JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE MINISTRY OF NATURAL RESOURCES,
THE GOVERNMENT OF THE REPUBLIC OF UGANDA

THE STUDY ON RURAL WATER SUPPLY IN MPIGI, MUBENDE AND KIBOGA DISTRICTS IN THE REPUBLIC OF UGANDA

FINAL REPORT

VOLUME ONE: MAIN REPORT

SEPTEMBER, 1996

SANYU CONSULTANTS INC., JAPAN

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(as of February, 1996)

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UShs. 1.00 = US$ 0.001

UShs. = Uganda Shillings

PREFACE

In response to a request from the Government of the Republic of Uganda, the Government of Japan decided to conduct a Study on Rural Water Supply in Mpigi, Mubende and Kiboga Districts in the Republic of Uganda and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team headed by Mr. Mitsuru Yoshikawa, Sanyu Consultants Inc. Japan, to Uganda two times between September 1995 to June 1996.

The team held discussions with the officers concerned of the Government of the Republic of Uganda and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I do hope this report will contribute to the promotion of the project and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officers concerned of the Government of the Republic of Uganda for their close cooperation extended to the study team.

September, 1996

Kimio FUJITA
President,
Japan International Cooperation Agency

September 3, 1996

Mr. Kimio FUJITA
President,
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to submit hereby the final report on the Study on *Rural Water Supply in Mpigi, Mubende and Kiboga Districts in the Republic of Uganda*. This report incorporates the advise and suggestions of the authorities concerned of the Government of Japan and your good Agency as well as the formulation of above-mentioned project. Also included are comments made by the Directorate of Water Development, the Ministry of Natural Resources of the Government of the Republic of Uganda during discussions which were held in Kampala.

The study had been carried out to cover the rural water supply sector in 282 communities with 225 thousand population in three target districts of Mpigi, Mubende and Kiboga. Based on the study, the target communities would be covered by deep boreholes equipped with handpump and other types of water supply facility.

The report consists of three volumes, namely Volume One; Main Report inclusive of Executive Summary, Volume Two; Supporting Report and Volume Three; Appendices.

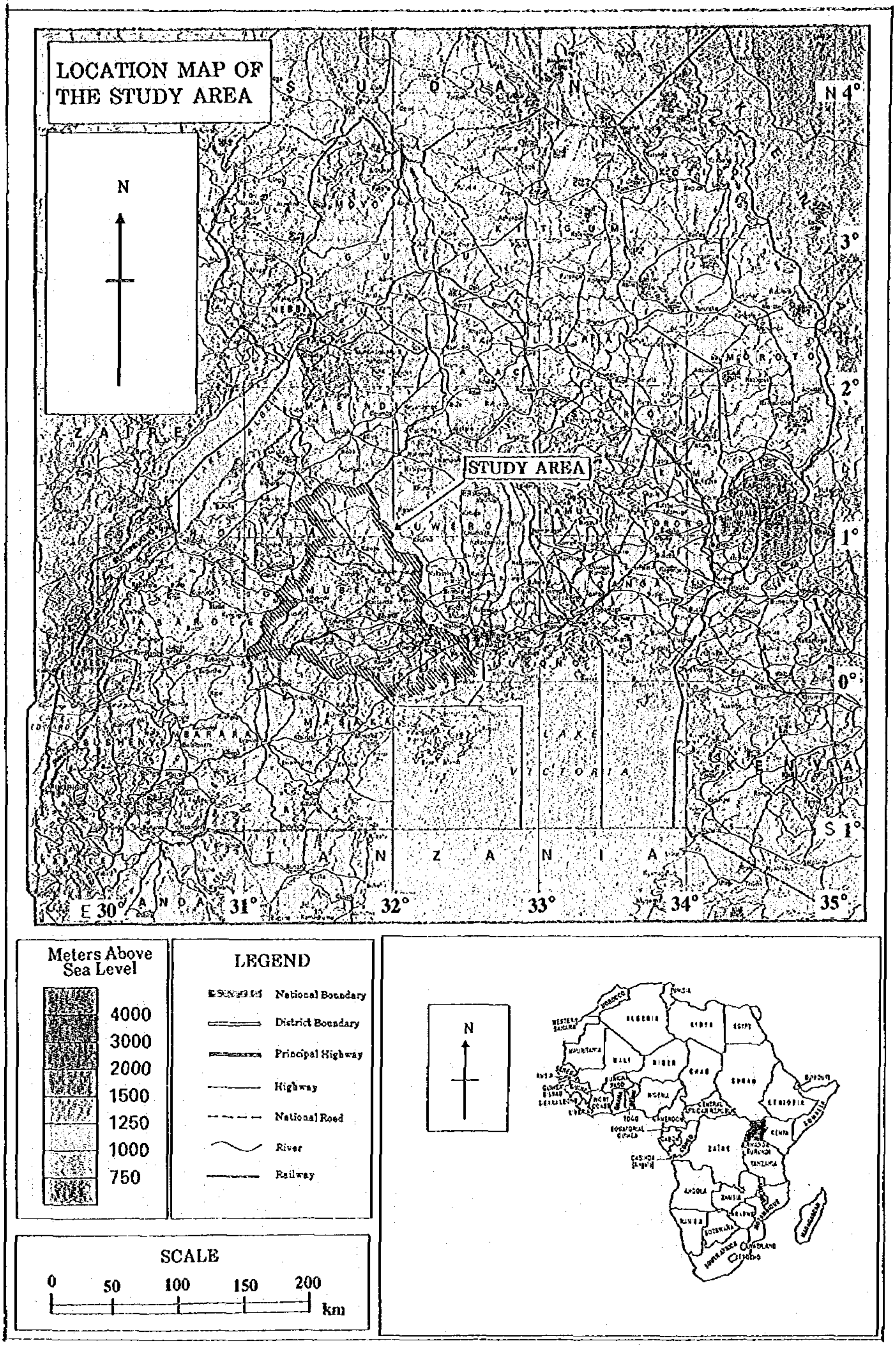
We wish to take this opportunity to express our sincere gratitude to the related officers of your good Agency and the Ministry of Foreign Affairs of the Government of Japan for their effective advise and suggestions for the study. We would also like to express our deep appreciation to the relevant officers of the Directorate of Water Development, other related agencies of the Government of the Republic of

