which is currently used for storing the entire database only has a Pentium 4 processor. Regarding other PCs, some are still working while some are not. However, even the PCs which are still working are also very old.

ii) The server which was installed during the previous National Water Master Plan (NWMP) in 1992 is not working. The server was working properly from 1992 until 1994, but it started to gradually breakdown until it totally stopped working.

iii) Under the assistance of the Government of the Netherlands, a study on the Water Resources Assessment and Planning (WRAP) was conducted, and new machines were bought. These machines were operated using the Unix system. The Oracle database system was also installed. The database section of MWI had used the two systems during the period from 1994 to 2003.

iv) Also, under the Canadian assistance, a new server was bought. However, the server was left without an operating system. Consequently, the server was not used.

2) Software

Currently, the entire database software has been transferred from Oracle to Microsoft Access after the server broke down. The administrator in the database section managed to work on Microsoft Access in order to keep the data organized and usable.

3) Personnel

There are four staff assigned to the database section in MWI: one manager, one administrator, and two persons on data entry. Also, there are some personnel in the second and third floors of the ministry who are working on data entry.

4) Database

Currently, water-related databases have not been updated by the database section of MWI since the responsibility of managing the database had been transferred to WRMA. However, the groundwater section in the MWI is still updating their database for entries or information related to groundwater.

(2) GIS and Cartographic Center

1) The GIS and Cartographic Center was greatly affected by the restructuring of the MWI;
2) The GIS and Cartographic Center in MWI, including the GIS software and hardware, were lost with exception for some PCs that still using GIS with limited functionality;
3) The room, which was used as GIS and Cartographic Center, was given to GTZ after that; and
4) The plotter which was used to print the maps is currently not working.

2.3.2 Database and GIS in WRMA

WRMA started its operation in 2005 as mentioned earlier. From 2005, WRMA took the responsibility of managing water-related database after receiving the entire database from the MWI. Thus, the Water Resources Management Information System (WRMIS) has been developed to support all elements of water resources management. The WRMIS is operational throughout WRMA. The following shows the current condition of the database section in WRMA:

(1) Database Section

1) Software

i) Both WRMA headquarters and its regional offices are using Microsoft SQL Server 2008 to store the water-related database.

ii) All WRMA offices from headquarters to sub-regional offices have ArcGIS 9.2 installed in their offices.

iii) The MIKE BASIN model is operated as an extension within the ArcGIS 9.2 environment. MIKE BASIN is currently available at the WRMA headquarters, and its regional offices.

2) Personnel

i) There are two persons assigned in the database section in the WRMA headquarters: one is the database administrator and supervisor, and the other is the information and communications technology (ICT) officer.

ii) In each regional office there is only one person working as a database administrator. However, the Machakos Regional Office does not have an ICT officer and a GIS specialist. In other regional offices such as in Kisumu and Nakuru, the database administrator is also the ICT officer and GIS specialist. Kakamega and Nanyuki have better situation since they have two officers working as ICT, database administrators and GIS specialists. In Embu, there is an officer working as an ICT officer and another officer working in database management.

(2) GIS Section

1) The WRMA headquarters does not have a GIS and Cartographic Center similar to the ones available in the MWI before the reformation. The WRMA headquarters currently has two floating licenses of ArcGIS 9.2. However, only the database administrator uses the ArcGIS software. The main use of the ArcGIS software is to operate the MIKE BASIN software in order to backup the database received from the regional and sub-regional offices, as well as to perform some basic GIS operations.

2) The regional offices use ArcGIS 9.2 mainly to store the collected data from the sub-regional offices into the server via the MIKE BASIN software. However, some regional offices such as Kakamega have better knowledge in GIS. They also have the ability to use the software to produce maps requested for their regional office.

Figure 2.1.1 shows the database flow from the WRMA sub-regional offices up to the WRMA headquarters. The data at the sub-regional offices are collected through individuals called “honoraria gauge readers”. These honoraria gauge readers go to the field to get the readings from different gauging stations. They then send the collected data to the sub-regional offices. However, sometimes due to insufficient budget, an honoraria gauge reader does not get paid for his work. This makes the sub-regional office unable to get the readings from the gauging stations during that period. Depending on the regional office, some data are received from the sub-regional offices once a month, while some data are received once every three months. The data collected from the sub-regional offices are sent either by CD or e-mail, to be stored through MIKE BASIN in the SQL Server 2008 of the WRMA regional offices. The collected data at the regional offices are also sent once a month using the same procedure, to be stored through MIKE BASIN in the SQL Server 2008 located at the WRMA headquarters.

2.4 Ongoing Projects and Existing Plans

Currently, there are no ongoing projects to upgrade the database sections in the WRMA offices. Nevertheless, WRMA has plans to improve the network connections among the offices of its headquarters, regions, and sub-regions which shall be linked via wide area network (WAN) connection instead of a local area network (LAN) connection. WRMA would like to utilize WAN to relay data among its employees located at various geographical locations. In essence, this mode of telecommunication allows WRMA to effectively carry out its daily function regardless of location. WRMA actually started to implement this plan experiencing trials in connecting among their offices via the internet. Until now, the implementation is still at its initial stage and is not yet fully utilized.

Previously, the Danish International Development Agency (DANIDA) and the Swedish International Development Cooperation Agency (SIDA) supported the Kenya Water Sanitation Programme (KWSP), which has assisted MWI in its provision of water services, management of water resources, and implementation of sector reforms from 2005 until the end of 2009.

The KWSP supported WRMA in its analysis of the temporal (time bound) and spatial (map-based) data information needs. A comprehensive assessment was made to determine the data types to be collected, method of data storage, management of time-series data, data inputting facility requirements, water allocation, and rainfall-runoff and hydrological analysis modeling requirements.

In addition, consideration was given to the need and functionalities of the water permit/ use database and management requirements of the borehole data. With the support of KWSP, the WRMA proceeded with the purchase of a MIKE BASIN-Temporal Analyst Enterprise (MB-TAE) software package. The MB-TAE was developed by the Danish Hydraulics Institute (DHI) through an extensive training program to upgrade the capacities within WRMA, and support the capabilities within the private sector.

Six missions have been proposed to support the MB-TAE roll-out program. It is intended that each mission will build on from the previous mission. The following general topics have been outlined for each mission:

1) Mission 1: Data Entry. It was held from September 28 to October 10, 2008 in Embu.
2) Mission 2: Quality Control and Reports. It was held from January 19 to 29, 2009 in Naivasha;
3) Mission 3: Rating Equations. It was held from March 24 to April 2, 2009 in Machakos;

4) Mission 4: Rainfall-Runoff Modeling. It was held from June 16 to 25, 2009 in Nyeri;
5) Mission 5: Water Balance/Water Allocation. It was hosted in Lake Victoria North Catchment in Eldoret from September 30 to October 8, 2009. Mission 5 covered the following topics:
   a) MIKE BASIN modeling - Basic Exercises
   b) MIKE BASIN modeling - Regional setup
   c) MIKE BASIN modeling - Case Study
   d) Rating curve review and calculation of discharge
6) Mission 6: Groundwater/WQ Issues. Mission 6 was not yet achieved, since KWSP (I) came to an end on December 2009. Therefore, this support program is incomplete and still remains as a future requirement. Currently, the WRMA requested to continue the training on MB by taking Mission 6. However, until this moment, this mission has not been accomplished.

2.5 Operation and Maintenance Issues

To ensure a sustainable and effective operation and maintenance of database section in the WRMA headquarters and its regional offices, the following issues have to be settled as soon as possible:

2.5.1 Customizing the Interface of SQL Server 2008 Software

There are many gaps in the database. One of the main reasons these gaps is the complicated interface of the SQL Server 2008 software. During the previous NWMP (1992), the JICA Study Team customized the Oracle interface software to be user-friendly in order to facilitate the database management in MWI. After 20 years, it is necessary to do the same thing. Only this time, it should be done for the SQL Server 2008 and not for the Oracle software.

The current interface of SQL Server 2008 is very complicated for personnel who are not specialized in IT. Therefore, to facilitate their work, the interface of the SQL Server 2008 should be customized as user-friendly so that it can be easily used and operated in the database sections of the WRMA headquarters and its regional offices. This customization should be prioritized to enhance the management of water resources database. Currently, all database personnel of the WRMA headquarters and regional offices are not using SQL Server as their main database software due to its complex interface, which makes them unable to operate this software.

2.5.2 Increase in the Number of Database Personnel

The number of well-trained personnel in the database sections must be increased to properly handle the water-related database at a national scale. One person in each database section in the WRMA headquarters and its regional offices is not enough. The personnel should have knowledge and experience in GIS, data entry, management and supervision. Moreover, the database section must have at least two IT specialists in the WRMA headquarters and one IT specialist in each regional office in order to solve the technical issues that may arise from time to time, and also to facilitate and improve the database management from an IT point of view.

2.5.3 Increase the Allocated Budget for Database Management

The improvement of the database management of water resources requires the additional allocated budget. By increasing the budget, many problems can be solved, such as by increasing the number of qualified personnel; increasing the number of people who will collect the data from the field; increasing, improving and renewing the monitoring gauging stations; and increasing and improving the software and hardware required for database management.

In order to increase the budget, it is important to focus on the improvement of funding. This means that MWI should give more focus and more emphasis on how to increase funds for water resources database, similar to the increase in funding to support some specific projects. Without sufficient funding for database management, it will be difficult to implement any project since projects need data for implementation.

2.6 Challenges and Key Issues

During the course of this study, the following challenges and key issues were noticed:

(1) Shortage of Manpower

Both the WRMA headquarters and regional offices have shortages in manpower for database and GIS. Currently, WRMA headquarters is taking the responsibility of managing the entire database at the national scale (the whole of Kenya), regarding water-related data such as river monitoring, groundwater, surface water, water quality, and some meteorological data. However, the WRMA headquarters only has one ICT officer and one database administrator. The database administrator should perform monitoring, supervising, and checking of the quality of water-related data received from the six regional offices. At the same time, the database administrator should also supply the needed information either internally or for a specific project, when required. Lastly, the database administrator should also provide the necessary maps in GIS format, regardless of its quality, when needed.

The situation at the regional offices is not better than the one at the WRMA headquarters. In general, one person works both as database administrator and ICT officer. In some regional offices, such as Machakos, there is only a database administrator. Most of the regional offices do not have well-trained GIS staff. Some of them do not even have a GIS specialist such as Machakos and Embu regional offices.

(2) Shortage of Database and GIS Technical Skills

Both the WRMA headquarters and the regional offices do not have a well-trained staff for managing the database in the SQL Server 2008 that is installed at the headquarters and regional offices. Normally, the database in the SQL Server is accessed through MIKE BASIN. In other words, the persons-in-charge are not well-trained on how to use the SQL Server in order to get access into the database directly from the server and not from MIKE BASIN.

The MIKE BASIN software is not a database entry software. It is designed for analyzing water sharing problems and environmental issues at an international, national and project scale. Using the MIKE BASIN software, the WRMA headquarters and its regional offices can do the following:

1) Solve multi-sector water allocation problems;
2) Improve reservoir and hydropower operations;
3) Conduct transparent water resources assessments;
4) Evaluate irrigation scheme performance and crop yield;
5) Assess nutrient loads from non-point and point sources;
6) Compare measures for water quality compliance; and
7) Store, analyze and visualize temporal data in GIS.

Both the WRMA headquarters and regional offices use the MIKE BASIN software just to store and visualize temporal data in GIS, which is considered an initial step toward the target of the software in making the necessary modeling when managing water resources data. Even though the staff of WRMA headquarters and regional offices have received training in using the MIKE BASIN software for about 2.5 months (5 times in every 2 weeks), they only know how to do step number seven in the list above. It may seem that the training was not only on the use of the MIKE BASIN, but also on how to prepare and organize the data to be stored in the database.

Regarding GIS, the staff of WRMA and the regional offices have not receive any training on using GIS, which is very important in water resources management. Therefore, the staff only knows the basics of GIS.

(3) Gaps in Database

There are many gaps in the database available at the WRMA headquarters and regional offices. The gaps in the database are due to the following reasons:

1) As a result of transferring the database from MWI to WRMA headquarters;
2) Due to the complicated interface of SQL Server which is difficult for the employees of WRMA headquarters and regional offices to operate, especially when they are not specialized in information technology (IT).
3) Due to the shortage in manpower, performing data entry of huge numbers of data records that are available in hard copies is inefficient;
4) Insufficient budget to pay for the honoraria gauge readers to take the readings from gauging stations;
5) Some stations or boreholes have records, but they do not have information on their locations;
6) Inadequate monitoring networks and poor monitoring infrastructure; and
7) Non-functioning monitoring stations.

(4) No Clear Policy of Data Management in Water Sector

As mentioned earlier, there is no clear data management policy in the water sector of Kenya at present. The existence of data management policy can solve a lot of problems related to data management of water resources. By this policy, sufficient budget can be allocated, sufficient number of personnel can be identified, and continuous training programmes can be organized. Without a clear policy on data management, the improvement of water resources database will be difficult.

(5) Ineffective Inter-ministerial Cooperation

Despite WRMA being an implementation agency under MWI, there is ineffective cooperation between the two agencies in terms of database. This may cause several problems in the future on how water resources projects can be planned and implemented. Currently, WRMA and MWI are dealing with each other in terms of database as independent organizations.

(6) Overlapping Responsibilities between WRMA and MWI in Managing Groundwater Database

Water resources database including surface water, groundwater, and water quality should be managed by WRMA. However, MWI is still managing and updating the boreholes records of its groundwater section. The groundwater section possesses the completion records of all boreholes in Kenya; regardless of the missing data in these boreholes which might not exist in WRMA. Therefore, the issue whether WRMA or MWI is responsible of managing groundwater data is not clear.

(7) Ineffective Management of Water-related Database among WRMA Headquarter and its Regional Offices

An interview was done to all WRMA regional offices located in the six catchments, and a questionnaire was submitted to the database section of each regional office, as shown in Table 2.5.1. One of the questions was how often the data is sent to WRMA headquarters. All the regional offices answered that the river gauging station data, for example, are sent once a month while some data are sent once every three months depending on the type of data. Considering the river gauging station data, it was found that some regional offices have more additional and updated information compared to the ones that exist in the WRMA headquarters. This gives an indication that the data are not sent from the WRMA regional offices to the headquarters regularly as indicated in the questionnaires, or that the data is not updated regularly in the WRMA headquarter, or both.

(8) Scattered Database among Different Organizations

The database which is carried out by this study covers different kinds of data. Some of these data are not currently under the responsibility of WRMA but also by other organizations, such as the National Irrigation Board (NIB) and the Water Services Board (WSB). Therefore, the presence of different organizations to manage water-related database is not an ideal way when planning for future projects as this will cause scattering of the database among different organizations. Furthermore, it will be difficult to collect the data again or at least to know which data are already updated. This issue has to be studied more deeply in the future, but unfortunately, it cannot be solved within this project.

(9) Inefficient Use of GIS in WRMA

The ArcGIS software is available in the WRMA headquarters and in all regional offices. However, the software is not used efficiently due to the lack of trained personnel as well as the problem in the database itself. This makes the GIS software not effectively operated. Currently, the database prepared in this study is mainly in GIS, which will be transferred at the end of this project to WRMA. Therefore, the use of GIS has to be given more attention by WRMA for it to be capable of updating and performing the necessary modifications smoothly and proficiently.

(10) Permit Database Not Considered for Water Balance Calculations

Currently, the permit database system is considered as a standalone system to give permits and provide authorization to users to abstract water from surface water and groundwater. There are four classes of water abstraction: Class A, Class B, Class C, and Class D. Class A considers a small amount of water abstraction, whereas Class D considers a big amount of water abstraction. In water balance calculations, the amount of water abstracted is not considered for all classes except for class D abstraction. Not considering the amount of water abstracted from all classes may have an effect on water balance calculations.

CHAPTER 3 PROPOSALS FOR STRENGTHENING OF DATABASE AND GIS

3.1 General

The current situation of the database sections at WRMA headquarters, and its regional and sub-regional offices makes it insufficient to manage the database of water resources for the entire country of Kenya. Improving the current situation is a must for effective management of water resources database. To improve the database sections at WRMA, there are several steps that should be followed and taken into consideration in the future. These steps are a combination of the improvement of legal, technical, and capacity building issues. Section 3.2 discusses in detail about improving and strengthening the database and GIS sections at WRMA.

3.2 Strengthening of Database System and GIS

3.2.1 Preparation of Policies on Water Resources Database Management

Most of the problems and issues identified in the previous sections are due to the absence of a clear policy on how to manage the water resources database. The presence of a well-defined legal policy will increase the attention on the importance of database management in the water sector.

The MWI prepared in June 2010 the "Draft Guidelines on Water Resources Data and Information Management". It is highly recommended to improve and revise this report until it reaches to a level of policy. Therefore, this report shall be finalized as soon as possible to be prepared for implementation. The implementation of this report shall be done in a form of policy on database management. The policy will identify the necessary budget and financial resources, collect data in an efficient way, share data amongst all the water sectors, provide adequate human resources to operate and manage the database system, and organize sufficient trainings to the personnel of the database section in order to be able to manage the database section. Identifying a clear policy can help a lot in improving the database sections at all WRMA offices, starting from its headquarters up to its sub-regional offices.

3.2.2 Improvement of the Existing Database System

As mentioned earlier in Section 2.6, there are many problems in the database sections at WRMA headquarters and in its regional offices. These problems should be solved to enhance the quality of database and GIS. To improve the condition of database sections at WRMA, it is recommended to take the following points into consideration:

1) The interface of SQL Server 2008 should be customized to be more user-friendly so that it can be operated easily in the database sections at WRMA headquarters and its regional offices;
2) Increase the number of personnel in the database section at WRMA headquarters. There should be at least one officer as ICT/server manager specialized in IT, one as database administrator and supervisor for all data obtained from the regional offices, and one GIS specialist to improve the quality of GIS maps.

3) An IT specialist should work in each regional office to take care of the database management as well as the server more efficiently.
4) Capacity building is necessary to all staff of WRMA regarding database management as well as GIS. Capacity building will improve the technical skills of all WRMA staffs on how to manage water-related database, and on how update GIS information more proficiently.

3.2.3 Establishment of a Water Information System Centre (WISC)

To solve the problem of ineffective inter-ministerial coordination and cooperation on the database, it is required to improve the quality of water-related database, as well as to avoid the overlap on who will manage the groundwater database. As an example, it is recommended to establish a water information system centre (WISC) at proper organization. The WISC will be a standalone centre responsible on all water resources information. The centre should be staffed with IT experts including database administrators, ICT officers, GIS experts, surface water and groundwater modellers, and data-entry staff. Also, the centre should be equipped with the necessary hardware such as plotters and scanners as well as the necessary software such as GIS, groundwater and surface water modelling softwares. The centre will be responsible on collecting data from the regional and sub-regional offices, data encoding for all available records in hard copies, performing training on water-related IT, providing quality standards of water database, and organizing all water information.

Tables

Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (1/6)

1) Kisumu Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML110, Pentium 4 3.2 GHz processor, 2.5 GB RAM
	Software	2. Operating system: Windows Server 2003 service pack 2 3. Database: SQL Server 2008 4. GIS: ArcGIS 9.2 - ArcEditor 2 floating licenses 5. Hydrological: Mike Basin software 6. Permit Database software
Current Condition of hardware and software		The Server at the regional office initially 512MB RAM upgraded to 2.5 GB RAM. It is however very slow and often hangs or takes too long to process information. The GIS software, SQL and MIKE BASIN are however in good condition. Client machines used for GIS work have 2GB+ RAM. There is however a problem with license acquisition from the server.
Number of Personnel		1. Database/GIS/ICT: 1 officer (regional office) 2. Data Entry: 1 person (Kisii sub-regional office)
Number of personnel collecting data from stations		Water level: 41 Evaporation: 11 Rainfall: 38
Is there quality standard for water-related Database		Yes.
Classification of Database quality		Medium
Frequency of data collection		Monthly
Number of agencies managing water-related database		2 agencies: WRMA, and KMD
How do you send the database to WRMA HQ?		A back up of the regional database is send to the headquarters monthly for restoring into the national database
Is there enough storage capacity?		The server storage capacity is 160 GB which is NOT enough
Is there a problem regarding Mike basin License at the regional office?	Regional Office	YES, the client computers cannot acquire license from the server.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (2/6)

2) Kakamega Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML370G5, Intel Xeon E5410, 2.33 GHz processor, 3.25 GB RAM
	Software	2. Operating system: Windows Server 2003 service pack 2 3. Database: SQL Server 2008 4. GIS: ArcGIS 9.2 - ArcEditor 1 license 5. Hydrological: Mike Basin software 6. Permit Database software
Current Condition of hardware and software		The condition of hardware and software are good, but there is a need to increase the number of licenses of Mike Basin software.
Number of Personnel		1. Database/GIS/ICT: 2 officer (regional office) 2. Data Entry: 3 person (sub-regional offices)
Number of personnel collecting data from stations		Water level: 102 Rainfall & Evaporation: 37
Is there quality standard for water-related Database		Yes.
Classification of Database quality		Medium. The reliability of data is not guaranteed
Frequency of data collection		- Ground water data: Monthly, transferred to WRMA HQ (once/month) - Surface water level: daily, transferred to WRMA HQ (once/month) - Rainfall: daily, transferred to WRMA HQ (once/month) - Water quality: (once/3 months) - Effluent of water form factory into river: (once/3 months)
Number of agencies managing water-related database		4 agencies: WRMA, KMD, private factors, and schools
How do you send the database to WRMA HQ?		Using email, and CDs
Is there enough storage capacity?		The server storage capacity is (146GB × 7 HDD), a total of 1,029 GB, which is enough
Is there a problem regarding Mike basin License at the regional office?	Regional Office	There is only 1 floating license of Mike Basin and there are 3 persons need to use the software including the surface water officer, which is not enough.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (3/6)

3) Nakuru Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML110, 3.2 Gigabyte RAM 2. 1 desktop HP Compaq Pentium D, Duo Core, 2.99 GHz running Windows XP 3. 1 Laptop Dell running Windows 7
	Software	1. Operating system: Windows Server 2003 2. Database: SQL Server 2008 3. GIS: ArcGIS 9.2 - ArcEditor 2 floating licenses 4. Hydrological: Mike Basin software 5. Permit Database software 6. Accounting: Navision software
Current Condition of hardware and software		1. The server is slow and old (2004), and cannot handle most of the operations despite having been upgraded. 2. The other two (2) computers are operating well. 3. The operation system and all the applications need upgrading despite of being all of them are working.
Number of Personnel		1. Database/GIS/ICT: 1 Database officer, and 1 surface water officer (regional office) 2. Data Entry: 5 data clerks (sub-regional office)
Number of personnel collecting data from stations		66 honoraria gauge readers
Is there quality standard for water-related Database		Yes. The integrity of the data is checked and confirmed during data entry at the sub-regional office and at the regional office.
Classification of Database quality		High
Frequency of data collection		- The data are collected daily from RGS. - Discharge measurements and water quality data are collected periodically depending on arising needs, parameters, season etc.
Number of agencies managing water-related database		3 agencies: WRMA, MWI, and KMD
How do you send the database to WRMA HQ?		Using backup CDs/DVDs, and sent monthly to WRMA HQ
Is there enough storage capacity?		The storage capacity is sufficient for now but not very secure i.e. hard drives and loose files. The express SQL server can only handle up to 4 gigabyte of data.
Is there a problem regarding Mike basin License at the regional office?		- The mike basin software can allow only 2 licenses but we require a minimum of 4 as there are other uses that will be included in the Login apart from the current 2 users. - Connectivity between the server and the client is always down as the server is obsolete and is also running other memory consuming programmes including ArcGIS, Mike basin, Permit database, Navision, DNS etc. - There is need to configure the tables in SQL to get access to the entire database in other data management programmes like MS Access for reporting purposes.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (4/6)

4) Machakos Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML370G5, E5410@2.33GHz, and 3.25 Gigabyte RAM. 2. 1 desktop computer Pentium III@3.2 GHz, 2.5 Gigabyte RAM, and HDD of 150 Gigabyte
	Software	1. Operating system: Windows Server 2003 2. Database: SQL Server 2008 3. GIS: ArcGIS 9.2 - ArcEditor 2 floating licenses 4. Hydrological: Mike Basin software 5. Permit Database software 6. Accounting: Navision software
Current Condition of hardware and software		The computers are slow, and need to be upgraded or changed to new faster one.
Number of Personnel		1. Data entry: 1 officer (regional office) 2. There is no ICT officer at the regional office 3. There is no GIS specialist at the regional office 4. Data entry: 5 officer (sub-regional offices)
Number of personnel collecting data from stations		5 persons as gauge readers collected data from the field
Is there quality standard for water-related Database		Yes
Classification of Database quality		Low
Frequency of data collection		- Water level from RGS, rainfall, evaporation stations: daily - Groundwater monitoring data: monthly - Water quality and flow measurements: Quarterly
Number of agencies managing water-related database		4 agencies: WRMA, KMD, KARI (Kenya Agricultural Research Institute), and TARDA (Tana-Athi Regional Development Authority)
How do you send the database to WRMA HQ?		Using backup CDs
Is there enough storage capacity?		The storage capacity is not enough to handle the entire database of regional office.
Is there a problem regarding Mike basin License at the regional office?	Regional Office	There is no problem in Mike basin license.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (5/6)

5) Embu Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML370G5, E5410@2.33GHz, and 3.25 Gigabyte RAM. 2. 1 desktop computer, and 4 additional laptops
	Software	1. Operating system: Windows Server 2003 2. Database: SQL Server 2008 3. GIS: ArcGIS 9.2 - ArcEditor 2 floating licenses 4. Hydrological: Mike Basin software 5. Permit Database software 6. Accounting: Navision software
Current Condition of hardware and software		Not clearly answered, but there is a network problem between the server and the client computers.
Number of Personnel		1. Database/GIS: 5 officers (regional office) 2. ICT and server management: 1 officer (regional office) 3. Data entry: 5 officers (sub-regional offices)
Number of personnel collecting data from stations		RGS: 33 honoraria gauge readers Rainfall and weather stations: 27 persons
Is there quality standard for water-related Database		Yes
Classification of Database quality		National Stations: High Other Stations: Low
Frequency of data collection		Daily
Number of agencies managing water-related database		3 agencies: WRMA, KMD, and MKEPP (Mount Kenya East Pilot Project)
How do you send the database to WRMA HQ?		Using email (once/month), and CDs
Is there enough storage capacity?		The storage capacity is enough to handle the entire database of regional office.
Is there a problem regarding Mike basin License at the regional office?	Regional Office	The problem is not in Mike basin, but in the network that connect the server – in which Mike Basin licenses exist – and the client computers. If there is a network problem or the server is down, Mike Basin cannot be used, and the database cannot be accessed.
	Sub-regional Offices	The sub-regional offices should be given licenses of Mike Basin in order to be able to see the data stored into Mike Basin software.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

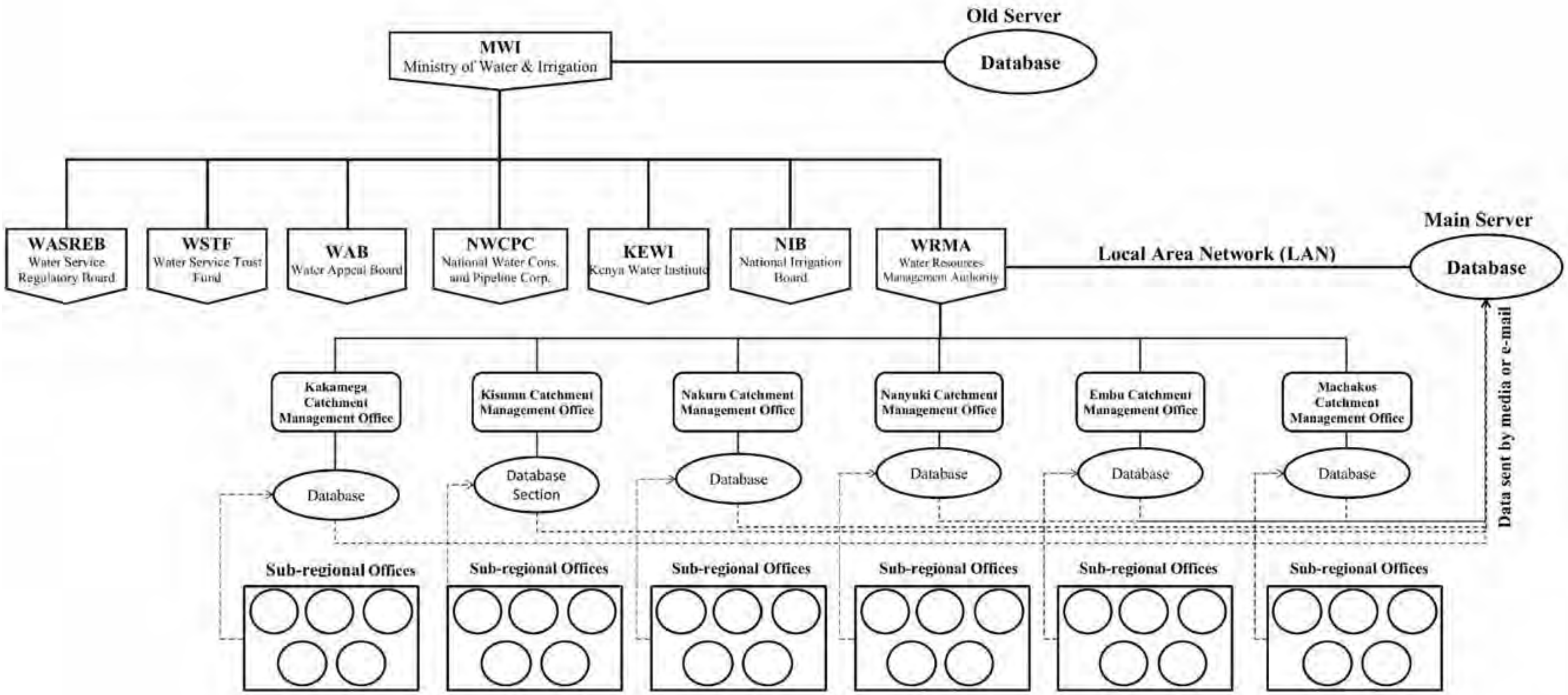
Table 2.5.1 Summary of the Questionnaire Results Obtained from Each Database/GIS Section in WRMA Regional Offices (6/6)

6) Nanyuki Regional Office

Question	Sub-category	Answer
Information about Database/GIS Section	Hardware	1. Server HP Proliant ML110, 2.5 Gigabyte RAM, and 150 GB HDD 2. Laptops
	Software	1. Operating system: Windows Server 2003 2. Database: SQL Server 2008 3. GIS: ArcGIS 9.2 - ArcEditor 2 floating licenses 4. Hydrological: Mike Basin software 5. Permit Database software
Current Condition of hardware and software		Although the hardware is operational, it is old with limited capacity, and obsolete. Regarding the software, the windows server should be upgraded to windows 2008. The Mike Basin/Temporal Analyst Enterprise software in Database/GIS section is adequate.
Number of Personnel		3. Database/GIS/ICT: 2 officers (regional office) 4. Data Entry: 1 surface water officer (regional office)
Number of personnel collecting data from stations		- 33 honoraria gauge readers - 6 Catchment Managements Officers (CMOs) at three sub-regions, namely Nanyuki, Isiolo, and Rumuruti.
Is there quality standard for water-related Database		Yes. There is a regular monthly backup of the database and data quality control before feeding into the database.
Classification of Database quality		High
Frequency of data collection		- The data are collected daily from RGS, and it is transferred from the sub-regional office to the regional office at the end of the month. - Groundwater data: collected once/month - Water Quality: collected once/3 months
Number of agencies managing water-related database		4 agencies: WRMA, Ewaso Ngiro North Development Authority (ENNDA), Center for Training and Integrated Research for Arid and Semi Arid Land (ASAL)Development (CETRAD), and KMD
How do you send the database to WRMA HQ?		Using backup CDs
Is there enough storage capacity?		The storage capacity is inadequate should be increased to take care of future demand.
Is there a problem regarding Mike basin License at the regional office?	Regional Office	- There are only two (2) licenses in the server. These can be increased to enable more users to access the GIS at the server. - The license of two (2) portable dongles which are used with laptops expired. They should be renewed.

