MINISTRY OF WATER AND ENVIRONMENT
THE REPUBLIC OF UGANDA
DIRECTORATE OF WATER RESOURCES
MANAGEMENT (DWRM) &
DIRECTORATE OF WATER DEVELOPMENT (DWD)

THE DEVELOPMENT STUDY
ON
WATER RESOURCES DEVELOPMENT AND MANAGEMENT FOR LAKE KYOGA BASIN
IN
THE REPUBLIC OF UGANDA

FINAL REPORT
SUMMARY

March 2011

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

OYO INTERNATIONAL CORPORATION
IN ASSOCIATION WITH
TOKYO ENGINEERING CONSULTANTS Co., Ltd.
AND
ORIENTAL CONSULTANTS Co., Ltd.

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Exchange rate on Mar. 2011 is US$1.00 = Uganda Shilling UGS 2,335.14
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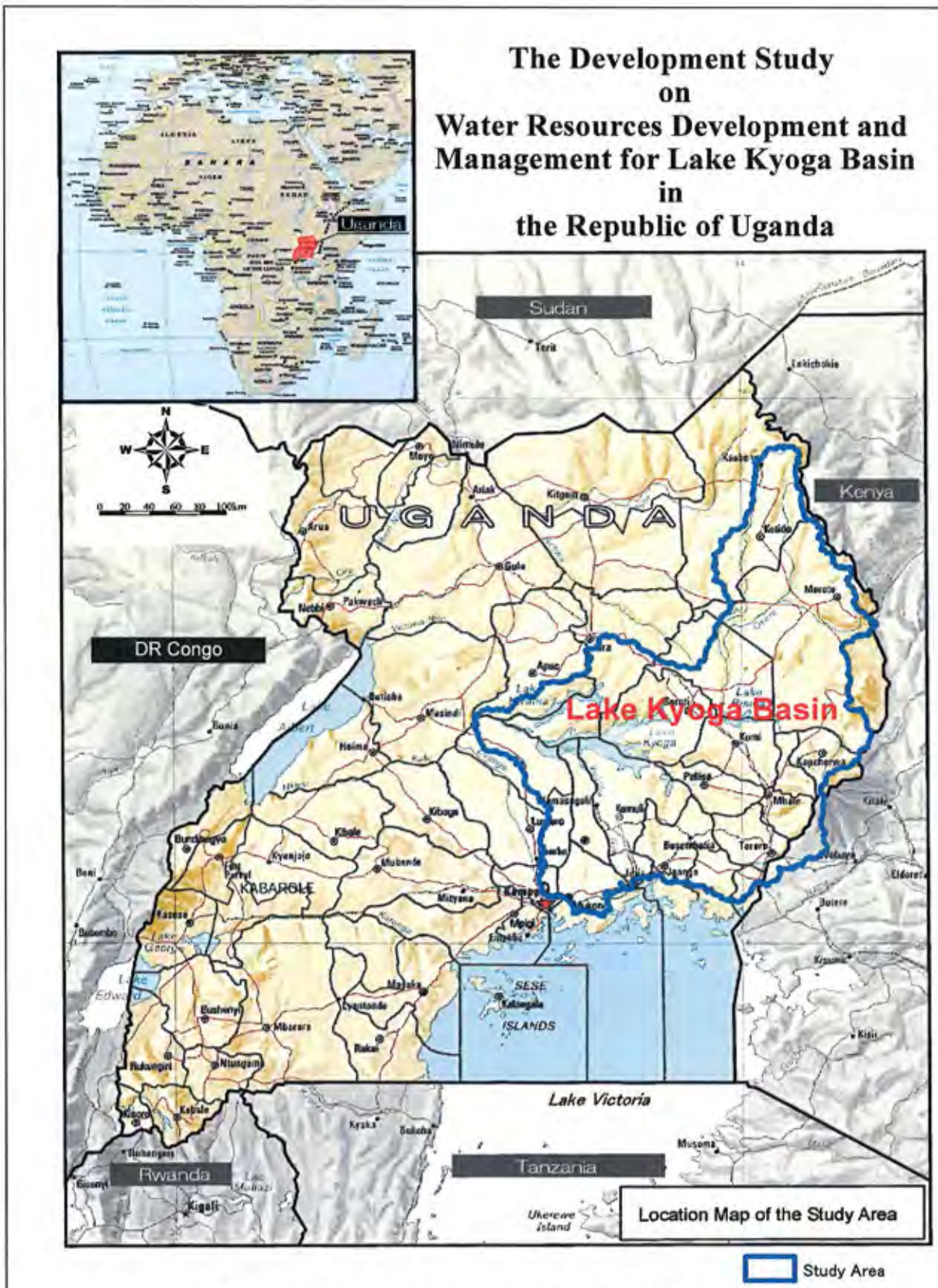

Location Map of the Study Area

EXECUTIVE SUMMARY

1. Background of the Study

Uganda is an agricultural country with 40% of GDP or 80% of total export covered by agricultural products. Approximately 70% of rural people who constitute 86% of total population are engaged in agricultural activities, rural areas therefore play very important roles for sustainable economic development in Uganda. It is important to take measures against poverty reduction in rural areas in which 96% of poverty people live. The national development plan (NDP April 2010), which incorporates "PEAP" (Poverty Eradication Action Plan 1997 to 2008) and intertwines sustainable economic growth with poverty eradication, aims to reduce absolute poverty to less than 24.5 % of total population by the year of 2015. NDP sets target for water and sanitation sector as below.

- By the year of 2015, 100 % of population in urban area can access to the safe water within 0.2 km and sanitation facilities.
- By the year of 2015, 77% and 90% of population in rural area can access to the safe water within 1.0 km and sanitation facilities, respectively.

The study area, Lake Kyoga Basin (hereinafter referred as to "the Basin") having approximately 58,000 km^2 equals to 25% of the area of Uganda, is one of the largest catchment areas among eight basins in the whole country. (refer to Figure-1) Approximately 9.3 million people (2008 estimated) are living in the Basin whose major industry is agriculture, which is composed chiefly of livestock farming mainly cattle and cash crop growing of cotton or coffee.

The Basin is considerably blessed with water resources, namely rivers, lakes and groundwater with an annual precipitation of more than 1,200mm. However, safe water supply coverage in the rural areas is approximately 57% on an average in comparison with a national coverage of 63% and besides Kaabong, Kotido, Abim and Bugiri districts have less than 40%.

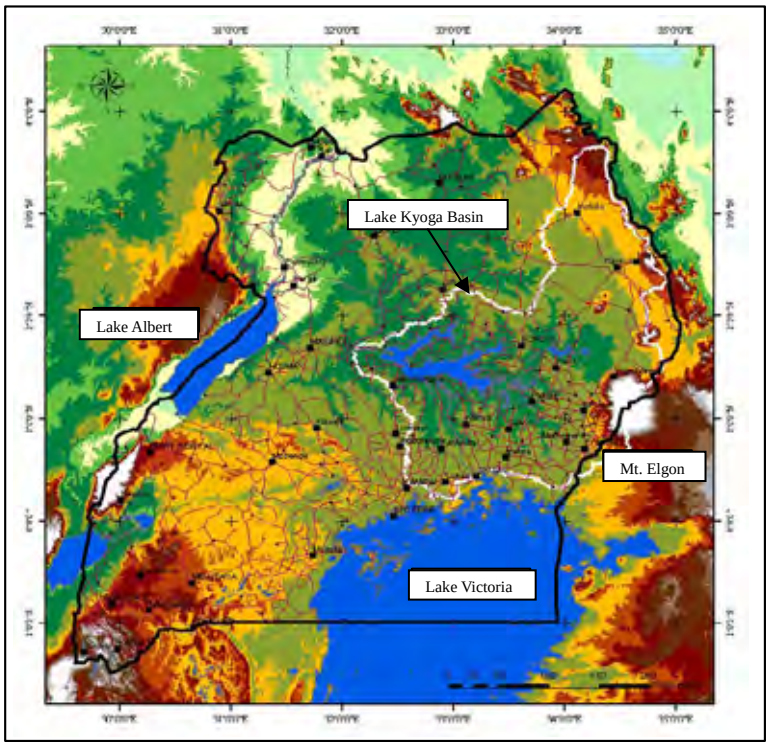

Figure-1 Location of the Study Area

On the other hand, here is serious surface erosion in the mountainous areas of the Basin, which leads to soil erosion and stream capture resulting into heavy damage to agriculture and the daily life of the people. This means that not only "water resources utilization" but also "prevention of flood and sediments disaster" have been recognized as critical issues.

2. Objectives of the Study

The objectives of the Study are

- To formulate a basic plan on water resources development and management for the Basin
- To formulate a master plan for rural water supply in priority areas
- To transfer technology and knowledge to the counterpart personnel through their direct participation into the Study.

3. Water Resources Potential Evaluation and Water Balance

Potential of surface water and groundwater in the entire Lake Kyoga basin was evaluated based on the survey results of this study. Total available water volumes are estimated as 556.1 MCM/year and 650.5 MCM/year in 1/10 and 1/3 drought years, respectively. This estimate with 1/10 drought year implies that water shortage to occur by 2020 (refer to Figure-2) Water balance analysis also suggests that five sub-basins: Okok, Okere, Lwere, Kyoga Lakeside, and Mpologoma, would face shortage of agricultural water in near future.

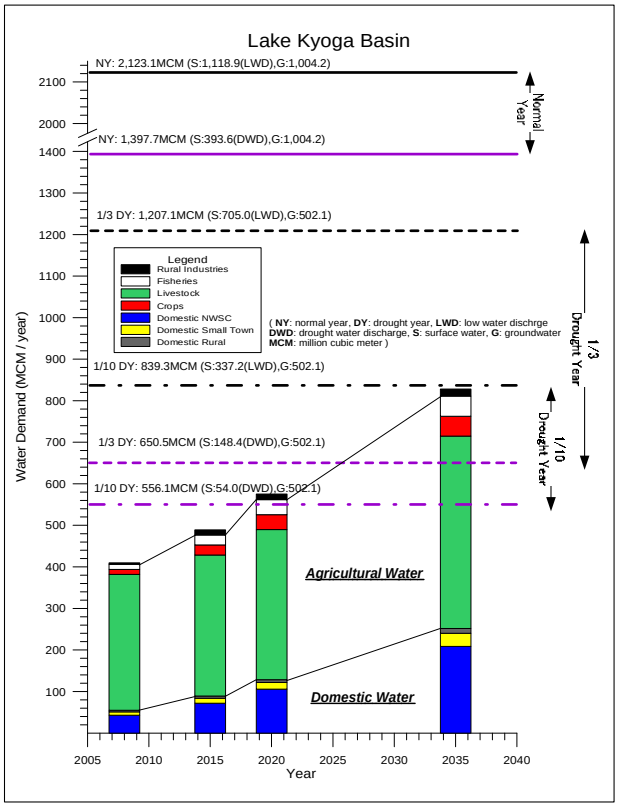

Figure-2 Water Balance between Demand and Resources

4. Major Issues on Water Resources and Development and Management

Eleven major issues on water resources development and management found in the study are listed below.