Uganda and others, who are listed in Appendix-2 of Volume One of the Report, for their close cooperation and warm assistance extended to the Study Team during its works in Uganda.

Very Truly Yours,

吉川 満

Mitsuru YOSHIKAWA
Team Leader,
Study on the Rural Water Supply
in Mpigi, Mubende and Kiboga
Districts in Uganda


LOCATION MAP OF THE STUDY AREA
N
STUDY AREA
S U D A N
Z A I R E
K E N Y A
T A N Z A N I A
LAKE VICTORIA
N 4°
3°
2°
1°
0°
S 1°
E 30°
31°
32°
33°
34°
35°
Meters Above Sea Level
4000
3000
2000
1500
1250
1000
750
LEGEND
National Boundary
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Principal Highway
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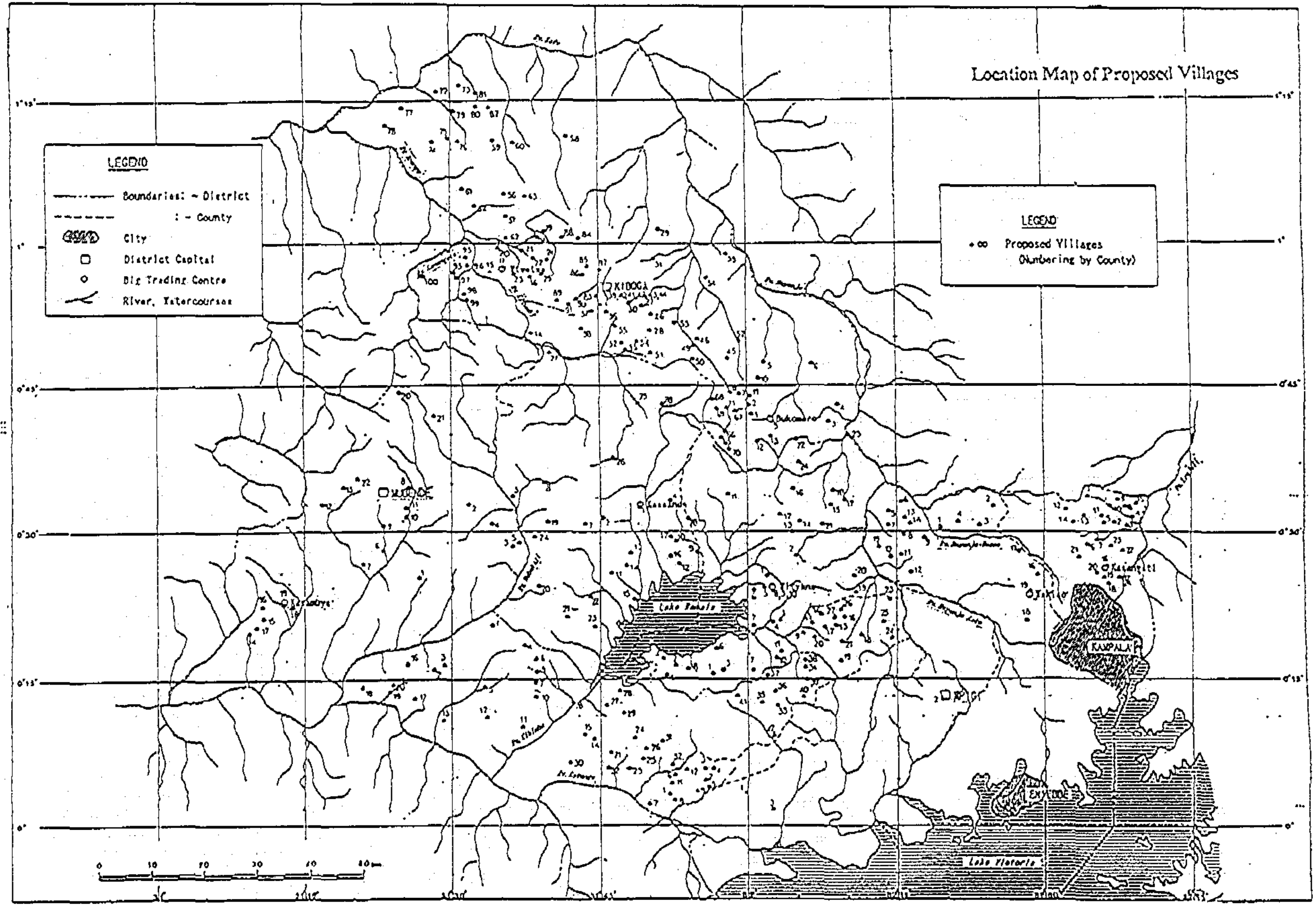
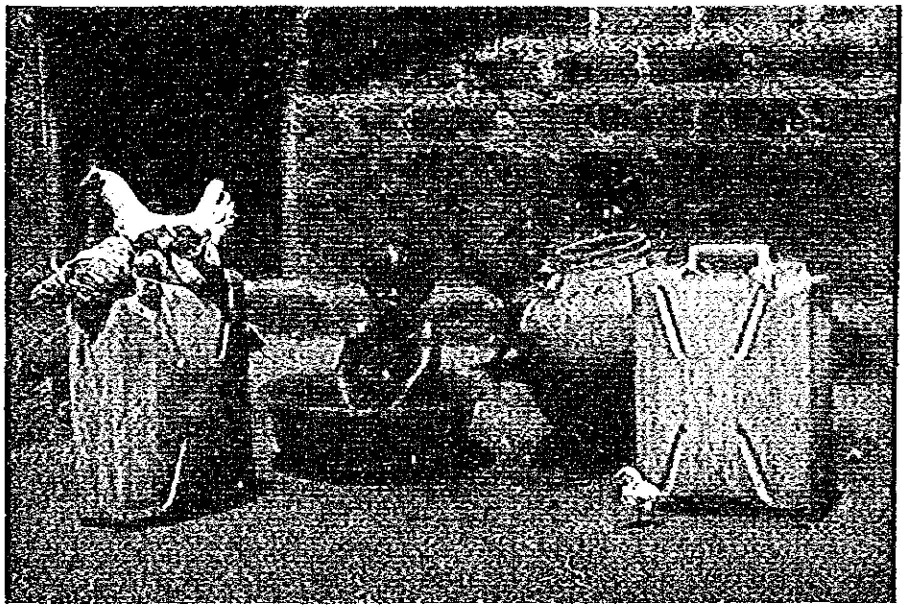
Location Map of Proposed Villages