Source: JICA Study Team based on Interview Surveys in WRMA Regional Offices

Figures



Source: JICA Study Team based on Interview Surveys in WRMA Headquarters and Regional Offices

THE DEVELOPMENT OF
THE NATIONAL WATER MASTER PLAN 2030

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 2.1.1
The Database Flow from Sub-regional Office to WRMA Headquarter

Sectoral Report (N)
Pilot Activities

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

FINAL REPORT
VOLUME – VI SECTORAL REPORT (3/3)

N: PILOT ACTIVITIES

Abbreviation

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List of Abbreviations and Acronyms

AWS	:	Automatic Weather Station
CAAC	:	Catchment Areas Advisory Committee
CBO	:	Community Based Organization
DDMC	:	District Disaster Management Committee
EDCP	:	Effluent Discharge Control Plan
ENN	:	Ewaso Ng'iro North
FDDM	:	Flood and Drought Disaster Management
GIS	:	Geographic Information System
GW	:	Groundwater
ICT	:	Information and Communication Technology
IT	:	Information Technology
JICA	:	Japan International Cooperation Agency
KenGen	:	Kenya Electric Generating Company
KFS	:	Kenya Forest Service
KMD	:	Kenya Meteorological Department
KRCS	:	Kenya Red Cross Society
KWS	:	Kenya Wildlife Service
LVN	:	Lake Victoria North
LVS	:	Lake Victoria South
MoU	:	memorandum of understanding
MWI	:	Ministry of Water and Irrigation
NEMA	:	National Environment Management Authority
NGO	:	Non-Governmental Organization
NIB	:	National Irrigation Board
NWMP	:	National Water Master Plan
PDB	:	Permit Database
RDA	:	Regional Development Authority
RGS	:	River Gauging Station
RV	:	Rift Valley
SCADA	:	Supervisory, Control and Data Acquisition
SCMP	:	Sub-catchment Management Plan
SQL	:	Structured Query Language
SW	:	Surface Water
TARDA	:	Tana and Athi River Development Authority
TCA	:	Tana Catchment Area
UTM	:	Universal Transverse Mercator
WAB	:	Water Appointment Board
WRMA	:	Water Resources Management Authority
WRO	:	WRMA Regional office
WRUA	:	Water Resources Users Association
XML	:	Extensible Markup Language

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 GENERAL

1.1 General

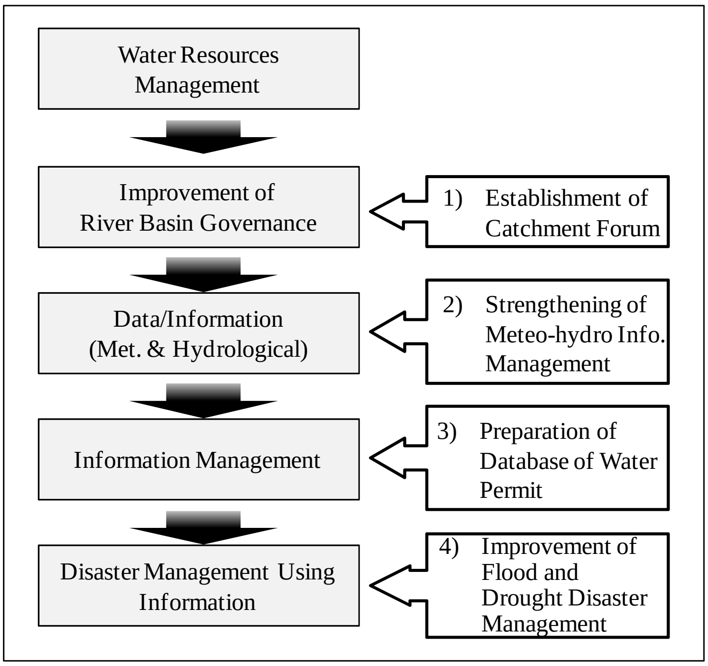
The objective of the pilot activities in the Tana catchment area is to strengthen the water resources management capacities and institutional system of the WRMA Tana Regional Office (WRMA-Tana).

The pilot activities have been implemented in the following successive phases:

Phase 1: December 2010 to June 2011
Phase 2: June 2012 to November 2012

For both phases, the sublet consultant, Norken (I) Ltd. (the Consultant), carried out the pilot activities in consultation with the JICA Study Team.

The first and one of the most important activities in water resources management is to achieve improved governance at the river basin level. Improving and maintaining meteorological and hydrological observations are also considered as cross-cutting measures in water resources management. Such observed data should be stored in the database system which should be used for water resources management, including flood and drought disaster management. The following figure illustrates the prioritized needs identified in WRMA-Tana and the pilot activities.



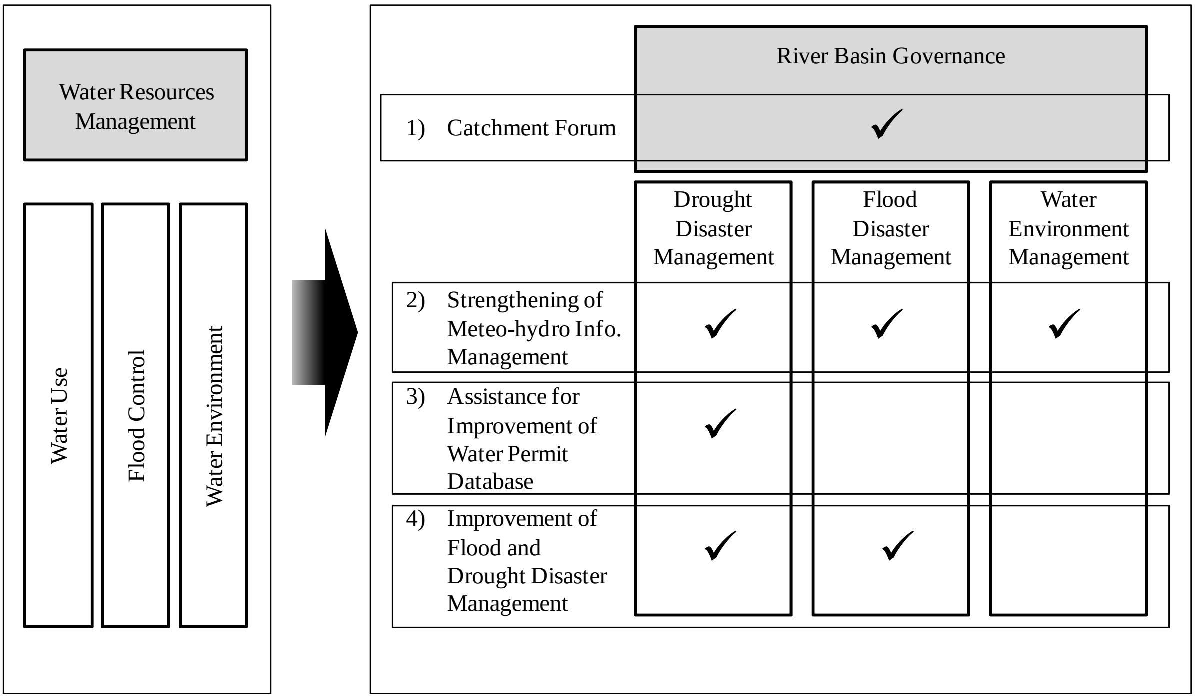
Source: JICA Study Team

Pilot Activities for WRMA Tana Regional Office

The following pilot activities were undertaken in WRMA-Tana:

a) Assistance for the Establishment of Catchment Forum for Improvement of Governance;
b) Assistance for the Strengthening of Hydrological Information Management;
c) Assistance for the Improvement of Water Permit Database; and
d) Assistance for the Improvement of Flood and Drought Disaster Management.

The key management elements in water resources management are i) securing safe water supply for various uses, ii) securing water quality for sanitation and ecology, and iii) securing safety against flood. The following figure describes the pilot activities which were carried out in this study, categorizing the management elements in water resources.



Source: JICA Study Team

Management Elements in Water Resources Management

CHAPTER 2 ASSISTANCE FOR ESTABLISHMENT OF CATCHMENT FORUM AND IMPROVEMENT OF GOVERNANCE

2.1 Objective of the Assistance

It is anticipated that the WRMA regional offices play the core role of water resources management in practice, together with the WRMA subregional offices under the decentralization policy. Section 15 (3) (e) of the Water Act 2002 provides for the establishment of a mechanism and facilities; enabling the public and local communities to participate in managing water resources within each catchment area. In addition, Section 15 (5) of the Water Act 2002 gives provision for encouraging and facilitating the establishment and operations of the Water Resources Users Associations (WRUAs) as forum conflict resolution and cooperative management of the water resources in catchment areas.

WRMA has established WRUAs at subcatchment level to meet the requirement of the above sections. There is a need for a catchment area forum for WRUAs in each of the six catchment areas to promote linkages when sharing experiences, ideas, and information on catchment-wide basis.

The JICA Study Team assisted WRMA at both the national and regional levels in order to establish the catchment forum for WRMA-Tana as a pilot activity for improving water resources management capacities and governance in the catchment area in line with Section 15 (3) and Section 15 (5) of the Water Act 2002.

2.2 Components of Pilot Activities

The pilot activity on the establishment of the catchment forum and improvement of governance comprises the following three components:

a) Awareness activities for the establishment of a catchment forum including education activities and community mobilization,
b) Assistance for the establishment of a catchment forum including selection of forum members, preparation of draft by-laws for the forum and building public relations for the forum, and
c) Assistance for operations of the catchment forum including arrangement of the forum, analysis of issues on catchment governance, proposal on governance improvement, and proposal on sustainable operations of the catchment forum.

2.3 Activities in the First Phase

2.3.1 Awareness Activities for Establishment of Catchment Forum

At the beginning of the pilot activities, the Consultant conducted visits to WRMA-Tana in Embu on January 4-5, 2011 to carry out the following activities:

a) Create an awareness for the establishment of a catchment forum;
   - Introduction of the four objectives of NWMP 2030
   - Explanation of necessity of the pilot activity on the establishment of a catchment forum
b) Analyze the current status of the WRMA-Tana’s organizational, institutional, and governance situation

c) Clarify the situation of water resources management and reconcile scoring differences between governance and institutional issues and key targets as documented in their strategic plan

d) Identify stakeholders that are involved in water resources management within the Tana catchment area

During the meetings, the Consultant also collected existing information and conducted key informant interviews with the staff of WRMA-Tana, which included: the regional manager, regional technical manager, enforcement officer, and WRUAs coordinator. In addition to these awareness activities in January 2011, the JICA Study Team and the Consultant conducted preparatory meetings before the catchment forum as shown in the table below.

Meetings with WRMA-Tana

Date	Purpose of Meeting	Participants from WRMA-Tana
January 4-5, 2011	Awareness Activity	• Regional Manager • Regional Technical Manager • Enforcement Officer • Community Mobilizer • WRUAs Coordinators • Water Resources Officer
March 7, 2011	Preparation for the First Catchment Forum	• Regional Manager • Regional Technical Manager • Enforcement Officer • Community Mobilizer • WRUAs Coordinators
May 26-27, 2011	Preparation for the Second Catchment Forum	• Regional Manager • Regional Technical Manager • Enforcement Officer • Community Mobilizer • WRUAs Coordinators

Source: JICA Study Team

Awareness activities for the staff of WRMA-Tana and mobilization activities for WRUAs were also conducted. Mobilization of the WRUAs was meant to:

a) Understand some challenges they face and their proposed solutions in terms of financial, organizational and legal aspects while administering their duties in water resources management and other conflict resolutions.

b) Create awareness over the planned catchment forum and seek the views of the WRUAs on the membership of the forum.

Due to the extent of the Tana catchment area, three WRUAs were preselected through the assistance of the WRUAs coordinators of WRMA-Tana. During the visits to the WRUAs, the JICA Study Team was accompanied by representatives from the WRMA subregional offices where each of the WRUA is located. The consultative meetings at the respective WRUA are summarized below.

Meeting with the Upper Thiba WRUA

Outline	Identified Issues faced by the WRUA
• WRUA Name: Upper Thiba • Date: February 2, 2011 • No. of Participants from the WRUA: 14 persons	• Financial constraints to effectively conserve the catchment through afforestation and removal of Eucalyptus trees. This problem is further compounded by the fact that for the last four years, despite writing numerous proposals, WRMA-Tana has not provided funds to the WRUA. Thus, making it difficult to mobilize and sensitize the community on the protection of water sources. • Poor communication and lack of linkages with other WRUAs. • Lack of office base to perform WRUA activities.

Source: JICA Study Team

Meeting with the Chinga WRUA

Outline	Identified Issues faced by the WRUA
• WRUA Name: Chinga • Date: February 2, 2011 • No. of Participants from the WRUA: 16 persons	• Inappropriate bookkeeping practices. • Voluntarism where the WRUA should monitor the riverine on quarterly basis without compensatory allowances on expenditures incurred and opportunities foregone. This has made it difficult to meet set targets. • Lack of vehicle to effectively monitor the riverine. • The WRUA has no finances to meet its recurrent costs. This is because it only depends on annual subscriptions fees from the members (i.e. KSh1,000 per member) which is irregular, delayed and unsustainable. • The WRUA has no physical office to run its operations. • WRUA meetings sometimes fail to take place due to lack of a quorum because members do not have enough money for bus fares to attend the meeting. • Resistance from farmers during catchment protection. For example, the WRUA members are being questioned on what legal basis it undertakes in some activities such as uprooting of Eucalyptus trees. Their efforts are further complicated by the fact that the owners are not compensated for the loss of these trees. • Lack of communication/linkage between the WRUAs i.e. Upper and Lower Thiba WRUAs. Thus hindering collaborative management of the river. • The WRUA membership is not well represented (i.e. no representation from the local administration, WSP and riparian farmers), thus, hindering their efforts in catchment protection. • Poor collaboration between the WRUA and community due to lack of recognition and identification. • There is lack of political will to support the WRUA.

Source: JICA Study Team

Meeting with the Ngakinya WRUA

Outline	Identified Issues faced by the WRUA
• WRUA Name: Ngakinya • Date: February 3, 2011 • No. of Participants from the WRUA: 15 persons	• Inability to enforce laws thus hindering the efforts of the WRUA in water management. • Lack of adequate training, e.g. in writing proposal and record keeping. • Lack of office base to carry out WRUA actives and keep records. • Encroachment and clearance of wetlands for farming activities. • Use of open channels irrigations that are uneconomical. • Illegal and over abstraction of water by the water users. This is compounded by the lack of proper planning of water abstraction intake works, e.g. 19 intakes within a span of 2 km in the river. • Water use conflicts. • Felling of forest trees thus leading to human wildlife conflicts. • Ignorance of the WRUA’s roles by the community. • Clearance of indigenous trees. • Pollution of water by fish farmers who have constructed fishponds in the wetlands. • Threats and problems of enforcing the Water Act 2002 (resistance from some who do not understand the act). • Lack of funds to implement the subcatchment management plan. • Quarrying activities at the catchment area.

Source: JICA Study Team


Chinga WRUA


Upper Thiba WRUA


Ngakinya WRUA

Consultative Meeting with WRUAs

2.3.2 Assistance for Establishment of Catchment Forum

In order to facilitate the establishment and operations of the catchment forum, the following forum materials were developed with assistance from the Consultant:

a) Catchment forum guidelines which incorporate the objectives, functions, membership, forum secretariat, forum meetings, responsibility of forum participants and operational costs of the catchment forum
b) Guidelines for selection of participants of the catchment forum
c) Cost estimates/budget of the forum

The forum guidelines were prepared instead of a specific by-law for the Tana catchment area in order to make the functions of the catchment forum flexible and adaptable in this stage. In developing the final forum guidelines, an interactive process was adopted involving meetings to get feedback from key stakeholders. The document was presented at the first catchment forum and was ratified by the members. After this process, the final document was produced and was called the “Catchment Forum Guidelines”. The guidelines are presented in Appendixes 1.1 and 1.2.

2.3.3 Assistance for Operation of Catchment Forum

In order to ensure the operations of the catchment forum, the Consultant, in collaboration with WRMA-Tana, prepared the following materials with assistance from the JICA Study Team:

a) Forum programmes and evaluation forms, and
b) Invitation letters for facilitated stakeholders and non-facilitated stakeholders.

The first and second catchment forums were successfully held on March 17, 2011 and June 2, 2011, respectively. The general overviews of each forum are outlined as follows:

(1) The First Catchment Forum

The first catchment forum had 63 participants and was held at Thika in accordance with the following agenda:

i) Participant registration
ii) Introduction of participants
iii) Opening remarks by the chairman
iv) Welcoming remarks by the regional manager of WRMA-Tana
v) Official opening speech by technical manager of the WRMA headquarters
vi) Presentations
    a) Water sector reforms and NWMP 2030 (technical manager of the WRMA headquarters)
    b) Basic facts – the Tana catchment area and water resources situation (regional manager of WRMA-Tana)
    c) Catchment Forum Guidelines (forum secretariat)
vii) Plenary discussions
viii) Election of a chairperson for the second catchment forum
ix) Adjournment

In the plenary discussions, participants had the opportunity to ask questions or comment on issues related to the presentations. The session was very interactive. As many as 18 questions and comments were raised. The areas of concern included the importance of dams in water conservation, climate change and its realities, protection of watersheds and wetlands, law enforcement, pace of sector reforms and water allocation. The questions were responded to by the technical manager of the WRMA headquarters and the regional technical manager of WRMA-Tana.

(2) The Second Catchment Forum

The second catchment Forum had 62 participants and was held at Kitui in accordance with the following agenda:

i) Participant registration
ii) Introduction of participants
iii) Opening remarks by the chairperson
iv) Welcoming remarks and official opening
v) Confirmation of minutes of the first catchment forum
vi) Presentations

a) Flood and drought management: challenges and mitigation in the catchment area (regional technical manager of WRMA-Tana)
b) Roles of WRUAs and their challenges during formation and operations (regional manager of WRMA-Tana)

vii) Group discussions and presentations
viii) Election of chairperson for the third catchment forum
ix) Adjournment

Three discussions groups were formed to deliberate on the main issues of the two presentations that had been prepared by the forum secretariat. The representation of the groups was all inclusive with majority being members of the WRUAs and a few observers. There were 12 discussion themes, which include challenges and issues faced by WRUAs during flood and drought. After the discussions, each group elected representatives to present the outcomes of their discussions.

2.4 Activities in the Second Phase

Following the second catchment forum held in the first phase of the study period, the third catchment forum had 68 participants and was held on July 18, 2012 at Nyeri with the following agenda:

i) Participant registration
ii) Introduction of participants
iii) Welcoming remarks and official opening
iv) Reading and confirmation of minutes of the second catchment forum
v) Presentations
    a) Water resources data management and information
    b) Flood and drought management
vi) Group work and presentations
vii) Wrap up of presentations and way forward
viii) Election of chairperson for the Fourth catchment forum
ix) Adjournment

Three discussion groups were formed to deliberate on the main issues of the above two presentations. The representation of the groups was all inclusive with majority being members of the WRUAs and a few observers. The topics of discussion are shown in the table below.

Discussion Topics for the Third Catchment Forum

Group	Discussion Topics
Group 1:	• What are the factors contributing to severity of drought, floods and landslides in Tana? • What are the possible responses and mitigation measures?
Group 2:	• What are the issues increasing vulnerability to drought, floods and landslides? • What are the possible responses and mitigation measures?
Group 3:	• What are the challenges experienced in water resources data collection and management and what are the solution to these challenges?

Source: JICA Study Team

Each of the group’s reporter presented the outcome of their respective group discussions. The participants discussed issues emanating from the topical presentations, group presentations and issues raised by different individuals. Various aspects were also discussed at length, in which, consensus were reached.

2.5 Key Issues that Emerged from the Pilot Activities on the Catchment Forum

The major issues that emerged during the pilot activity on the catchment forum were the enforcement of regulations that were cited as one of the challenging aspects of catchment governance. Some of the highlights are as follows:

a) There is one enforcement officer per region. Water rights officers in the subregions have no support staff and rely only on the police for enforcement.
b) Permit holders are unwilling to pay water use charges, either due to lack of awareness or negligence. WRMA-Tana was found to be in the process of trying to recover large amounts of water use revenue especially from large consumers such as water service providers. It is unacceptable that these service providers charge consumers and collect revenue, but are unwilling to pay due fees to WRMA.
c) Illegal abstraction was found to be rampant in the Upper Tana catchment area. Controlling this practice is a big challenge for WRMA-Tana because of the modus operandi of these abstractors. It works this way: someone invests in a portable water pump. It is hired out to a second party, who moves along the river taking contracts from farmers to irrigate their land (through furrows). This makes it difficult for WRMA to enforce because when arrested, they do not have an abstraction permit that WRMA can hold accountable or suspend, for example. If WRMA confiscates the pump, other contractors take over, and the pump owner may just buy another pump and continue.
d) The cost of enforcement is relatively high. In one operation it cost WRMA KSh8,000 per day (US$100) to conduct an enforcement campaign along the stretch of river.
e) Conflicting legislations on the roles and responsibilities, for example, overlap WRMA and NEMA's roles. WRMA has the mandate to issue effluent discharge permits at no fee provided to meet the WRMA designs requirements. However, NEMA also does the same but at a fee. When WRMA has issued a permit, NEMA can still legally order to issue another permit.
f) WRUA is the basic unit that WRMA uses to implement catchment governance. If well-capable, WRUA should be able to develop allocation plans, catchment studies, conservation programs, etc. However, there is a general lack of capacity for WRUAs in the Tana catchment area to implement some of these activities. Furthermore, most WRUAs are not set up to run on a day-to-day basis. They lack offices for meetings and record keeping.

The following are some of the key proposals in dealing with the above regulatory challenges:

a) WRMA must continue to educate the public so that its mandates are widely understood. Water use education must go on for as many users as possible to become aware of the regulations.
b) Regarding illegal abstraction via mobile pumps, community enforcement through WRUAs is the most effective way to reduce the problem. WRUAs should be encouraged to consolidate river abstraction points to enhance policing and water use regulation. Where this is not viable, WRUAs can impose self-regulation among its members through their constitutions and bylaws. Some of WRUAs in the Upper Tana catchment Area have already enforced self-regulation with regard to irrigation times (night as opposed to day).

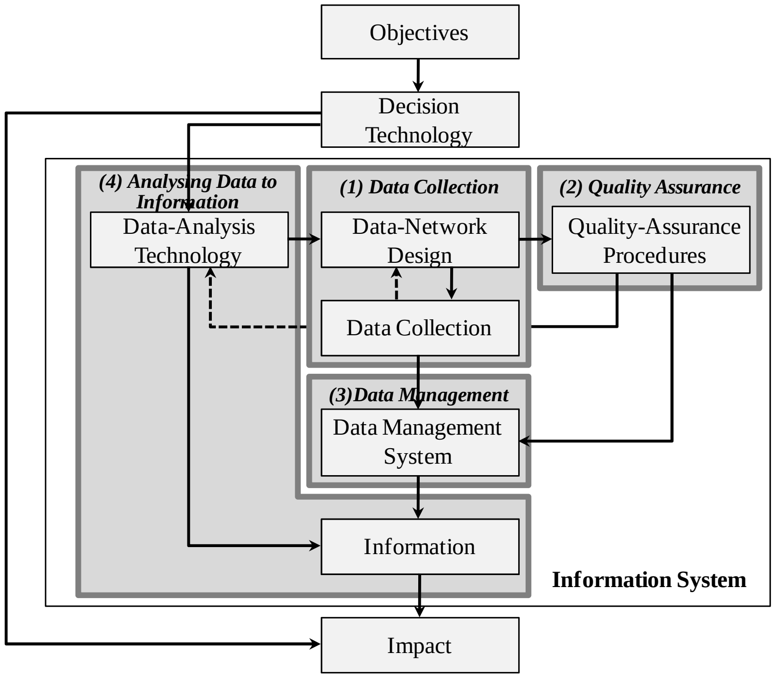
CHAPTER 3 ASSISTANCE FOR STRENGTHENING OF HYDROMETEOROLOGICAL INFORMATION MANAGEMENT

3.1 General

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

In order to achieve the objective of water resources management, it is necessary to: i) accurately grasp the quantity and quality of water resources through monitoring; ii) evaluate water resources; and iii) allocate water equitably through the issuance of water permits. The basis of water resources management is proper management of hydrometeorological information. Therefore, hydrometeorological data such as rainfall, river discharges and water levels, reservoir water levels, spillout discharge from reservoirs are important.

As described in the figure below, hydrometeorological information system is defined to be composed of; i) data collection, ii) quality assurance, iii) data management, and iv) analysing data to information. Needless to say, the information should be practically utilized such as warning for evacuation in the occurrence of a flood.



Source: JICA Study Team based on Guide to Hydrological Practices, Volume I, Hydrology – From Measurement to Hydrological Information, WMO-No. 168, Sixth edition, 2008

Components of Hydrological Information System

3.2 Activities in the First Phase

3.2.1 Discussion with Concerned Stakeholders on Basic Information

The present condition of hydrometeorological information in the Tana catchment area was obtained through various discussions with relevant agencies, as described in the table below.

Discussion with Concerned Stakeholders on Basic Information

Basic Information	Participants	Date	Venue
Hydrometeorological Information at WRMA-Tana	WRMA-Tana Regional Manager (1), Surface Water Officer (1), Database/ICT Officer (1)	Jan. 26, 2011	Embu
Information on Reservoir Operation by KenGen Tana	KenGen Seven Forks Asst. Manager (1), Chief Engineers / Asst. Chief Engineer (5)	Apr. 3-4, 2011	Masinga, Kamburu, Gitaru, Kindaruma, Kiambere
Meteorological Information at the KMD Headquarters	KMD Headquarters Asst. Director (1)	May 20, 2011	Nairobi

Note: The number in parenthesis indicates the number of participants.
Source: JICA Study Team

The findings on the present condition are explained as follows.

(1) Data Collection

From the aspect of flood early warning; i) rainfall, ii) river water level, and iii) reservoir data (reservoir water level and outflow discharge) are essential. Such data are collected by the different agencies. The available data in the Tana catchment area as well as its collectors are explained as follows.

Meteorological Data (WRMA)

WRMA-Tana has been managing 36 rainfall gauging stations in the Tana catchment area. Among those, rainfall gauging stations, three stations are installed with automatic gauging. WRMA-Tana also established three automatic weather stations (AWSs) which record air temperature, relative humidity, rainfall, wind speed, wind direction, etc. The locations of automatic meteorological stations in the Tana catchment area are described below.

Meteorological Stations Operated by WRMA Tana Regional Office

Category	Name of Station	Latitude	Longitude
Automatic Rain gauge (Not Real-Time)	Githambo tea factory	N/A	N/A
	Meru Forest Station	N/A	N/A
	Maua DC’s office	N/A	N/A
Automatic Weather Stations (Not Real-Time)	DWO(Kerugoya Office)	N/A	N/A
	DWO(Murang’a)	N/A	N/A
	DWO(Kitui)	N/A	N/A

Source: WRMA Tana Regional Office

The meteorological data from WRMA-Tana is, however, available only up to the recent four to five years.