- Shortage of reliable basic data for water resources development and management
- Uncertain potential of water resources: surface water and groundwater
- Restriction of access to the surface water due to the Nile Water Agreement
- Climate change
- Lack of water supply and demand balance
- Insufficient rural water supply coverage
- Inadequate stakeholders collaboration for water resources development and management
- Lack of ambient water quality standards for conservation of water environment
- Lack of flood and sediment disaster mitigation
- Insufficient man power and organizing ability
- Insufficient community participation

5. Formulation of the Basic Plan on Water Resources Development and Management

The Basic Plan on the Water Resources and Management for Lake Kyoga Basin was formulated for the short term to 2015, middle term to 2020, and long term to 2035 in consideration of the above-mentioned major issues. (refer to Table-1)

Table-1 Schedule of the Basic Plan on Water Resources Development and Management for Lake Kyoga Basin

Item			Sub-basin No.											Planning Phase																							Responsible Organization
		year	1	2	3	4	5	6	7	8	9	10	11	Short Term (2010-2015)						Middle Term (2016-2020)					Long Term (2020-2035)													
			Ok	Or	Aw	Lw	Ak	Ab	Ky	Mp	Lu	Vi	Se	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	
1.	**Comprehensive Water Resources Management**																																						
	1-1	Water Resources Assessment																																					
		(1) River Gauging Station Network	X	X	X	X	X	X	X	X	X	X	X																										DWRM
		(2) Lake Water Gauging Station Network			X		X	X	X																														DWRM
		(3) Groundwater Monitoring Network	X	X	X	X	X	X	X	X	X	X	X																										DWRM
		(4) Meteorological Monitoring Network	X	X	X	X	X	X	X	X	X	X	X																										DWRM
		(5) Guidelines of Well Drilling and Pumping Test	DWRM																																				DWRM
		(6) Water Resources Database System	DWRM, L.Kyoga WMZ																																				DWRM
	1-2	Organization Strengthening for WRDM																																					
		(1) Setting up Sub-basin Liaison Council	X	X	X	X	X	X	X	X	X	X	X																										DWRM
		(2) Capacity Development of DWRM	DWRM, L.Kyoga WMZ																																				MoWE, DWRM
2.	**Effective, Stable and Equitable Water Supply**																																						
	2-1	Controlling Water Demands																																					
		(1) Effective Water Use	X	X	X	X	X	X	X	X	X	X	X																										DWD
		(2) Introduction of Water-saving Technology	X	X	X	X	X	X	X	X	X	X	X																										DWD, MAAIF
		(3) Awareness of Water User	X	X	X	X	X	X	X	X	X	X	X																										MAAIF, DWD, DWO
	2-2	Increasing Water Supply through WRDM																																					
		(1) Urban Water Supply (Small Town Dominant)	X	X	X	X	X	X	X	X		X	X	Coverage Rate 42% to 69%								Coverage Rate 69% to 76%					Coverage Rate 76% to 100%													DWD, NWSC
		(2) Rural Water Supply	X	X	X	X	X	X	X	X	X	X	X	Coverage Rate 60% to 77%								Coverage Rate 77% to 83%					Coverage Rate 83% to 100%													DWD
		(3) Agricultural Water Supply	X	X		X			X	X							Basic Study			M/P、F/S			Implementation																	MAAIF, DWD
3.	**Prevention of Flood and Sediment Disaster for Life and Property**																																						
	3-1	Deforestation Prevention Plan																																					
		(1) Clarifying Boundary of Protected Area of Forest	X	X	X	X			X																														NFA, DFO
		(2) Expansion of Landuse Regulation and Development Prohibited Area and Thoroughness of the Regulations	X	X	X	X			X																														MoLG
		(3) Tree-Planting Program	X	X	X	X			X																														NFA
		(4) Study and Research on Agro Forestry	X	X	X	X			X																														DEA
		(5) Enhancement of Public Awareness of Forest Protection	X	X	X	X			X																														DFO
	3-2	Flood Prevention Plan																																					
		(1) Construction and Rehabilitation of Surface Water Storage Facility	X	X	X	X	X	X	X	X	X																												MAAIF
		(2) Road Development for Transportation of Emergency Materials and Evacuation Route	X	X	X	X	X	X	X	X	X																												MoWT
	3-3	Erosion and Sediment Management Plan																																					
		(1) Specifying Disaster Risk Area by Disaster Type	X	X	X	X			X																														MoDPR, DWRM
		(2) Designation of Regulated Area of Landuse and/or Development	X	X	X	X			X																														MoLHU
		(3) Relocation	X	X	X	X			X																														MoDPR
		(4) Education of Disaster Management to Community	X	X	X	X			X																														MoDPR
		(5) Development of Evacuation Site and Route	X	X	X	X			X																														MoDPR, MoWT
	3-4	Common Measures for Flood and Sediment Disaster																																					
		(1) Publicity and Thoroughness of Regulated Items in National Environment Regulations	X	X	X	X	X	X	X	X	X																												DOE,NEMA
		(2) Establishment of System for Collection, Accumulation and Sharing of Disaster Information	X	X	X	X	X	X	X	X	X	X	X																										MoDPR, DWRM
		(3) Preparation of Hazard Map and Risk Map	X	X	X	X	X	X	X	X	X																												DWRM
		(4) Establishment of Early Warning System for Disasters	X	X	X	X	X	X	X	X	X																												MoDPR, DWRM
		(5) Community Based Disaster Management Activities	X	X	X	X	X	X	X	X	X																												District
4.	**Conservation Plan of Water Environment**																																						
	4-1	(1) Establishment of Ambient Water Quality Standards	X	X	X	X	X	X	X	X	X	X	X																										DEA
		(2) Strengthening Water Quality Monitoring System	DWRM, L.Kyoga WMZ																																				DEA
		(3) Sewerage Treatment System	X	X	X	X	X	X	X	X	X	X	X																										NWSC
5.	**Setting up System for Collection, Sharing and Transmission of Relevant Data on WRDM**		DWRM, L.Kyoga WMZ																																				DWRM

Note: **Ok**: Okoke,**Or**: Okere, **Aw**: Awaja, **Lw**: Lwere, **Ak**: Akuweng, **Ab**: Abalan, **Ky**: Kyoga Lake-side, **Mp**: Mpologoma, **Lu**: Lumbuye, **Vi**: Victoria Nile, **Se**: Sezibwa, **WRDM**: Water Resources Development and Mangement, **WMZ**: Water Management Zone
DWD:Directorate of Water Development, **DWRM**: Directorate of Water Resources Management, **MoWE**: Ministry of Water and Environment, **MAAIF**: Ministry of Agriculture, Animal Industry and Fisheries, **DWO**: District Water Office
NWSC: National Water and Sewerage Corporation, **NFA**: National Forestry Authority, **DEA**: Directorate of Environment Affaires, **DFO**: District Forestry Office, **MoWT**: Ministry of Works and Transportation, **MoDPR**: Ministry of Diaster Preparadness and Refugees

6. Priority Evaluation of the Basic Plan

Rural water supply was selected as the top priority item by comprehensive evaluation of the relative contribution of each item in the Basic Plan to the eight millennium development goals.

7. Evaluation of the Basic Plan

There are no technical difficulties for implementation of the structual and non-structual measures in the Basic Plan. In terms of the economic evaluation, the validity of the rural water supply project has been confirmed based on the 12.7% EIRR which is larger than the discount rate of 10%. However, external funding is essential for implementation of basic infrastructures such as water supplies given the current financial situation of Uganda. The results of the social environment evaluation pose no unavoidable negative factors that affect forestation as well as construction of facilities such as water supply, storage, and filtration facilities.

8. Formulation of the Rural Water Master Plan

Three priority districts, Soroti, Pallisa, and Iganga, were selected by evaluating five indices on both the natural and social condition for the Rural Water Supply Master Plan, which is the top priority project of the Basic Plan.

It was concluded that implementation of piped water system for the Rural Growth Centre (RGC) would be very effective for drastic improvement of the rural water supply coverage as that of RGCs is considerably (10% to 40%) lower than the sub-county average and also the average of non-RGC rural areas according to the results of RGC survey and WATSUP. The contents of the Master Plan is summarized in Table-2.

9. Evaluation of the Rural Water Supply Master Plan

The master will provide economical benefits to Uganda. However, external funding to support construction of facilities is inevitable given the financial situation of the country. Even for operating

Table-2 Summary of the Master Plan for Rural Water Supply

District	Descriptions		2010 (Present)	2015 (Short Term Plan)	2020 (Middle Term Plan)	2035 (Long Term Plan)	Total
Iganga			**Coverage**				
	RGC		27.1%	95.6%	100.0%	100.0%	-
	Out of RGC		69.1%	73.8%	79.6%	100.0%	-
	Whole District		63.0%	77.1%	82.6%	100.0%	-
			Required Water Supply Facilities				
	RGCs Areas	Construction	-	21 RGCs	5 RGCs	3 RGCs	**29 RGCs**
		Extension	-	-	21 RGCs	26 RGCs	**-**
	Other Rural Areas	Boreholes	-	306 nos.	406 nos.	2,035 nos.	**2,747 nos.**
		Repair	-	70 nos.	69 nos	-	**139 nos.**
		Replace	-	180 nos.	252 nos.	1,491 nos.	**1,923 nos.**
Pallisa			**Coverage**				
	RGC		36.5%	91.8%	100.0%	100.0%	-
	Out of RGC		58.7%	75.2%	81.1%	100.0%	-
	Whole District		56.5%	76.9%	83.1%	100.0%	-
			Required Water Supply Facilities				
	RGCs Areas	Construction	-	11 RGCs	6 RGCs	-	**17 RGCs**
		Extension	-	-	11 RGCs	17 RGCs	**-**
	Other Rural Areas	Boreholes	-	390 nos.	361 nos	1,638 nos.	**2,389 nos.**
		Repair	-	47 nos.	47 nos.	-	**94 nos.**
		Replace	-	160 nos.	233 nos.	1,297 nos.	**1,690 nos.**
Soroti			**Coverage**				
	RGC		60.1%	97.2%	100.0%	100.0%	-
	Out of RGC		71.2%	75.6%	81.7%	100.0%	-
	Whole District		70.4%	77.0%	82.9%	100.0%	-
			Required Water Supply Facilities				
	RGCs Areas	Construction	-	7 RGCs	3 RGCs	1 RGC	**11 RGCs**
		Extension	-	4 RGCs	11 RGCs	14 RGCs	**-**
	Other Rural Areas	Boreholes	-	303 nos.	437 nos.	2,202 nos.	**2,947 nos.**
		Repair	-	84 nos.	84 nos.	-	**168 nos.**
		Replace	-	169 nos.	244 nos.	1,532 nos.	**1,945 nos.**

and maintaining the existing water supply facilities, the water charge collection rate of 75% must be achieved for wells with a hand pump, and roughly UGX 2,000/m^3 water charge must be collected without delinquency for the piped water supply system in RGCs. In terms of environmental and social consideration, there are slight potential impacts, but they are avoidable.

10. Selection of the Priority Projects

In order to meet the short-term goal of 77% rural water coverage by 2015, target RGCs of the priority projects were selected in the following manner. The total scores of the following items for every (61) RGCs in the three districts in the basin were used for the initial selection of 39 RGCs.

- Coverage rate of safe water supply
- The number of the existing public, administrative, and business facilities
- Expected water yield at the RGC site and its success rate
- Population
- Population served per each borehole
- Availability of electricity
- Yields observed at test boreholes

Figure-3 Location of Priority Projects

The selected RGCs were further classified into three priority groups. The following 13 RGCs belong to the first priority group. (refer to Table-3 and Fifgure-3)

- Soroti District：Kidetok, Tubur, and Acuna
- Pallisa District：Kadama, Kasassira, and Kameke
- Iganga District：Nabitende B., Namungalwe, Nambale, Nakabugu, Nakalama, Lambala, and Naigobya

Table-3 Results of Prioritization of Piped Water Supply System

Priority Group	Iganga District				Pallisa District				Soroti District			
	Rank	RGC	Score	Population	Rank	RGC	Score	Population	Rank	RGC	Score	Population
First Priority Group	1	Nabitende B.	36.0	17,459	3	Kadama	32.4	12,888	2	Kidetok	32.5	1,265
	4	Namungalwe	32.0	14,474	10	Kasassira	22.2	6,666	5	Tubur	26.6	2,433
	6	Nambale	25.1	5,717	13	Kameke	20.8	3,194	7	Acuna	24.6	2,069
	8	Nakabugu	22.8	5,814	15	Kapala	18.9	2,574	19	Mugarema	18.1	5,125
	9	Nakalama	22.3	6,905	18	Buseta	18.1	2,839	25	Kagwara P.	17.3	3,796
	11	Lambala	21.6	2,515	21	Kibale P.	17.8	2,833	35	Mulondo	12.8	2,214
	12	Naigobya	21.3	1,942	23	Nabisuwa	17.4	2,074	36	Pingire Etem	12.6	1,582
Second Priority Group	14	Busesa	19.7	4,825	24	Kabweri	17.3	1,562				
	16	Kyanvuma	18.7	2,050	28	Butebo	15.6	1,358				
	17	Nakivumbi	18.2	2,750	30	Agule	15.0	2,988				
	20	Nondwe	17.9	4,264	33	Boliso ITC	13.0	1,253				
	22	Nabitende K.	17.6	2,822								
	26	Bukooma	17.1	2,533								
Third Priority Group	27	Kiwanyi	16.3	3,033								
	29	Namusisi	15.4	1,960								
	31	Ikumbya	14.3	1,508								
	32	Busiiro	13.1	2,231								
	34	Busalamu	13.0	1,972								
	37	Buwologoma	10.8	2,262								
	38	Bumanya	10.3	2,280								
	39	Nawampiti	9.1	2,485								

11. Recommendations

(1) Improvement of the Water Resources Monitoring System

In addition to its amount, the accuracy and continuity of the fundamental data, such as meteorological, hydrological, and hydrogeological, data are essential for Integrated Water Resources Management (IWRM).

(2) More Human Resources and Capacity Development

More human resources and their capacity development (C/D) are needed for more efficient water resources development and management in the Lake Kyoga Basin.

(3) Arbitration of Conflicts between Water Resources Stakeholders

Conflicts between water resources stakeholders are expected along with their development. Arbitration of such conflicts by basin or sub-basin lead by the Water Resources Management Zone Office (WRMZO) and the Sub-basin Liaison Council is needed.

(4) Improvement of the Rural Water Coverage

New facilities are needed to improve the plateau of the rural water supply coverage. However, appropriate O/M of the existing facilities should not be neglected.

(5) Establishment of the O/M System for Water Supply Facilities

Collection of water charges without delinquency is the most important requirement for independent operation and maintenance of the water supply facilities by Uganda as explained in the financial evaluation in the Rural Water Supply Master Plan. Though maintainable O/M systems have been sought in Uganda, establishment of a feasible and efficient O/M system without delay is desired.