Photographs of the Study Area



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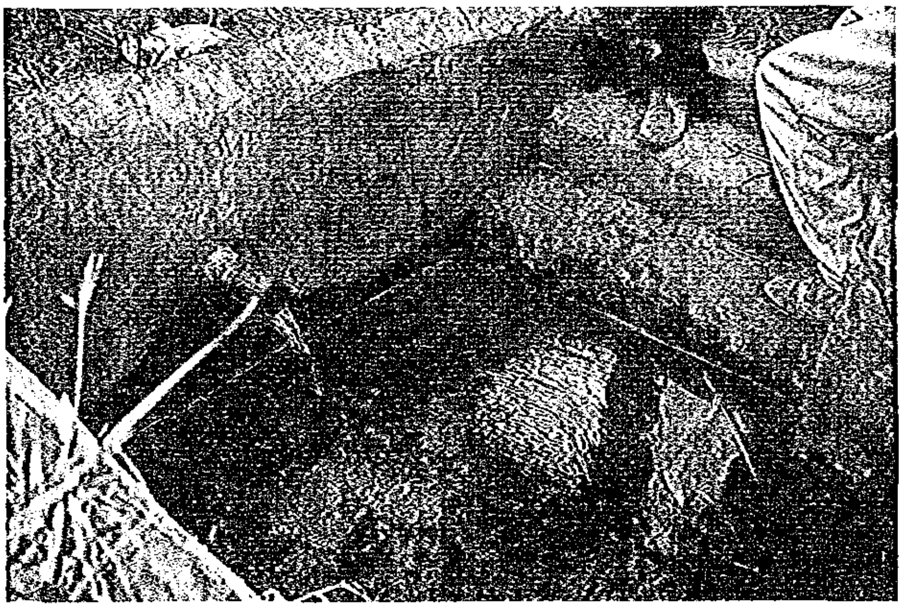
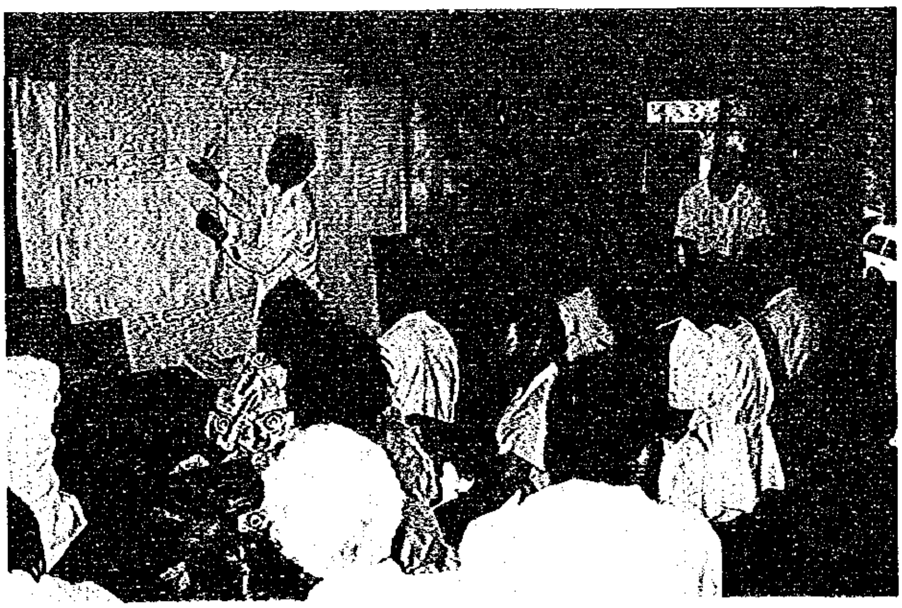


Protected Spring
at *Ssinde* (High Iron
Content)