<u>Meteorological Data (KMD)</u>

KMD operates four hydromet and six synoptic AWSs in the Tana catchment area. The observed records are transmitted to the KMD headquarters by telemetric system and those records can be seen in real time.

From the aspect of flood early warning, rainfall data is indispensable. KMD is mandated to collect rainfall data.

There is no data sharing agreement with WRMA in the Tana catchment area.

<u>Hydrological Data (WRMA)</u>

There are 43 hydrological/river gauging stations (RGSs) in the Tana catchment area which are operated by WRMA. Based on the Catchment Management Strategy of WRMA-Tana, the RGSs are classified as follows: one national station (priority 1), six management units stations (priority 2), 22 inter-management unit stations (priority 3), and 14 special purpose stations (priority 4).

Among the 43 RGSs, 30 stations are operational as of October 2010. In addition to these stations, this study has rehabilitated five RGSs in the Tana catchment area, namely, 4BC05 (Rwamuthambi), 4F09 (Ura), 4DC03 (Rupingazi), 4F10 (Kazita), and 4F17 (Thingithu). These five stations are classified as inter-management unit stations. WRMA is now rehabilitating some of the abandoned or non-operational RGSs.

Since the telemetry system has not yet been equipped for those hydrological stations, real-time data is not delivered to WRMA-Tana during flood events.

<u>Reservoir Data (KenGen)</u>

There are five major dams in the middle reach of the Tana River which regulate the river flow in the downstream. These dams are operated by Kenya Electric Generating Company (KenGen). The features of each dam are given in the following table.

Dams/Reservoirs in the Tana Catchment Area Operated by KenGen

Name of Dam	Year Constructed	River	Dam Height (m)	Catchment Area (km^2)	Gross Storage (Mm^3)	Spillway Type
Masinga	1981	Tana	55	7,335	1,560	Free Overflow
Kamburu	1975	Tana	56	9,520	150	Radial Gates
Gitaru	1978	Tana	30	9,525	20	Radial Gates
Kindaruma	1968	Tana	24	9,807	16	Vertical Gates
Kiambere	1988	Tana	112	11,975	585	Free Overflow

Source: KenGen

Kiambere Dam is located at the most downstream among the five dams. The dam has a fixed weir spillway which cannot control the spillout discharge once the reservoir water level reaches the crest level of the spillway.

KenGen collects data on reservoir operations including reservoir water levels, volumes, spilling volumes and operating discharges.

(2) Quality Assurance

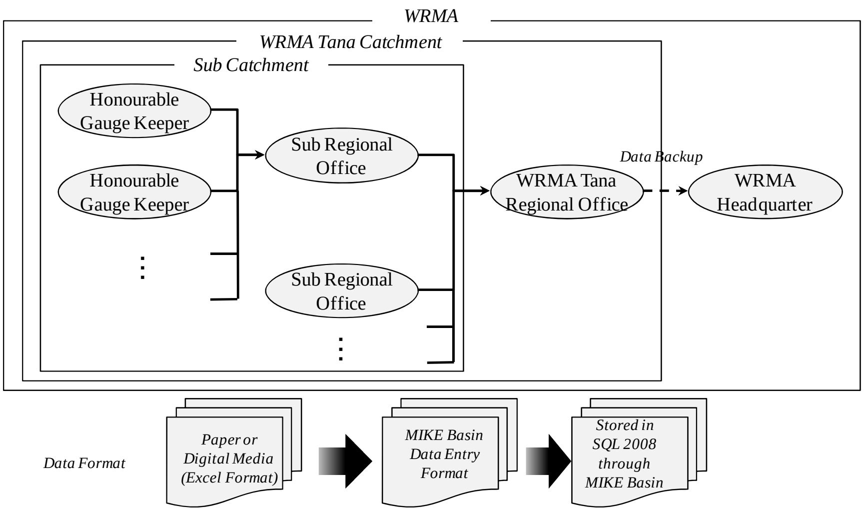
Accuracy of the water level–discharge rating (H-Q) curve is important to assure the quality of data. The H-Q curves are produced from the recorded water levels and discharges. It is necessary to perform discharge measurements regularly to keep the reliability of data; however, some RGSs have a limited number of discharge measurement records especially for high flows.

It is important to continue discharge measurements especially for high flows in order to improve and update the rating curves. In order to improve the accuracy of H-Q curves, WRMA acquired equipment to measure high and low flow.

(3) Data Management

Hydrological Data (WRMA)

WRMA-Tana uses Microsoft SQL Server 2008 for its database and, ArcView and MIKE BASIN to visualize temporal hydrological data. The observed water levels are inputted into either paper or digital media (excel) by designated gauge keepers. Then, it is collected by the subregional office. The subregional office converts the collected data to MIKE BASIN format using data entry program, then submits to WRMA-Tana. WRMA-Tana delivers the backup to the WRMA headquarters once a month. The flow of hydrological data management is described in the following figure.



Source: JICA Study Team from interview with the WRMA Tana Regional Office

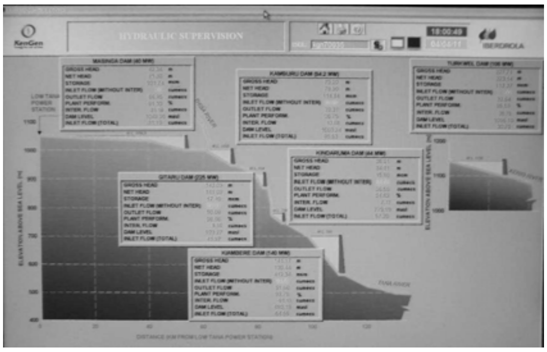
Flow of Data Management

The collected hydrometeorological data is stored using Microsoft SQL Server 2008, through the MIKE BASIN software.

Due to the lack of coordination between WRMA-Tana and the WRMA headquarters, discrepancies/inconsistencies between their data is expected.

Reservoir Data (KenGen)

In 2009, KenGen installed a type of system called Supervisory, Control and Data Acquisition (SCADA) to monitor the status of reservoirs for the abovementioned five dams, as shown in the photo on the right. The system enables the remote control of the Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere power stations from the Kamburu control room. With the SCADA system, instantaneous information on the five reservoirs can be monitored which include the dam reservoir water level, storage volume and outlet flow.



Source: JICA Study Team

SCADA System of Reservoirs in the Tana catchment area

When excessive spilling is imminent or 700.36 m MSL, which is equivalent to 98.54 m^3/s, is attained in the Kiambere reservoir, the operations manager of Eastern Hydro informs the government in writing through the Provincial Disaster Management Committee (Eastern, North Eastern and Coast) to warn people downstream of the impending high water flows.

The real-time information of reservoirs is, however, not delivered to WRMA-Tana.

(4) Analysing Data

Available hydrometeorological information is not effectively used for flood early warning except for the case where water levels are used for flood and drought warnings.

The gauging stations RGS 4G01 at Garissa and 4G02 at Garsen contain criteria to warn the locals in flood or drought conditions. For example, the water level at RGS 4G01 at Garissa is used for flood early warning and evacuation at the downstream, as shown in the table below.

Criteria of Gauge Reading at RGS 4G01 (Garissa) for Extreme Condition

Extreme Condition	Elevation of Staff Gauge		
	Alert	Alarm	Major Event
Flood	3.0 m	3.5 m	4.0 m
Drought	1.5 m	1.2 m	-

Source: WRMA Tana Regional Office

3.2.2 Workshop on Strengthening of Hydrometeorological Information Management in the Tana Catchment Area

The workshop on strengthening of hydrometeorological information management in the Tana catchment area was held at WRMA-Tana in Embu. The details of the workshop are shown in the table below.

Workshop at the WRMA Tana Regional Office

Activities	Participants	Date	Venue
Workshop at WRMA Tana	WRMA Headquarters Surface Water Officer (1) WRMA Tana Regional Manager (1), Surface Water Officer (1) Comm. Mob. Officer(1), Coordinator (1)	June 7, 2011	WRMA Tana Regional Office

Note: The number in parenthesis indicates people participated.
Source: JICA Study Team

The purpose of the workshop was to understand the present activities and to have group discussions on the idealized image, challenges, necessary activities and candidates of pilot activities which will be implemented in the next phase.

The opinions raised in the workshop are as follows:

a) Garissa and the delta area of Tana are flood prone areas. Those areas have been suffering from floods every three years (used to be a six year return period).
b) Flood inundation in Garissa occurs due to the heavy rainfall in Kitui, Murang'a, and Nyambene Hills, and due to the spilling of the Kiambere Reservoir.
c) No official data sharing has made between WRMA and KenGen as well as WRMA and KMD.

Also, an idealized image of the hydrological information management was discussed in the workshop among the WRMA officers, as described in the table below.

Idealized Image of Hydrometeorological Information Management

Condition	Idealized image
Normal	• Hydrometeorological data/information is shared between the relevant agencies • Data is reliable and assured with high quality • Hydrometeorological data/information can be seen on the personal computers in the offices • Captured data is well-analyzed and ready to be used • Understanding the condition of water resources as whole catchment not as a small area
Flood	• Hydrometeorological data/information is shared between the relevant agencies • Data is reliable and assured with high quality • Flood early warning system is established • Key stations are selected and equipped with telemeter • Captured data is well-analyzed and ready to be used • Preparedness to flood is improved
Drought	• Hydrometeorological data/information is shared between the relevant agencies • Data is reliable and assured with high quality • Preparedness to drought is improved

Source: JICA Study Team

According to "Developing Early Warning Systems: A Checklist" (2006, International Strategy for Disaster Reduction), flood early warning is composed of four key elements, namely; i) risk knowledge, ii) monitoring and warning service, iii) dissemination and communication, and iv) response capability.

Through the meetings, it was confirmed that WRMA is basically expected to engage in items i) and ii), but not in iii) and iv).

3.2.3 Stakeholders Meeting on Strengthening of Hydrometeorological Information Management in the Tana Catchment Area

Another meeting was held at the KMD headquarters which was attended by officers from the WRMA headquarters and the KMD headquarters in order to discuss about the sharing of hydrometeorological data/information.

Stakeholders Meeting at KMD

Activities	Participants	Date	Venue
Stakeholders Meeting at KMD	WRMA Headquarters Surface Water Officer (1) KMD Headquarters Asst. Director (1)	June 10, 2011	KMD Headquarters

Note: The number in parenthesis indicates people participated.

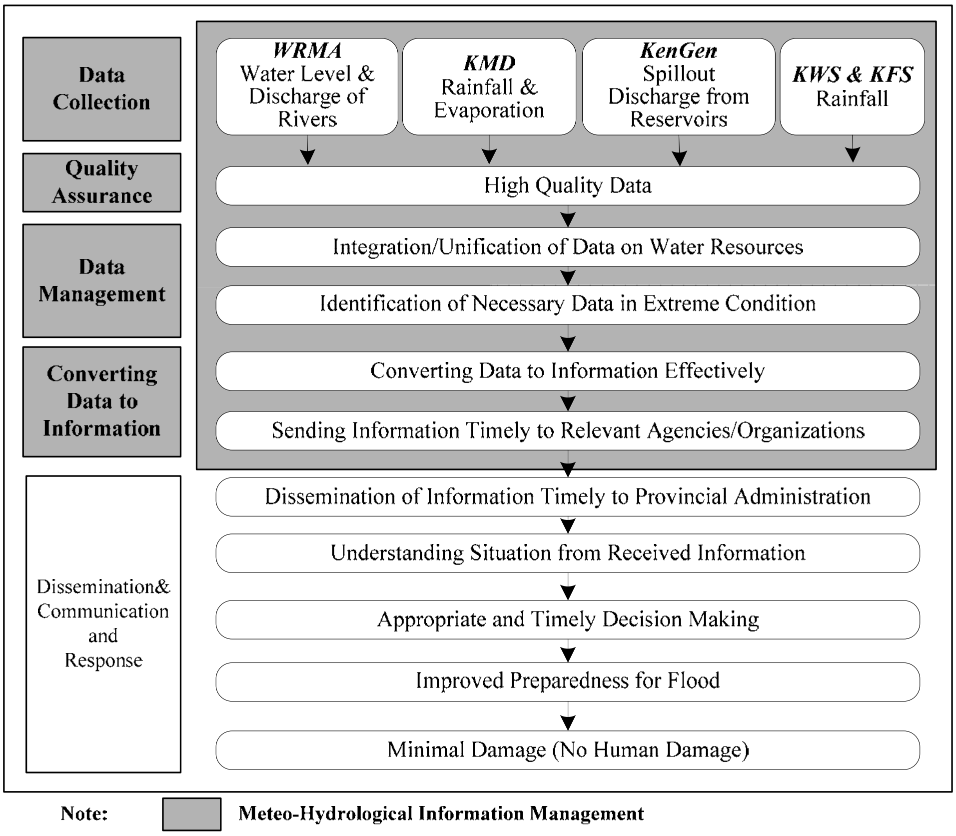
Source: JICA Study Team

The KMD officer explained the lessons learnt from the early warning system in the Nzoia River and raised the following issues on water resources management:

a) Lack of responsible agencies for flood early warning
b) No integration of meteorological and hydrological data
c) Insufficient skills on modelling, data handling and management of staff
d) Limited budget for housing and equipment
e) Low quality of data

3.2.4 Idealized Image of Hydrometeorological Information Management in the Tana Catchment Area

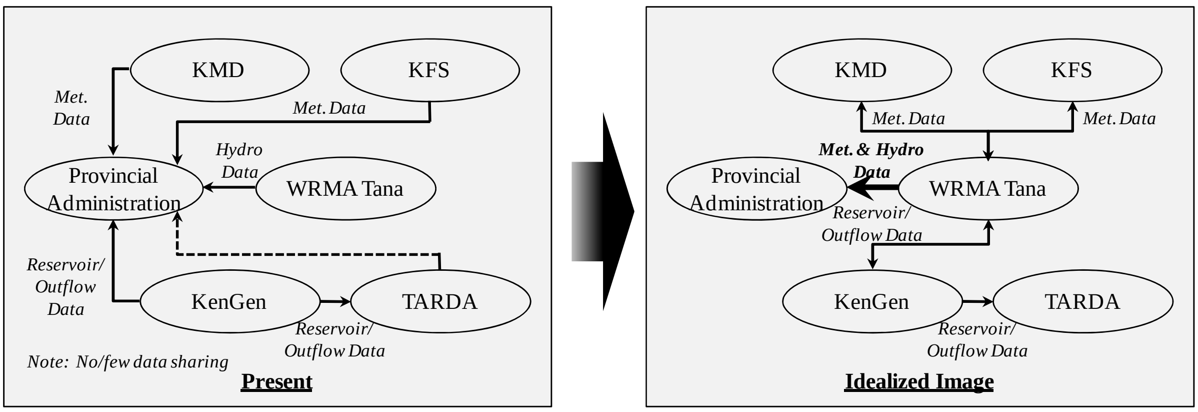
The idealized image of hydrological information management from the view of flood early warning in the Tana catchment area is illustrated below. The figure summarises the opinions raised in the workshop and the stakeholders meeting:



Source: JICA Study Team

Idealized Image of Hydrometeorological Information Management for Flood Early Warning in the Tana Catchment Area

Although data sharing is important in water resources management, it was found out that the relevant agencies provide meteorological or hydrological data directly to the provincial administration at present. In order to achieve integration/unification of data, WRMA-Tana should take the lead to collect, organize, and provide necessary data to the provincial administration. The present system and the idealized image of data sharing are illustrated in the figure below.



Source: JICA Study Team

Present System and the Idealized Image of Data Sharing and Data Provision

3.2.5 Necessary Activities for Strengthening of Hydrometeorological Information Management in the Tana Catchment Area by WRMA

The following activities are necessary to achieve the idealized image of hydrometeorological information management in the Tana catchment area by WRMA.

(1) Capacity Building Program

a) Capacity building on designing of appropriate hydrometeorological network (including preparation of guidelines)
b) Capacity building on operations and maintenance of river gauging stations (including training of WRMA staff and WRUAs)
c) Capacity building on hydrometeorological analysis including development of rainfall-runoff models

(2) System Enhancement Plan

a) Construction/rehabilitation/reconstruction of river gauging stations
b) Colouring staff gauges to indicate alert/alarm levels
c) Upgrading of river gauging stations with automatic logger and telemeter
d) Installation of rain gauges and evaporimeters

(3) Data/Information Improvement Plan

a) Assessment and improvement of rating curve (H-Q)
b) Flood situation and damage survey
c) Developing the flood database

(4) Data Sharing Plan among Relevant Agencies

a) Discussion among relevant agencies on role allocation
b) Signing of memorandum of understanding (MoU) for data sharing between WRMA-Tana and KenGen as well as between WRMA-Tana and KMD

3.3 Activities in the Second Phase

Based on the findings in the first phase activities and discussion with WRMA-Tana, the preparation of a manual on hydrometeorological information management was selected as a pilot activity in the second phase of the strengthening of hydrometeorological information management. Also, the following activities were carried out.

3.3.1 Discussion about Operations and Maintenance Issues through Workshops

In order to understand the current status in terms of operating and collecting hydrometeorological data, the Consultant had interviews with the regional and subregional offices and investigated the gauging stations. The workshop was held two times. The first workshop was held at WRMA-Tana in Embu on August 9, 2012 to discuss the issues related to operations and maintenance of the river flow gauging stations. The major issues identified are as follows:

a) Challenges/limitations in the operations and maintenance of the hydrometeorological network in the Tana catchment area
b) How data gathering and information sharing can be improved in WRMA-Tana

c) Technical requirements for improving hydrological data management
d) Applications of GIS in hydrometeorological data management
e) Essential information that should be included in the manual on hydrometeorological information management
f) Improvement of the monitoring network for surface water and water quality in order to produce reliable and usable data.

3.3.2 Preparation of Manual on Hydrometeorological Information Management

The second workshop was held on October 30, 2012 to share the draft manual and to collect the comments in order to improve the utilization of the manual. The comments on the manual were incorporated in the final manual. The manual is presented in Appendix 3.1.

The manual on hydrometeorological information management consists of the following items:

a) Hydrological services, stream flow records and gauging procedures
b) Hydrometeorological network design
c) Measurement of precipitation
d) Evaporation and evapotranspiration
e) Selection of stream gauging station sites
f) Gauging station controls
g) Establishment of gauging stations and measurement of stage
h) Discharge measurement
i) Discharge rating curves
j) Rehabilitation of the hydrometric network
k) Establishment of colour coding indicating alert/alarm levels of water resources
l) Data collection, processing, storage and retrieval
m) Information management

3.4 Analysis of Key Issues on Hydrometeorological Information Management

The following are some of the issues discussed during the pilot activity:

(1) Recommendations for Improving the Operations of Gauging Stations

a) The WRUAs should become more involved in raw data collection.
b) Metal gauging installations should be replaced with concrete and plastic posts and struts where vandalism is widespread.
c) The regional and subregional WRMA staffs should undertake annual appraisal of the mechanical condition of the gauging stations.
d) Data collection procedures should be standardized, coordinated and controlled. Gauge readers are to be engaged in the collection procedures. They should make two daily water level readings. However, there may be a need to separate the management unit gauging stations and inter-management unit stations so that two daily recordings are done for management unit stations and one daily recording is done for inter-management unit stations.
e) The region should improve its water resources monitoring network by rehabilitating some of the abandoned stations and establishing new ones where necessary.

f) The existing discharge rating curves in the Tana River basin are valid for the low range of river stages. This situation was brought about due to the lack of facilities to make discharge measurements at high water levels. The region has recently received gauging equipment that allows flow measurements at high flows. Accordingly, the region should make an appropriate program to measure the river flow during rainy seasons and consequently update the current discharge rating curves. The program should include budgeting for field work during both the long rain and the short rain season.

g) The gauge readers should be paid their fees promptly to motivate them in their activities.

(2) Recommendations for Improving Monitoring of Water Quality and Pollution Control

a) Provision of adequate equipment and reagents
b) Provision of adequate budget for water quality sampling and analysis
c) Deployment and training of water quality staff in all subregions
d) Development of effluent discharge control plans and their application at industry level

(3) Recommendations on Use of GIS in Hydrometeorological Information Management

The MIKE BASIN program installed at WRMA-Tana has been limitedly used due to certain deficiencies that are either related to the software, availability of data and capability of the users. Thus, the following are recommended:

a) The personnel involved in the use of MIKE BASIN should be provided with continuous training in order to improve their skills.
b) The WRMA management should provide dedicated terminals for data entry into the MIKE BASIN in all subregional offices.
c) In order to ensure standardized recording of geographical coordinates, it is recommended that geographical coordinates in reports and documents be given in decimal degrees and the reference datum indicated. It is also easy to convert decimal degrees coordinates to UTM coordinates.

CHAPTER 4 ASSISTANCE FOR IMPROVEMENT OF WATER PERMIT DATABASE

4.1 General

More than 5,000 permits for surface water abstraction had been issued in the Tana catchment area. This number is more than 50% of all permits given in Kenya. From the aspect of water resources management, there are needs to improve the management of water permits in Kenya. Considering the proportion of the number of permits, a pilot activity on water permits was decided to be carried out in the Tana catchment area.

Water permits are issued for water usage/abstraction for domestic, commercial, industrial, irrigation, hydropower and other purposes. Data and information on the quantity and quality of both surface and groundwater are necessary for effective and sustainable management of water resources as well as for planning. Data on water permits are stored in the database to ensure efficient and secure management of permit data and to support decision making on water allocation.

The water permit database was newly developed in 2009, and the WRMA headquarters and regional offices including WRMA-Tana are in the process of updating records. Under such circumstances, the water permit database does not need to be updated at this moment. This pilot activity concentrates on identifying the issues on water permit data itself especially focusing on surface water including application form, content of data, etc. through various discussions, as described below.

(1) History of Water Permit Database

The original water permit database system was established during NWMP (1992) as part of the hydrological database system of MWI. The permit database system is important to understand and estimate the amount of water abstracted from either surface water or groundwater. An applicant is obligated to fill an application form in order to get a permit to abstract water. When the application form reaches the Water Appointment Board (WAB), it is given a serial number, and a file for the application is opened. WAB sets out standards for the allocation of water, and based on such standards, permits are then either issued or rejected. During NWMP (1992), 15,000 records of surface water abstraction permits were stored in the hydrological database system of MWI.

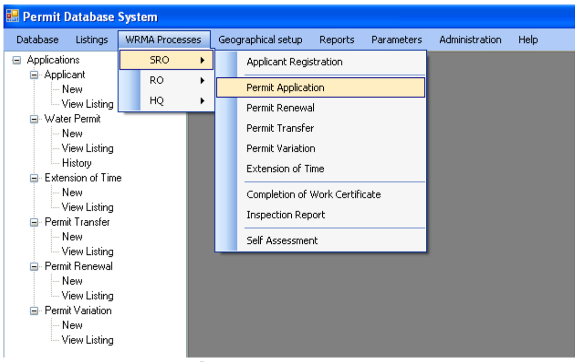
Following the Water Act 2002, the entire database of water permits was transferred to WRMA. One of WRMA’s principal mandates is to receive and determine the applications of permits for water use. Consequently, WRMA established a new database system for water permits called Water Permit Database (PDB), which had been developed by a private company in 2010. This PDB system was distributed to WRMA including its headquarters, regional offices, and subregional offices.

(2) Contents of Database

The interface of PDB system is shown in the figure on the right. The water permit includes the information of applicant, the amount of water abstraction for different periods, its location, etc.

The following categories exist under the application module of PDB:

a) Applicant Registration: allows to input the details of the applicant
b) Application Process: includes permit application, extension of time, permit renewal, and permit variation
c) Application Process: classified into four categories: A, B, C, and D by the amount of abstraction and importance



Source: JICA Study Team

Permit Database System

(3) Procedure for Water Permit Application

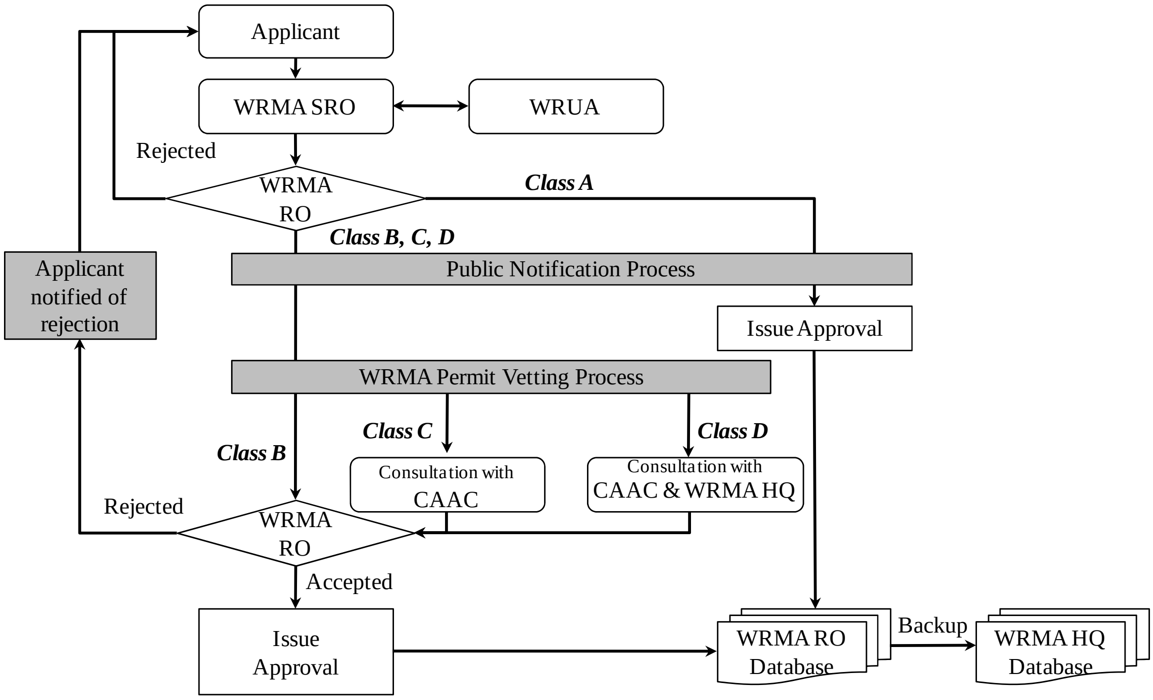
There are four categories of water resources use. The categories range from A to D, with category D having the highest risk. Each category is described in the table below.

Category of Water Resources Use Activities

Category	Description	Office to Determine
A	Water use activity deemed by virtue of its scale to have a low risk of impact on the water resources.	Regional office
B	Water use activity deemed by virtue of its scale to have a potential to make a significant impact on the water resources.	Regional office
C	Water use activity deemed by virtue of its scale to have a significant impact on the water resources.	Regional office in consultation with the CAAC
D	Water use activity which involves either two different catchment areas or is large-scale or complex and which is deemed by virtue of its scale to have a measurable impact on the water resources	Regional office in consultation with the CAAC and headquarters

Source: Kenya Gazette Supplement No.92 (28 September, 2007)

As illustrated in the following figure, water permit procedures differ depending on the category. Water permits, classified under A to C, are processed between subregional offices in the Tana catchment area and WRMA-Tana. However, if the water permit is classified as category D, the process would be limited between WRMA-Tana and the WRMA headquarters. In other words, WRMA-Tana should posses all water permits classified from A to D.



Note: HQ: headquarters, RO: regional office, SRO: subregional office
Source: From the WRMA Performance Report 1, July 2010 as modified by the JICA Study Team

Permit Application Process

Thresholds shall be based on resource status (availability and demand) and may be variable in different areas. Each catchment area will have catchment specific thresholds for surface water and for groundwater depending on the resource status. Within the same catchment, each subcatchment will have its own thresholds to reflect the different resource endowment status even within the same catchment.

Approved permits are stored in the database of WRMA-Tana as well as sent to the database of the headquarters as backup.

4.2 Activities in the First Phase

4.2.1 Interview on the Water Permit Database at WRMA-Tana

The interview on PDB in WRMA-Tana took place as described below.

Interview on Water Permit Database at WRMA-Tana

Activities	Participants	Date	Venue
Interview	<u>WRMA-Tana</u> Regional Manager (1) / Surface Water Officer (1) Database/ICT Officer (1)	Jan. 26, 2011	WRMA Tana Regional Office

Source: JICA Study Team

The comments raised during the interview are as follows:

a) WRMA-Tana is now updating the data for the PDB.
b) WRMA-Tana is the only office with a full set of data on water permits in the Tana catchment area.
c) There is no linkage between the PDB and the hydrological database (MIKE BASIN).
d) The availability of water resources in the Tana catchment area needs to be updated.

4.2.2 Discussion on the Water Permit Database in the WRMA Headquarters

Present conditions and issues regarding water permits were discussed on a daily work basis with the technical manager and the relevant officers of the WRMA headquarters. The details are given below.

Discussion on the Water Permit Database in the WRMA Headquarters

Activities	Participants	Date	Venue
Discussion	WRMA Headquarters Technical Manager (1) / Water Right Officer (1) Surface Water Officer (1) / Database/ICT Officer (1)	Daily Work Basis	WRMA Headquarters

Source: JICA Study Team

The comments given in the course of the discussions are as follows:

a) The number of permit applications stored in the PDB of the WRMA headquarters and WRMA-Tana are not identical.
b) Furthermore, there are differences in the number of parameters which are stored in the PDB of the WRMA headquarters and WRMA-Tana.
c) There is a need to update the thresholds based on the available water resources which will be updated in this study.