(6) Public Awareness of Water Saving

The analysis of water supply and demand shows rapid increase of water demand expected in near future in the Basin. Therefore, public awareness of water saving is important to cope with the increasing demand.

(7) Acquisition of Funding Sources for the Rural Water Supply Master Plan

Roughly UGX 340 million/year is needed just to execute the Rural Water Supply Master Plan which is only for three out of about 80 districts in Uganda. Given the annual budget of UGX 1,500 million/year for the water related sector of Uganda, this amount is considerably large. Therefore, acquisition of funding sources needs to be seriously considered.

(8) Early Start of the Priority Projects and Acquisition of Groundwater Resources

The priority projects for the 13 selected RGCs should be started as soon as possible to improve the water coverage rate of the rural water supply. More detailed groundwater exploitation survey is necessary to acquire withdrawal volume for implementation of the projects.

(9) Water Supply Facilities for Rural Areas outside RGC

Water supply facilities, mainly deep wells with a hand pump, need be constructed in the rural areas outside RGC. Roughly 200 wells need to be installed every year in the three districts. A

framework to accommodate that needs to be soon established. In addition, delinquency of water charges needs to be reduced for the level-1 operation and maintenance of the wells including the existing ones.

(10) Acquirement of Agricultural Water

Shortage of crop water is of a concern in five sub-basins, Mpologoma in particular. Planning and construction of flood water storages, valley tank and pond for example, as supplemental water storage should be carried out immediately.

(11) Dealing with Flood and Sediments Disasters

Destruction of the natural environment around the Mt. Elgon, along with the climate change, appears to have increased flooding and sediment disasters in the area. A basic survey to grasp the condition of the natural environment should be started soon.

(12) Environmental and Social Consideration

The water supply projects for the RGCs in the districts will go through the stages of F/S, basic design, detailed design, and implementation by turns. At the F/S stage, DWD needs to prepare application documents for NEMA based on "The Guideline for Environmental Impact Assessment in Uganda (1997)". Though will be eventually resolved, some differentials between those who benefit from new water supply facilities and those who do not may initially emerge. Therefore, an appropriate explanation of the project to the local communities is needed to avoid unnecessary conflicts.

(13) Population Control

The rapid population increase in Uganda, which ranks the third place in the world, is one of the main the causes of the rapid rise of the water demand and destruction of the natural environment around Mt. Elgon. Water supply planning and implementation with the population growth in consideration is of course important, but that with population control would be more effective.

(14) Expansion of the Study to Other Basins

Expansion of the water resources operation and management plan of this Study to other seven districts is strongly recommended.

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ABBREVIATION

ADB	African Development Bank
ADC	Austrian Development Cooperation
ASL	Above Sea Level
AVNIR	Advanced Visible and New Infrared Radiometer
BADEA	Arab Bank for Economic Development in Africa
BH	Borehole
BHN	Basic Human Needs
BOD	Biochemical Oxygen Demand
B/C	Benefit by Cost
CBMS	Community Based Management System
CBO	Community Based Organization
CFR	Central Forest Reserve
CMO	Catchment Management Organization
COD	Chemical Oxygen Demand
C/P	Counterpart
CRED	Centre for Research on the Epidemiology of Disasters
DANIDA	Danish International Development Agency
DEA	Directorate of Environmental Affairs
DEM	Digital Elevation Model
DHI	Danish Hydraulic Institute
DO	Dissolved Oxygen
DWD	Directorate of Water Development
DWO	District Water Office
DWRM	Directorate of Water Resources Management
DWSCC	District Water and Sanitation Coordination Committee
EA	Environmental Audit
EC	Electric Conductivity (mS/m)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EM-DAT	Emergency Events Database
ETM	Enhanced Thematic Mapper
EU	European Union
FAO	Food and Agriculture Organization

FIEFOC	Farm Income Enhancement and Forestry Conservation Project
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GFS	Gravity Flow Scheme
GIS	Geographic Information System
GoU	Government of Uganda
GPS	Global Positioning System
HH	Household
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IRR	Internal Rate of Return
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resources Management
ITCZ	Inter-Tropical Convergence Zone
JFP	Joint Partnership Fund
JICA	Japan International Cooperation Agency
JSR	Joint Sector Review
JTR	Joint Technical Review
LANDSAT	Land sensing Satellite
LC	Local Council
LFR	Local Forest Reserve
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MAC	Maximum Allowable Concentration
MCM	Million Cubic Meter
MDG	Millennium Development Goals
MERECP	Mount Elgon Ecosystem Conservation Programme
MoEMD	Ministry of Energy and Mineral Development
MoES	Ministry of Education and Sports
MoFA	Ministry of Foreign Affair
MFPED	Ministry of Finance Planning and Economic Development
MGLSD	Ministry of Gender, Labour and Social Development
MoH	Ministry of Health
MoLG	Ministry of Local Government
MoWLE	Ministry of Water, Land and Environment
MoWE	Ministry of Water and Environment
MoWT	Ministry of Works and Transport

MoTTI	Ministry of Tourism, Trade and Industry
NAADS	National Agricultural Advisory Services
NASA	National Aeronautics and Space Administration
NDP	National Development Plan
NEMA	National Environment Management Authority
NFA	National Forestry Authority
NGO	Non Government Organization
NGWDB	National Groundwater DataBase
NPV	Net Present Value
NSWG	National Sanitation Working Group
NWSC	National Water and Sewerage Corporation
OFDA	Office of U.S. Foreign Disaster Assistance
O&M	Operation & Maintenance
PCA	Principle Component Analysis
PEAP	Poverty Eradication Action Plan
RGC	Rural Growth Center
RWS	Rural Water Supply
RWSS	Rural Water Supply and Sanitation
SIDA	Swedish International Development Cooperation Agency
SRTM	Shuttle Rader Topography Mission
SS	Suspended Solids
SSIP	Strategic Sector Investment Plan
SWAP	Sector Wide Approach
TDS	Total Dissolved Solid
TLU	Tropical Livestock Unit
TM	Thematic Mapper
TNTC	Too Numerous To Count
TOR	Terms of Reference
TSU	Technical Support Unit
UBoS	Uganda Bureau of Statistics
UFW	Unaccounted For Water
UGX	Ugandan Shilling
UK	United Kingdom
ULGA	Uganda Local Governments Association
UNICEF	United Nations Children’s Fund
UNITAR	United Nations Institute for Training and Research

UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNOSAT	UNITAR Operational Satellite Applications Programme
UNRA	Uganda National Road Authority
UO	Umbrella Organization
USA	United States of America
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
UWA	Uganda Wildlife Association
UWA-FACE	UWA-Forest Absorption Carbon-dioxide Emission
UWASNET	Uganda Water and Sanitation NGO Network
UWSS	Urban Water Supply and Sanitation
VAT	Value Added TAX
VSW	Vegetation-Soil-Water
WATSUP	Water Atlas Up-date Project
WESWG	Water and Environment Sector Working Group
WfP	Water for Production
WFP	World Food Programme
WGS	World Geodetic System
WHO	World Health Organization
WMO	World Meteorological Organization
WMZ	Water Management Zone
WPC	Water Policy Committee
WRM	Water Resources Management
WRMD	Water Resources Management Department
WSDF	Water and Sanitation Development Facility
WSC	Water and Sanitation Committee
WSSB	Water Supply and Sanitation Board
WSSWG	Water and Sanitation Sector Working Group
WUC	Water User Committee

Chapter 1
Introduction

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Uganda is an agricultural country with 40% of GDP or 80% of total export covered by agricultural products. Approximately 70% of rural people who constitute 86% of total population are engaged in agricultural activities, rural areas therefore play very important roles for sustainable economic development in Uganda. It is important to take measures against poverty reduction in rural areas in which 96% of poverty people live. The national development plan (NDP April 2010), which incorporates "PEAP" (Poverty Eradication Action Plan 1997 to 2008) and intertwines sustainable economic growth with poverty eradication, aims to reduce absolute poverty to less than 24.5 % of total population by the year of 2015. NDP sets target for water and sanitation sector as below.

- By the year of 2015, 100 % of population in urban area can access to the safe water within 0.2 km and sanitation facilities.
- By the year of 2015, 77% and 90% of population in rural area can access to the safe water within 1.0 km and sanitation facilities, respectively.

The study area, Lake Kyoga Basin (hereinafter referred as to "the Basin") having approximately 58,000 km^2 equals to 25% of the area of Uganda, is one of the largest catchment areas among eight basins in the whole country. (refer to Figure 1-1) Approximately 9.3 million people (2008 estimated) are living in the Basin whose major industry is agriculture, which is composed chiefly of livestock farming mainly cattle and cash crop growing of cotton or coffee.

The Basin is considerably blessed with water resources, namely rivers, lakes and groundwater with an annual precipitation of more than 1,200mm. However, safe water supply coverage in the rural areas is approximately 57% on an average in comparison with a national coverage of 63% and besides Kaabong, Kotido, Abim and Bugiri districts have less than 40%.

On the other hand, here is serious surface erosion in the mountainous areas of the basin, which leads to soil erosion and stream capture resulting into heavy damage to agriculture and the daily life of the people. This means that not only "water resources utilization" but also "prevention of flood and sediments disaster" have been recognized as critical issues.

Under these circumstances, the Government of the Republic of Uganda and the Government of Japan agreed

No.	Basin	Area (km^2)
1	Lake Victoria Basin	59,858
2	Lake Kyoga Basin	**57,669**
3	Kyoga-Nile Basin	26,796
4	Lake Edward-George Basin	18,624
5	Lake Albert Basin	18,223
6	Aswa Basin	26,868
7	Albert Nile Basin	20,004
8	Kidepo Basin	3,129

(Source: NORPLAN (2005) "Water Resources Management Sub-sector Reform Study")

Figure 1-1 Eight Basins in Uganda

in August 2008 to conduct "The Development Study on Water Resources Development and Management for Lake Kyoga Basin in the Republic of Uganda" (hereinafter referred to as "the Study") in order to formulate "The Basic Plan on Water Resource Development and Management" for sustainable and effective water resources management, and "The Master Plan for Rural Water Supply" to accelerate actual construction of water supply facilities in the rural areas in the Basin.

1.2 Objectives of the Study

The objectives of the Study are

- To formulate a basic plan on water resources development and management for the Basin
- To formulate a master plan for rural water supply in priority areas
- To transfer technology and knowledge to the counterpart personnel through their direct participation into the Study.

1.3 Study Area

The study area is whole Lake Kyoga Basin, which covers approximately 58,000 km^2 in the eastern part of Uganda. The number of the related districts in the Basin is 38 as shown in Figure 1-4 (July 2009).

However, there were off-limit areas for the security reasons to the Study Team in the northern part of the Basin . Therefore, such areas were included in the "Basic Plan on Water Resources Development and Management" but excluded in the "Master Plan for Rural Water Supply".

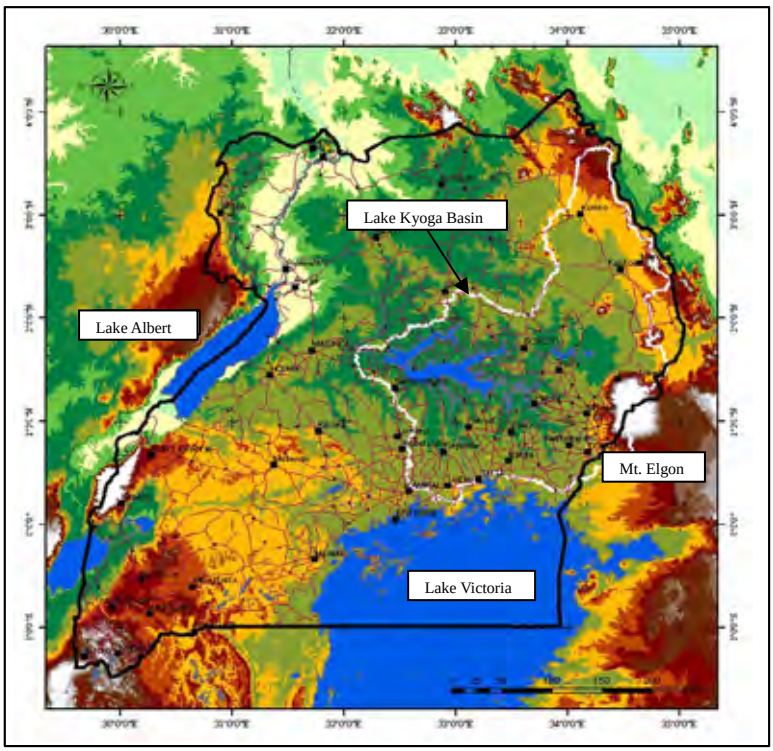


Figure 1-2 Location of the Study Area

1.4 Implementation of the Study

Directorate of Water Resources Management (DWRM) and Directorate of Water Development (DWD) acted as the counterpart agency to the JICA Study Team and provided the counterpart team with the necessary staff. Ministry of Water and Environment (MoWE) organize a joint steering committee, which included delegates from JICA Study Team and other appropriate related organizations under the Co-chairmanship of DWRM and DWD. The members of JICA Study Team and Counterpart Team are listed as shown in Table 1-1.