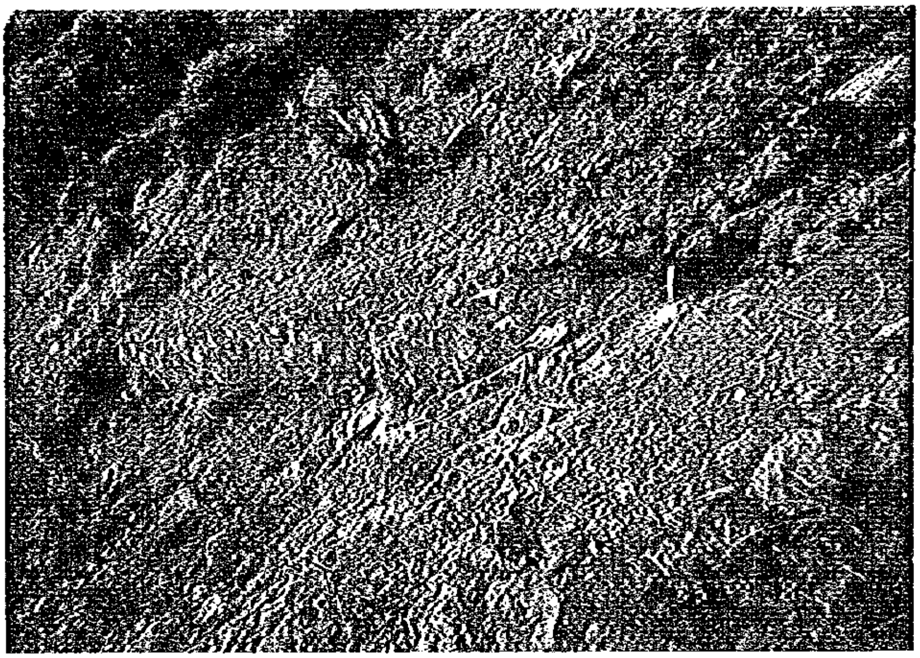


Village Training
Intervention

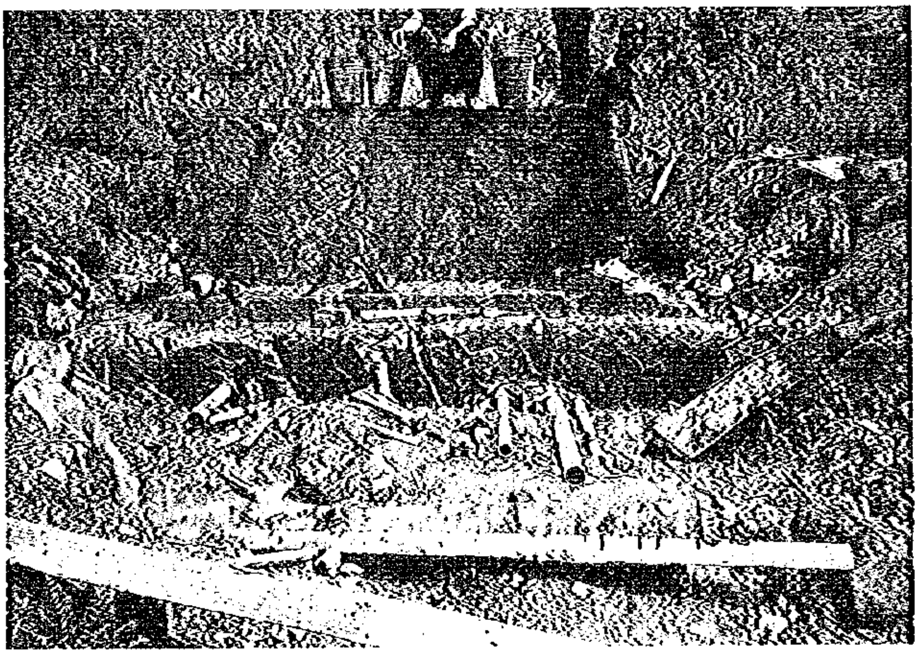
Borehole with a Handpump

Valley Dam

Handpump by Valley Dam



Spring (Source of Gravity Fed Scheme) Lukalu, Kiboga District



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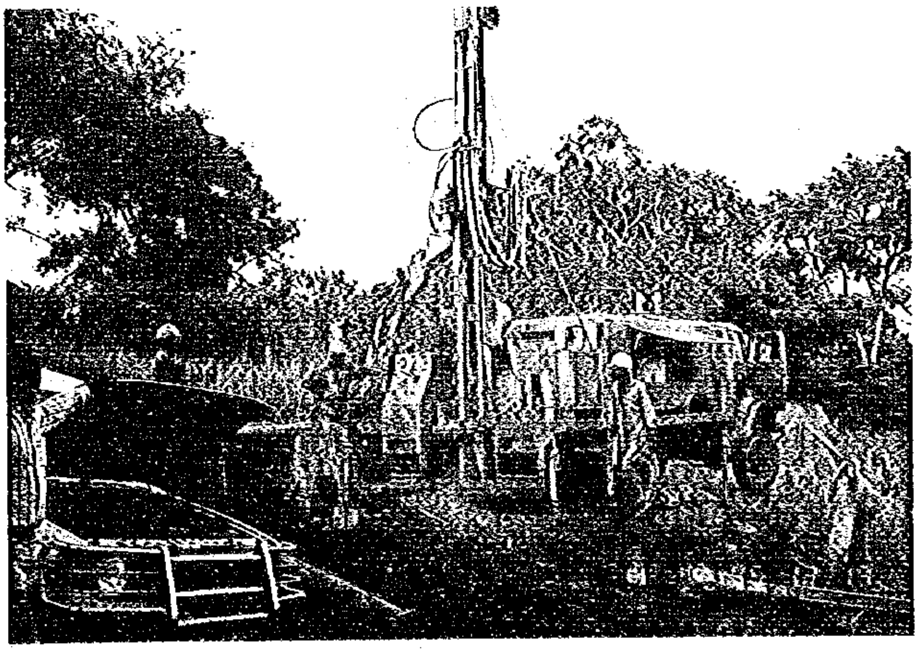

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ABBREVIATIONS

AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
ARI	Acute Respiratory Infections
AVSI	Associazione Volontari per il Servizio Internazionale (International Service Volunteer's Association, NGO, Italy)
BH	Borehole
BMS	Borehole Maintenance Supervisor
BMU	Borehole Maintenance Unit
CAO	Chief Administrative Officer (former DES), civil servant coordinating all civil service activities at the District level.
CBHC	Community Based Health Care
CBMS	Community Based Maintenance System
CDA	Community Development Assistant
CDD	Control of Diarrhoeal Diseases
CDO	Community Development Officer
CHW	Community Health Care Worker
CIDA	Canadian International Development Agency
CMR	Child Mortality Rate
DA	District Administrator, personal representative of the President at the District
DANIDA	Danish International Development Agency
DCDO	District Community Development Officer
DHE	District Health Educator
DHI	District Health Inspector
DHT	District Health Team
DHV	District Health Visitor
DMO	District Medical Officer