4.2.3 Project Working Group Meeting on the Database

The Project Working Group Meeting regarding the database was held at the MWI on April 7, 2011. The objective of the meeting was to have a presentation and discussions on the database of the WRMA including the PDB. Officers from both the WRMA headquarters and the MWI participated.

The comments made in the Project Working Group Meeting are as follows:

a) There are three sets of permit data which include: i) the original set of data the MWI had, before reforms were made, ii) the set of data when the WRMA started its operations, and iii) the set of data wherein the WRMA were using the new numbering system. The WRMA has been advertising to old permit holders to renew, and be given an incentive that would waiver the renewal fee. The response on the incentive showed encouragement from the old permit holders.
b) There is a need to have an adequate number of personnel who have the right set of relevant skills for managing the database.
c) The data in the regions and subregions should be reflected in the WRMA headquarters database; however, this is not the case now.

4.2.4 Findings on Water Permit Database from Water Use Survey

A water use survey was carried out to grasp the current status of water use in the country. The number and parameters of water permits stored in the database of the WRMA headquarters and WRMA-Tana which have been obtained from the survey are described below.

Number of Files and Parameters in Water Permit Database

Office		No. of Files	No. of Parameters
WRMA Headquarters		1,421	11
WRMA-Tana	SW	5,511	67
	GW	1,437	67

Source: JICA Study Team

The following were the major findings of the water use survey regarding the water permit database:

a) There are differences in the number of parameters stored in the water permit database. These parameters are represented by the title of each item, such as name of applicant, class, amount of water use, water source, date issued permit, permit expiry date, etc. Some offices store only ten parameters, while other offices store more than 60 parameters to control water permit.
b) The WRMA headquarters stores much less parameters than the regional offices.
c) WRMA LVN, WRMA LVS, WRMA RV, and WRMA ENN use the same format on the permit status, i.e., application, authorization and permit.
d) On the other hand, WRMA-Tana applies its own permit status, such as “PR: application in process”, “AU: authorization”, “AP-CW: approval to construction works with Class A”, “PE: permit”, “PE-AP: permits issued by water apportionment board”, “AP: approval to water user”.
e) Furthermore, the WRMA Athi regional office uses different subcategories under ordinal categories. The following table shows such categories and subcategories.

Categories and Subcategories Applied in the WRMA Athi Regional Office

Category	Subcategory
Application	• No Authorization • Not known
Authorization	• Expired Authorization • Valid Authorization
Permit	• Expired Permit • Valid Permit • In Use • Operational

Source: From the WRMA Performance Report 1, July 2010 as modified by the JICA Study Team

There is no precise definition of each subcategory so far.

4.2.5 Issues on Water Permit and the Permit Database

Based on the interview, the following issues were raised on the water permit and the PDB during the discussion and the Project Working Group Meeting, as well as from findings from the water use survey:

a) It was noticed that not all parameters are filled up in PDB.
b) There are discrepancies between data stored in WRMA-Tana and the WRMA headquarters.

c) The headquarters does not have all the records of permits in its database.
d) Since there is no status indicating which permit applications in PDB were rejected, it is unclear which applications had been rejected.

4.3 Activities in the Second Phase

Based on the findings in the first phase activities and discussions with WRMA-Tana, the preparation of the water use permit manual was selected as a pilot activity in the second phase on the improvement of water permit database management. The following activities were carried out.

4.3.1 Discussion about Operations and Maintenance Issues through Workshops

In order to understand the current status/condition of operating the permit database, the Consultant visited and interviewed the regional offices. Then, a workshop was held two times. The first workshop aimed to discuss the main issues and predetermined pertinent issues. The workshop was held at WRMA-Tana in Embu on August 1, 2012.

During the workshop, the following major issues related to permit database management were raised:

a) Challenges encountered in meeting some conditions for permits and authorization (e.g. measuring devices and use of flood flow for irrigation).
b) How the handling of the applications by other officers rather than the WROs could be improved in order to minimize errors and delays.
c) Ways through which some of the documents required in permit can be distinguished.
d) Challenges in evaluating permit applications at the regional level and propose ways on how to improve the process.
e) Proposed ways to improve the register of authorization and permits.
f) Challenges in issuance of supplementary permits.
g) Challenges in getting all the required attachments for permit application from a customer.
h) Ways in which the WRMA forms can be improved in order to simplify the application by the client.
i) Challenges that delay the permit application process and ways on how to improve the process.
j) Challenges encountered by permit database users in their daily use of the permit database regarding application.
k) Issues that should appear in the permit database manual.
l) Additional items to be recorded in the permit database.

4.3.2 Preparation of Water Use Permit Manual

The second workshop, which was held on October 30, 2012, was aimed to share the draft manual and to collect the comments in order to improve the utilization of manual. The comments on the manual were incorporated in the final manual. The manual is presented in Appendix 4.1.

The manual on water use permit is consists of the following items:

a) Procedures on applying for a permit at WRMA
b) Categories of water use activities
c) Permit application process and requirements

d) Fees for assessment, water use permits and water use charges
e) Tana catchment area thresholds
f) Technical reports and required formats

4.4 Analysis of Key Issues on Permit Database Management

The permit database in WRMA-Tana is a tool which helps implement the WRMA's mandate of ensuring conservation, protection and wise use and management of the water within the Tana catchment area. Through consultative visits and workshops, the following were identified as some of the key challenges related to permit database management at WRMA-Tana.

a) Editing is not possible and users are forced to redo the application to correct mistakes (naming of forms not appropriate).
b) Duplicates cannot be eliminated. Thus, the reports do not give their true status.
c) Permit numbering is not continuous.
d) Drainage area number cannot be edited once input (e.g. 4EA cannot be edited to 4E or 4EB).
e) Users can easily mix coordinates and coordinate zones.
f) Editing of locations is cumbersome and at times not possible.
g) Users cannot review what has been exported or imported.
h) The export folder does not reflect the name of the client for the file. It only reflects the date.
i) Some permits are print in blank. Unless the administrator is called in, users cannot do anything about it.
j) Pop-ups give the wrong total number of issued authorizations. Also, class A authorizations do not expire.
k) The dates of old permits and authorizations are set to current. Thus, the expiry and validity cannot be tallied.
l) Getting data output from the permit database is not easy; thus, users are forced to export form after form for them to get data.
m) The billing module in the permit database does not issue bills but require entry of a non-existent bank slip number.
n) The permit database still has bugs in the form of SQL errors.

CHAPTER 5 ASSISTANCE FOR IMPROVEMENT OF FLOOD AND DROUGHT DISASTER MANAGEMENT

5.1 General

Water-related disasters are dealt with by various organizations since flood or drought phenomena affect a wide range of sectors such as; health, livestock, agriculture, etc., and water supply.

In case there are various stakeholders for disaster management under the insufficient condition of preparation of laws, regulation, institution and organization, there might be duplications or deficiencies of activities among them. In order to avoid such duplications or deficiencies of activities, it is essential to develop an efficient coordination system among stakeholders.

Through the pilot activities in the Tana catchment area, it is planned to clearly identify the current conditions on flood and drought disaster management at the catchment level, and then propose how to minimize the gaps between a desirable management system and the current conditions.

5.2 Activities in the First Phase

5.2.1 Discussion with Relevant Organizations

At the beginning of the pilot activities, the JICA Study Team had several discussions with the relevant organizations in order to understand their organizational general overviews and coordination systems at the catchment level. The summary of discussions are provided in the table below.

Pilot Activities Discussion with Relevant Organizations

Date	Organization	Participants (Position)	Main Topics
March 23, 2011	TARDA-Embu	• Tana Regional Coordinator	• Clarification of concerned organizations to disaster management in the Tana River catchment • Organizational general overview - Legal background - Roles and responsibilities - Organizational structure - Actual activities • Coordination system within the organizations • Coordination system between the WRMA and the other organizations • Challenges in disaster management at catchment level
March 23, 2011	WRMA-Tana	• Regional Technical Manager • Surface Water Officer • Monitoring and Evaluation Officer	
March 24, 2011	DDMC-Garissa	• Chairman of DDMC / District Commissioner • Secretary of DDMC / MDNKOAL District Coordinator • Subregional Manager of WRMA-Lower Tana	
June 14, 2011	KMD Headquarters	• Assistant Director of Hydrometeorological Service	

Note: TARDA = Tana and Athi River Development Authority
DDMC = District Disaster Management Committee
MDNKOAL = Ministry of State for Development of Northern Kenya and Other Arid Lands
Source: JICA Study Team

5.2.2 Activities of the Relevant Organizations on Disaster Management

From the results of the discussions, it was confirmed that the organizations, as listed below, play key roles in flood and drought disaster management in the Tana catchment area. Among them, WRMA-Tana is regarded as the lead organization for pre-disaster related activities within the catchment. As well as the current coordination situation between WRMA-Tana and those relevant organizations, their legal background, roles and responsibilities, organizational structure, and major activities are summarized below.

(1) WRMA Tana Regional Office

Legal background

Sections 10 and 14 of the Water Act 2002 provided legal background for the establishment of regional offices of WRMA. WRMA-Tana was established in 2005.

Roles and responsibilities

The mission of WRMA-Tana is to manage, regulate and conserve water resources judiciously, involving stakeholders to enhance equitable allocation and environmental sustainability.

Organizational structure

There is no specialized department or section for flood or drought management. Therefore, the water conservation officer and the surface water officer which belong to Water Conservation and Surface Water Department, are basically in charge of both flood and drought management at the catchment level. WRMA-Tana has five subregional offices, namely in Meru, Kirinyaga, Muranga, Kitui and Garissa. There are 82 permanent staff in both regional and subregional offices in the Tana catchment area as of July 2010.

Major activities

In water-related disaster management at the catchment level, WRMA-Tana is responsible for water resources management at the pre-disaster stage. Their activities include hydrological monitoring, flood and drought forecasting, warning issuance, and riparian structure/land management in normal, flood and drought conditions.

Currently, WRMA-Tana carries out hydrological monitoring at 36 rainfall gauging stations and 43 water level gauging stations (30 are operational as of July 2010) in the Tana catchment area.

In order to manage flood prone areas, WRMA-Tana has attempted, not by numerical calculation, to evaluate the relationship between river water level and the extent of inundation area based on past experienced floods. However, there are no records which clearly show the inundation area of past floods.

As one of WRMA-Tana’s warning activities, in order to forecast flood and drought occurrence, alert/alarm levels are set at two gauging stations along the Tana River. Based on those river water levels, flood/drought warnings are issued. There are two channels that could disseminate flood warnings to the public, the first is through WRUAs, and the second is through District Disaster Management Committee (DDMC). Mass media outputs such as radio and television are also used for disseminating flood warnings. Regarding drought warning, WRMA-Tana prepares printed media and distributes it to major water users such as the regional offices of the National Irrigation Board (NIB).

(2) Tana and Athi River Development Authority (TARDA)

TARDA has three regional offices, one of it being in Embu.

Legal background

Major regional development authorities (RDAs) are involved primarily in the development of water storage infrastructure. TARDA-Embu was established in 2007 through the Tana and Athi River Development Authority Act (Cap443).

Roles and responsibilities

The mission of TARDA is to undertake integrated regional resources planning, and promote and undertake development within the Tana and Athi Rivers basins for the sustainable socioeconomic well-being of the people. Among the core activities of TARDA include disaster-related functions which are mainly to undertake studies on river morphology and flood control, and to plan and construct multipurpose reservoirs/dams.

Major activities

Regarding water-related disaster management, TARDA-Embu is concerned primarily with dam release warnings to downstream residents. Along the Tana River, there are currently five hydropower dams operated by KenGen, namely; Masinga, Kamburu, Gitaru, Kindaruma and Kiambere Dams. Usually the monitoring results of reservoir water level, inflow and outflow discharge records for Masinga and Kiambere Dams are directly reported to the TARDA headquarters in Nairobi since such dams are owned by TARDA.

When spillout from the reservoir is expected, the dam offices operated by KenGen shall inform the TARDA headquarters of the spillout in advance. The TARDA headquarters then disseminate spillout information to downstream residents through their Tana Delta Irrigation Project office as well as to the provincial administration. In this regard, dam release warnings are currently disseminated without passing through WRMA-Tana.

(3) Weather Station Offices of the Kenya Meteorological Department (KMD)

KMD does not operate regional offices; however, there are weather stations which act as collection and dissemination centres for meteorological and climate data.

Legal background

The present KMD started as a small colonial service for East Africa way back in 1929. It provides meteorological and climatological services to various sectors of the economy. KMD was officially formed in 1977 when the East African community broke up. Currently, KMD belongs to the Ministry of Environment and Mineral Resources.

Roles and responsibilities

The responsibilities of KMD include collection, analysis, interpretation, dissemination and archiving of meteorological and climate data. Coupled with these, the roles of KMD are weather monitoring, weather forecasting, climate prediction, provision of early warnings, weather and climate advisories, climate change detection and attribution, food security, research and outreach programmes. In performing their roles and responsibilities, KMD ensures safety of life, protection of property and conservation of the natural environment.

<u>Organizational structure</u>

KMD operates six synoptic stations, four hydro-met automated weather stations and over 400 manual rainfall stations in the Tana catchment area. Synoptic station offices are fully owned by KMD, with each office having 10 staff employees. The hydro-met station offices are operated in collaboration with the Nairobi Water and Sewerage Company, the fishery department, the forestry department, and provincial administrations. Other manual rainfall stations have been established by organizations operating within the catchment, including WRMA-Tana.

<u>Major activities</u>

The major activities of the KMD's weather stations include carrying out meteorological observation. Among the observation items, rainfall data are useful and necessary for disaster forecasting; however, it is a reality that such data are not shared with WRMA-Tana because they are automatically and directly transmitted to the KMD headquarters.

(4) District Disaster Management Committee (DDMC)

<u>Legal background</u>

There is no clear legal background of the establishment of DDMC. The Office of the President/Ministry of State for Special Programmes established DDMC in each district through the official circular.

<u>Roles and responsibilities</u>

DDMC plays key roles in coordination of post-disaster related activities such as rescue and relief operations for all kinds of disasters at the district level.

<u>Organizational structure</u>

DDMC is chaired by District Commissioner and its secretary is the Drought Management Officer. Members of DDMC are basically district officers from various sectors, representatives of private organizations such as NGOs, community based organizations (CBOs), religious organizations, research institutions, etc. Under the committee, subcommittees for water, sanitation, infrastructure, medical and health, information, etc. are also set up.

<u>Major activities</u>

In normal conditions, regular meetings are held once a month. Once a disaster occurs, meetings are held frequently as necessary. The regional offices of WRMA and KMD also participate in the meeting.

DDMC is responsible for the coordination of post-disaster related activities with implementing and administrative units such as district, division, location, sublocation offices in cooperation with private sectors.

According to the interview with DDMC-Garissa, the committee is well-functioning. There is no duplicated activities within the member organizations since the committee have overall coordination.

(5) Water Resources Users Associations (WRUAs)

Legal background

Sections 15 (3) (e) and 15 (15) of the Water Act 2002 provides legal background on the establishment of WRUAs.

Roles and responsibilities

WRUAs play an important role in water dispute and conflict management.

Organizational structure

A WRUA is an association of water users, riparian land owners, or other stakeholders who have formally and voluntarily associated themselves for the purposes of cooperatively sharing, managing and conserving a common water resource. The regional offices of the WRMA work in consultation with stakeholders at the grassroots level through WRUAs.

Major activities

The main activities of WRUAs are as follows:

a) Exchange of information and ideas on water resource use;
b) Discuss potential projects and developments that may affect water usage with a view to obtain the consent of other WRUA members and the public;
c) Resolve conflicts on water use;
d) Monitor water availability and use;
e) Lobby for resources to improve availability, reliability, quality or other aspects of water resources.

As described above, WRUAs play a key role in flood disaster management through hydrological monitoring, reporting of water-related disasters to the WRMA regional and/or subregional offices, clearing of water ways to open up flooded flow channels for flood water, and dissemination of information on early flood warning.

(6) Kenya Red Cross Society (KRCS)

Legal background

KRCS is a humanitarian relief organization created through an Act of Parliament, Cap 256 of the Laws of Kenya of December 21, 1965. Previously the society existed as a branch of the British Red Cross between 1939 and 1965. As a voluntary organization, KRCS operates through a network in eight regions and 64 branches spread throughout the country.

Roles and responsibilities

The mandates of KRCS that are given in Section 5 (1) of the KRCS Act Cap 256 of the Laws of December 21, 1965. The disaster-related mandates are as follows:

a) To provide relief to victims of catastrophe or disasters.
b) To carry on and assist in the work for the improvement of health, the prevention of diseases and reduction of suffering in times of peace or war.

Organizational structure

The highest level of KRCS is the Council, the policy making organ, which is headed by the Governor. The Council consists of the KRCS National Executive Committee members and four representatives of each of the eight regions. Out of the eight regions, five regions have its branches in the Tana catchment area. These branches include Kitui, Thika, Garissa, Lamu, Tana River, Embu and Meru.

Major activities

The main activities of the disaster management department include disaster preparedness, disaster response, special programmes (climate change adaptation and food security) and tracing. Regarding pre-disaster related activities, KRCS support flood evacuation activities.

5.2.3 Overall Coordination at the Catchment Level

(1) Demarcation of Roles and Responsibilities

According to the discussions held in the course of the first phase of the study, it was found that there are no specific laws governing flood and drought management in the country. Accordingly, demarcation of roles and responsibilities among the relevant organizations has not been clearly decided. There are actually some duplications and overlaps of activities; however, it has not been really acknowledged as a problem due to the large size of the catchment area.

(2) Coordination System among Relevant Organizations

DDMC holds regular meetings at least once a month. Because of this, post-disaster related activities are relatively well-coordinated among the relevant organizations. However, pre-disaster related activities such as warning dissemination are not systematically coordinated. Although warning information is provided based on hydrological condition, sometimes it does not reach the public or end water users.

5.2.4 Issues Identified on Disaster Management at Catchment Level

Through the discussions in the pilot activities, several issues in the current disaster management at the catchment level were raised by relevant organizations. From the aspects of preparation of law, regulations, institutions and organizations, the following issues were identified:

(1) Insufficient Documentation of the Management System

According to the discussion results, the procedures of necessary activities for disaster management are recognized by most of the officers; however, such procedure documents or records have not been prepared. This leads to confusion, miscommunication or misunderstanding, especially in the case that new officers are engaged in the management by personnel relocations.

(2) Duplication and Deficiency of Activities

Currently there is no complete deficiency identified on any necessary activity on disaster management; though some improvements, such as flood forecasting activities, are necessary in the future. On the other hand, there is duplication of some activities, such as catchment conservation by WRMA and TARDA, hydrological monitoring by WRMA and KMD, and evacuation assistance by DDMC and KRCS. Such activities are worth reviewing to avoid unnecessary overlaps.

(3) Lack of Hydrological Information Sharing

There is no noteworthy coordination between WRMA-Tana and the KMD's synoptic/hydro-met stations because all these stations transmit data directly to the KMD headquarters. Information is available to WRMA for planning and resolving of catchment management issues upon official request. However, it was noted that information flow between KMD and WRMA-Tana is not effective due to the lack of a well-defined coordination system between the two bodies. Improvement of hydrological information sharing system will contribute to effective disaster forecasting to be made by WRMA-Tana in the future.

5.3 Activities in the Second Phase

Based on the findings in the first phase activities and discussion with WRMA-Tana, the preparation of a manual on information management for flood and drought disasters was selected as a pilot activity in the second phase on the improvement of water permit database management. The following activities were carried out.

5.3.1 Discussion about the Flood and Drought Disaster Management through Workshops

To understand the requirements of WRMA, the Consultant had interviews with WRMA-Tana. Workshops were also held twice. The first workshop was held at WRMA-Tana in Embu on September 6, 2012 to discuss the major issues and predetermined pertinent issues. During the workshop, the following major issues related to flood and drought disaster management (FDDM) had been raised:

a) How WRMA-Tana can assist WRUAs to incorporate FDDM activities in subcatchment management plans (SCMPs)
b) How WRMA-Tana can develop a proactive FDDM system
c) Technical and social challenges to FDDM at WRMA-Tana
d) Issues to be addressed by the FDDM manual

Regarding the items listed above, it was found out through the first workshop that the nonexistence of scientific information regarding flood and drought disasters is the primary issue. The aim of the manual was thus modified to information sharing in terms of implementation of FDDM.

5.3.2 Preparation of Manual on Information Management for Flood and Drought Disasters

The second workshop was held on October 31, 2012 to share the draft manual and to collect the comments of it in order to improve the utilization of the manual. The comments on the manual were incorporated into the final version of the manual. The manual on information management for flood and drought disasters is presented in Appendix 5.1.

The manual consists of the following items:

a) Types of floods and droughts experienced in the Tana catchment area
b) Analysis and presentation of flood and drought information
c) Roles and responsibilities of stakeholders
d) Information sharing system
e) Coordination system among relevant bodies

5.4 Analysis of Key Issues on FDDM

The existing institutional setup in Kenya emphasizes flood management at the expense of drought management from the aspect of formulation of a management strategy. MWI prepared its "Flood Mitigation Strategy" in June 2009, although no specific drought management strategy has been prepared yet. Furthermore, the following observations on the current flood management have been made in Flood Mitigation Strategy by MWI:

a) Current flood management in Kenya is not structured nor anchored in responsible agencies.
b) Current interventions are more reactive than preventive with the vulnerability of the community at risk that determines the extent of the flood disasters.
c) Long-term mitigation measures need to be planned, proposed, and implemented.
d) Funding for flood management has not been adequate and commensurate with the magnitude of the problem.
e) The hydrometeorological database is weak.
f) Presently there is no established flood flow forecasting system on any of the flood prone rivers in the river basins (except for Nzoia).
g) KMD and WRMA are not fully equipped for real-time observation of rainfall/ flows.

Specific experiences for flood and drought management in the Tana catchment area include the following:

a) The operators of the hydropower dams (KenGen and TARDA) are very conservative with information on dam operations. WRMA does not even know if these operators have a manual on flood mitigation at their dams.
b) There are elements of flood early warnings through observation of gauge levels, but this has not been developed into a system.
c) The community have myths about what causes the flooding and they look up to WRMA for compensation when it floods; arguing that it is the water that WRMA is conserving that is affecting them.
d) The expanse of the Tana catchment area through different topographic terrains and climatic conditions provides a unique challenge for flood and drought information management.
e) There is lack of technical capacity to address flood and drought management.
f) There are many different agencies with as many strategies toward disaster management, with poor coordination between the various actors.

The causes of floods in the Tana catchment area include the following:

a) Land is extensively cultivated in Upper Tana, thereby exposing it to soil erosion.
b) Deforestation of catchment areas increases runoff.
c) Silt load from ephemeral streams that join the Tana River in its late stages enhance meandering of the river, causing river induced floods.

The pilot process determined a number of options that WRMA-Tana could use to improve flood and drought disaster management. Such options are as follows:

a) Awareness creation in the community through the use of WRUAs,
b) Reclamation of wetlands and riparian zones, again by giving capacity to WRUAs to include such activities in their SCMPs,

c) Sensitization of WRUAs on structural measures of flood and drought management, like construction of storage structures, and
d) Training of WRMA staff to enhance their technical capacity on FDDM, with emphasis on information management.

A key proposal emerging from the process is that WRMA should facilitate coordination between WRUAs and other stakeholders. With this, programs proposed by these stakeholders for adoption into WRUAs action plans will complement specific flood and drought management needs of each subcatchment.

CHAPTER 6 FINDINGS THROUGH PILOT ACTIVITIES

6.1 General

Some issues and challenges necessary for the improvement of the existing status were identified through pilot activities. These findings will be reflected in the WRMA action plan toward 2022.

6.2 Actions to be Taken by WRMA Regional Offices

6.2.1 Establishment of a Catchment Forum and Improvement of Governance

Sustainable operations of the WRMA's catchment forum require its continued effective execution of the mandate for which it had been established. The pilot forum will be extended from Tana to all other catchments. Therefore, some of the strategies to ensure its sustainability include the following:

a) The catchment forum guidelines should be strictly adhered to in the formation and operations of the forums in order to ensure the proper functioning of the forums.
b) The principle of cost sharing should be embraced in order to ensure affordability and sustainability of the catchment forums. Stakeholders should provide appropriate levels of financial, technical and managerial resources. The foundation was already laid in the pilot catchment forum. WRUAs and social groups were sponsored by WRMA, but government, corporate and non-governmental organizations met their own costs for participating in the forum. It was envisaged that in the future, WRMA will request other organizations to support the forum in line with the principle of corporate responsibility and cost sharing.
c) In future catchment forums to be conducted in various WRMA regions, there will be a need to consider venues that are less costly in order to ensure the affordability and sustainability of the forums.
d) Choosing of the workshop topics should involve WRUA members since the main objective of the forum is for the WRUAs to discuss issues that are key to their mandates and operations. The major issues should also be attractive and relevant. This will obtain positive responses from participants of the catchment forums, thereby promoting actionable proposals that can assist WRMA in getting solutions for conflict resolution and water resources management.
e) WRUA member's participation during the meetings should be encouraged in order for the forum to address issues on conflict resolution and cooperative management of water resources in the catchment area.
f) Time management needs to be strengthened in all future catchment forums to avoid meetings ending late so that WRUA members could return to their respective places and not incur additional costs for accommodation.
g) Capacity building of the forum secretariat in all the catchment areas should be undertaken through training on formation and operations in order to ensure that the forum meets its mandate.

6.2.2 Strengthening of Hydrometeorological Information Management

(1) Improving the operations of gauging stations at WRMA-Tana

a) The WRUAs should become more involved in raw data collection.
b) Metal gauging installations should be replaced with concrete and plastic posts and struts where vandalism is widespread.

c) The regional and subregional WRMA staff should undertake annual appraisal of the mechanical condition of the gauging stations.

d) Data collection procedures should be standardized, coordinated and controlled. Gauge readers are to be engaged in the collection procedures. They should make two daily water level readings. However, there might be a need to separate the management unit gauging stations with the inter-management unit stations so that two daily recordings are done for management unit stations and one daily recording is done for inter-management unit stations.

e) The region should improve water resources monitoring network by rehabilitating some of the abandoned stations and establish new ones where necessary.

f) The existing discharge rating curves in the Tana River basin are valid for the low range of river stages. This situation was brought about due to the lack of facilities to make discharge measurements at high water levels. The region has recently received gauging equipment that allows flow measurements at high flows. Accordingly, the region should make an appropriate program to measure river flows during the rainy seasons and consequently update the current discharge rating curves. The program should include budgeting for field work during both the long rains and the short rains.

g) Gauge readers should be paid their due fees promptly to motivate them in their activities.

h) Recommendations for improving monitoring of water quality and pollution control.

i) Provision of adequate equipment and reagents.

j) Provision of adequate budget for water quality sampling and analysis.

k) Deployment and training of water quality staff in all subregions.

l) Development of effluent discharge control plans and their application at industry level.

(2) Use of GIS in Hydrometeorological information management

The MIKE BASIN program installed at the WRMA regional office in Embu has been limitedly used due to certain deficiencies that are either related to the software, availability of data and capability of the users. Thus, the following are recommended:

a) The personnel involved in the use of MIKE BASIN should be provided with continuous training in order to improve their skills.

b) The WRMA management should provide dedicated terminals for data entry into the MIKE BASIN in all subregional offices.

c) In order to ensure standardized recording of geographical coordinates, it is recommended that geographical coordinates in reports and documents be given in decimal degrees, with the reference datum indicated. It is also easy to convert decimal degrees coordinates to UTM coordinates.

6.2.3 Improvement of Water Permit Database

From field survey and consultative meetings undertaken prior to the first workshop of this pilot activity, it was noted that most officers (secretaries, human resources officers, IT officers, and clerical officers) who assist in data entry do not have a good background in the permitting processes. Thus, they have to rely on the water rights officers from time to time to achieve successful data entry. This issue therefore calls for the need for training and capacity building of data entry officers on water rights issues, permitting processing and effective use of the PDB system.

The PDB system in use at WRMA has a number of shortcomings that needs improvement for effective usage. Some of the areas proposed for improvement include the following:

a) Forms should be well-placed and appropriately named to avoid users from searching for them. For example, the editing module is under listings, and because users cannot easily find it, they opt to re-enter customer details. This will eliminate double registrations and also unnecessary permit numbers.
b) The drainage basin and location fields should not be locked. Users should be allowed to edit because mistakes on such fields lead to the rejection of many applications by the regional technical committee.
c) The PDB billing module prompts for a receipt number instead of producing an invoice. Thus, it cannot produce bills and billing reports. This should be improved to avoid the current scenario where the users have ended up using excel sheets that could be erroneous in producing bills.
d) Produce complete reports instead of a page after page report that is time consuming.
e) Include all WRMA forms.
f) Import/Export file is coded (XML). There should be a report to show users a list of what they have exported/imported on a daily basis for easy decision making
g) Adjustment such that class A permits do not show “pending” since the WRM rules stipulate that they should get approval and not a permit. The PDB should also issue approval for class A.
h) Adjustments so that the use of characters such as apostrophes is not a hindrance to permit issuance by the system.
i) Adjustments to include proposed drainage boundaries.
j) Adjustments to harmonize permit numbering to have one common file number. This will ease problems in manual filing.
k) Adjustments to eliminate problems in registration of old permits. The process is cumbersome and not user-friendly and has been abandoned in most subregions.
l) Adjustments to include all missing thresholds, e.g. Dams, EDCP etc.
m) Modules to capture drainage of swamps applications, though rare, should be available in any subregion in case an encounter of this kind of application might happen
n) Create modules where spatial distribution of abstraction points can be viewed automatically once an application is entered.
o) Module to enable export of data in batch form to allow sharing of these data with other applications, e.g. excel. At the moment, the PDB can only export one page at a time.