Table 1-1 Member Lists of the JICA Study Team and Counterpart Team

No	Assignment Title	JICA Study Team	Counterpart Study Team
1	Team Leader / Water Resource Management	Mr. Norifumi YAMAMOTO	Mr. Twinomujuni Jackson (DWRM)
2	Deputy Team Leader / Water Supply Planning	Mr. Soichiro YUMOTO	Eng. Ahmed Sentumbwe (DWD)
3	Meteorology / Hydrology	Mr. Ichiro TANAKA	Mr. Maximo Twinomuhangi (DWRM)
4	Hydrogeology (1)	Mr. Shinichi ISEKI	Ms. Eva Lwanga (DWRM)
5	Hydrogeology(2) / Test Drilling Survey	Mr. Iwao HAMADA	Mr. Erisa Kyeyune (DWD)
6	Basin Management / Flood Control Planning	Mr. Kenji MORITA	Mr. Benjamin Sekamuli (DWRM)
7	Remote Sensing / GIS	Mr. Soichiro KAGEYAMA	Mr. Maximo Twinomuhangi (DWRM)
			Mr. Benjamin Sekamuli (DWRM)
8	Water Balance Analysis / Simulation	Mr. Toru YORITATE	Mr. Tom Kanyike (DWRM)
9	Water Quality / Environmental and Social Consideratio	Mr. Rikichi ANDO	Mr. Simon Etimu (DWRM)
10	Socio-economy / Financial & Project Evaluation	Dr. Reza MAHABUB Dr. Kazuki NAKAMURA	Mr. Collins Amanya (DWD)
11	Facility Planning / Cost Estimation	Mr. Matasaburo TSUKUDA	Mr. Felix Twinomucunguzi (DWD)
12	Organization Operation & Maintenance	Mr. Terutoshi OZAWA	Eng. Ahmed Sentumbwe (DWD)
13	Coordinator	Mr. Kenji AKAMATSU	-

1.5 Study Schedule

The Study is scheduled to be completed in a period of approximately 25 months between March 2009 and March 2011. Total schedule of the Study is shown in Figure 1-3.

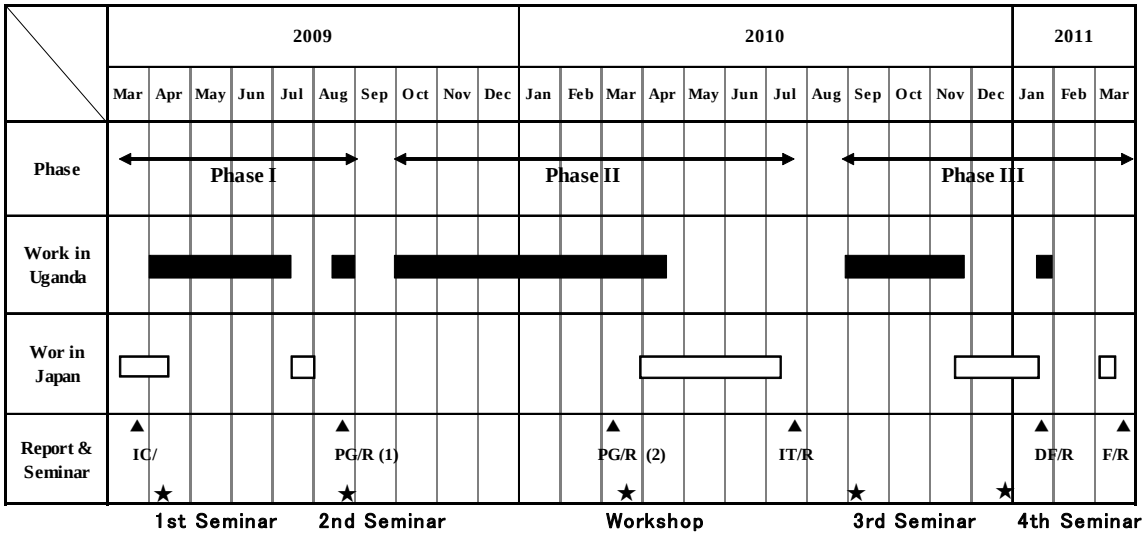


Figure 1-3 Total Schedule of the Study

Chapter 2
Natural Conditions

CHAPTER 2 NATURAL CONDITIONS

2.1 Definition of Lake Kyoga Basin

The Basin and sub-basin boundaries were redefined precisely with DEM (Digital Elevation Model) data by SRTM (Shuttle Radar Topographic Mission) as illustrated in Figure 2-5. The total area of the Basin is calculated to approximately 58,230 km^2 by DEM data. Ninety eight percent (98%) of the Basin: 57,080 km is in Ugandan side and two percent (2%): 1,150 km$^{2:}$ is Kenyan side.

2.2 Meteorology and Hydrology

2.2.1 Meteorology

(1) Rainfall

Mean annual rainfall varies 989 mm (Kakooge) to 2,477 mm (Buginyanya) spatially and the average is 1,466 mm in the Basin. Figure 2-1 shows that the Basin experiences typically two rainy seasons between March to May and September to November.

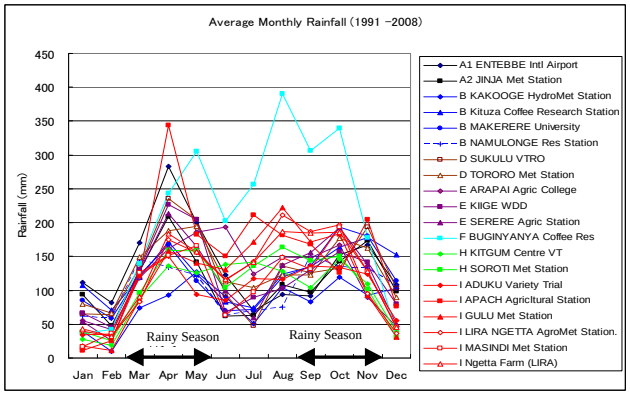


Figure 2-1 Average Monthly Rainfall

(2) Air Temperature

Figure 2-2 presents monthly mean, maximum and minimum temperature at the meteorological stations. It is higher on January - February and lower on June - July.

(3) Sunshine Hours

As shown in Figure 2-3, annual variation patterns of sunshine hours among the stations are the longest in January and the shortest in April, July or October. Daily mean sunshine hour a year is 6.8 hours in the Basin.

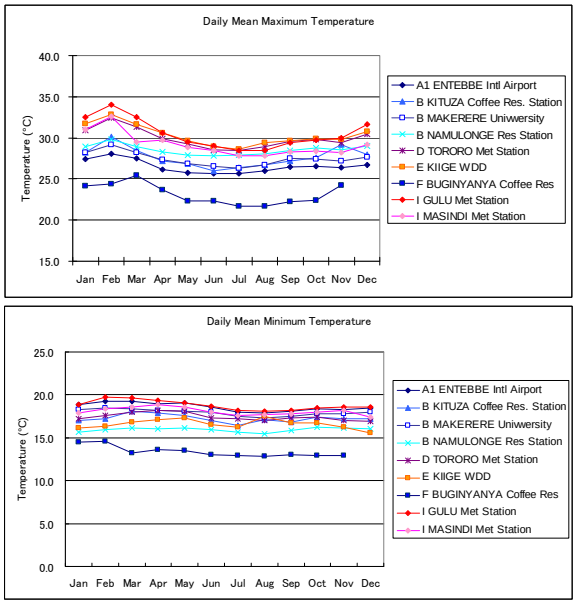


Figure 2-2 Mean Max. and Min. Temperature

(4) Pan Evaporation

Many stations show their highest value in February, and a few in January or December as shown in Figure 2-4. The annual mean pan evaporation is 1,751mm. The value exceeds annual mean rainfall in the Basin. The highest value was recorded at Nakapiripirit station in January. The record of Nakapiripirit station shows more remarkable seasonal change than those of the other stations.

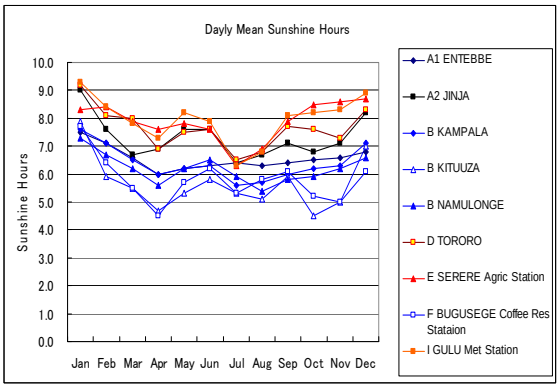


Figure 2-3 Daily Mean Sunshine Hours

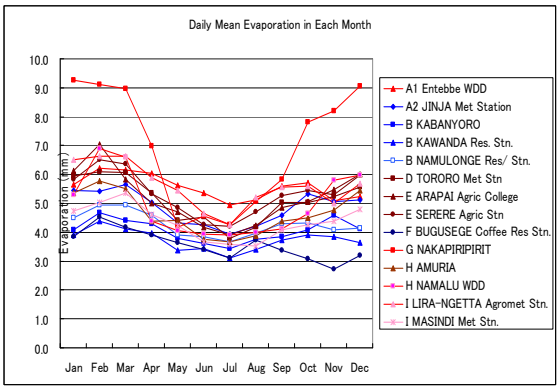


Figure 2-4 Daily Mean Evaporation

2.2.2 Hydrology

(1) River Network and Gauging Stations

The gauging stations are located in the Basin as illustrated in Figure 2-5. Since some existing gauging stations have disadvantages based on the site survey results in this study, it is strongly recommended to review their install points and observation method.

(2) River Flow Regime

1) Longitudinal Profile of the Rivers

The rivers run from northern part and eastern part of the Basin such as Awoja, Okok and Mpologoma rivers have mountainous area in the upstream and their gradients change to steep slope quickly in the upstream, especially in Awoja and Mpologoma rivers of which gradients in the upstream are more than 1/20. Their rivers' sections until upstream border of wetland have gentle slope of about 1/4,000 to 1/2,500

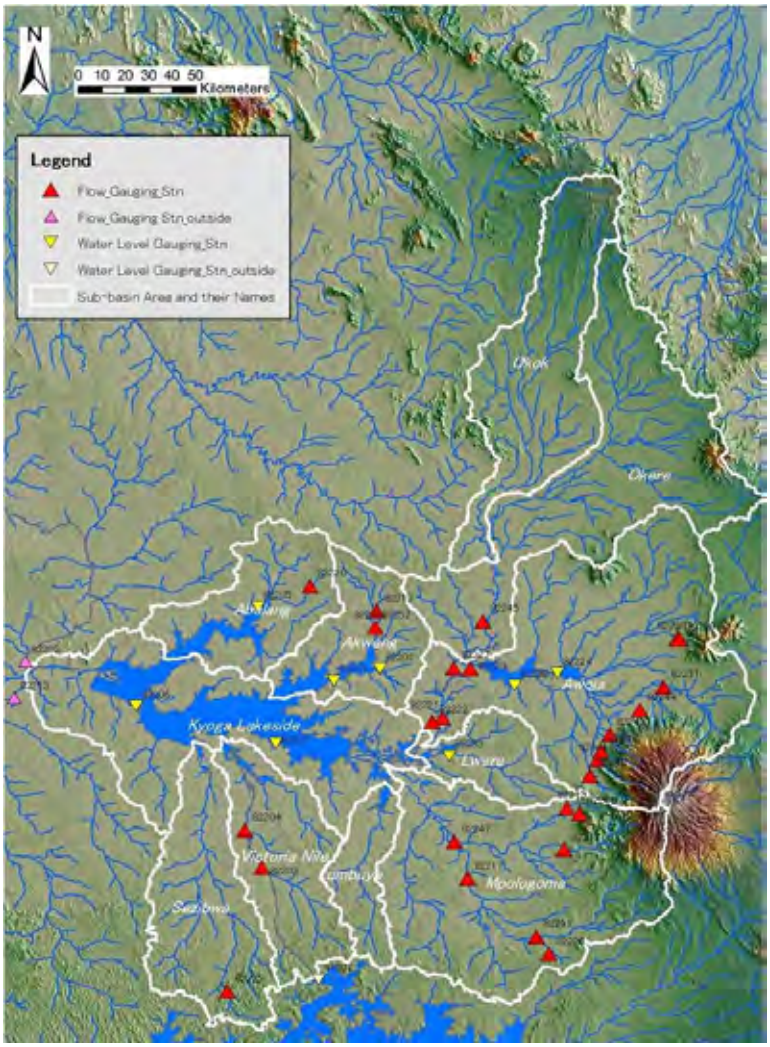


Figure 2-5 River Network, Sub-basins and River Gauging Stations

2) River Flow Regime

The results of flow regime analysis are summarized as follows.