6.2.4 Improvement of FDDM

(1) Recommendations for the WRMA Action Plan

The WRMA’s role in drought management should be less of forecasting and more of planning. Such planning activities should include:

a) Assisting stakeholders to plan or prepare for drought situations by providing relevant guidance, including but not limited to information on the magnitude and seasonality of flood flows.
b) Guidance to WRUAs to develop effective SCMPs that include flood flow storage structures.
c) Guidance to WRUAs to develop effective SCMPs that include construction of water retaining structures like surface water reservoirs in dry lands.

d) Enforcing water conservation and storage measures as prerequisites for normal abstraction approvals.
e) Coordinating with KMD on drought early warning systems and issue of drought alert water rationing schedules.
f) Operationalization of the manual on flood and drought disaster information management.

(2) Improvement of Coordination

There is an important need for improved coordination of stakeholders in the Tana catchment area. This particularly refers to the follows:

a) Coordination for information sharing among WRMA-Tana, TARDA and KenGen regarding operations of the hydropower dams;
b) Coordination between WRMA and NIB with regard to control of flooding of the paddy fields and water use between NIB and the local community;
c) Coordination for information sharing between KMD Embu regional office and WRMA-Tana

It is desirable that these stakeholders recognize the role of information sharing in contributing to FDDM. Information should not be contained by one organization only, but must be shared freely and at minimum cost.

(3) Improvement of Data Collection

Information can only be shared when data that generate such information is collected. WRMA-Tana should improve its historical information database through regular collection of data including, but not limited to the following:

a) Water level records of rivers
b) Velocity records (gauging)
c) Flood marks
d) Flood extent, including depth ranging
e) River cross sections

(4) Improvement of Early Warning Mechanisms

WRMA-Tana has established at least one colour-coded staff gauge to warn of the risk of flooding. The number of these gauges should be increased at strategic locations. Furthermore, a system for coordination of information collected from these gauges should be established, especially with emphasis on the role of WRUAs in collecting and transmitting this data to WRMA. Similar gauges are required for drought monitoring.

(5) Capacity Building of WRUAs

An enabling environment for WRUAs, which are the basic management unit at the subcatchment level, is necessary. This will be created with guidance from WRMA for WRUAs in the stewardship role for the care of gauging stations, management of gauge readers (who are WRUA members) and collection of flood and drought damage data.

Overall, WRMA should facilitate the coordination between WRUAs and other stakeholders. This would be beneficial so that the programs proposed by these stakeholders for adoption into WRUA action plans are seen to be in line with the specific needs of FDDM at each subcatchment.

Appendixes

Appendix 1.1

Guidelines for Selection of Forum Participants

The following are some of the guidelines that will assist the forum secretariat in selection of the participants in each of the proposed category of stakeholders:

1. WRUAs

- The maximum number shall be 45
- Cluster the existing WRUAs into sub-catchment zone areas and determine the appropriate number of representatives from each cluster.

2. CAAC

- The CAAC can appoint two participants to represent them in the forum.

3. WRMA

The WRMA representation could be 17 drawn as follows:

- Head office: 2
- Regional offices: 10
- Sub-Regions: 5

4. Other GOK institutions

Consider other GoK institutions that are key in water resources management e.g WSBs, NIB, TARDA etc.

5. Major Water Users

This shall include major water users who can be seriously affected by the water resources management of the catchment and are located in places where there is no existing WRUA. For example, the Tana Delta Project.

6. Non-State Actors

Consider very active Non-State Actors with a bias of water resources management and has interacted with WRUAs effectively. Also consider their contribution on a given issue in the forum.

7. Social Groups

Consider active social groups who are involved in water resources management and have interacted with WRUAs effectively. Also consider their contribution on a given issue in the forum.

Note: Consider gender balance in selection of representative in each of the category.

Appendix 1.2

Water Resources Management Authority- Tana

Catchment Forum for Strengthening the Capacity of Water Resources Management- WRMA Tana

Catchment Forum Guidelines

March 2011

Prepared with assistance of:

NIPPON KOEI
Challenging mind, Changing dynamics

Norken (I) Ltd
Engineering and Management Consultants

1. Introduction

The Water Act 2002 provides for the establishment of catchment management strategies for the management, use, development, conservation, protection and control of water resources within each catchment area. In order to achieve this, Section 15(3)(e) of the Act provides for the establishment of a mechanism and facilities for enabling the public and communities to participate in managing water resources within each catchment area. This is also supported in the water sector reforms that saw decentralization and participation of stakeholders in the management of national water resources. In addition, section 15(5) of the Act gives provision for encouraging, and facilitating the establishment and operations of Water Resources Users Associations (WRUAs) as fora for conflict resolution and co-operative management of the water resources in catchment areas. Water Resources Management Authority (WRMA) has established WRUAs at sub catchment level. There is need for a catchment area forum for WRUAs in each of the six catchment areas to promote linkages when sharing experiences, ideas and information on catchment-wide basis.

One of the objectives of the National Water Master Plan - 2030 is also to establish strategies for strengthening the capacity of water resources management in each of the six catchment areas of Kenya, which include Tana, Athi, Ewaso-Ngiro North, Rift Valley, Lake Victoria North and Lake Victoria South. In order to achieve this, the proposed catchment forum for stakeholders involved in the use and management of water resources should be held at least once every year. These guidelines are meant to ensure the sustainability and effective operation of planned catchment forums.

2. Objective

The objective of the catchment forum is to promote an exchange of information, experiences and perspectives among the stakeholders with the ultimate goal of advising WRMA on strategic direction in improving catchment management and conflict resolutions.

3. Functions

i. The Catchment Forum shall:
   - Serve as a stakeholder mobilization tool for discussing, sharing of ideas and experiences in water catchment management issues.
   - Discuss issues that affect the whole catchment.
   - Showcase and transfer Best Practices between the WRUAS

ii. Decisions by the Forum regarding how the catchment shall be managed will assist WRMA in getting solutions for conflict resolution and water resources management. However, WRMA shall have the ultimate decision to incorporate a specific proposal.

iii. The Forum shall only be convened by WRMA and is not self-regulatory because of the vastness of the area it covers.

4. Membership

i. The membership of the forum shall be drawn from the following categories and percentages of the total anticipated participants:
   a. WRUAs, represented by a number of representatives from WRUAs within a sub-catchment (75%)
   b. WRMA and its institutions (10%)
   c. Other Government institutions that are actively involved in the water resources management and use (5%)
   d. Major water users where WRUAs do not exist (5%)
   e. Non-state actors and social groups who are actively involved in water related activities within the catchment (5%)

ii. Representation in each category shall be drawn as per the stake they hold in water resources management and the issues planned for discussion at the Forum.

iii. In order to have a fair representation and a manageable forum, the number of participants shall not be more than 60.

iv. WRMA shall always ensure the attendants of the right number of their relevant personnel into the catchment Forum.

5. Catchment Forum Secretariat

WRMA shall be the holder of the secretariat. The WRMA stakeholder relations office will be the office directly involved in the forum process, along with the conservation and enforcement offices.

(a) The Forum Secretariat shall be responsible for providing Secretariat duties and ensuring successful management of the Forum.

(b) The forum secretariat shall consist of:

   i. Regional Manager
   ii. Regional Technical Manager
   iii. Stakeholder Officer
   iv. Enforcement Officer
   v. Conservation Officer
   vi. Any co-opted member as deemed necessary.

(c) The forum secretariat shall be based at the WRMA regional office.

(d) The Chairmanship of the forum who will be responsible for presiding over the catchment forum meeting shall be selected before the catchment forum meeting as follows:

(i) First meeting, the Secretariat will select a chairperson among the invited WRUA participants,

(ii) End of every forum meeting, the participants will select the chairperson for the next forum meeting among the WRUA participants.

6. Catchment forum meetings

(i) **Venue of meetings:** The catchment forum meetings shall be held at an appropriate location within the Catchment.

(ii) **Frequency of meetings:** The Catchment Forum meetings shall be held at least once in a year and participants shall be notified in writing at least 14 days in advance.

(iii) **Duration:** Four (4) hours of deliberations

(iv) **Procedure at the meetings:**

- Registration session for all participants attending the Catchment Forum
- Presentations
- Group discussions
- Plenary session
- Selection of a chairperson for the next meeting

7. Group Discussion Meetings

(i) Group meetings shall be established to discuss on key emerging issues out of the presentations and give insights into the topical issues presented by the key note speakers.

(ii) The formation of groups will be based on expertise and relevance in handling the issues at hand.

(iii) The various group meetings shall select their own chairperson and a secretary to take the notes and report in a plenary session.

8. Responsibility of the participants

The Catchment Forum participants shall be expected to:

- Confirm their attendance at least 2 days before the Forum.
- Register with the Forum secretariat before the start of the meetings.
- Attend and actively participate in all Forum meetings.

9. Operational costs

The Forum is essentially a WRMA catchment management tool through which the stakeholders shall provide their inputs and benefit from the sharing of ideas, information, experiences and issues. Therefore, the principle of cost sharing shall be embraced in order to ensure affordability and sustainability of the forum. Thus, the operational costs for the forum shall be met as follows:

(i) The basic operational costs of the secretariat shall be met by WRMA.

(ii) WRMA and other willing stakeholder shall meet the following costs:

- Conference expenses
- Allowances for WRUA and social group representatives

(iii) The following groups of stakeholders shall meet their own expenses

- Other Government institutions
- Water Sector institutions
- Non Governmental Organizations
- Major water users

Appendix 3.1

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

ASSISTANCE FOR PILOT ACTIVITIES IN TANA CATCHMENT

PILOT ACTIVITY ON ASSISTANCE FOR STRENGTHENING OF HYDRO-METEOROLOGICAL INFORMATION MANAGEMENT

MANUAL ON HYDRO-METEOROLOGICAL INFORMATION MANAGEMENT

(FIRST EDITION)

Submitted by:

Norken International Ltd
ENGINEERING AND MANAGEMENT CONSULTANTS

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PILOT ACTIVITY ON ASSISTANCE FOR STRENGTHENING OF HYDRO-METEOROLOGICAL INFORMATION MANAGEMENT

Manual on Hydro-Meteorological Information Management

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GLOSSARY OF TERMS

Backwater effect - The rise in surface elevation of flowing water upstream from and as a result of an obstruction to flow. In stream gauging, a rise in stage produced by a temporary obstruction such as ice or weeds, or by the flooding of the stream below. The difference between the observed stage and that indicated by the stage-discharge relation is reported as backwater.

Backwater flooding - Flooding caused by a restriction or blocking of flow downstream. Examples include a narrowing of the channel, high flow in a downstream confluence stream, or high tide blocking high river flows from entering estuaries.

Channel - Natural or artificial waterway, clearly distinguished, which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water.

Channel detention - Volume of water which can be temporarily stored in channels during flood periods.

Channel flow - Flow of water with a free surface in a natural or artificial channel (watercourse).

C**hannel scour -** Erosion of a channel.

Channel storage - Volume of water stored in a channel.

Climate - Synthesis of weather conditions in a given area, characterized by long-term statistics (mean values, variances, probabilities of extreme values, etc.) of the meteorological elements in that area.

Climatic change - Significant change observed in the climate of a region between two reference periods.

Catchment Area (Basin) - The area draining into a river, reservoir, or other body of water.

Calibration (rating) - Experimental determination of the relationship between the quantity to be measured and the indication of the instrument, device or process which measures it.

Calibration tank (rating tank) - Tank containing still water through which a current meter is moved at a known velocity for calibrating the meter.

Climatological station - Station from which climatological data are obtained.

Climatological station for hydrological purposes - Climatological station set up in a drainage basin specifically to augment the existing climatological network in order to meet hydrological requirements.

Confluence - Joining, or the place of junction, of two or more streams.

Contracted weir - Weir having a crest that does not extend across the whole channel width.

Control - Physical properties of a channel which determine the relationship between stage and discharge at a location in the channel.

Control section - Reach of a stream channel in which there exists a unique discharge-stage relationship or Section of an open conduit or stream where the discharge is uniquely determined by the water level immediately upstream.

Crest gauge - Device used to record the highest water gauge height.

Cross section (of a stream) - Section of a stream at right angles to the main (average) direction of flow.

Current meter - Instrument for measuring the velocity of water at a point. Traditionally the term refers to instruments with cups or propellers.

Dam (barrage; barrier; weir) - Barrier constructed across a valley for impounding water or creating a reservoir.

Data collection system - Coordinated system for collecting observations from a hydrological network and the transmission of the observations to a data-processing facility.

Data processing - Handling of observational data until they are in a form ready to be used for a specific purpose.

Datum level - Horizontal surface used as a reference to which elevations are related.

Discharge (rate of flow) - Volume of water flowing through a river (or channel) cross section in unit time.

Drainage basin (catchment area; drainage area; river basin; watershed) - Area having a common outlet for its surface runoff.

Evaporation (of water) - Emission of water vapour by a free surface at a temperature below the boiling point. Amount of water evaporated.

Evaporation rate - Quantity of water which is evaporated from a given water surface per unit time.

Evapotranspiration - Quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration.

Flash flood - Flood of short duration with a relatively high peak discharge.

Flood plain - Nearly level land along a stream flooded only when the streamflow exceeds the water carrying capacity of the channel.

Frequency analysis - Procedure involved in interpreting a past record of hydrological events in terms of future probabilities of occurrence, e.g. estimates of frequencies of floods, droughts, storages, rainfall, water quality, waves.

Gauge datum - Vertical distance of the zero of a gauge referred to a certain datum level.

Gauge height- Height of water surface above a gauge datum. It is used interchangeably with the terms stage and water level.

Gauging site (gauging section) - Location on a stream where measurements of water level and discharge are regularly made.

Groundwater - Subsurface water occupying the saturated zone.

Groundwater hydrology (geohydrology) - That branch of hydrology which deals with groundwater, taking into account the geological conditions.

Hail - Precipitation of small balls or pieces of ice (hailstones) with a diameter ranging from 5 to 50 mm, sometimes more, falling either separately or agglomerated into irregular lumps.

Historical data - Hydrological and meteorological data of events which occurred in the past.

Hydrogeology - That branch of geology which deals with groundwater and especially its occurrence.

Hydrograph (discharge hydrograph; flood hydrograph; sediment hydrograph; stage hydrograph;) - Graph showing the variation in time of some hydrological data such as stage, discharge, velocity, sediment load, etc. (hydrograph is mostly used for stage or discharge).

Hydrological cycle - Succession of stages through which water passes from the atmosphere to the earth and returns to the atmosphere: evaporation from the land or sea or inland water, condensation to form clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporation.

Hydrological element - Some hydrological phenomena such as water level (stage), discharge or precipitation.

Hydrological forecast - Statement of expected hydrological conditions for a specified period and for a specified locality.

Hydrological network (hydrometric network) - Aggregate of hydrological stations and observing posts situated within any given area (river basin, administrative region) in such a way as to provide the means of studying the hydrological regime.

Hydrological observation - Direct measurement or evaluation of one or more hydrological elements, such as stage, discharge, water temperature, etc.

Hydrological observing station - Place where hydrological observations or climatological observations for hydrological purposes are made.

Hydrology - Science that deals with the waters above and below the land surfaces of the earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, their reaction with their environment, including their relation to living beings. Also the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the earth, and treats the various phases of the hydrological cycle.

Hydrometeorology - Study of the atmospheric and land phases of the hydrological cycle, with emphasis on the interrelationships involved.

Hydrometric station - Station at which data on water in rivers, lakes or reservoirs are obtained on one or more of the following elements: stage, stream flow, sediment transport and deposition, water temperature and other physical properties of water, characteristics of ice cover and chemical properties of water.

Mean- The sum of a set of observations divided by the number of observations. Also referred to as

Median - For a continuous frequency distribution, the value of the variate which divides the total frequency into two equal halves. For an discrete data, the middle value of the ranked data if n is odd, or the mean of the two central values if n is even.

Mean annual flood - The average of all the annual flood stages or discharges of record. It may be estimated by regionalization, correlation, or any other process that can furnish a better estimate of the long-term average than can the observed data. Some investigators arbitrarily define the mean annual flood as the stage or discharge having an exceedence interval of 2.33 years.

Mean annual precipitation (rainfall) — The average of all annual precipitation values known, or an estimated equivalent value derived by such methods as regional indexes or *Isohyetal* maps.

Mean annual runoff — The average value of all annual runoff amounts usually estimated from the period of record or during a specified base period from a specified area.

Mean annual temperature — The average of the daily maximum and minimum temperatures.

Mean depth — The average depth of water in a stream channel or conduit. It is equal to the cross-sectional area divided by the surface width.

Meteorological drought — A drought said to occur when annual rainfall (or precipitation) is less than the long-term average annual rainfall.

Meteorology — The science that deals with the phenomenon of the atmosphere, especially weather and weather conditions.

Mode - In a distribution of a discrete variate, the variate which occurs most frequently. In a distribution of a continuous variate, the variate with maximum probability density.

Orographic precipitation - Precipitation caused by the ascent of moist air over orographic barriers.

Precipitation - Liquid or solid products of the condensation of water vapour falling from clouds or deposited from air on the ground. Amount of precipitation on a unit of horizontal surface per unit time.

Precipitation intensity (rainfall intensity) - Amount of precipitation (rainfall) collected in unit time interval.

Precipitation station - Station at which observations of precipitation only are made.

Primary data processing - Processing of raw observational data such as cleaning, checking, correcting the data to be used in analysis and computations. A hydrological yearbook is a typical example of the results of primary data processing.

Principal hydrometric station (base station; permanent station; primary station) - Hydrometric station at which one or a number of elements are observed for a period of many years taking into account the significance of such elements in relation to the physical environment. Such a station is usually equipped with recording instruments.

Velocity rod - Any natural or man-made body which is supported and partly or fully immersed in water, its vertical motion indicating the changes in water level or its horizontal movement indicating the velocity of water at the surface or at various depths.

ACRONYMS AND ABBREVIATIONS

WRMA	Water Resources Management Authority
NWMP	National Water Master Plan
JICA	Japan International Cooperation Agency
AWLR	Automatic Water Level Recorder
ADCP	Acoustic Doppler Current Profiler
ADV	Acoustic Dopler Velocimeter
GH	Gauge Heights
WRUA	Water Resources Users Association
TCA	Tana Catchment Area

CHAPTER 1- INTRODUCTION

1.1 Background

The Water Resources Management Authority (WRMA) was created under the Water Act 2002 and charged with being the lead agency in water resources management.

A key mandate for the Water Resources Authority is to assess the country's water resources. To be able to do so requires good quality data. Thus, a well-functioning monitoring network from which continuous and reliable data are being collected is very crucial and is the starting point for any assessment.

Towards achieving its mandate, the Water Resources Management Authority undertook some training courses in 2006 related to the monitoring network in the country. The training demonstrated that there is need to develop a number of manuals on operational hydrology. These manuals would serve as important guidelines and help to ensure that Hydrometeorological operations are done in a proper and uniform way. The development of the manual on Hydro-meteorological information management is as a result of the pilot activity on " Assistance for Strengthening of Hydro-Meteorological Information Management" in Tana Catchment under the National Water Master Plan - 2030 (NWMP-2030) that is being developed by JICA.

The development of this manual involved active participation of WRMA Tana staff who made their contributions in a workshop where pertinent hydro-meteorological issues were discussed. Towards this end, the current manual has been prepared to fill some of the gaps observed in the field of operational hydrology at Tana Catchment. In the future, the manual will be expanded to the other catchment areas of Kenya, which include Athi, Ewaso-Ngiro North, Rift Valley, Lake Victoria North and Lake Victoria South.

1.2 Purpose of the Manual

The purpose of this manual is to provide a description of standardized hydrometeorological information management procedures. The manual presents procedures in hydro-meteorological network design, stream gauging, discharge measurement and computation, data collection, processing and dissemination.

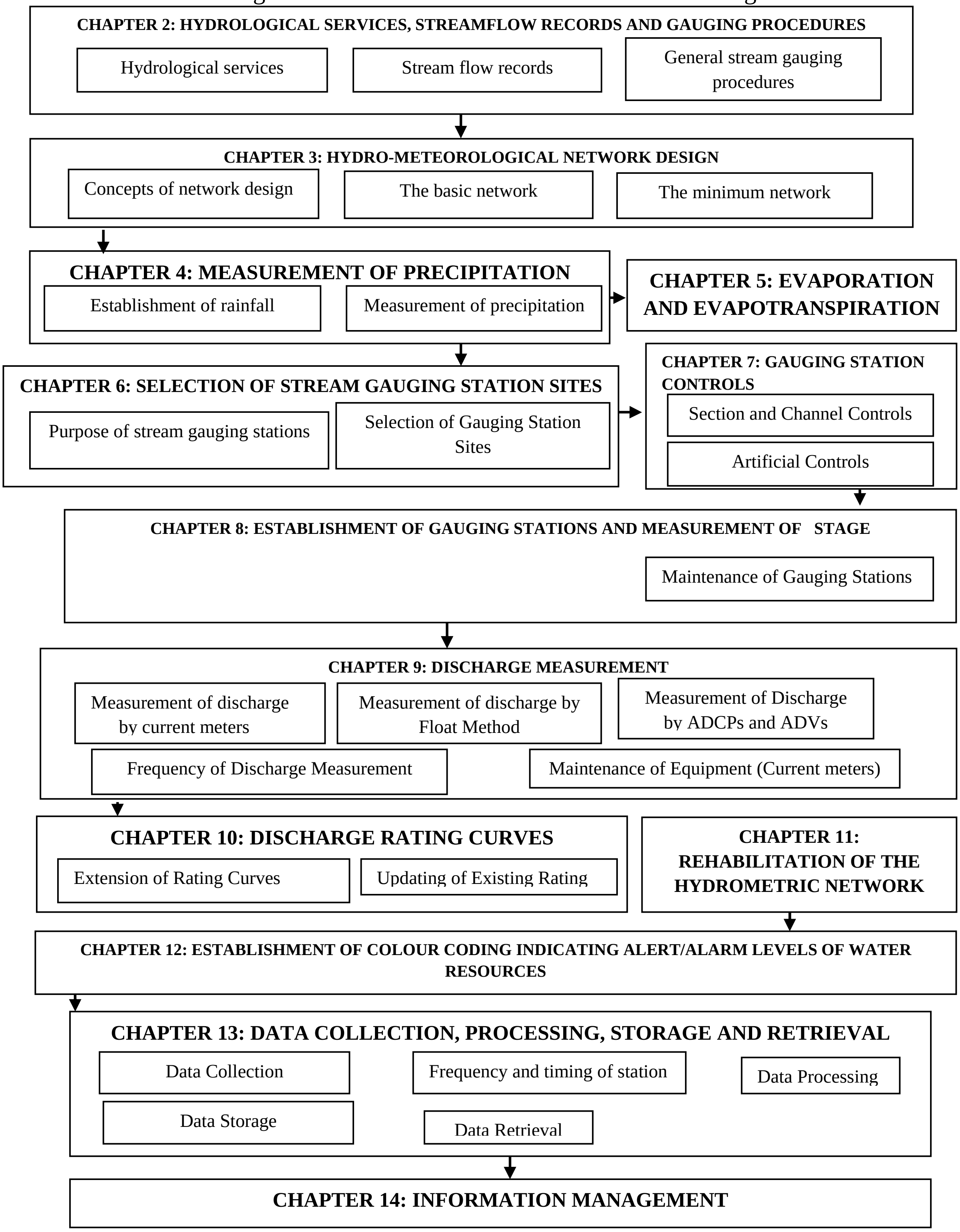
This manual will be useful to all water resources management personnel, and particularly, the staff of the Water Resources Management Authority (WRMA) involved in hydrological field work.

The manual is also important to the Water Resources Users Associations (WRUAs) which will be working together with WRMA in hydro-meteorological data collection.

In view of the broad scope of hydrolometeorological studies, this manual has focused on the basic requirements for hydrological measurements and computations. In future, there might be need to develop separate manuals dealing with specific subject such as hydrological field work; discharge computations; establishment of climatological gauging network, etc, in which more details will be included for each manual.

1.3 Structure of the report

A flow chat summarizing the contents of this manual is as shown in the figure below:



CHAPTER 2-HYDROLOGICAL SERVICES, STREAM FLOW RECORDS AND GAUGING PROCEDURES

2.1 Hydrological services

In general, a Hydrological Service provides the necessary information for water resources assessment, which is defined as:

> *"The determination of the sources, extent, dependability, and quality of water resources, upon which is based an evaluation of the possibilities for their utilization and control."*

In Kenya, the above responsibility has been given to the Water Resources Management Authority.

With the growing recognition of such issues as global climatic change and the environmental impacts of urbanization, there is an increasing emphasis upon reliable water information as the foundation for sustainable development and management of water resources. This implies that future generations, as well as the present one, will continue to enjoy adequate and available water supplies to meet their social, environmental, and economic needs.

Water-resources information may be required at a single, specific place, such as at a proposed dam site, or across an entire region, for example along a proposed highway route that crosses numerous watercourses. In the first case, information may be economically collected at the single site or in the catchment area upstream. Such information might be called use-specific. In the second case, it would be impracticable to collect information at every river crossing. General purpose data, representative of the whole region, must then be collected at a few locations, and a means must be provided of transferring the information to other sites for which no data are available. To achieve this capability, a basic network of observation stations will be required. The principal characteristic of the data obtained from such a network is that they may be used for a variety of unforeseen purposes. They are representative of the hydrology of the area, and they must be collected to standards that are able to meet the reasonable requirements of any likely user.

To meet these requirements, a Hydrological Service must:

a) Establish the requirements of existing or possible future users of water resources information;

b) Define the standards (accuracy, precision, timeliness, accessibility, etc.) of the data that are implied by those requirements;

c) Design and establish hydrometric networks to measure the various types of data required. Both use-specific and basic networks, that may be complementary or even overlapping, may be needed;

d) Develop methods for transferring information from measurement sites to other locations in the region for which it is representative;

e) Collect data and maintain quality control of the data-collection process by inspection of field installations and field practice;

f) Process and archive data and maintain control of the quality and security of the archived data;

g) Make the data accessible to users, when, where, and in the form they require, including:

- Dissemination of hydrological forecasts and warnings;
- Publication of yearbooks of basic data in paper and computer compatible (CD-ROM, etc.) form;
- Preparation of reports on water resources in which data are comprehensively analyzed. This may include media such as hydrological atlases or databases in geographical information systems; informative or educational material for use by the general public, the news media, and schools;
- Information for project design including the frequencies of stream flow extremes.

h) Inform potential users of the information that is available and assist them to make the best use of it;

i) Develop new technology and carry out research into hydrological and related processes to assist the user in interpreting and understanding the data;

j) Develop staff training and other functions related to quality assurance, such as the preparation of instruction manuals and assessment or acceptance testing of new instrumentation;

k) Ensure coordination with other agencies that acquire water-related or other relevant information, such as hydrogeological, water-use, topographic, land-use, or climatic information.

A schematic flow chart of an operational hydrological system is given in Figure 1.

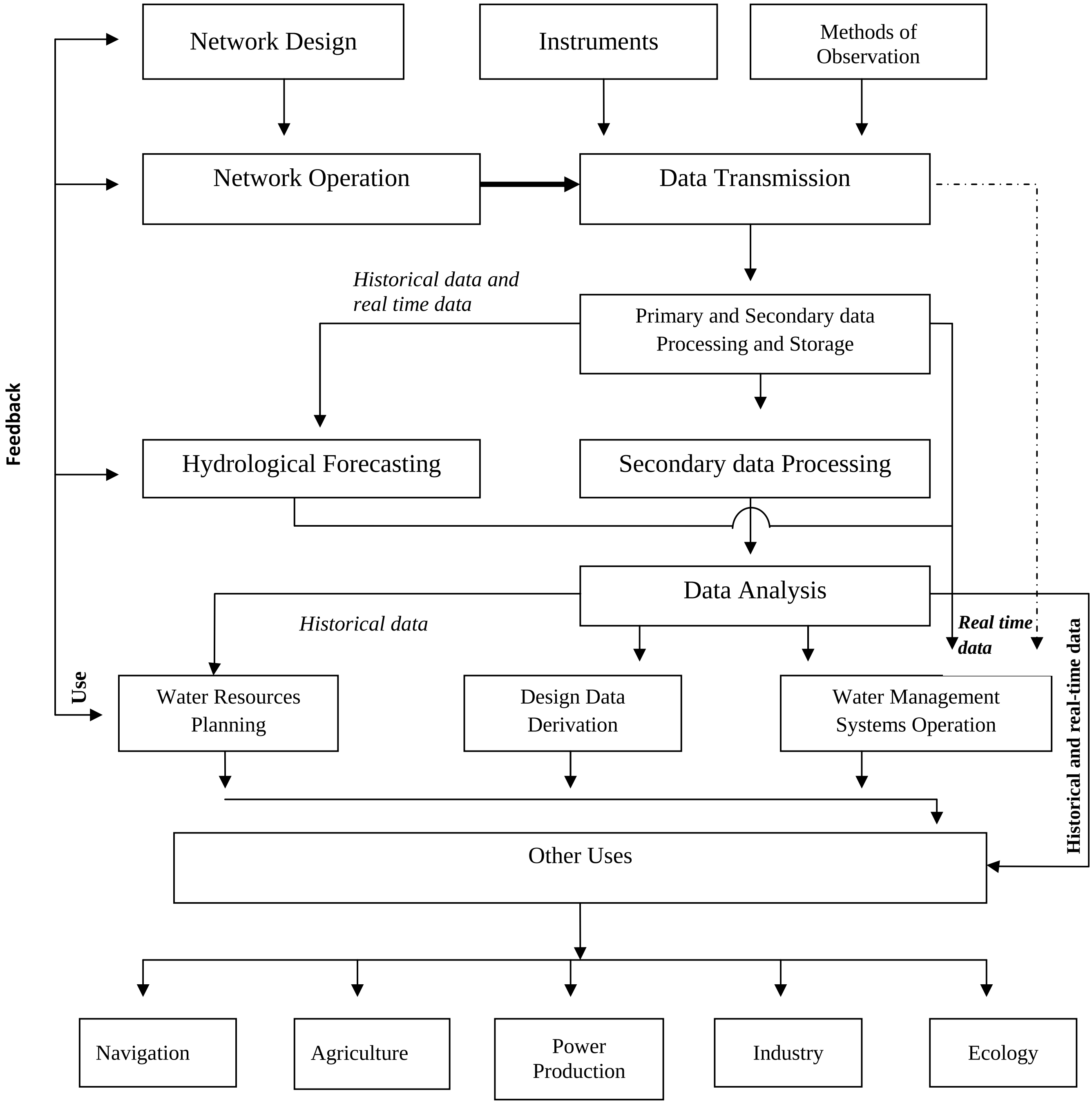


Figure 1: Operational hydrometeorologgical system

- *Source: Guide to Hydrological Practices, WMO No. 168*

2.2 Stream flow records

Records of stream flow are the basic data used in developing reliable surface water supplies because the records provide information on the availability of stream flow and its variability in time and space. The records are therefore used in the planning and design of surface water related projects, and they are also used in the management/operation of such projects after the projects have been built or activated.

Stream flow, when it occurs in excess, can create hazards; floods cause extensive damage and hardship. Records of flood events obtained at gauging stations serve as the basis for the design of bridges, culverts, dams, and flood control works, flood plain delineation and flood warning systems.

The stream flow records referred above are primarily continuous records of discharge at stream gauging stations, a gauging station being a stream site so instrumented and operated that a continuous record of gauge height and discharge can be obtained. Networks of stream gauging stations are designed to meet the various demands for stream flow information including an inventory of the total water resources.

2.3 General stream gauging procedures

After the general location of a gauging station has been determined from a consideration of the need for stream flow data, its precise location is so selected as to take advantage of the best locally available conditions for gauge height and discharge measurement and for developing a stable relation between gauge height and discharge. Discharge measurements are then made at periodic intervals, to verify the gauge height-discharge relation or to define any change in the relation caused by changes in channel geometry and/or channel roughness.

Artificial controls such as low weirs or flumes are constructed at some stations to stabilize the gauge height-discharge relations in the low flow range. These control structures are calibrated by gauge height and discharge measurements in the field.

The data obtained at the gauging station are reviewed and analyzed by competent personnel. Discharge ratings are established, and the gauge height record is converted into a discharge record by use of the discharge rating. The mean discharge for each day and extremes of discharge for the years are computed as required.

A continuous record of gauge height is obtained by installing instruments that sense and record the water –surface elevation in the stream. Discharge measurements are initially made at various stages in order to establish the stage-discharge relationship at all ranges.

CHAPTER 3 – HYDRO-METEOROLOGICAL NETWORK DESIGN

3.1 Concepts of network design

A hydrological-data network is a group of data-collection activities that are designed and operated to address a single objective or a set of compatible objectives. Frequently, the objective(s) is (are) associated with a particular use that is anticipated for the data being collected in the network — for example, for a water-resources assessment, a development plan, or a project design. A particular hydrological station gauge may be included in more than one network if its data are being used for more than one purpose. In most parts of the world this is more commonly the case than not.

On the other hand, a single network may consist of several types of stations or gauges if they are all contributing information to the network's objective. For example, both rain gauges and stream gauges might be included in a flood-warning network. The term network is frequently used in a less rigorous sense. It is often possible to hear of surface-water network, groundwater network, rainfall network, or water quality network when referring to an aggregation of gauges and stations that have no coherence in their objectives. Data-collection sites included in a network under this looser definition may even have disparate uses for the data being collected. This disparity of usage is more than just a semantical oddity. It can cause confusion and false expectations when network analysis and design are being discussed among program managers and hydrologists.

Ideally, a network design would be based on a maximization of the economic worth of the data that are to be collected. However, such is not the case in the real world. In the majority of the cases in water-resources decision making, the economic impacts of hydrological data are never considered. Decisions are made based on the available data, and the option of delaying the decision to collect more data is frequently not explored.

3.2 The basic network

The worth of the data that derive from a network is a function of the uses that subsequently are made of them. Nevertheless, many of the uses of hydrological data are not apparent at the time of the network design and, therefore, cannot be used to justify the collection of specific data that ultimately may be of great value. In fact, few hydrological data would be collected if *a priori* economic justifications were required. However, modern societies have developed a sense that information is a commodity that, like insurance, should be purchased for protection against an uncertain future. *Such an investment in the case of hydrological data is the basic network*, which is established to provide hydrological information for unanticipated future water-resources decisions. The basic network should provide a level of hydrological information at any location within its region of applicability that would preclude any gross mistakes in water-resources decision making. To accomplish this aim, at least three criteria must be fulfilled:

a) A mechanism must be available to transfer the hydrological information from the sites at which the data are collected to any other site in the area;
b) A means for estimating the amount of hydrological information (or, conversely, uncertainty) at any site must also exist;
c) The set of decisions must include the option of collecting more data before the final decision is made.

3.3 The minimum network

In the early stages of development of a hydrological network, the first step should be the establishment of a minimum network. Such a network should be composed of the minimum number of stations which the collective experience of hydrological agencies of many countries has indicated to be necessary to initiate planning for the economic development of the water resources. The minimum network is one that will avoid serious deficiencies in developing and managing water resources on a scale commensurate with the overall level of economic development of the country. It should be developed as rapidly as possible by incorporating existing stations as appropriate. In other words, a minimum network will provide the basic framework for network expansion to meet future needs for specific purposes. It is emphasized that a minimum network will not be adequate for the formulation of detailed development plans and will not meet the numerous requirements of a developed region for the operation of projects and the management of water resources. Once the minimum network is operating, regionalized hydrological relationships, interpreted information, and models can be formulated for estimating general hydrological characteristics, including rainfall and runoff at any location in the area. The basic network of observing stations should be adjusted over time until regional hydrological relationships can be developed for ungauged areas that provide the appropriate level of information. In most cases, this adjustment will result in increases in the densities of hydrologic stations. Since models are used to transfer the information from the gauged sites to the ungauged, the goodness of the model is also a factor in determining the density of the basic network. If a model is particularly good, it can distil the information from the existing data better than a poorer model, and the better model would require less data to attain a given level of regional information than would the poorer one. In an extreme situation, the regional model might be so good that the level of data collection in the basic network could be reduced.

Owing to the broad dependence on the stations in the basic network, it is very important that the records from all of these stations be of high quality. Even if the installation of a station is adequate, its records may be of little value if it is not operated for 20 years or more. A minimum network, in which stations are abandoned or irregularly observed, will have its effective density reduced and is, therefore, no longer an adequate minimum network. For that reason, care should be taken not only in establishing, but also in providing for the continuing operation of these stations and for monitoring the reliability and accuracy of the collected records.

Economics, as well as technical considerations, are involved in the design and implementation of basic networks, and the number of stations requiring observation over an indefinitely long period cannot be excessive. Consequently, a sampling procedure may be adopted to maximize the cost effectiveness of the basic network. One such approach categorizes the stations as either *principal* or *base stations*, or *secondary stations*. The secondary stations are operated only long enough to establish a stable relationship (usually by means of correlations) with one or more of the base stations. A new secondary station can then be established with the equipment and funds that had been in use at the discontinued site. Records can be reconstructed at the discontinued site by means of the base-station records and the inter-station relationship. At times, it may be necessary to re-establish secondary stations if it is believed that the conditions either at the secondary site or at its related base station(s) have changed.

The perpetual nature of the principal stations in the basic network provides a basis for monitoring long-term trends in hydrological conditions in the region. This is particularly important in light of potential changes in the hydrological cycle that could be caused by land-use changes or by increases in stratospheric greenhouse gasses.

Recognizing that the hydrological cycle is a continuum, and its inter-connections permit the partial transfer of information obtained in one part of the cycle to another, the efficiency of such transfers is proportional to the degree of hydrological understanding that is captured in the models that are used to route the water (and the information) between the parts of the cycle.

For example, precipitation records on or near a gauged drainage basin permit the reconstruction of streamflow records during periods when the stream-gauge malfunctions if a valid precipitation-runoff model has been calibrated during times when all gauges were functioning properly. This procedure is bound to gain recognition as the WRMA staff gain more knowledge and understanding of the MIKE BASIN Software.

To compliment the overall network, it is also necessary to include equipment that measures other climatic parameters, especially evaporation. For example, the Automatic Weather Stations (AWS) which are being installed in various regions in Kenya are playing a major role in the improvement of climatic databases and the provision of data for research.

From the concept of minimum network comprising stream gauging, precipitation and other climatic measuring stations, it is necessary to consider the density of this network. The World Meteorological Organization (WMO), has recommended general rules in the establishment of a basic minimum density of stations, proposing an area that is influenced by each station, whether a non-recording or a recording station as tabulated in the following tables. However and based on the experience, the recommended area sizes are too big for Kenya.

Table 1: Recommended minimum densities of precipitation stations

Physiographic Unit	**Minimum density per station (km^2 per station)**	
	Non-recording	Recording
Coastal	900	9000
Mountainous	250	2500
Interior plains	575	5750
Hilly/undulating	575	5750
Small islands	25	250
Urban areas		10 - 25
Polar/arid	10 000	1,000,000

Table 2: Recommended minimum densities of evaporation stations

Physiographic Unit	**Minimum density per station (km^2 per station)**
Coastal	50,000
Mountainous	50,000
Interior plains	50,000
Hilly/undulating	50,000
Small islands	50,000
Urban areas	50,000
Polar/arid	100,000

Table 3: Recommended minimum densities of river gauging stations

Physiographic Unit	**Minimum density per station (km^2 per station)**
Coastal	50,000
Mountainous	50,000
Interior plains	50,000
Hilly/undulating	50,000
Small islands	50,000
Polar/arid	100,000

The above narrative relates very well with the new setup of the gauging network in the Tana Catchment Area. Principle gauging stations are equivalent to the National and Management Unit Stations, while the secondary stations are equivalent to inter-management stations.

On precipitation and evaporation network, the Tana Catchment Area is ahead in the field as initial studies on the establishment of the network were completed under the Physiographical Baseline Survey for the Upper Tana Catchment. The study results provide a basis for the improvement of the gauging network in the Tana River basin.

As stated throughout this manual, the quality of data collected is the single most important activity and the Regional Water Resources Management Authority in the Tana Basin should ensure that the gauge readers are motivated to guarantee the correctness of the data they record.

CHAPTER 4 – MEASUREMENT OF PRECIPITATION

4.1 Introduction

This manual has been prepared with the main focus towards the operational hydrology components. However, due to its importance in the hydrological cycle and being the source of the water resources being discussed, it is necessary to briefly describe the precipitation process.

From the hydrological view point, any form of moisture reaching the earth's surface from the atmosphere is called precipitation, (rain, hail, snow).

In a tropical country like Kenya, major portion of the precipitation occurs in the form of rain only.

There are four basic conditions which are to be satisfied for precipitation to occur. They are:

i) Accumulation of moisture of sufficient intensity to account for the observed rates of precipitation;
ii) Cooling of air to the dew point temperature to produce saturation condition;
iii) Condensation;
iv) Growth of small water droplets to precipitable size.

Sometimes, it is common for the first three conditions to occur but not the fourth in which case the clouds will gradually dissipate without producing any precipitation.

Precipitation data is of utmost importance to hydrologists as it forms the basis of many hydrological studies. The variations in the rainfall distribution over space and time create serious hydrological problems such as floods and droughts.

4.2 Establishment of rainfall stations

In a perfect exposure, the catch of the raingauge would represent the precipitation falling on the surrounding area. However, this is difficult to attain in practice because of the effect of the wind. Much care has to be taken in the choice of the gauge location.

Wind effects are of two types: the effects on the gauge itself, which generally reduces the amount of water collected, and the effects of the site on the wind trajectories, which are frequently more important and can give rise to either an excess or a deficiency in measured precipitation. The disturbance created by an obstacle depends on the ratio of the obstacle's linear dimensions to the falling speed of precipitation. This effect is reduced, if not entirely overcome, by choosing the site so that the wind speed at the level of the gauge orifice is as small as possible, but so that there is not any actual blocking of precipitation by surrounding objects, and/or by modifying the surroundings of the gauge so that the airflow across the orifice is horizontal.

The gauge should be exposed with its orifice being horizontal over ground level. Where possible, the gauge site should be protected from wind movement in all directions by objects (trees, shrubs, etc.) of as nearly uniform height as possible. The height of these objects above the orifice of the gauge should be at least half the distance from the gauge to the objects, but should not exceed the distance from the gauge to the objects (to avoid interception of precipitation that should reach the gauge).

The ideal situation is to have the angle from the top of the gauge to the top of the encircling objects between 30° and 45° to the horizontal.

4.3 Measurement of precipitation

A variety of instruments and techniques have been developed for measuring various aspects of precipitation such as the amount, intensity, rain drop size distribution, etc. However, the present manual is limited to only those which are used to measure the amount.

All forms of precipitation are essentially measured on the basis of the vertical depth of water that would accumulate on a level surface if the precipitation is retained where it fell.

Precipitation is usually measured in millimeters (mm) and tenths of millimeters. If the amount is less than 1 mm it is recorded as *trace.*

In Kenya, standard non-recording raingauges and the Tipping-Bucket recording gauges are the most common instruments used by agencies involved in the measurement of rainfall. Figure 15 shows a typical standard raingauge used in Kenya. A standard raingauge consists of a circular funnel with a diameter of 5 inches (12.7 cm) and a sharp top edge. The water flows through a narrow opening to minimize the loss of water by evaporation – into a collecting glass bottle which is placed in a metal can with a metal can cover. The metal can is placed in a watertight casing, which is partly dug down into the ground. Figure 2 depicts an installed standard raingauge.

The measurement of rainfall is normally done once a day (0900 hours)

Figure 2: Typical Standard raingauge used in Kenya

The Tipping Bucket Raingauge has almost become the choice recording raingauge in Kenya, particularly where donor funds have been utilized to procure the raingauges.

The principle of the tipping bucket recording gauge is simple. A light metal container is divided into two compartments and is balanced in unstable equilibrium about a horizontal axis. In its normal position the container rests against one of two stops, which prevents it from tipping completely. The rain is led from a conventional collecting funnel into the uppermost compartment. After a predetermined amount of rain has fallen, the bucket becomes unstable in its present position and tips over to its other position of rest. The compartments of the container are so shaped that the water can now flow out of the lower one and leave it empty. Meanwhile, the rain falls into the newly positioned upper compartment. The movement of the bucket, as it tips over, is used to operate a relay contact and produce a record that consists of discontinuous steps.

CHAPTER 5 – EVAPORATION AND EVAPOTRANSPIRATION

5.1 Introduction

Evaporation and evapotranspiration are two of the most important phases of the hydrologic cycle. These phases redistribute the heat energy between surfaces and the atmosphere. Estimates of evaporation and evapotranspiration are required in the design of reservoirs, irrigation systems, scheduling and frequency of irrigation, water balance and simulation studies.

Evaporation is the process by which water from the liquid or solid state passes into the vapour state and is diffused into the atmosphere. Sublimation is the process by which water is converted from solid state to vapour without passing the liquid state. Transpiration is the process by which water passes from liquid to vapour state through plant metabolism. Evapotranspiration is the combined process by which water is evaporated from wet surfaces and transpired by plants.

5.2 Evaporation

Evaporation is expressed as the depth of water in mm escaped from a unit area in a given time. Although the physical processes of evaporation is responsible for the removal of water from wet surfaces, the rate of water loss is greatly influenced by the rate at which the soil or plant can move water to the evaporation surface. A number of factors, both meteorological and physical, affect the rate of evaporation from a water body. The meteorological factors include; radiation; temperature; humidity; wind and atmospheric pressure. The physical factors include water quality and size and shape of the evaporation surface.

5.3 Measurement of evaporation

In Kenya, evaporation is measured by means of a stainless standard Evaporation Pan, measuring 121 centimeters in diameter and 25.4 centimeters deep.

The evaporation pan is placed on wooden planks which are set and leveled on the ground in a grassy location, away from bushes, trees and other obstacles which obstruct natural air flow around the pan, thus representing open water in an open area. A perimeter fence is build around the evaporation pan plot to prevent animals from approaching and destabilizing the pan. In addition, a wire grill is placed over the pan to prevent birds from drinking from it (see Figure 3). Other equipment installed in the evaporation pan plot includes:

a) An anemometer at a height of two metres above the pan for determining wind movement over the pan;
b) A non-recording precipitation gauge;
c) Thermometers or thermographs to provide maximum, minimum, and current temperatures of the water in the pan;
d) Maximum and minimum thermometers or thermographs for air temperatures or
e) A hygrothermograph or psychrometer if data on the temperature and humidity of the air are desired.

With the availability of resources, it would be appropriate to install an automatic weather stations to record the above parameters in the pan evaporation plot.

The depth of water on filling the pan is determined by a gauge hook attached to the side of the tank or an evaporation micrometer, (see Figure 4). Water is added or removed from the pan by a cup of standard size. It is necessary to measure rainfall, air temperature, water surface temperature, atmospheric humidity and wind movements to fully evaluate the readings obtained from the evaporation pan.

At the beginning of a day, (say 0900 hours), the water level in the pan is at the gauging hook. After 24 hours, a number of standard cups of water are added or taken out to recover the water level in the pan. One standard cup is equivalent to 0.5 mm in the pan. The evaporation is therefore determined by the formula:

$E = R \pm (0.5 * P)$ mm,
Where;
E = evaporation (mm)
R = Rainfall (mm)
P = number of cups added (+) or taken out (-) from the pan.

Evaporation micrometer

The evaporation micrometer (***Hook Gage/Stilling Well***) consists of a hook at the end of a stem that is graduated to tenths of mm over a range of several mm. The three-legged hook gauge and adjusting nut assembly support the hook and provide for adjustment of the height of the hook when the hook gage is installed on the top of the stilling well. The adjusting nut is threaded to screw onto the stem of the hook. After assembly, the hook gauge is placed on the top of the stilling well with the three legs of the gauge resting on the top rim of the well with the hook centered in it. The threaded stem of the gauge should be vertical and the adjusting nut must turn easily to adjust the height of the hook within the well. The relative height of the hook in the well is indicated by the scales on the horizontal surface of the gauge.

At the time of observation, the hook gage is placed on the stilling well and, if necessary the hook is lowered in the well until the hook point is below the surface of the water. Slowly the adjusting nut is turned until the hook point just pierces the water surface. The gauge is removed from the well and the gauge reading is recorded.

The best method of measurement is to keep the pan filled to the same level each day, recording water lost to evaporation each time, since keeping the pan filled to the same level makes for a better control of water temperature.

The amount of evaporation is a function of temperature, humidity, wind and other ambient conditions. In order to relate the evaporation to wind current or expected conditions, the maximum and minimum temperatures as well as the other parameters are recorded with the evaporation.

5.4 Evapotranspiration

Evapotranspiration can be estimated by the use of soil evaporimeters and lysimeters, by the water- or heat-budget methods, by the turbulent-diffusion method, or by various empirical formulae based on meteorological data. Use of soil evaporimeters and lysimeters allow direct measurement of evapotranspiration from different land surfaces and evaporation from the soil between cultivated plants. Transpiration of vegetation is estimated as the difference between measured evapotranspiration and contemporaneously measured evaporation from the soil.
There is no single standard instrument for measuring evapotranspiration.
In the past, a lysimeter was installed in the Lake Victoria Basin for the estimation of evapotranspiration but the study was abandoned in the 1970s.

Figure 3: Standard evaporation pan

Figure 4: Stilling well with micrometer

CHAPTER 6 – SELECTION OF STREAM GAUGING STATION SITES

6.1 Purpose of stream gauging stations

The purpose of stream gauging stations is to provide systematic records of stage and discharge. Continuous streamflow records are necessary in the design of water supply and waste systems, in designing hydraulic structures, in the operations of water management systems, and in estimating the sediment or chemical loads of streams, including pollutants.

Since continuous measurement of discharge is not usually feasible, records of discharge are computed from the relationship between stage and discharge, as defined by periodic discharge measurements and a systematic record of stage or from a measuring structure that has been calibrated in either a laboratory or the field.

6.2 Selection of Gauging Station Sites

The general location of a gauging station is dependent on the specific purpose of the stream flow record.
After the general location of a gauging station has been determined, its precise location is selected to obtain the best locally available conditions for stage and discharge measurement and for developing a stable discharge rating.

The ideal gauge site satisfies the following criteria:

1. The general course of the river is straight for a reasonable distance upstream and downstream from the gauge site. WMO recommends a distance of 100 metres upstream and downstream of the gauge site.
2. The total flow is confined to one channel at all stages and no flow bypasses the site as subsurface flow;
3. The streambed is not subject to scour and fill and is free of aquatic growth;
4. Banks are permanent, high enough to contain floods, and are free from brush;
5. Unchanging natural controls are present in the form of a bedrock outcrop or other stable riffle for low flow and a channel constriction for high flow – or a falls or cascade that is un-submerged at all stages;
6. A pool is present upstream from the control at extremely low stages to ensure a recording of stage at extremely low flow, and to avoid high velocities at the stream ward end of gauging- station intakes during periods of high flow;
7. The gauge site is far enough upstream from the confluence with another stream or from tidal effect to avoid any variable influence the other stream or the tide may have on the

stage at the gauge site;

8. A satisfactory reach for measuring discharge at all stages is available within reasonable proximity of the gauge site. It is not necessary for low and high flow to be measured at the same river cross-section;

9. The site is readily accessible for ease in installation and operation of the gauging station.

Rarely will an ideal site be found for a gauging station and judgment must be exercised in choosing between adequate sites, each of which may have some shortcoming. Often, unfavorable conditions exist at all possible sites for installing a needed gauging station, and a poor site must be accepted.

In summary, there are mainly four criteria in selecting a site for establishing a stream gauging station, namely:

- *Accessibility* – The station should be accessible under all conditions, particularly during flooding period;

- *Adequacy* – The station must be able to cover the full range of discharges which may occur;

- *Stability* - The stage-discharge relationship at the site should change with time as little as possible. This aspect is very important both from the stand point of cost of operation and accuracy of discharge computations.

- *Permanency* – The station is so situated that the installation is almost permanent and is not likely to be disturbed. One of the most important features of stream flow record is its unbroken length.

CHAPTER 7 – GAUGING STATION CONTROLS

The conversion of a record of stage to a record of discharge is made by the use of a stage-discharge relationship. The physical element or combination of elements that control the stage-discharge relationship is known as a control. The major classification of controls differentiates between section control and channel control. Another classification differentiates between natural and artificial controls.

7.1 Section and Channel Controls

Section control exists when the geometry of a single cross-section is such as to constrict the channel, or when a major downward break in bed slope occurs at a cross-section. The constriction may result from a local rise in the stream bed, as at a natural riffle or rock ledge outcrop or at a constructed weir or dam. It may also result from a local constriction in width, which may occur naturally or may be caused by some man-made channel encroachment, like a bridge with a waterway opening that is considerably narrower than the width of the natural channel.

Channel control exists when the geometry and roughness of a long reach of channel downstream from the gauging station are the elements that control the relationship between the stage and discharge. The effective channel control increases with increase in discharge. In general, the flatter the stream gradient, the longer the reach of the channel control.

7.2 Artificial Controls

An artificial control is a structure built in a stream channel to stabilize and constrict the channel at a section, and thereby simplify the procedure of obtaining accurate records of discharge. The artificial controls built in natural streams are usually broad-crested weirs that conform to the general shape and height of the streambed. In canals and drains, where the range of discharge is limited, thin-plate weirs and flumes are the controls commonly built. Thin-plate weirs are built in those channels whose flow is sediment free and whose banks are high enough to accommodate the increase in stage (backwater caused by the installation of a weir). Flumes are largely self-cleaning and can therefore be used in channels whose flow is sediment laden but their principal advantage is that they cause relatively little backwater and can therefore be used in channels whose banks are relatively low.

Figures 5 to 7 show types of artificial controls built in some of the rivers in Kenya.

Figure 5: Broad-crested weir

Figure 6: Thin-plate V-Notch weir

Figure 7: Combined V-Notch and Broadcrested weir (Compound weir)

CHAPTER 8 – ESTABLISHMENT OF GAUGING STATIONS AND MEASUREMENT OF STAGE

8.1 ESTABLISHMENT OF GAUGING STATIONS

8.1.1 Establishment of Gauge Datum

A datum is a reference from which survey measurements are made. A datum plane is a permanently established horizontal plane, surface, or level to which soundings, ground elevations, water surface elevations are referred

The datum of a gauge may be a recognized datum, such as mean sea level, or an arbitrary datum plane chosen for convenience. Arbitrary datum plane is selected for the convenience of using gauge heights of relatively low numbers. To eliminate the possibility of minus values of gauge height, the datum selected for operating purposes is below the elevation of zero flow on the control for all conditions.

A permanent datum is maintained so that only one datum for the gauge height record is used for the life of the station.

In Kenya, a datum of 100m is assumed when establishing a gauging station.

8.1.2 Installation of manual gauges:

The common gauge used in Kenya is the vertical staff gauge which is graduated in centimeters and installed in such a way that some portion of it will be in the water at all stages.

A staff station is a regular gauging station where only manual gauges are installed. The water level is read on the gauge plate by an observer (gauge reader).

The following points should be observed when installing manual gauges:

1. The zero point of the staff gauge must be low enough to measure the lowest possible flow in the stream;
2. The gauge plates must be mounted firmly and vertically. The gauge plates are supplied in sections of 0.0-1.5m, 1.5-3.0m, etc. or in sections of one metre length; (Figure 8)
3. The range of the gauges must be great enough to measure the maximum possible flood;
4. A benchmark must be established to enable the elevation of the staves to be calculated and checked regularly. (A benchmark is a permanent point of reference of known elevation. In Kenya, the benchmark is usually a bolt set in a concrete block or a bolt set in a bridge pier, etc. The elevation is assumed to be 100.00m. The benchmark is used when it is necessary to replace staves which have been washed away by floods. (The Survey of Kenya Benchmarks are related to the datum of mean sea level)Recently, a process has

been initiated to relate the elevation to the nearest Survey of Kenya Benchmarks).

5. Due to vandalism of metal installations of gauges, WRMA had initiated a program whereby concrete posts are used as the anchors for the staff gauges in areas that are prone to vandalism. (Figure 9)

6. The gauge reader is thoroughly instructed on how to read the gauge, how to record the readings and how to forward the records to the field officers.

After the installation of a new gauging station, an "Installation Report" is completed and filed appropriately. (A sample template of an Installation Report previously used by the Ministry of Water Resources and Development is attached as Annex 1. WRMA could adopt the same template for its river gauging station installation reports).

Figure 8: Installation of manual vertical gauges on metal posts

Figure 9: Staff gauged installed on concrete post

8.2 MEASUREMENT OF STAGE

8.2.1 Manual staff gauge

The stage of a stream or lake is the height of the water surface above an established datum plane. The water-surface elevation referred to some arbitrary or pre-determined gauge datum is called the gauge height. Gauge height is often used interchangeably with stage. Gauge height is usually expressed in metres and hundredths of a metre.

A record of stream gauge height is useful in itself, for designing structures affected by stream elevations or in planning the use of flood plains.

A record of gauge height is obtained by systematic observations of a non-recording gauge (staff gauge) or by means of an automatic water level recorder. A staff gauge station is a regular gauging station where only manual gauges are installed. The water level is read daily on the gauge plate by an observer.

It is recommended that the gauge readers be advised to read the gauges twice daily at 0800hours and at 1600 hours.

The advantages of non-recording gauge include the initial low cost and ease of installation. The disadvantages include the need for an observer and lack of accuracy of the estimated continuous gauge height graph drawn through the plotted points of observed gauge height. For long-term operations, the advantages of a recording gauge far outweigh those of a non-recording gauge.

However, the cost of automatic water level recorders has constrained their use in Kenya.

In the past, the Ministry of Water and Irrigation used to operate flood gauges in some of the manually operated gauging stations. A flood gauge comprised a stick or metal rod, coated with soluble paint and placed in a protective casing. Holes were drilled in the casing to allow the water level inside the casing to rise to the same level as the water in the river. The paint on the length of the stick dissolved as the water level rose. The observer then related the flood stick to the gauge plate in order to record the maximum flood mark.

8.2.2 Automatic Water Level Recorder (AWLR)

Many different types of continuously recording stage gauges are in use. They may be classified according to both mode of actuation and mode of recording. A commonly used installation consists of a stilling well connected to the stream by inlet pipes and a float in the stilling well connected to a wheel on a recorder by a beaded wire or perforated tape. In general, two inlet pipes are sufficient for the rivers found in Kenya.

Automatic water level recorders are installed together with external manual gauges to enable comparison of the readings and making the necessary changes on the AWLR.

A continuous recording gauge that has been recently introduced in Kenya is the Thalimedes Data Logger (Figure 10). The Thalimedes is a float-operated shaft encoder with data logger, used to continuously measure surface water and groundwater levels. A Thalimedes Data Logger installed in a stilling well inside a data logger house is depicted in Figure 11.