- In the northern area of the Basin, it has annual average discharge, but no low[1] and drought water discharge[2]. It is difficult to use surface water stably.
- In the southern area of the study area, it has some low and drought water discharges
- The stations near Mt. Elgon, they have small discharge, but sometimes has high water condition (flooding), but the stations far from Mt. Elgon have stable discharge.
- In Awoja sub-basin located at north of Mt. Elgon, the gauging station has low water discharge, but no drought discharge.
- In Mpologoma sub-basin located at southwest of Mt. Elgon, the flow regimes are more stable than the other sub-basin, and it has low and drought water discharges.
- The flow regime of a gauging station with wider catchment is getting more stable than others having smaller catchments.

(3) Lake Water Level Change

Lake Kyoga Basin has many lakes such as Lake Kyoga, Lake Kwania, Lake Bisina and Lake Opeta as shown in Figure 2-6, and their water level observations have been done. However, only one gauging stations at Bugondo Pier in Lake Kyoga has been working by now.

The lake water level changes of Lake Victoria and Lake Kyoga are summarized in Figure 2-7. This means that the lake hydrology is governed by the discharge from the Victoria Nile. In rough order of magnitude, the variations between high and low lake water levels can be seen to vary 0.5-1.0 m from year to year between extreme events. The 1962-1964 floods and the 1997-1998 floods added 1-2 m to these levels. It is said that the causes are record rainfalls in the years.

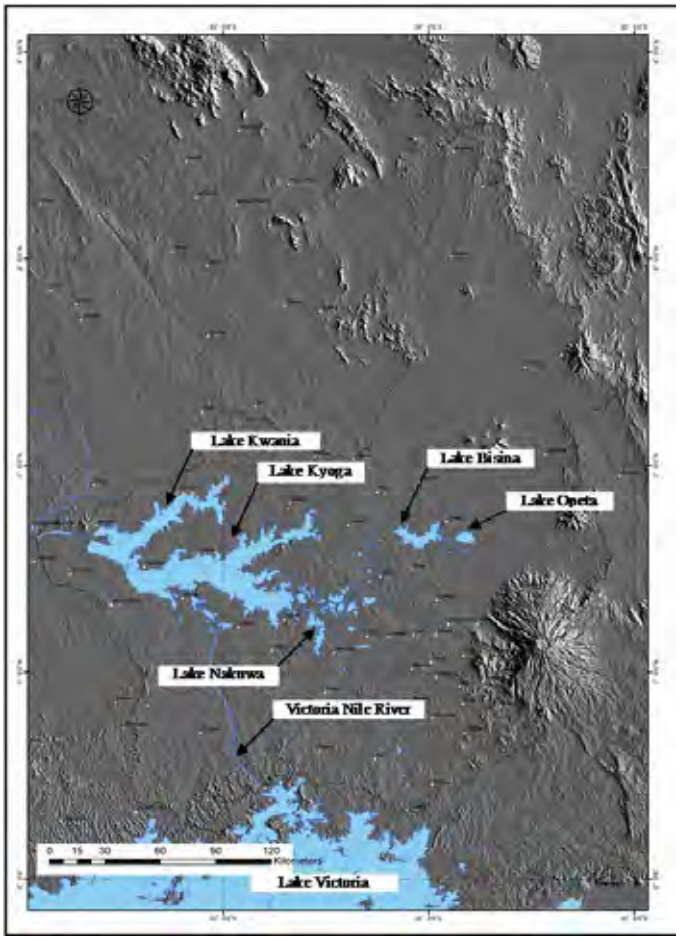


Figure 2-6 Main Lakes in Lake Kyoga Basi

[1] Low water discharge: 275th discharge from the greatest daily discharge.
[2] Drought water discharge: 355th discharge from the greatest daily discharge.

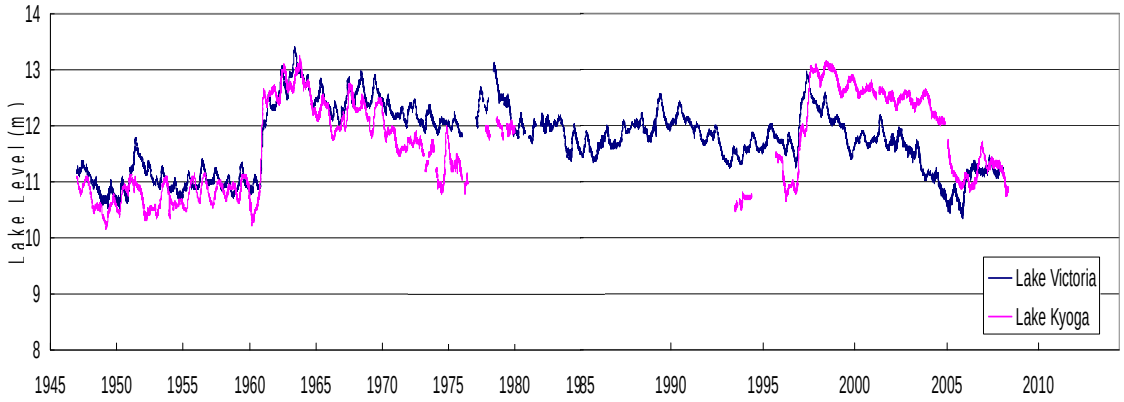
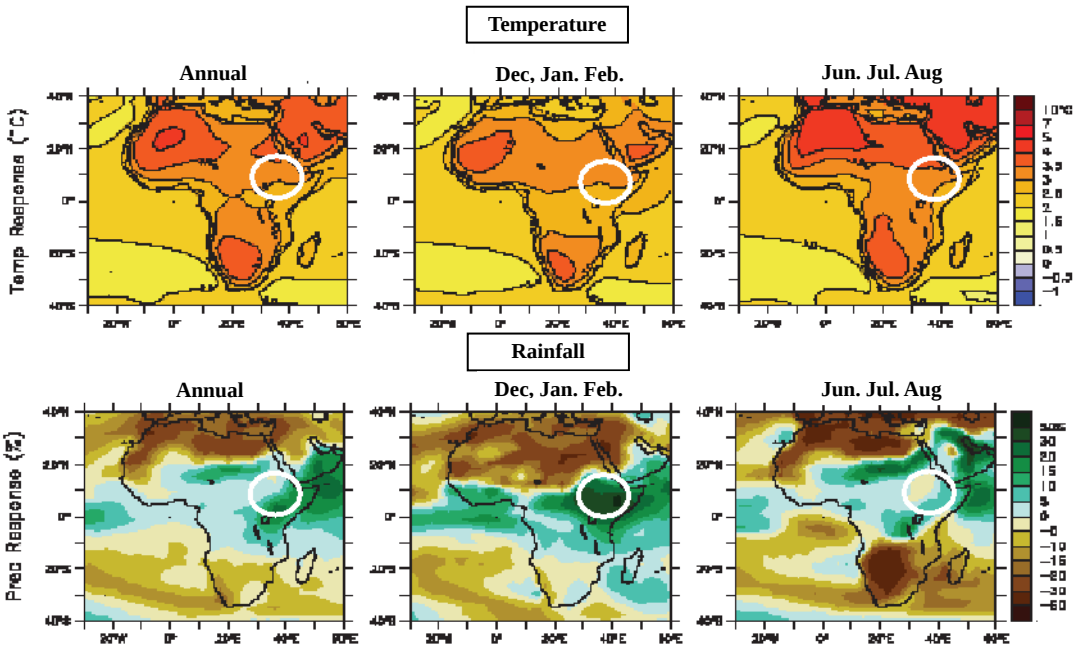


Figure 2-7 Water Level Changes of Lake Kyoga and Lake Victoria

2.2.3 Climate Change Projection in IPCC Fourth Assessment Report

According to IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report, temperature of Africa will increase; however, annual rainfall around Uganda is likely to increase in the 21st century. (refer to Figure 2-8)



source：IPCC Fourth Assessment Report WG1 Page 869

Figure 2-8 Temperature and Precipitation Changes in IPCC Report

The government of Uganda issued "Climate Change: Uganda National Adaptation Programmes of Action (2006)". The report studied rainfall data from 1943 to 1999. The key points stated are summarized below.

- There is increasing variability in most regions of Uganda other than the central region; however, rainfall variability does not show any significant trends.
- On the other hand there is clear increase of frequency of droughts in recent years,

- Although it is predicted (IPCC Assessment Reports 1995/2001) that precipitation will increase in some areas of East Africa as a result of climate change, evapotranspiration will also increase due to a rise in temperatures thus reducing the benefit of the increase.

2.3 Geomorphology and Geology

2.3.1 Geomorphology

Lake Kyoga Basin is located in the eastern part of Uganda and consists of peneplanes, hills and mountains as presented in Figure 2-9. Its altitude ranges from 1,030m at the exit of Lake Kyoga to 4,321m at the peak of Mt. Elgon. Topography of the Basin is roughly tilted from the east to the west. Most of the rivers in the Basin have swamps because of its gentle slope. Lake Kyoga, whose water area is 1,720 Km ^{2}, is very shallow: approximately maximum 6m depth.

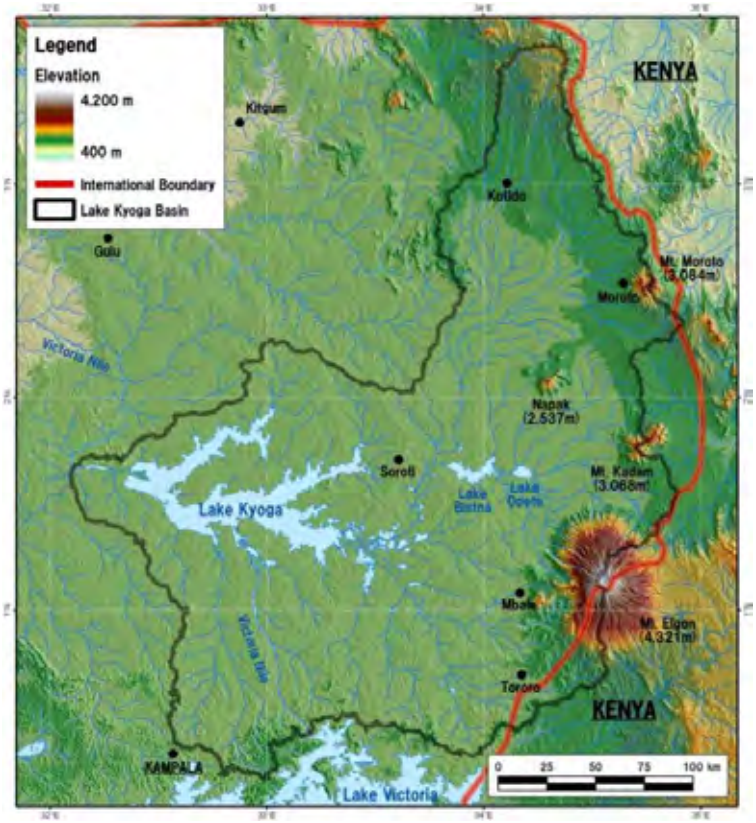


Figure 2-9 Geomorphology of Lake Kyoga Basin

Mt. Elgen along the east rim of Lake Kyoga Basin is the one of the oldest volcano in East Africa, whose area of skirts is 3,500km^2. The boundary of the Basin from Moroto to Kitido is overlapping the rim of Eastern Rift Valley, and the national boundary is also taking along this.

The clear lineament structures: Aswa Shear Belt, which is extended from the northwestern part to the central part of the processed image, could be clearly extracted as shown in Figure 2-10. Concerning the surface textures of plane which assume a dominant position in the study area, the northern part with smooth textures differs from the southern west part with well-developed granular textures. These differences are concerning to the geology and surface soil.