Changes in water level are transferred via a float-cable-counterweight-system to the float pulley on the encoder unit. The rotation caused by this action is converted to an electrical signal, which is transferred by the transducer cable to the data logger and then saved as a measured value. The storage intervals are preset in accordance with the hydrological measured values required. The measured values are downloaded using a computer.

A template on automatic instrument installation report is attached as Annex 2.

Figure 10: Thalimedes Data Logger

Figure 11: Ott Thalimedes Data logger installed in a data logger house

In addition to the float – operated shaft encoder, the Ministry of Water and Irrigation had operated electronic pressure transducers for stage monitoring. These systems operated in the Lake Victoria basin but somehow they did not gain wide support for their continued use.

8.3 Maintenance of gauging stations

For manually operated gauging stations, the gauge readers should be instructed to keep the gauging site and the approach to the gauge clear and clean. The lower gauge plates should be cleaned frequently to keep the plate readings clear.

In connection with automatic water level recorders, the current procedure is to install the recorder in a data logger house that is surrounded by a data logger fence. In this case the access to the station is limited and consequently, the officer in charge of the station will maintain the station. The officer will make frequent visits to the station in order to check on the operational status of the equipment, download the measured values and ensure that the compound inside the data logger fence is kept clean.

CHAPTER 9- DISCHARGE MEASUREMENT

River discharge, which is expressed as volume per unit time, is the rate at which water flows through a cross-section. Discharge at a given time can be measured by several different methods, and the choice of the method depends on the availability of measuring equipment and conditions encountered at a particular site.

In the past, measurement of discharge by current meters and floats were the normal procedures. However, state-of-the-art flow measuring equipment including the Acoustic Doppler Current Profiler (ADCP) and the Acoustic Dopler Velocimeter (ADV) have been introduced in Kenya.

9.1 Measurement of discharge by current meters

9.1.1 General/Overview

Current meters are used to measure flow velocities in rivers, canals, etc. The principle of operation is based on the proportionality between the velocity of the water and the resulting angular velocity of the current meter rotor. By placing a current meter at a point in a stream and counting the number of revolutions of the rotor during a measured interval of time, the velocity of water at that point is determined. A common type of current meters used in Kenya is the Universal Current Meter shown in Figure 12.

Figure 12: Universal current meter

The depth of flow in a cross-section is measured at verticals with a rod or sounding line. As the depth is measured, observations of velocity are obtained with a current meter at one or more points in the vertical. The measured widths, depths, and velocities permit computation of discharge for each segment of the cross-section. The summation of these segment discharges is the total discharge. The continuity equation of discharge is defined by:

$$Q = \sum A_i V_i$$

Where: A_i – Area of a section (m^2); Vi – Mean velocity in the section

Discharge measurements need not be made at the exact location of the stage gauge because the discharge is normally the same throughout a reach of channel in the general vicinity of the gauge. Sites selected for measurements should ideally have the following characteristics:

a) The velocities at all points are parallel to one another and at right angles to the cross-section of the stream;
b) The curves of distribution of velocity in the section are regular in the vertical and horizontal planes;
c) The velocities are greater than 0.150 m/s;
d) The bed of the channel is regular and stable;
e) The depth of flow is greater than 30cm;
f) There is no aquatic growth.

9.1.2 Measurement of cross-sections

The accuracy of a discharge measurement depends on the number of verticals at which observations of depth and velocity are obtained. Observation verticals should be located to best define the variation in elevation of the stream bed and the horizontal variation in velocity. It is recommended that the interval between any two verticals should not be greater than 1/20 of the total width and the discharge between any two verticals should not be more than 10 per cent of the total discharge.

Channel width and the distance between verticals should be obtained by measuring from a fixed reference point (initial point on the bank), which is in the same plane as the cross-section. Normally, the distance between verticals is determined from a graduated tape or beaded wire temporarily stretched across the stream or from semi-permanent marks painted on a bridge handrail or suspension cable.

Depth is read directly on a graduated rod set on the stream bed if measurements are by wading. If the drum-wire-weight system is used for measurement, the current meter and weight are lowered until the bottom of the weight just touches the water surface, and the depth dial reading is set at zero. The weight is then lowered until it rests on the stream bed, and the depth is read on the dial.

9.1.3 Measurement of velocity using the current meter

Velocity is observed at one or more points in each vertical by counting revolutions of the rotor during a set period of time depending on the velocity of the river. In most cases, a period of 60 seconds is found to be appropriate. For shallow channels, the current meter should be held in the desired position by means of a wading rod. For channels too deep or swift to wade, it should be positioned by suspending it from a wire or rod from a bridge, cableway, or boat. When a boat is used, the meter should be held so that it is not affected by disturbances of flow caused by the boat. After the meter has been placed at the selected point in the vertical, it should be allowed to become aligned with the direction of flow before readings are started. The current meter should be removed from the water at intervals for examination.

For measuring very low velocities, special current meters (e.g. Baby Ott) are used.

The horizontal axis of the current meter should not be situated at a distance less than one and one-half times the rotor height from the water surface, nor should it beat a distance less than three times the rotor height from the bottom of the channel.

Figure 13 depicts a current meter gauging by wading.

Figure 13: Current meter gauging by wading

9.1.4 Determination of mean velocity in a vertical

The mean velocity of the water in each vertical can be determined by one of the following methods:

(*a*) Velocity distribution method;
(*b*) Reduced point methods; and
(*c*) Integration method.
(d) The surface velocity

Selection of the appropriate method depends on the time available, the width and depth of the water, the bed conditions, and the rate of change of stage, the existence of ice cover, and the required accuracy.

In Kenya the reduced point and the surface velocity methods are the common methods of choice when undertaking current meter gauging.

Reduced point methods

a) One-point method — Velocity observations are made at each vertical by placing the current meter at 0.6 of the depth below the surface. The value observed is taken as the mean velocity in the vertical.

b) Two-point method — Velocity observations are made at each vertical by placing the current meter at 0.2 and 0.8 of the depth below the surface. The average of the two values is taken as the mean velocity in the vertical. Care, however must be taken that the meter setting is not closer to the bed than 0.1m or incorrect registering of velocity will occur.

c) Three-point method — Velocity observations are made by placing the current meter at each vertical at 0.2, 0.6 and 0.8 of the depth below the surface. The average of the three values, are taken as the mean velocity in the vertical as:-

$$\boldsymbol{v_{av} = (v_{0.2} + v_{0.6} + v_{0.8})/3}$$

d) Surface velocity method – A measurement of surface velocity, is taken when it is not possible to use one of the previous methods. The velocity measured at the surface is greater than the mean velocity in a vertical and a ***"correction factor"*** must be used. In Kenya, a correction factor of 0.85 is generally used.

In most cases, this method is used in shallow depths near river banks, where velocities are low and the flow is a small percentage of the total flow. Thus, a small error in the choice of the correction factor does not affect the total discharge significantly.

9.1.5 Computations of discharge

(1) Arithmetical methods

(a) **Mean-section method** — The cross section is regarded as being made up of a number of segments bounded by two adjacent verticals. If $\mathbf{v_1}$ is the mean velocity at one vertical and $\mathbf{v_2}$, the mean velocity at the adjacent vertical, and if $\mathbf{d_1}$ and $\mathbf{d_2}$ are the total depths measured at verticals 1 and 2, and **b** is the horizontal distance between verticals, then the discharge ***q*** of the segment is:

$$q = (v_1 + v_2)/2 * (d_1 + d_2)/2 * b$$

The total discharge is obtained by adding the discharge from each segment;

$$Q = \sum q_i$$

(b) **Mid-section method** —. The midsection method is elaborated with reference to Figure 11 below. This method is the normal choice in Kenya.

The Water Resources Management Authority generally uses the midsection method of computing stream discharge using current meter velocity measurements. In this method, the stream cross section is divided into rectangular subsections. At the center of each of these subsections (called a vertical), a depth and velocity measurement is made, and the distance from a reference point point on the river bank is determined. It is assumed that the mean velocity in each vertical represents the mean velocity in a partial rectangular area. The mean velocity in each vertical is determined by measuring the velocity at selected points in that vertical. The cross-section area for a segment extends laterally from half the distance from the preceding vertical to half the distance to the next vertical, and vertically, from the water surface to the sounded depth as shown in Figure 14.

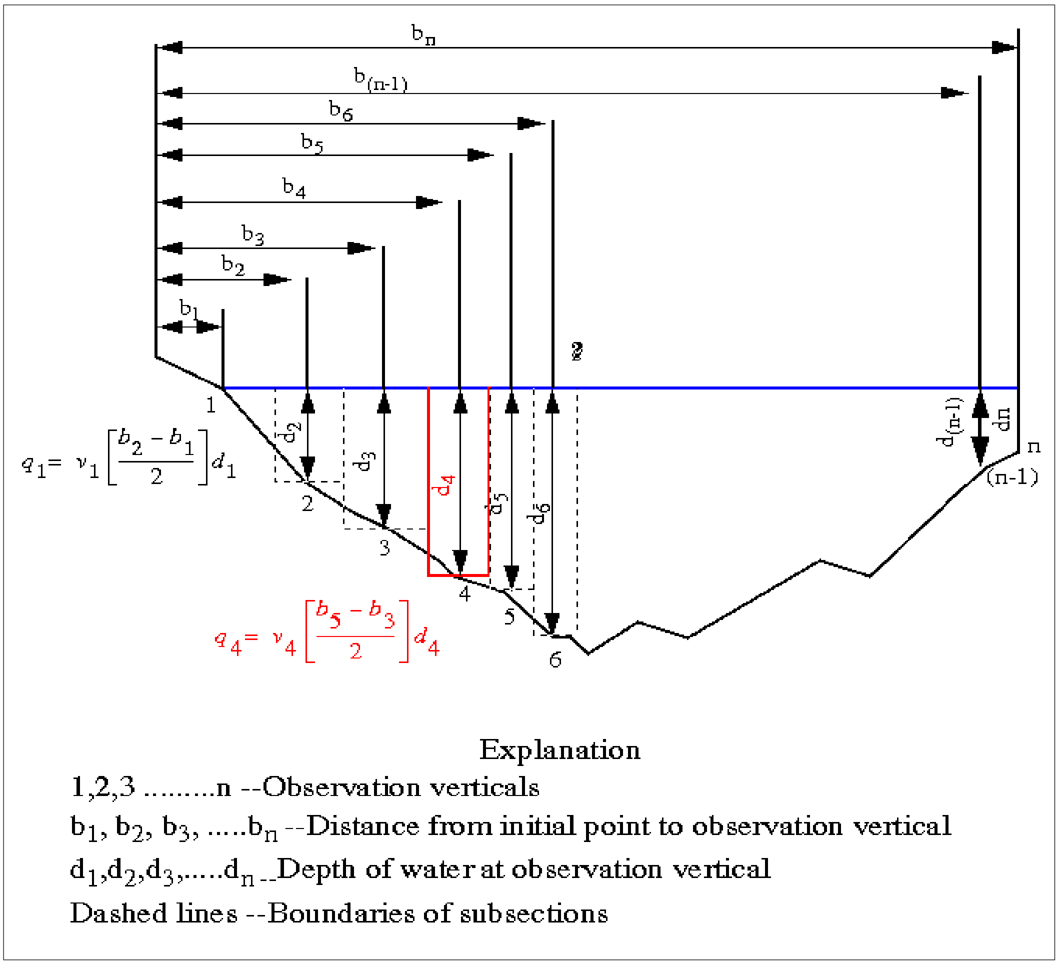


Figure 14: Sketch of mid-section discharge measurement

The cross section (Figure 14) is defined by depths at locations 1, 2, 3, 4. . . . n. At each location the velocities are sampled by current meter to obtain the mean of the vertical distribution of velocity. The partial discharge is now computed for any partial section (segment) at location *i* as:

$$q_i = v_i \, [1/2(b_i - b_{(i-1)}) + 1/2(b_{(i+1)} - b_i)] \, d_i$$
$$= v_i [\, 1/2(b_{(i+1)} - b_{(i-1)})] \, d_i$$

Where:

qi = discharge through partial section i,
vi = mean velocity at location i,
bi = distance from initial point to location i,
$b(i\text{-}1)$ = distance from initial point to preceding location,
$b(i+1)$ = distance from initial point to next location,
di = depth of water at location i.

Thus, for example, the discharge through partial section 4 in Figure 11 is;

$$\boldsymbol{q_4 = v_4\ [1/2(b_5\text{-}b_3)]\ d_4}$$

The procedure is similar when i is at an end section. The "preceding location" at the beginning of the cross section is considered coincident with location 1; the "next location" at the end of the cross section is considered coincident with location n. Thus,

$$\boldsymbol{q_1 = v_1\ [1/2(b_2\text{-}b_1]\ d_{1,\ \text{and}}}$$

$$\boldsymbol{q_n = v_n\ [1/2(b_n\text{-}b_{(n\text{-}1)}]\ d_{n.}}$$

For the example shown in Figure 11, q_1 is zero because the depth at observation point 1 is zero. However, when the cross-section boundary is a vertical line at the edge of the water as at location n, the depth is not zero and velocity at the end section may or may not be zero. The above water edge equations are used whenever there is water only on one side of an observation point such as at the edge of the stream, piers, abutments etc. It usually is necessary to estimate the velocity at an end section because it normally is impossible to measure the velocity accurately with the current meter close to a boundary. There is also the possibility of damage to the equipment if the flow is turbulent. The estimated velocity is usually made as a percentage of the adjacent section.

The summation of the discharges for all the partial sections is the total discharge of the stream.

9.2 Measurement of discharge by the float method

This method is used when either it is impossible to use a current meter because of unsuitable velocities or depths, or the presence of material in suspension, or when a discharge measurement must be made in a very short time.

(a) Selection of sections

Three cross-sections are selected along a reach of straight channel. The cross-sections should be spaced far enough apart for the time that the float takes to pass from one cross-section to the next to be measured accurately. A travel time of 20 seconds is recommended, but a shorter time may have to be used on small rivers with high velocities where it is often impossible to select an adequate length of straight channel.

(b) Floats

Surface floats or rod floats may be used. A surface float has a depth of immersion less than one-quarter the depth of the water. Surface floats should not be used when they are likely to be affected by wind. Floating trees may serve as natural floats during periods when it is unsafe to be on the river.

(c) Measuring procedure

Float observations must be uniformly distributed over the width of the stream. The float should be released far enough above the upper cross-section to attain a constant velocity before reaching the first cross-section. The time at which the float crosses each of the three cross-sections should be noted with a stop-watch. This procedure should be repeated with the floats at several locations across the stream.

Distances of the float from the bank as it passes each cross-section may be determined by suitable means. The depth of flow at points in the cross-section may be determined by surveying methods.

(d) Computation of velocity

The velocity of the float is equal to the distance between cross- sections divided by the time of travel. The corrected velocity of flow in each section equals the float velocity multiplied by a coefficient that is based on the shape of the vertical velocity profile and the relative depth of immersion of the float. The coefficient to be applied to the measured velocity should be determined, if possible, for each site by an analysis of discharge measurements that have been made by current-meter.

When using natural floats, their velocity should be plotted as a function of the corresponding distance from the bank, and the mean surface velocity across the river should be determined from this plot. The mean velocity of flow in the cross-section is equal to the mean surface velocity multiplied by a coefficient, K, the value of which is deduced, if possible, from preceding measurements made with a current meter for smaller discharges.

(e) Computation of discharge

Discharge in each section is computed by multiplying the average area of the cross-section of the stream section by the mean velocity of flow in the section. The total discharge is the sum of these discharges.

With the provision of the state-of-the-art flow measuring equipment, (ADCP, ADV) discharge measurement by floats is rarely applied in Kenya except on very small streams or canals where water depths and velocities are very small.

9.3 Measurement of Discharge by ADCPs and ADVs

Acoustic Doppler Current Profilers (ADCPs) and Acoustic Doppler Velocity meters (ADVs) have been introduced in Kenya within the last ten years for the sole purpose of discharge measurement in rivers across the country. ADCPs are used in the bigger rivers while ADVs are used in the smaller streams (Figures 15 and 16)

With the ADV, the technique involves wading through the stream and taking a series of velocity measurements at different locations throughout the cross section. These measurements are combined with location and water depth information to compute the total discharge.

Measurement of discharge using these new equipment is gaining acceptance as the personnel in the institutions become familiar with their use.

Detailed guidance in the use of these equipment are contained in the user's manuals supplied with the equipment.

Figure 15: Discharge measurement by ADCP

Figure 16: Discharge measurement by ADV

9.4 Measurement of discharge by precalibrated measuring structures

9.4.1 Weirs

A weir is an overflow structure built across an open channel. It has a specific size and shape with a unique free-flow head-discharge relationship. The edge or surface over which the water flows is called the crest. Discharge rates are determined by measuring the vertical height from the crest to the water surface in the pool upstream from the crest.

There are generally two types of weirs; sharp-crested and broad-crested weirs. Although the sharp-crested weirs tend to be more accurate than broad-crested weirs, they are much more prone to damage from floating debris.

Sharp-crested weirs

There are generally four types of sharp-crested weirs that are in use, namely;

- The rectangular weir
- The triangular (V-notch) weir $\boldsymbol{\theta}$
- The trapezoidal weir
- The compound weir

Rectangular weir
The discharge formula for a sharp-crested rectangular weir is given by:
$\mathbf{Q = 2/3 \times C_d \times L \times \sqrt{2g} \times H^{3/2}}$
Where:

Q – discharge (m^3/s);
C_d – discharge coefficient that is determined for each weir. Generally, C = 0.62
b – length of the crest
H – head of water above the crest (m)
g – 9.81 m/s^2

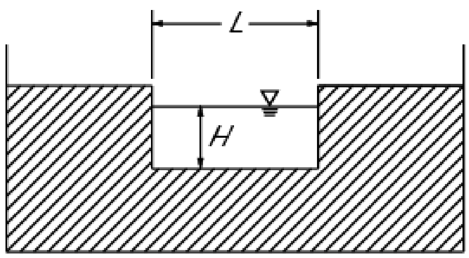


Figure 17: Sharp-crested rectangular weir

V-notch (triangular) weir

The discharge formula for a sharp-crested V-notch weir is given by:

$$Q = 8/15 \times C_d \times \sqrt{(2g)} \times \tan Ø/2 \times H^{5/2}$$

Where:
Q – discharge (m^3/s)
C_d – discharge coefficient
Ø – angle included between sides of the notch
H – gauged head referred to crest
g – 9.81 m/s^2

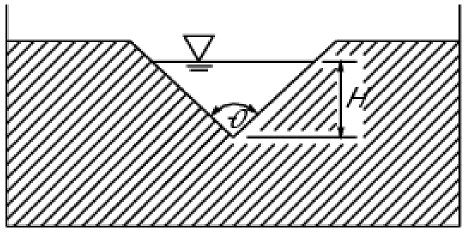


Figure 17: V-notch weir

(The coefficient C_d varies from 0.608 at H= 0.050 m to 0.590 at H = 0.381 for a 90^0 notch.)

Broad-crested weirs

The general discharge formula for a broad-crested weir is given by:

$$Q = C_d(\sqrt{(g)}bH^{3/2}$$

Where:
Q – discharge (m^3/s)
C_d – discharge coefficient
g – 9.81 m/s^2
b – length of the crest (m)
H – gauged head (m)

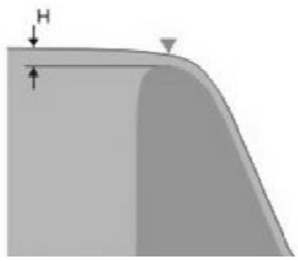


Figure 18: Broad-crested weir

The C_d value depends on the shape of the upstream corners and the breadth, b, of the crest. With square upstream corner and a relatively small breadth, the C_d value is about 0.6. However, the coefficient C_d is experimentally determined.

9.4.2 Flumes

Flumes are primary devices that constrict an open channel flow for measurement. Once the flow is backed up behind the constriction there is a defined relationship between the depth up stream and the flow through the constriction. This relationship can either be determined from an equation or a table. The level of flow can be measured by a staff gage, or by an automatic water level recorder similar to the method used for a normal gauging station.
Flumes can satisfactorily be used in debris-laden streams unlike the weirs.

Weirs and flumes provide perfect permanent controls when they are carefully maintained. However, due to the initial high costs in their construction, these structures are rarely constructed in large rivers.

9.5 Measurement of discharge by the Slope-Area method

The discharge of rivers is usually measured by the current meter method or the other methods described in this chapter. During flood periods, however, it is frequently impossible or impractical to measure the discharges by any of the above methods. Consequently, many peak discharges must be determined after the passage of the flood by indirect methods, such as slope-area method.

Indirect methods of determining peak discharge are based on hydraulic equations which relate the discharge to the water-surface profile and the geometry of the river channel. A field survey is made after the flood to determine the location and elevation of high-water marks and the characteristics of the channel. In the application of the slope-area method, discharge is computed on the basis of a uniform-flow equation involving channel characteristics, water-surface profiles, and s roughness coefficient. In this, the slope of the water surface, the cross-section area and the wetted perimeter are determined. In addition, the roughness coefficient is estimated.

In applying the slope-area method for the determination of discharge, the Manning equation is preferred due to ease of use.

The Manning equation, written in terms of discharge is given by:

$$Q = 1/nAR^{2/3}S^{1/2},$$

Where:
Q – discharge in m^3/s;
A – cross-section area
R = A/P – hydraulic radius (m) where P is the wetted perimeter
S – Friction slope,
N – roughness coefficient

9.6 Frequency of discharge measurements

Factors to be considered in scheduling the number and distribution of discharge measurements within the year include:

(a) Stability of stage-discharge relationship;
(b) Seasonal discharge characteristics and variability; and
(c) Accessibility of the gauge in various seasons.

9.7 Maintenance of equipment (Current meters)

To insure reliable observations of velocity, it is necessary that the current meter be kept in good condition.

Before and after each discharge measurement the meter vanes, pivot and bearing, and shaft should be examined for damage, wear, or faulty alignment. The conductor wire should be adjusted to prevent interference with meter balance and rotor spin. During measurements, the meter should periodically be observed when it is out of the water to be sure that the rotor spins freely.

Meters should be cleaned and oiled frequently when in use. If measurements are made in sediment-laden water, the meter should be cleaned immediately after each measurement.

After oiling, the rotor should be spun to make sure that it operates freely. If the rotor stops abruptly, the cause of the trouble should be sought and corrected before using the meter. The duration of spin should be recorded on the field notes for the discharge measurement. A significant decrease in the duration of spin indicates that the bearings require attention.

Meter repairs by the surface water officers should be limited to minor damage only. That is particularly true of the rotor, where small changes in shape can significantly affect the meter rating.

For the ADCPs and ADVs, the staff using these equipment should strictly follow the directions given in the User Manuals given by the manufacturers.

9.8 Safety considerations for field staff

Hydrological measurements are made under an extremely wide range of conditions, many of which are potentially hazardous to the personnel taking them. Knowledge of the hazards and the means by which they can be minimized are essential for hydrological personnel.

Safety at recording stations

In order to access the gauging site, well-constructed footpaths, steps, ladders, etc. are essential for safety on steep river banks. These need to be constructed for safe access in wet weather.

Safety while working from bridges

The main hazards in carrying out measurements or sampling from bridges are in being struck by passing traffic or being tipped over the side of the bridge by undue force or weight on the suspended equipment.

On *traffic hazards*, bridges with a pedestrian lane may provide a good margin of safety. In other circumstances, it is imperative to warn motorists with adequate signs and, if practical, flashing lights. Personnel should wear fluorescent or brightly-coloured clothing, and portable traffic markers may be deployed to shift traffic flow away from the work area.

On *suspended equipment*, the potential leverage on equipment, such as bridge (gauging) cranes, means that they are prone to being tipped over the side of the bridge if the suspended equipment should become caught on river-borne debris below. Extra care should be taken against these dangers during floods.

Gauging cranes or frames need to be suitably counterbalanced or tied down.

Safety precautions while wading

Where it is possible to wade streams, hydrological measurements may be made more simply and directly than by other means. However, it becomes hazardous when the depth or velocity, or both, are excessive.

The personnel need to exercise caution and be experienced to decide whether wading should be carried out in a particular situation. As a general guide, if the product of the depth in metres and the velocity in metres per second exceed 1.0, the stream is unlikely to be safe to wade. A person's build and attire will influence this. Waders have more drag than bare legs

Correctly fastened lifejackets of an appropriate size and design should generally be worn in flowing water, where there is a possibility of entering such water, or where conditions could otherwise become hazardous.

Safety lines/Taglines

When making discharge measurements, a rope/line strung across the stream can be useful as a support. It can also double as a line for measuring distance and should be securely anchored at both ends to sustain the weight and drag of a person against the flow of the river.

One should select a crossing with negotiable depths, velocities, and bed material, plan a route diagonally downstream, and walk across with short steps, facing the opposite bank, and side-on to the current. It can be helpful to use a wading rod (without current meter) on the upstream side to probe the depth and give support. If the crossing becomes too difficult, one should retreat, possibly by stepping backward until it is possible to turn around, and perhaps try an easier crossing.

Responsibility

Personnel must not be obligated to wade rivers in situations where they feel unsafe. Experience and confidence are important factors but must be tempered with sensible caution.

Safety precautions while working from boats

Many types of boats are used for hydrological purposes, each having their own safety requirements. These must always be observed, as boating is inherently dangerous.

The boat operator must be familiar with all operating and emergency procedures, and all regulations governing the intended operations. Craft must be in good repair, adequate for the conditions that could be encountered, and must not be overloaded.

Lifejackets

Lifejackets must be worn at all times in small craft and, in larger craft, there must be sufficient lifejackets on board for all passengers and crew.

Use of taglines

Measuring lines or taglines are frequently used for measuring the distance across a river. These need to be of an adequate size and type of material to prevent stretch, and hold the necessary flags. However, the lighter the cable, the less tension is necessary in its rigging, and thus handling will be easier.

Use of dinghies

In rivers, one should row using the ferry-glide technique, heading diagonally upstream into the current. The rower is then facing in the direction of travel downstream, and steerage around any obstacles can be accomplished.

Personnel should be competent at rowing; oars should be of a suitable length, and secure rowlocks of the closed type are recommended.

Other hazards

Hydrological field personnel should be familiar with, and always be on the lookout for other hazards posed by their working environment. These include, for example, poisonous plants, stinging or biting insects, dangerous animals, quicksand, electrical storms, and so forth. Also, bodily contact or ingestion of some waters may pose significant health risks. In some localities, there may be a possibility of attack by other people, who may be engaged in illegal or warlike activities, for example. Employers have a responsibility to ensure that their staff are never unknowing to any such risks.

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CHAPTER 10 – DISCHARGE RATING CURVES

10.1 Overview

Continuous records of discharge at gauging stations are computed by applying the discharge rating for the stream to records of gauge height. Other synonyms for discharge rating include stage-discharge relation, rating curve and station rating.

Discharge ratings for gauging stations are determined empirically by means of discharge measurements made in the field. Common practice is to measure the discharge of the stream periodically by a current meter, noting the concurrent gauge height. The introduction of state-of-the-art measuring equipment comprising of ADCPs and ADVs has greatly reduced the time taken to make a discharge measurement at a gauging station. Measured discharge is then plotted against concurrent gauge height on graph paper to define the rating curve.

At a new station, many discharge measurements are needed to define the stage discharge relationship throughout the entire range of stage. Periodic measurements are undertaken thereafter to confirm the stability of the rating or to follow changes (shifts) in the rating. It is important that the stage discharge relationship be defined for flood conditions.

Discharge rating for a gauging station is of the form:

$$Q = a\,(H - H_0)^{b}$$

Where,

Q -------------is discharge;
(H-H_0) ------- is head or depth of water on the control;
H -------------- is gauge height of the water surface;
H_0 ------------ is gauge height of zero flow;
a -------------- is the discharge when the head (H-H_0) equals 1m;
b ------------- is slope of the rating curve.

Rating curves are usually plotted and analyzed using logarithmic graph paper. The relation between Q and H can usually be represented by a power function, which plots as a straight line on logarithmic graph paper. Consequently, a portion of a rating curve that is applicable to any one control may be plotted as a straight line, thus facilitating extension or interpolation of the rating curve. In addition to the rating curves, equations appropriate to the curves are developed and used to compute discharge instead of developing rating tables.

In a preliminary step in the development of rating curves, the current meter discharge measurements are tabulated and summarized on a form. The discharge is then plotted as the abscissa, corresponding gauge height is plotted as the ordinate, and a curve or line is fitted by eye to the plotted points. Alternatively, the curve fitting and the generation of an equation can be done using the available computer software.

10.2 Extension of Ratings Curves

10.2.1 Low-flow extensions

Low flow extensions (extrapolations) are best performed on rectangular coordinate graph paper so that the point of zero flow can be plotted. A rating curve is extended down to the point of zero flow using a smooth curve.

10.2.2 High flow extensions

The high flow end of the rating curve can be extended somewhat using straight line extrapolations of logarithmic rating curves. It is, however, cautioned that only as a last resort should the rating curve be extended beyond a discharge value equal to twice the greatest discharge measured. Otherwise, longer extensions can be performed by defining the upper end of the rating curve using some form of indirect peak-discharge measurement.

It is, however, noted that with the introduction of the new state-of-the-art discharge measurement equipment, it is now possible to make direct measurements during high flows.

Other methods used in the extension of rating curves but not elaborated in this manual include:

1. Conveyance –slope method;
2. Areal comparison of peak-runoff rates;
3. Step-backwater method;
4. Flood routing.

The above methods are briefly described in the following sub-titles.