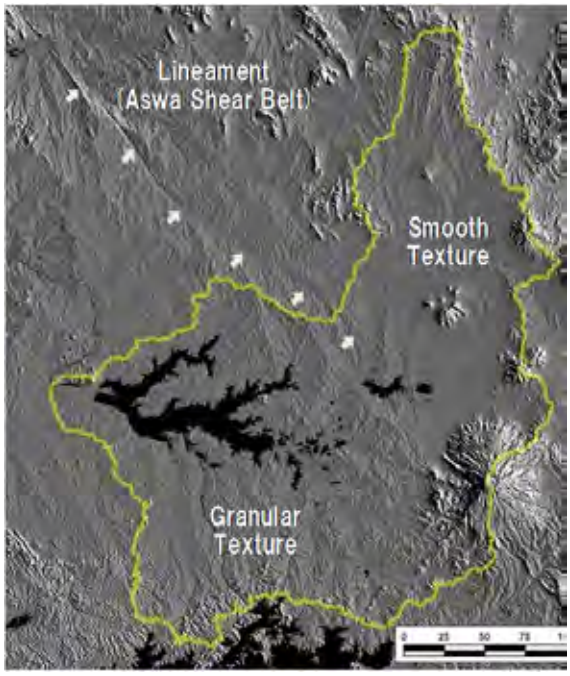
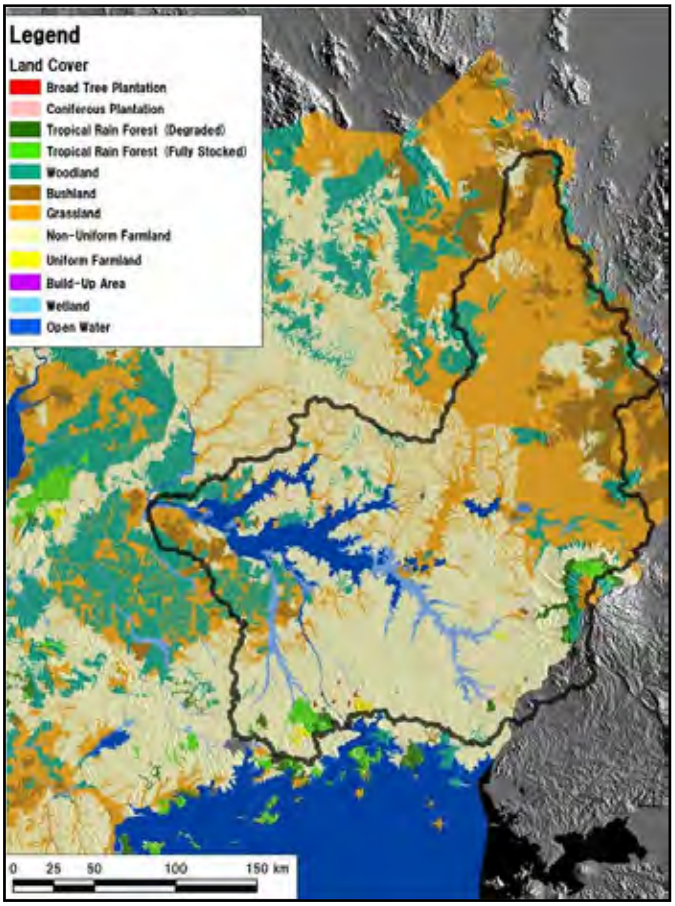


Figure 2-10 Shaded Relief Image

2.3.2 Land Cover of Lake Kyoga Basin

Land cover of Lake Kyoga Basin is shown in Figure 2-11. Sum of forests and woodlands is 8.5% as one third of the value of Whole Uganda, and grassland and small-scale farmland are 28.5% and 45.8% respectively, which are about 8% higher than the values of Whole Uganda. As shown in the figure, central part of the Lake Kyoga Basin is widely covered by small-scale farmland and most part of Karamoja region is covered by grassland. Forests spread only in some parts of vicinity of the Basin boundary of northern, eastern and southern parts, and around Lake Kyoga in western part of the Basin.



Data Source: GIS data of National Biomass Study (1996), Forest Department

Figure 2-11 Land Cover of Lake Kyoga Basin

2.3.3 Geology

Geology of the Basin is shown in Figure 2-12 and its stratigraphy is summarized in Table 2-1. Approximately 2/3 of the Basin is covered by Precambrian formations, which were formulated 3 billion to 600 million years ago. These rocks are metamorphosed by orogenic movements, which were activated during Precambrian. Although the geology is classified by the period, types, magnitudes of metamorphism and so on in each area, most of the rocks are classified into Gneisses and Granites. After the time to now, the basin area has been located on the continental crust and never sunk into the ocean except only once when the transgression of Karoo was happened. The volcanic activities began in the middle Tertiary: 23 million years ago concurrently with the formulation of

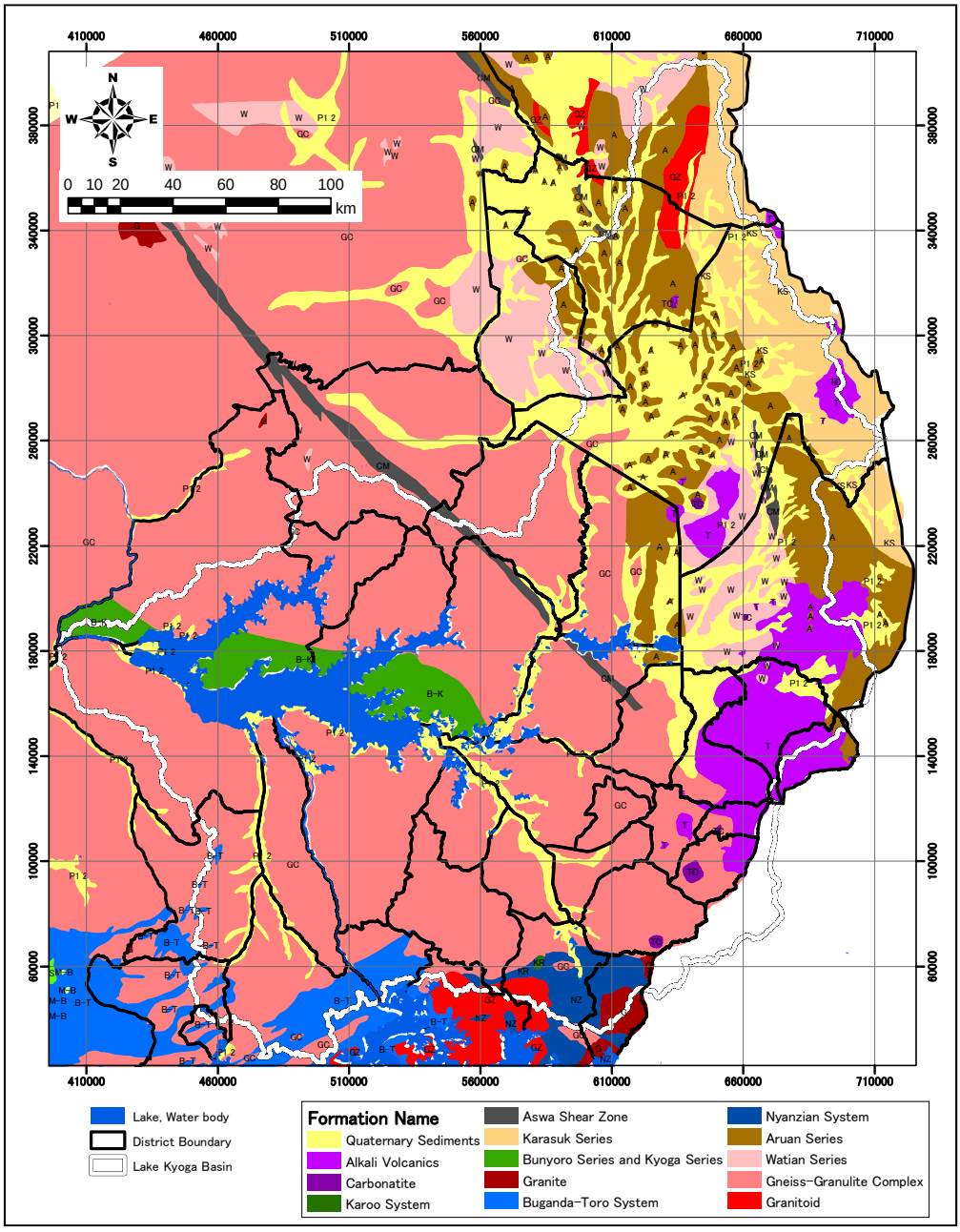
Table 2-1 Stratigraphy of Lake Kyoga Basin

Era	Period	Epoch	Name	Age (Ma)	Symbol	Lithology
Cenozoic	Quaternary	Pleistocene to Recent	Quaternary Sediments	0 - 1.6	P1	Sediments, alluvium, black soils and moraines
	Tertiary	Miocene	Volcanic	12.5 - 25	T	Volcanic Rocks and Associated sediments; Nephelinite, Phonorite,.....
		Miocene - Oligocene	Carbonatite Centre	20 -35	TC	Carbonatite and Syenite
Paleozoic	Lower Permian		Karoo System	256 - 290	KR	Shales
Precambrian	Proterozoic	Aswa Shear Zone		600 - 700	CM	Cataclasite, mylonite
		Karasuk Series		700 - 800	KS	Mozambique Belt: acid gneiss, amphibolites, quartzites, marbles, and granulite facies rocks
		Kioga Series		800 - 1,000	K	Shales, arkoses, quartzites, and tillite
		Granite		1,000 - 1,350	G	Mobilized and intrusive granites
		Buganda-Toro System		1,800 - 2,500	B-T	shales, argillites, phylites, mica-schists, basal quartzites, and amphibolite
		Nyanzian System		2,400 - 2,700	NZ	Metavolcanics, banded ironstones, cherty quartzites and greywackes
	Archean		Aruan Techtonic	2,600	A	Banded gneiss
			Watian Series	2,900	W	Granulite facies rock: charnokites, enderbites and retrograded derivatives
		Gneissic -Granulitic Complex		-3,400	GC	Undifferenciated gneiss and granulite facies rock in the north: gneiss, granite, amphibolite, charnockite, enderbite, quartzite
					GZ	Granitoid and highly granitized rocks

1) The Atlas of Uganda (1962); Department of Geological Survey and Mines, Ministry of Energy and Mineral.
2) Uganda Geology (2004); Department of Geological Survey and Mines, Ministry of Energy and Mineral.
3) Geology of East Africa (1997); Thomas Schluter, Gebruder Borntraeger.

the Great Rift Valley. It formulated several volcanoes in the eastern part of the Basin, for example: Mt. Elgon.

Mt. Elgon was higher than the current Mt. Kilimanjaro (5,895m) before, and the rivers in Uganda were flowing east to west. However, after forming the Western Rift Valley, an elongated lake (Lake Obweruka) was formed including the current Lake Edward and Lake Albert, and Mt. Ruwenzori were uplifted. Therefore, the rivers couldn't flow to west and formed Lake Victoria and Lake Kyoga. The current River Nile was formed about 30,000 years ago.



Source:Uganda Geology (2004)

Figure 2-12 Geological Map of Lake Kyoga Bsain

2.4 Water Quality Analysis

2.4.1 Water Quality Survey

The Study Team investigated the entire basin except the restricted area to enter for security reasons, to examine the water quality condition of the water sources. The survey was conducted in rainy season and dry season as follows.

- Rainy season; Survey was carried out from May 20 to June 10 in 2009.
- Dry season; Survey was carried out from January 19 to February 7 in 2010

The analysis items are 25 items for understanding the basic aspect and pollution aspect as well as hydrogeological aspect. Sampling points were totally 200 points consisting of 10 lakes, 39 rivers, 95 deep wells (boreholes), 20 shallow wells and 36 springs as shown in .Figure 2-13

The average values of the important water analysis parameters for different types of water sources: lake, river, borehole, protected spring and shallow well in each sub-basin are shown in Table 2-2. Values highlighted in yellow and red in the table exceed the urban and rural drinking water standard, respectively. In general, both water types: surface water and groundwater is not so bad quality; however, groundwater is relatively better than surface water.

2.4.2 Analysis of the Existing Water Quality Data

Existing water quality data is available in reports from the water quality monitoring network and

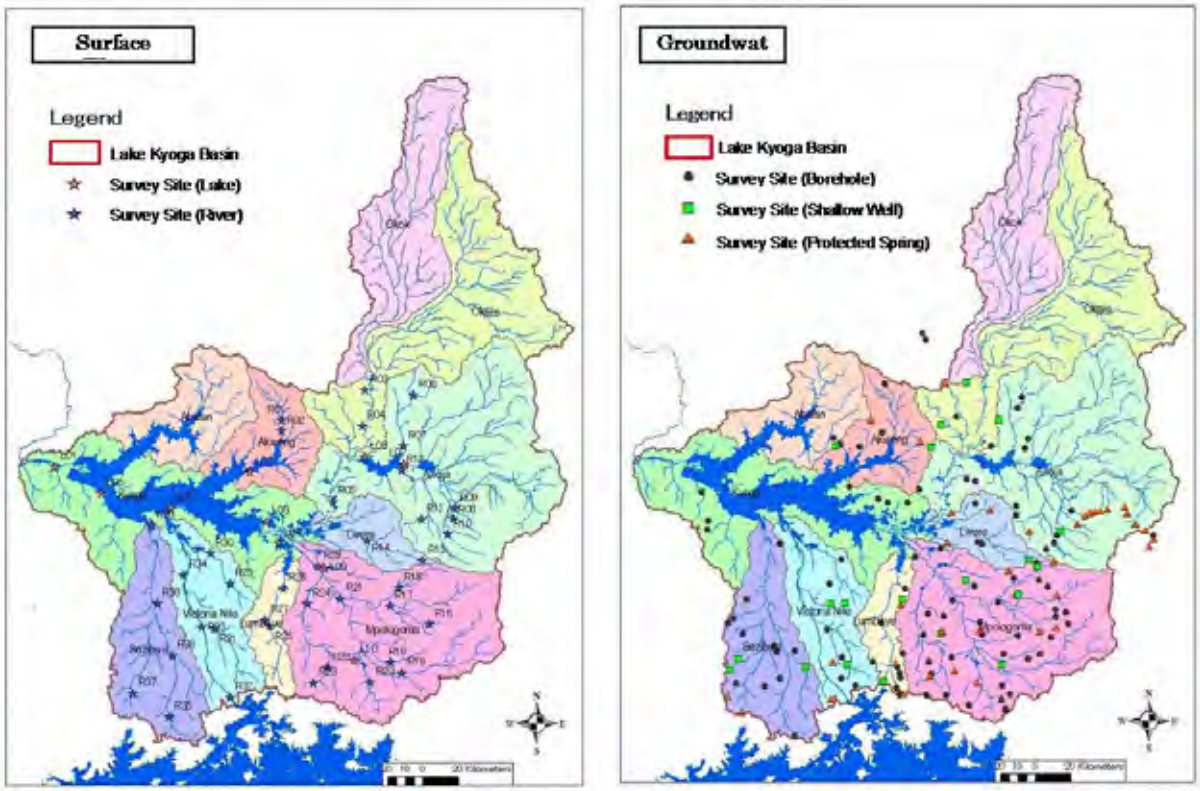


Figure 2-13 Location of Water Sampling Points

well drilling reports from contractors. There are 30 water quality monitoring sites in the Basin, and measurements of lake, river, groundwater, urban water, and drinking water have been performed since 1998. On the other hand, water quality data of 1,532 wells is available from the drilling reports.

As for rivers, the Nile shows good water quality except for the existence of Coliform groups. The monitoring points for municipal and industrial pollution, however, are severely contaminated with turbidity, iron, Coliform groups values exceeding the MAC, and they show very high BOD and COD of 130 mg/l and 97 mg/l, respectively.

Water quality data obtained upon well has been organized to find average values per district. Many districts have Turbidity, Color, Ca, Mn, and Fe values exceeding the urban drinking water standard. Kumi and Namutumba districts have Fe, and Sironko has Mn values exceeding the rural MAC standard.

Table 2-2 Results of Water Quality Survey

(Surface Water)

SOURCE TYPE	Subbasin	Number of Samples	Basic Items				Harmful Items				Pollution Items			
			pH	Turbidity (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (μS/cm)	Coliform Group (group/100ml)	BOD5 (mg/l)	NH4 (mg/l)
Lake	3 Awoja	2	7.3	1.1	247	156	0.11	< 0.001	0.49	0.060	464	TNTC	1.5	0.11
	5 Akweng	1	7.9	8.8	121	75	0.00	< 0.001	0.40	0.230	276	TNTC	2.8	0.08
	7 Kyoga lakeside	5	7.8	8.8	101	53	0.01	< 0.001	0.27	0.352	196	TNTC	4.3	0.14
	8 Mpologoma	2	7.4	17.6	186	110	0.00	< 0.001	0.28	2.140	261	TNTC	3.3	0.17
	Total	10	7.6	9.0	149	87	0.03	< 0.001	0.33	0.639	271	TNTC	3.4	0.13
River	2 Okere	2	6.7	10.8	172	113	0.06	< 0.001	0.28	1.398	296	TNTC	2.5	0.13
	3 Awoja	8	7.1	32.0	137	68	0.02	< 0.001	0.25	3.064	227	TNTC	4.0	0.22
	4 Lwere	2	6.7	24.3	123	72	0.10	< 0.001	0.25	5.288	218	TNTC	6.0	0.08
	5 Akweng	2	6.5	2,063.1	98	65	0.07	< 0.001	0.12	4.552	169	TNTC	2.5	0.27
	8 Mpologoma	11	7.1	182.8	124	83	0.07	< 0.001	0.37	4.710	218	TNTC	5.1	0.09
	9 Lumbuye	3	6.8	3.6	244	119	0.16	< 0.001	0.62	2.372	982	TNTC	3.7	0.06
	10 Victoria Nile	6	7.3	17.9	205	101	0.01	< 0.001	0.25	0.662	241	TNTC	1.8	0.07
	11 Sezibwa	5	7.2	17.0	65	45	0.06	< 0.001	0.27	2.440	238	TNTC	4.7	0.22
	Total	39	7.04	193.0	140	80	0.06	< 0.001	0.31	3.133	283	TNTC	4.0	0.14

*1 TNTC means, 'Too Numerous To Count'.

(Ground Water)

SOURCE TYPE	Subbasin	Number of Samples	Basic Items				Harmful Items				Pollution Items	
			pH	Turbidity (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (μS/cm)	Coliform Group (group/100ml)
Borehole	2 Okere	2	6.5	12.3	144	82	0.02	< 0.001	0.20	0.638	258	9
	3 Awoja	13	6.6	13.0	300	187	0.02	< 0.001	0.48	0.660	538	31
	4 Lwere	3	6.1	12.2	118	46	0.04	< 0.001	0.43	1.092	164	8
	5 Akweng	4	6.6	29.1	145	70	0.01	< 0.001	0.33	1.311	256	7
	6 Abalan	1	6.7	4.8	105	41	0.00	< 0.001	0.33	0.525	180	2
	7 Kyoga Lakeside	7	6.6	14.7	283	187	0.04	0.002	0.34	0.942	505	15
	8 Mpologoma	35	6.4	4.9	316	183	0.01	0.001	0.43	0.441	469	<1
	9 Lumbuye	8	6.2	6.4	154	72	0.03	0.001	0.35	0.146	247	<1
	10 Victoria Nile	7	6.6	0.8	264	136	0.01	< 0.001	0.41	0.085	451	<1
	11 Sezibwa	15	6.5	35.2	194	119	0.03	0.001	0.46	3.817	310	<1
	Total	95	6.4	11.9	258	150	0.02	0.001	0.42	0.962	414	<1
Protected Spring	2 Okere	1	5.6	55.7	60	28	0.12	< 0.001	0.02	1.335	99	1
	3 Awoja	13	6.4	6.9	113	68	0.00	< 0.001	0.27	0.362	224	<1
	4 Lwere	2	5.9	60.5	89	29	0.06	< 0.001	0.22	0.562	186	<1
	5 Akweng	2	6.3	29.3	78	23	0.01	< 0.001	0.09	0.668	122	20
	8 Mpologoma	10	6.4	13.9	133	76	0.01	< 0.001	0.27	0.507	237	<1
	9 Lumbuye	3	6.1	1.8	185	98	0.02	< 0.001	0.43	0.068	286	<1
	10 Victoria Nile	3	6.5	0.6	172	88	0.00	< 0.001	0.34	0.046	632	<1
	11 Sezibwa	2	5.8	7.9	56	43	0.01	< 0.001	0.17	0.109	133	24
	Total	36	6.3	13.7	121	67	0.01	< 0.001	0.26	0.397	250	<1
Shallow Well	2 Okere	2	5.9	34.0	175	79	0.01	< 0.001	0.08	1.940	302	36
	3 Awoja	2	6.6	22.5	212	148	0.01	< 0.001	0.38	0.890	359	<1
	4 Lwere	1	6.4	6.1	220	73	0.01	< 0.001	0.42	1.453	321	<1
	5 Akweng	2	6.7	6.4	136	68	0.02	< 0.001	0.37	0.548	248	4
	8 Mpologoma	5	6.4	26.5	305	197	0.02	< 0.001	0.29	0.787	516	<1
	9 Lumbuye	2	6.2	7.8	131	49	0.03	< 0.001	0.46	0.439	281	<1
	10 Victoria Nile	3	6.5	0.7	359	194	0.00	< 0.001	0.40	0.038	654	48
	11 Sezibwa	3	6.2	37.8	94	50	0.04	< 0.001	0.21	3.496	170	<1
	Total	20	6.37	19.8	220	124	0.02	< 0.001	0.31	1.181	388	<1

Standards	Basic Items				Harmful Items				Pollution Items			
	pH	Turbidity (NTU)	TDS (mg/l)	Hardness (CaCO3) (mg/l)	Mn (mg/l)	As (*1) (mg/l)	F (mg/l)	Fe (mg/l)	E.C. (μS/cm)	Coliform Group (group/100ml)	BOD5 (mg/l)	NH4 (mg/l)
Standards for urban treated drinking water	6.5- 8.5	10 NTU	500mg/l	500mg/l	0.1 mg/l	0.05 mg/l	1.0 mg/l	0.3 mg/l		0 /100ml		
Rural drinking water Standards	5.5 - 8.5	10 NTU	1000mg/l	600mg/l	1.0 mg/l		2.0 mg/l	1.0 mg/l		0 /100ml		
Rural drinking water Maximum Allowable	5.0 - 9.5	30 NTU	1500mg/l	800mg/l	2.0 mg/l	0.5 mg/l	4.0 mg/l	2.0 mg/l		50/100 ml		
WHO criteria (drinking water)		5 NTU	1000mg/l		0.1 mg/l	0.01 mg/l	1.5 mg/l	0.3 mg/l		0/100 ml		1.5 mg/l
Drinking water criteria (Japan)	5.8-8.6	2 NTU	500mg/l	300mg/l	0.05 mg/l	0.01 mg/l	0.8 mg/l	0.3 mg/l		Nil		
Ambient Standards (Lake, Type C :Japan)	6.0- 8.5											
Ambient Standards (River, Type C :Japan)	6.5- 8.5										5mg/l	

*1 As for Arsenic, the values in the table shows the test results obtained in japan.
*Evaluate Average Value : : Over Criteria value (Urban drinking water)、 : Over Criteria value (Rural drinking water MAC)
* As for average of Coliform Groups, '< 1' means there are some sites which result is 'TNTC'.

2.5 Hydrogeology

2.5.1 Hydrogeological Analysis

Data from NGWDB were used for hydrogeological analysis mainly. The numbers of data, which were used for analysis, are shown below. Table 2-3 shows the summary of drilling depth, static water level, well yield, and depth to bedrock of each geological unit.

- Drilling Depth data: 4,709
- Static Water Level Data: 4,094
- Pumping Test Data: 4,416
- Depth to Bedrock: 3,834
- Water quality (TDS) data: 1,530

Table 2-3 Drilling Depth, Static Water Level, Well Yield and Depth to Bedrock of each Geological Unit

	Formation Name	Symbol	Drilling Depth		Static Water Level		Well Yield		Depth to Bedrock	
			Data No.	Average (m)	Data No.	Average (m)	Data No.	Average (m3/h)	Data No.	Average (m)
1	Quaternary	P1 2	190	66.1	166	16.2	178	1.9	151	26
2	Alkali volcanics	T	49	64.6	47	15.9	46	2.3	32	28
3	Carbonatite	TC	17	58.7	16	19.4	15	2.2	11	35
4	Karoo System	KR	5	78.9	3	16.0	3	4.6	5	28
5	Aswa Shear Zone	CM	53	64.9	51	8.0	53	2.5	50	26
6	Karasuk serise	KS	15	78.8	15	29.4	14	1.7	7	11
7	Kyoga Series	B-K	65	69.4	58	20.9	62	4.0	50	39
8	Granite	G	75	55.2	71	12.6	72	1.9	57	31
9	Buganda-Toro System	B-T	338	69.9	238	19.5	302	1.8	284	35
10	Nyanzian System	NZ	98	55.1	86	13.7	92	2.5	69	32
11	Aruan Series	A	77	85.2	64	23.3	71	2.0	62	24
12	Watian Series	W	75	71.4	63	21.7	66	2.7	49	34
13	Gneiss-Granulite Complex	GC	3551	62.5	3127	13.9	3345	1.9	2946	28
14	Granitoid	GZ	101	56.1	89	15.3	97	2.0	61	28
			4709	63.5	4094	14.7	4416	2.0	3834	29

2.5.2 Results of Hydrogeological Analysis

(1) Drilling Depth Distribution

A drilling depth distribution map of the existing boreholes is shown in . Figure 2-14 Although each borehole has been drilled in different conditions, this distribution appears to indicate the actual depth of the aquifer that is needed to secure sufficient amount of water. Therefore, a drilling depth roughly represents the well construction cost. The average drilling depth is 64 m. The central and southern parts of the basin have relatively shallow drilling depths. On the other hand, the drilling depth is deeper in the Karamoja area, north-eastern part of Lake Kyoga Basin, Apac district, Nakasongola district, Kumi district around the Lake Kyoga, and Kapchorwa district in the northern part of Mt. Elgon.

(2) Static Water Level Distribution

Static water level distribution of the existing boreholes is shown in Figure 2-15.