1. Conveyance –slope method

The conveyance-slope method is based upon the Manning equation in which

$Q = KS^{1/2}$

Where;
- Q = Discharge in m^3/s
- S = Friction Slope (Energy gradient)
- $K = 1/nAR^{2/3}$
- n = Manning roughness coefficient
- A = River cross-section area
- R = Wetted perimeter

Values of A and R corresponding to any gauge height can be obtained from a field survey of the discharge measurement cross-section, and values of n are available in hydrological technical books. Thus the value of K, combining all the elements that can be measured or estimated, can be computed for any given gauge height. Values of gauge height versus K, covering the complete range of gauge height up to the required peak gauge height, are computed and plotted on rectangular graph paper. A smooth curve is fitted to the plotted points.

Values of slope, S – the energy gradient (friction slope), are usually not available even for measured discharges. However, for the measured discharges, $S^{1/2}$ are computed by dividing each measured discharge by its corresponding K value; S is then obtained by squaring the resulting value of $S^{1/2}$. Values of gauge height vs S for the measured discharges are plotted on rectangular graph paper, a curve is fitted to the plotted points and the curve is extrapolated to the required peak gauge height. This extrapolation is guided by the fact that the value of S tends to become constant at the higher gauge heights. That constant slope is the stream-bed. However, if the upper end of the curve of the gauge height vs S has not reached the stage where S has a near constant value, the extrapolation of the curve will be subject to uncertainty and in that situation, the general slope of the stream-bed determined from a topographic map, provides a guide to the probable constant value of S that should be attained at high stages.

The discharge for any particular gauge height is obtained by the multiplication of appropriate values of K and $S^{1/2}$, thus allowing the construction of the upper end of the stage-discharge relation.

2. Real comparison of peak-runoff rates

When flood levels are produced over a large area by intense storms, the peak discharges are often estimated at gauging stations where they are not recorded through comparison with the records at gauged stations. Each known peak discharge is converted to peak discharge per unit of drainage area, i.e. peak discharge expressed in terms of cubic metres per second per square kilometre.

The peak discharges estimated by this method are used only as a guide in extrapolating the rating curve at a gauging station.

3. Step-backwater method

The step backwater method is a technique in which water surface profiles for selected discharges are computed by successive approximations. The computations start at a cross-section where the stage-discharge relation is known or assumed, and they proceed to the gauge site whose rating requires extrapolation. *(It is beyond the scope of this manual to treat the subject of step-backwater method. The subject is discussed in most standard hydrology texts)*

4. Flood routing

Flood routing techniques may be used to test and improve the overall consistency of discharge records during major floods in a river basin. However, the number of direct observations of discharge during such flood periods is generally limited by the short duration of the flood and the inaccessibility of gauging stations. Through the use of flood-routing techniques, all observations of discharge and other hydrological events in a river basin may be combined and used to evaluate the discharge hydrograph at a single site. The resulting discharge hydrograph can then be used with the gauge height hydrograph for that gauging station to construct the stage-discharge relation, or, if only a peak gauge height is available at the location, the peak gauge height may be used with the peak discharge computed for the hydrograph to provide the end point for a rating curve extrapolation. *(It is beyond the scope of this manual to deeply treat the subject of flood routing; it is discussed in detail in most standard hydrology text books).*

10.3 Updating of Existing Rating Curves

There is need to assess the existing rating curves for the rivers in the Tana catchment. However, satisfactory assessment of the rating curves is dependent on satisfactory assessment of the gauging stations in order to identify whether a rating curve is valid and whether the station has a stable control. The following table provides a simple strategy for the updating of existing rating curves.

Table 4.0: Strategy for the updating of rating curves

	Station and rating curve status	**Strategy / Actions**
1	• Stable control • Valid rating curve – covering the whole GH range	• A few discharge measurements per year to check that the rating curve is still valid.
2	• Stable control • Valid rating curve – but covering part of the rating curve only	• Strategic campaign measurements to focus on the range not yet covered. • A few discharge measurements per year to check that the rating curve still is valid.
	• Unstable control • Valid rating curve	• Assess the need for frequency of discharge measurements, based on how unstable the control is and the reason it is unstable (e.g. scouring / sedimentation, weed growth, backwater effect, etc.)
	• Very unstable control	• Consider the possibility of re-establishing the station at a more stable site.
3	• New station, or • Existing station with no valid rating curve	• Intense campaign discharge measurement programme to try to establish a valid rating curve within the shortest possible time.

CHAPTER 11 –REHABILITATION OF THE HYDROMETRIC NETWORK

11.1 Overview

In addition to the process of establishing new gauging stations, there is need to revisit the rehabilitation of gauging stations that were operational previously but due to varied constraints were abandoned but later identified as important stations requiring rehabilitation.

A key mandate for the Water Resources Management Authority (WRMA) is to assess the country's water resources. To be able to do so requires good quality data. Thus, a well-functioning monitoring network from which continuous and reliable data are being collected is very crucial and is the starting point for any assessment.

Following the development of the Catchment Management Strategy for Tana River Catchment Area, certain gauging stations were identified as priority stations that would need to be made fully operational to ensure the availability of continuous and reliable discharge data.

A station can provide continuous and reliable discharge data if the conditions that have been stated previously in this manual are satisfied. These conditions are summarised hereunder:

1) **Proper location of the station:**
   The gauging station is properly sited and has a stable control so that regular discharge measurements can ensure that the gauge heights (GH) can be properly converted into discharge.

2) **Continuous collection of reliable gauge height data:**
   Good quality water-level records have to be collected continuously from the station. This requires a well-trained observer to read the water level from the staff gauge at least once a day. For selected stations this may be supported by recordings from an automatic water-level recorder.

3) **Existence of a valid rating curve:**
   A valid rating curve, which will be able to transfer the measured GH into reliable discharge records must exist. It such one does not exist it must be established as soon as possible. If a valid rating curve exists, regular discharge measurements has to be carried out to check and/update the rating curve. The required frequency of discharge measurements will depend on the stability of the control. For very stable controls only a few discharge measurements per year are required whereas more frequent discharge measurements may be required for unstable controls.

11.2 Rehabilitation of the gauging stations

The actual rehabilitation of gauging stations could be divided into three groups; namely:

1) Improvement of the gauging control;
2) Rehabilitation of the installations;
3) Final survey of the gauging stations.

These three major activities should be undertaken in the sequence mentioned above and are briefly described below.

11.2.1 Improvement of the control

The improvement of the gauging control has not been given much attention for many years across the country. Thus it is important that the actual measures to improve the control and channel reach around the control are thoroughly discussed with and understood by the regional staff.

The Installation Report for the gauging station is the appropriate point to start where details of the installation are recorded.

11.2.2 Rehabilitation of the installations

For a station to be fully functional and produce unambiguous data, it is crucial that the datum of the staff gauges must not be changed, but should be maintained throughout the operation of the station. Before starting the rehabilitation of the installations, it is important that the officers responsible for the work obtain the original installation reports to get the vertical position of the staff gauges relative to the bench mark.

Bench mark:

1) The original bench mark has to be identified (hopefully done during the station assessment);
2) A new bench mark should be established if the old bench mark cannot be identified.

Staff gauges:

1) Rehabilitation of staff gauges
   - Any defective staff gauge, the staff plate and/or the iron angle line must be replaced;
   - It has to be checked that all the iron angles lines (posts) have a proper foundation and proper side support (strut) to the force from the flow;
2) Levelling of the staff gauges:
   - All the staff gauges will need to be levelled and located according to their positions when originally installed;
   - The level of each separate staff gauge section must be checked relative to the station bench mark by accurate levelling between the bench mark and the staff

gauges.

- The levelling is checked by a closed levelling circuit, starting and finishing on the bench mark.
- The new level of each staff gauge section should be entered into the stream gauging station check survey sheet along with the level before adjustment, so that the difference between the old and new levels of each staff gauge can be calculated.

3) Automatic water level recorder:

- If an older automatic water level recorder has existed and should be maintained, there may be a need for rehabilitation of the recorder and installation. This will among other things, include checking and possible flushing and clearing of intake pipes and stilling well;
- If a new automatic water level recorder is to be installed, such installation has to be as close as possible to the manual staff gauges;

Once the rehabilitation has been completed, final details of the station should be prepared comprising the following:

1) Sketch of station location: This should show the stations location in relation to infrastructure such as roads, junctions the river, and other distinct things, so it is clear how to get to the station. For an existing station, the original sketch made when the station was constructed can be used, e.g. with some additions / modifications;
2) Sketch showing the location of the different installations such as bench mark, staff gauges, stilling well, control (if a section control) and location of suitable cross-sections for discharge measurements;
3) A cross section through the staff gauges extended up each bank, with elevation of each staff gauge section, bench mark, stilling well and intakes;
4) For artificial controls, a separate plan of the structure should be made.

CHAPTER 12 – ESTABLISHMENT OF COLOUR CODING INDICATING ALERT/ALARM LEVELS OF WATER RESOURCES.

The Water Resources Management Rules of 2007 provide for the classification of water use permits into four categories depending on the impact that a water use of a given amount would have on the resource within different sub-catchments and aquifers in the country.

The Water Resources Management Authority (WRMA) has assessed each subcatchment or aquifer to determine the resource status. The state into which each subcatchment could be classified was identified as alarm, alert and satisfactory; where alarm denotes a state that requires careful attention and satisfactory denotes a state that does not experience stress currently. Table 5.0 depicts the status of water resources classification as identified by the WRMA.

In theory, it would have been helpful to have clear criteria to distinguish the different resource state. However, WRMA has not developed these criteria and consequently, WRMA regional office staff made subjective decisions based on experience by balancing the availability and relative degree of stress on the resource.

Table 4: State of water resources classification

Category	**State of the resource**
Category 1	**ALARM**
Surface Water	Resource is periodically scarce Water reserve threatened
Groundwater	Water quality or levels declining
Water Quality	Catchment severely degraded Pollution levels high Risk to human life is high
Conflicts	Potential for conflicts are high
Category 2	**ALERT**
Surface Water	Trend is towards scarcity
Groundwater	Trend is towards over abstraction
Water Quality	Declining trend in water quality
Conflicts	Ingredients for conflicts, e.g. ethnic, religious, language divisions
Category 3	**SATISFACTORY**
Surface Water	Water resource sufficient in quantity and quality
Groundwater	No measured impacts
Water Quality	Water quality adequate, low risk
Conflicts	Low risk of conflicts

Based on the identified classifications, there is need to monitor the resources at category one and category two. In the case of category one, the management focus would to move the resource from category one to category two with the ultimate goal of improving the resource class to category three. In the case of category two, the management focus would to ensure that the resource does not deteriorate to category one and in the same process improve the resource to category three.

Following on the above classification, there is need to establish an easy physical method to recognize the resource status and this is where colour-coded staff gauges come into play.

The colour coding of staff gauges is an appropriate method to immediately inform a water user (both professional and nonprofessional), the status of the water resources in the river and assist in proposing the most economic and sustainable way of using the water.

Figure 20: Colour coding of RGS 4G04 in Hola (Lower Tana)

The colour coding is of particular importance to the Water Resources Users Associations (WRUAs), bodies that constitute formal, legally bound groups of water users, often grouped around a particular water source with responsibility for managing and maintaining part of the system that serves them. The need for these Associations has received Government and donor support with the growing impetus of decentralizing the management of water resources from the central Government to the users.

Proper management of any resource requires a good understanding of its availability, its qualities and demands. The Water Act 2002 vests the mandate for the management of water resources to the Water Resources Management Authority (WRMA). Nevertheless, the contribution of the Water Resource User Associations (WRUA) is also provided for. The WRUAs are in the best position to help out in the monitoring of water resources since they have a good and continuous representation on the ground. This involvement is supported by the observation that the rivers are exhibiting increasing water scarcity and rising demand and deteriorating water quality, implying that suitable monitoring has to be maintained in order to guide the planning process, decision making and help any conflicts that arise.

Whereas in the past the focus was for the government to provide water resources monitoring services to the people, complexity and the heavy demands of this task has shown that the local communities and users have to be involved for success. It is therefore necessary to encourage self-community policing in monitoring stream flow and abstraction.

To achieve the above goal, the regional and sub-regional WRMA staff will collaborate with the WRUAs established in the various river subcatchments to install colour coded staff gauges that will indicate the water resource status in each river that might be in the satisfactory, alert and alarm status.

To install the colour coded staff gauges, the WRMA sub-regional staff will collaborate with the WRUAs to make current meter gauging that will relate the discharge to water levels. Thus by installing a staff gauge, the local community will be able to physically relate the expected discharge and the level indicated on the staff gauge. Based on the river level situation, the managing community (WRUA) will be in a position to advise the WRMA and water abstractors on the situation of water in the river. In particular, the WRUA in collaboration with WRMA could impose restrictions on abstractions for irrigation when the water level decreases to the alarm level to ensure the availability of the Reserve.

CHAPTER 13 - DATA COLLECTION, PROCESSING, STORAGE AND RETRIEVAL

13.1 Data Collection

When a station has been established and the instrumentation has been installed, two types of data will be collected at the site, namely; descriptive details of the site and its location, and the hydrometeorological observations that it has been established to measure.

Once established, the installation should be operated and maintained to its predetermined standard. In general, this involves the execution of an adequate schedule of inspection and maintenance to ensure continuity and reliability of data, and the development of routine check measurements and calibrations (rating curve updates for river gauging stations) to ensure data of the required accuracy.

The descriptive details of the gauging station include:

- Geographical coordinates which are recorded as latitude and longitude, Universal Transverse Mercator (UTM) coordinates ARC 1960 datum, and, for the site on a stream, its distance upstream/downstream from a reference point if applicable;
- Information concerning changes at the site, including instrumentation changes, should be added to the narrative description to provide a historical description of the site and the region that it represents.

13.2 Frequency and timing of station visits

The frequency and timing of readings and thus visits to the site should be determined by the anticipated data usage and should be adequate to define the observations over time. Station visits will, thus, be for purposes of observation or collection of data and for maintenance of the site.

For manually operated gauging stations, the daily observations are recorded on a specially printed form which should ideally be sent to the sub-regional office at the end of the month for initial processing. However and due to the financial expenses involved, the gauge readers keep the records until the WRMA sub-regional staff collect them during their visits to the station.

For the automatic stations, the WRMA regional staff make frequent visits to the station to download the data. During these periods, the staff check on the operational status of the equipment and make corrections where necessary. The frequency and timing of visits will be constrained by the length of time that the station can be expected to function without maintenance. Too long of a time between visits may result in frequent recorder malfunction and in loss of data, while frequent visits are both time consuming and costly.

Precipitation and evaporation observations are made daily at 0900 hours. Most of these data is collected by the Kenya Meteorological Department (KMD) while the collection by WRMA compliments the work of KMD. However, the two institutions are not connected in this activity and each institution is responsible for the documentation of its data. It would be appropriate if the two organizations could develop a mechanism that would allow some data sharing among the institutions. This could be achieved through a memorandum of understanding or such other mechanism acceptable to both.

For river gauging stations, it is recommended that all recordings be made twice daily at 0800 hours and 1600 hours and the gauge readers should be advised accordingly.

13.3 Data Processing

Data processing entails transforming the raw data into forms that enable ready manipulation and efficient storage for prospective users. Data typically enter the system via key punching of manuscript records, by mechanical conversion of analogue records, or in a digital form. Raw data are commonly compressed or reformatted into their most usable forms, and they should be subjected to a variety of quality checks at appropriate stages.

In particular, initial checking would involve the following:

a) Ensuring the completeness and correctness of the information, i.e., dates, station, name, and station identification if required in subsequent machine processing;
b) Ensuring completeness of the data;
c) Checking the observer's arithmetic;
d) Comparison of the observer's report with the recorded data.

Regardless of the type of data being processed or the path that its processing takes, a basic requirement is to maintain a standard of operation that will not degrade the quality of the data.

The system should have sufficient flexibility to allow easy correction, addition, or upgrading of faulty sections of the data. At the same time, it must be protected by a high level of security to ensure that any alterations to the database are legitimate and authorized. All original versions of a data set, plus the corrected version, should be archived. This allows the extraction process of any set of data to be checked.

The main components of primary processing comprise:

a) *Data adjustments for known errors* — These are the errors reported by the field technician or those persons responsible for manual quality control of the incoming data sets. Corrections for these errors must be made before the data are submitted for validation.
b) *Aggregation and interpolation of data* — Many variables, because of their dynamic nature, must be sampled at relatively short periods, but are only utilized as averages or totals over longer periods. Thus, for many hydrological applications, climatological variables may be required only as daily values, but must be sampled with greater frequency to obtain reliable daily estimates.
   Temperature and wind speed are good examples, but, in many cases, the same is true for water level and river-flow data.
c) *Assessment of derived variables* — The most frequently derived variables are runoff and potential evapotranspiration. However, the full range of derived variables is very broad

and includes many water quality indices.

One important database management decision is whether derived variables need to be stored after they have been estimated and reported. It is obviously not essential to occupy limited storage space with data that may be re-computed from the basic data held. The basis for making this decision is:

i) How often will the derived variables need to be retrieved?
ii) How complex are the computations required, both in terms of the algorithms used and the amount of background data required?
iii) Are the objectives of the database to store basic data for users to process themselves, or to compile inventories of all important (basic and derived) variables?

d) *Output of statistical summaries* — These are the routine outputs, usually on a monthly and annual basis, of data processed during the database updating cycle. These outputs may also be considered as the basic data retrieval outputs and, with this in mind, many elements of the primary processing and data-retrieval software should be common.

e) *Conversion to database storage formats* — The complexity of this operation depends upon the difference between the formats in which input data are provided and the formats of the master database files.

13.4 Data Storage

Hydrometeorological data can be stored in the original form or in computer form. Raw data, whether field forms, charts or reports must be available after processing. Some errors in reporting and processing may not come to light until scrutinized by users.

Time required to locate data stored in computer form usually takes only a few seconds for online storage systems to a few hours for off-line storage systems.

Data on the operation of water resources projects are collected and usually stored in a manner similar to other hydrological data. However, such data are usually stored by the user and this makes it difficult to retrieve it. It is recommended that data on the operation of water resources projects should be stored in such a manner that they can be linked with the hydrological data system under the institution in charge of hydrological activities so as to facilitate the reconstruction of the natural hydrological regime of flows. (e.g. operation of the Seven Forks Dams along the Tana River by KenGen).

Storage of conventional topographic, geologic and soil data represent relatively limited volumes that can be preserved in original form or in computer form. However, difficulties are encountered when checking the data for consistency with data stored in the original form. In this case, it is recommended that the data be stored in GIS format.

With the introduction of the MIKE BASIN program, WRMA has developed a new system for the storage of its hydro-meteorological data.

13.5 Data Retrieval

The ability to rapidly retrieve selected data sets is one of the fundamental advantages of electronic hydrological data processing. Efficient retrieval systems allow the water-resources planner to concentrate on data analysis by minimizing the previously time consuming tasks of locating, collating, and manually processing data.

A comprehensive retrieval system should contain the following features:

a) A wide range of data-selection criteria — Typically these should be by variable, basin, station, time period, and variable value (or range). In particular, it should be possible to select data on the basis of any combination of these criteria;

b) Data interpolation/aggregation in time and space — Perhaps the most important of these options are the interpolation of irregular into regular time-series and the aggregation of short time-interval series into totals or averages of a longer time base (i.e., conversion of hourly into daily values or daily into ten-day values).

   If some form of geographical/hydrological referencing system is used, spatial data adjustments may also be made;

c) Computation of simple statistics — Some facility should exist to enable the computation of simple statistics for the period(s) of record selected. This would include totals (if relevant), means, standard deviations, and ranges. More comprehensive statistics — cross-correlations, multiple regressions, probability analyses, etc. — may be offered as part of the standard retrieval system, or the selected data may be passed to a statistical package;

d) Selection of output format — this feature allows for the direct output of data in (specified) tabular or plotted format and for the creation of data files in formats suitable for further processing. In this latter case, the retrieved data set may be stored for input to statistical packages or user-specific application programs.

The WRMA has been provided with MIKE BASIN software for the manipulation of data in their data bases. Currently, the manipulation is restricted to the regional offices of the WRMA, but in the future, there might be need to allow some access by the sub-regional offices.

CHAPTER 14 – INFORMATION MANAGEMENT

14.1 Introduction

“Management” is defined as the organization of and control over the structure, processing and delivery of information.” Information management is the collection and management of information from one or more sources and the distribution of that information to one or more audiences. This sometimes involves those who have a stake in, or a right to that information. The objective of information management is to ensure that essential information is managed and disseminated to managers and stakeholders so as to support transparent decision-making and to gain commitment and political support for the decisions made.”

The information management process is schematically represented by the diagram shown in figure 21.

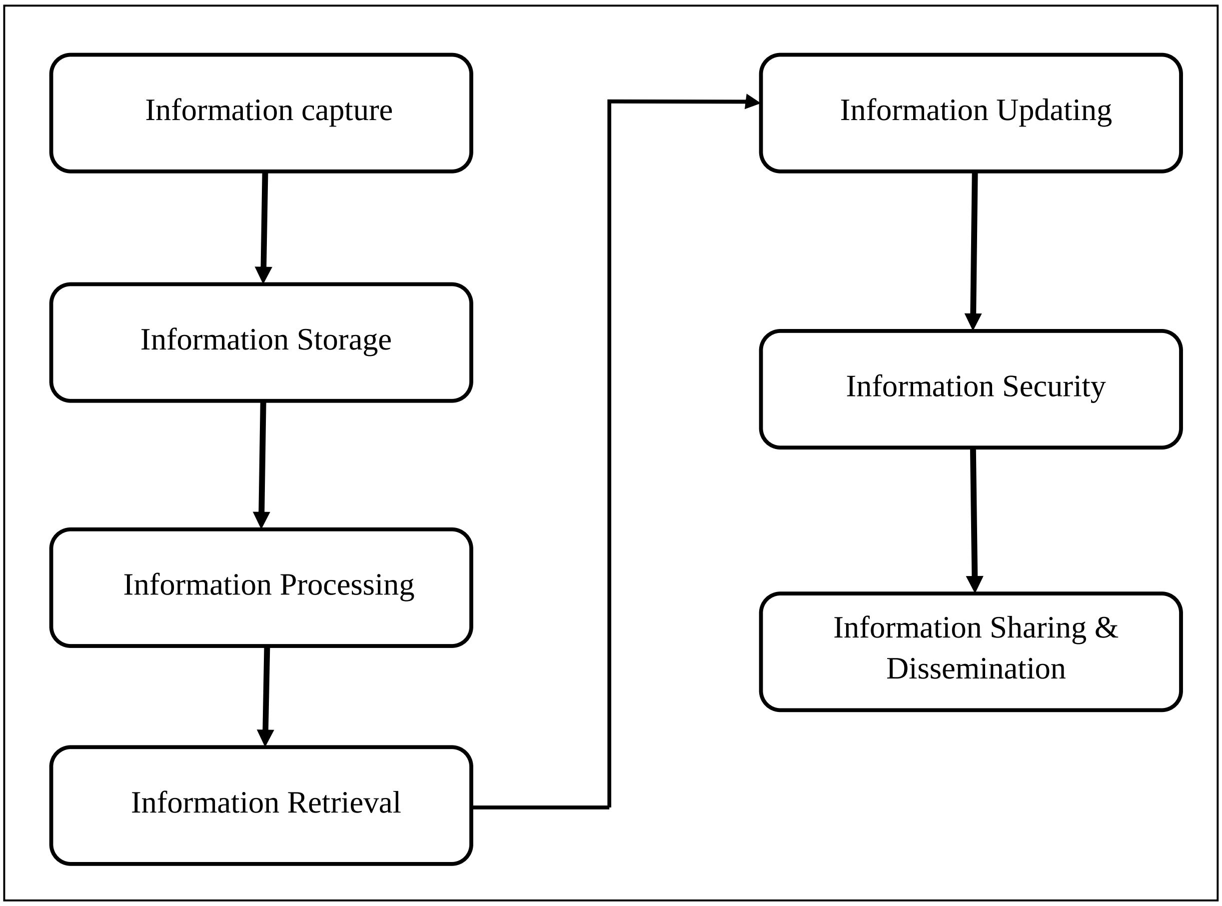

Figure 21: Information management process

Generic information types and their characteristics include:

- Static information - e.g. river name, river length, basin size;
- Dynamic information - e.g. river flow data, rainfall data, water quality data
- Raw Data - from measuring equipment or survey;
- Processed information - Information that meets a defined need and is processed from raw data;
- Report type information - Combination of text, figures and tables, organised within a set of narrative text;
- Spatial type information - Information stored in the form of maps and is geo-referenced to a map.

14.2 Information Management Outputs

Under information sharing and dissemination, different information users require differently formatted information outputs to make the appropriate decisions. For an example:

a) Information outputs for water allocation required by water managers:
   - Quantity and quality of surface and groundwater available for allocation;
   - List of water users permit holders and their conditions;
   - Maps showing quantity and quality of surface and groundwater; surface water extraction points, well locations and amount of water extracted;
   - List of non-compliance by water users and actions taken;
   - List of complaints by water users and actions.

b) Political Stakeholders will generally require summary information and reports on status of water management and water allocation in a river basin. The output may take the form of a half-yearly or annual report.

c) Water Users/ Stakeholders will need summarised information and reports at regular intervals on status of water in a river basin. The information may take the form of monthly report; in the form of leaflets/fliers or summarised annual reports on indicators of public interest. The stakeholders may also need access to a system to make complaints and to make queries on the water management and water allocation.

14.3 Training of staff

Whatever the level of technical sophistication of a data-collection authority, the quality of its staff will always remain its most valuable resource. Careful recruitment, training, and management is the key to attaining and maintaining the appropriate personnel.

With respect to data collection and processing, employee education, although costly and time consuming, can be a sound investment that results in greater productivity and effectiveness. A carefully structured training program is essential for all personnel engaged in data collection because they are in a strong position to influence the standard of the final data. Formal training should aim at providing both a general course in first principles, plus training modules to teach in-house procedures. All material should be relevant and current.

Where processing is not carried out by the data collector, it is important that data processors be trained in data-collection techniques to ensure that data are processed according to the intent of the collector. It is a good practice to give processing staff periodic field experience to build a physical association with the data and their origins. Such knowledge on the part of the processor can allow interim interpretations of incorrectly presented data, pending confirmation from the collector. The data collector has the primary responsibility for the quality of data collected while at the processing stage, the staff should recognize that they have the responsibility to maintain the quality and integrity of the data.

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ANNEXES

ANNEX 1: TEMPLATE OF AN INSTALLATION REPORT FOR METRIC GAUGES

WATER RESOURCES MANAGEMENT AUTHORITY

R.G.S. INSTALLATION REPORT FOR METRIC GAUGES

R.G.S. NO…………………………………. River………………………………………

Latitude ………………..……. Longitude ……….………. Altitude…….……………………..

Location…… ……………………..……………………..

Access via… ……………………………………………..

Meter Reader……………………..……………………..

Address ……… ………..……………………………….

Administration via …….…….…………………….……

Officer responsible for routine inspection and repairs…..……………………………………….

Date established/Metric gauges installed………………………………………………………...

Records will be sent in to…… ……………………………………………………………….

R.L. of benchmark……….. ………………………………………..………..………….

Position of Benchmark… ………………………………………………………..……………

R.L. of zero of metric plates ……………………………………………………………….

R.L. of zero of old plates…… ……………………………………………………………….

R.L. of weir crest(s)…… ………………………………………………………………………

No. and type of staves… …………………………. on Right/ left bank.

R.L. of zero of weir plate, if any…………………………………………………………………..

Flood sticks installed…………………………………… ……………….…….………………..
Staves installed downstream to measure degree of drowning…………………………………...

……………………………………………….R.L. of their zero……………….……………..

Twin staves for slop/area method:- Distance between………………..……..…………………..

R.L. of zero of second test……………………………………………………………………….

Position of current meter gauging site……………………………………………………...

……………………………………………………………..…….………………………

Description of control, position & material…………….…………..……………………………

Shape of river channel…………… ……..…………………..…….……………………………….

Material of river bed… ………………….…………………………………………………...

Material of river banks….………………………………………………………………………

Cableway installed/to be installed. ………………………………………………………………

FOR STAFF STATION:-

Cross-section of line of staves and at c/m gauging site to be taken.
Longitudinal section 100 meters u/s and d/s to be taken.

FOR WEIRS:- Section across stream on line of weir showing weir crest online and details of depth and nature of foundations of weir and wing falls.

Cross-section of weir through each type and level of crest.

Sketch of site and reach of river showing bends, constrictions in the channels, falls etc. Position of staff gauge, protective pitching or apron, position of Bench mark.

ANNEX 2: TEMPLATE OF AN INSTRUMENT INSTALLATION REPORT

WATER RESOURCES MANAGEMENT AUTHORITY

INSTRUMENT INSTALLATION REPORT

Type of Instrument…………………………………………………………………………

M.O.W. Number ……………………………………. Maker's Number………………………..

Location …………………………………..

Latitude……………………… Longitude…………………………

Altitude………………………

R.G.S. if applicable…………………………………

Drainage Area…………………….. M.O.W. Division ……………………………….

Date of Installation……………………………. Installed by ………………………………….

Reader's Name……………………………………………………………………………

Readers Address or address of person to whom correspondence or supplies should be sent

……………………………………………………………………………………………

Charts and records will be sent to ………………………………………………………….

Officers responsible for regular inspection and maintenance or repairs………………………….

Description of station and any further information:-

Station…………………………………………………

Signature………………………………………

Date……………………………………………………

Designation……………………………………

ANNEX 3: SAMPLE SIGNBOARD ON COLOUR CODING AT WRMA TANA