The belt-like zone from north-northwest to south-southeast in the central part of Lake Kyoga Basin show shallow static water levels. On the other hand, the static water levels are low in the Karamoja area in the north-eastern part of Lake Kyoga Basin, Apac district, Amolatar district, Nakasongola district, Kayunga district, and Kamuli district around the Lake Kyoga

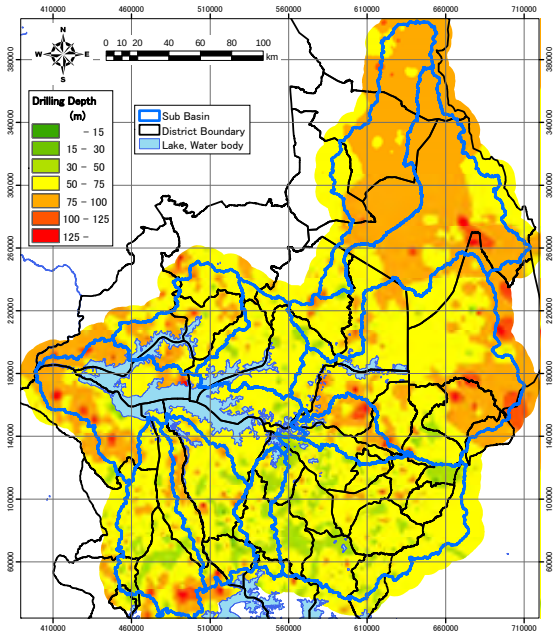


Figure 2-14 Drilling Depth Distribution

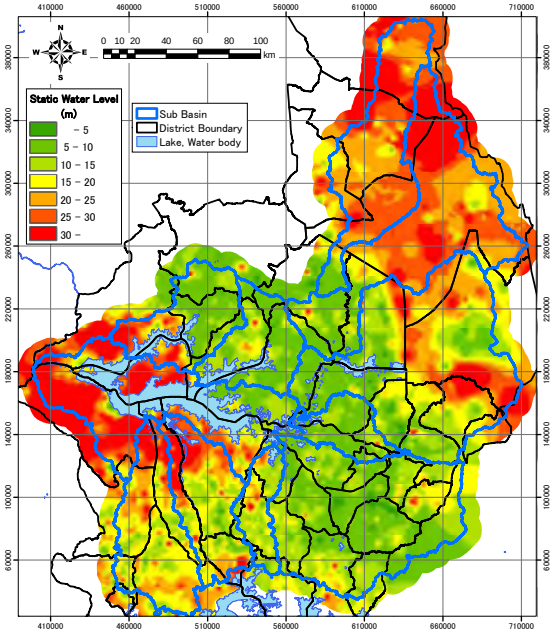


Figure 2-15 Static Water Level Distribution

(3) Well Yield Distribution

Distribution of the well yield from the existing wells is shown in Figure 2-17. The results of constant pumping tests are used as well yield data for this analysis because this parameter is available for many wells from NGWDB.

The Karamoja area in the north-eastern part of the Lake Kyoga basin, Sorotit, Amolatar, Apac, Dokolo, and Kaberamaid districts in the northern shore of Lake Kyoga have a large yield per well whereas the southern area of Lake Kyoga has a relatively low yield.

(4) Water Quality Distribution (TDS)

A distribution map of Total Dissolved Solid (TDS) is shown as a water quality map in Figure 2-16. TDS is a good indicator of the comprehensive water quality including salinity and iron content. Surroundings of Lake Kyoga, especially the Apac district, Amolatar district, and Kaliro district shows a high value in TDS, which indicates high salinity in the ground water.

Figure 2-18 shows a typical trilinear diagram obtained from the water analysis performed in this survey. The key diagram in the middle of the figure is divided into four areas as:

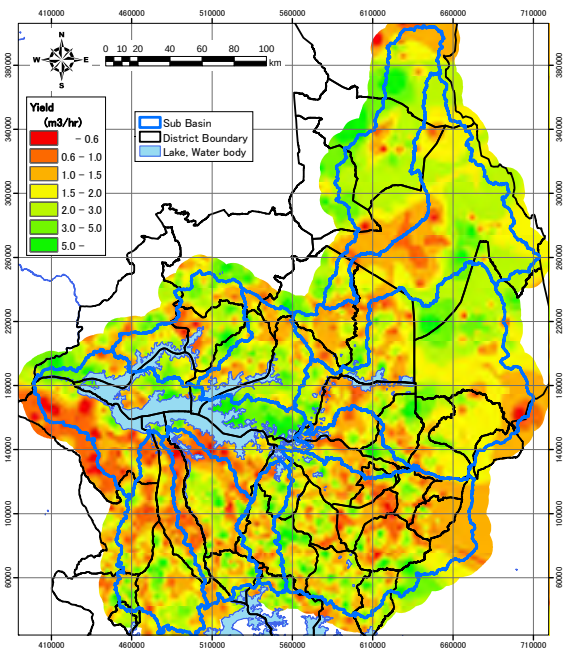


Figure 2-17 Well Yield Distribution

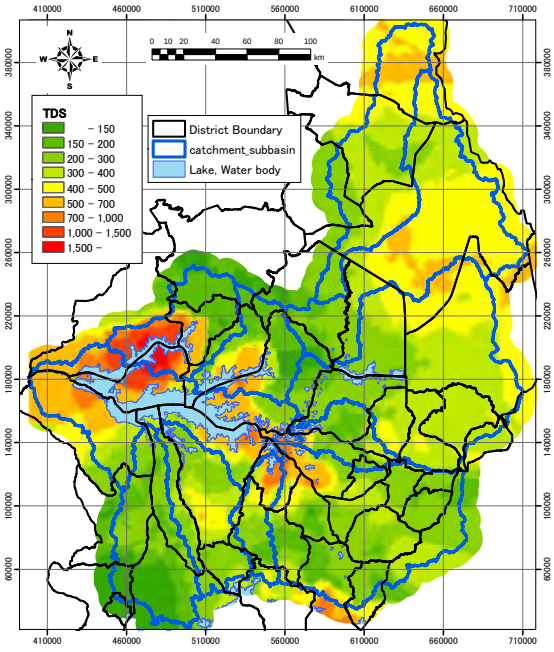


Figure 2-16 TDS Distribution

I. Ca (HCO_3) type: river water and shallow groundwater

II. $NaHCO_3$ type: freshwater of artesian groundwater

III. $CaSO_4$, CaCl type:

IV. Na_2SO_4, NaCl type: seawater, fossil water, hot spring, mine water

Since most of spring, shallow and deep groundwater obtained in this survey is plotted within I and II, their origin of water seems to be surface water or shallow groundwater. (refer to the supporting report for more detail information)

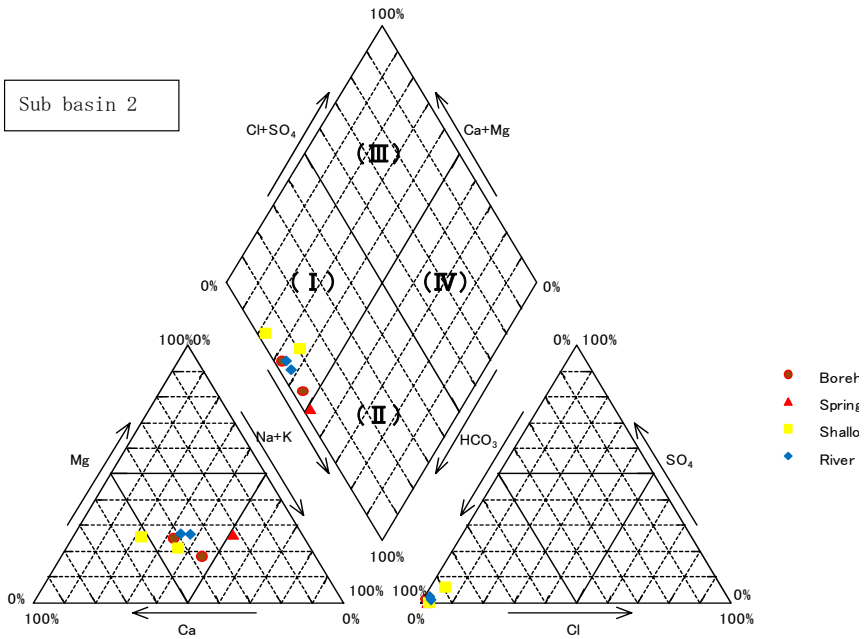


Figure 2-18 Piper Diagram (Okere Sub-Basin)

2.5.3 Direction of Groundwater Flow

Groundwater flow can be estimated by drawing curves perpendicular to contours of the groundwater surface level. Figure 2-19 shows that most of the groundwater flow toward Lake Kyoga, but there are some exceptions with local water storage.

2.5.4 Hydrogeological Condition by Geological Unit

Geological properties of the gneissic, sedimentary, and gneissic-granitic areas in Pre-Cambrian, volcanic-rock areas in Tertiary, and sediments in Quaternary are described below.

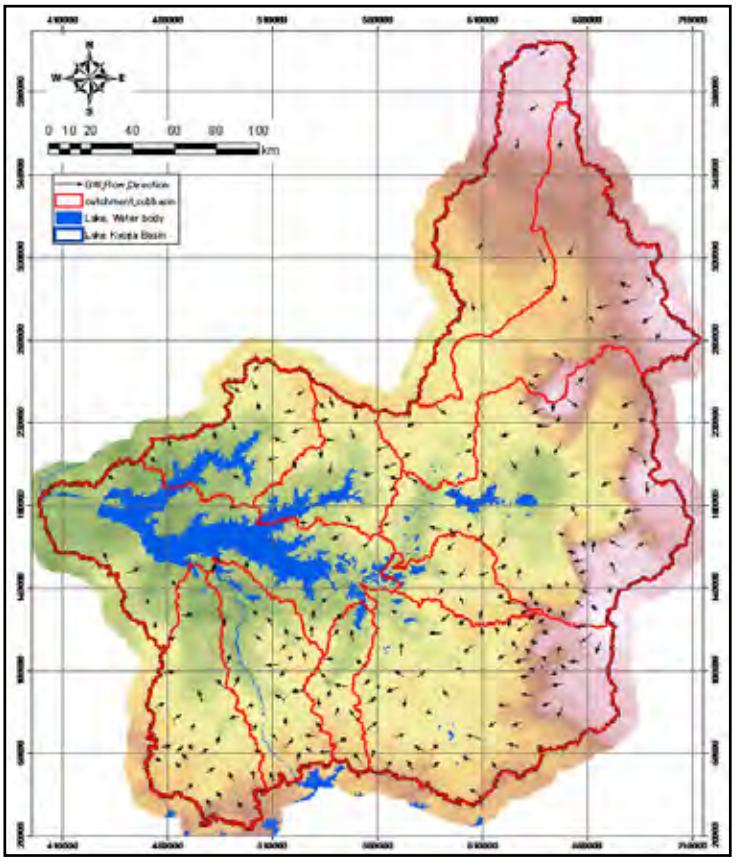


Figure 2-19 Direction of Groundwater

(1) Pre-Cambrian

The Pre-Cambrian in the Lake Kyoga Basin can be categorized into gneissic-granitic and sedimentary rock areas. The gneissic-granitic area occupies a very large area in the central basin. The sedimentary rock area corresponds to the Buganda-Toro System, Kyoga Series, and Karoo System in Paleozoic. It is distributed over the north shore of Lake Kyoga and small parts of the Mukono, Jinja, and Bugiri districts.

1) Gneissic-Granitic Rock Area

Granite is a coarse-grained igneous rock. Gneiss as a metamorphic rock has coarse grain and banded structure. The original rock seems to be granite in this area. Characteristically, granite or Gneiss is easy to be weathered and has many fractures near the surface. Weathered granite forms sandy state near surface. Clay mineral called “Kaoline” derives from weathered granite. The low land such as pocket or small basin accumulates the clay. Although the clay formulates aquiclude layer, this is good material for brick. Therefore, brick production area seems to be bad groundwater recharge.

Additionally, fractures occur not only vertical but also horizontal in granitic rocks. Many small

hills of granite called "Inselberg" with more resistant rock masses, which formed through weathering process, are observed in granitic area.

Groundwater in weathered zone, which can be regarded as stratum water, and fissure water in fissure zone are expected in the granite area. However, both of these aquifers are different from ordinary aquifer in stratum like sand or gravel layer. It is more complex structures. Therefore, thickness of the weathered layer or the place which has much more fissures has to be investigated for groundwater development.

2) Sedimentary Rock Area

Although these rocks are sedimentary rocks, these were formulated in Pre-Cambrian. Since they have very high consolidation and cementation, it is not expected that the pore zone in the rock has water. Therefore, fissure water is expected in the bedrock as the same as granitic rock. However, if the weathered zone is relatively thick, deep groundwater is expected around the lower part of weathered zone and the upper part of bedrock.

(2) Volcanic Rocks in Tertiary

The areas distributing volcanic rocks are eastern part of Lake Kyoga Basin, Kapchorwa district, Sironko district. Water level is very deep, and it is difficult to apply geophysical survey. Development of spring is suitable in this area. If protection facility for taking the spring water will be constructed, it can be avoid the contamination by constructing protection at the place where the spring is flowing out from rock or confined water is coming up directly.

(3) Sediments in Quaternary

Sands and gravels layer in alluvium are very suitable layer for taking shallow groundwater. In Lake Kyoga Basin, especially around Lake Kyoga, alluvium area becomes swamp in rainy season, and it is difficult to develop groundwater in such an area. However, Karamoja area is higher than wetland around Lake Kyoga, and much alluvium area along rivers. It is reasonable to develop shallow groundwater in Karamoja area.