DWD	Directorate of Water Development, MNR (former WDD)
DWO	District Water Officer
E.C.	Electric Conductivity
EIRR	Economic Internal Rate of Return
EM	Electro-Magnetic
ERP	*Economic Recovery Programme* (1987/88 - 1992/93)
EU	European Union
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GOJ	Government of Japan
GOU	Government of the Republic of Uganda
HA	Health Assistant
HH	Household
HIV	Human Immuno-deficiency Virus
HP	Hanpump

HPM	Handpump Mechanic
HQ	Headquarters
HU	Health Unit
IDA	Internation Development Association
IMR	Infant Mortality Rate
JICA	Japan Internation Cooperation Agency
LC	Local Council (former RC)
MFEP	Ministry of Finance and Economic Planning
MGCD	Ministry of Gender and Community Development (former MWIDYC)
MMR	Maternal Mortality Rate
MNR	Ministry of National Resources
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGO	Non-Governmental Organization
NRM	National Resistance Movement
O&M	Operation and Maintenance
PHC	Primary Health Care
PROWWESS	Promotion of the Role of Women in Water Supply and Sanitation
PV	Present Value
RDP	Rehabilitation and Development Plan
RUWASA	Rural Water and Sanitation, Eastern Uganda Project by DANIDA
RWP	National Rural Water Supply Programme
S/C	Sub-County
S/W	Scope of Work
SCF	Standard Conversion Factor
SIDA	Swedish International Development Authority
SWIP	South West Integrated Health and Water Project, UNICEF (1990 - 95)
TB	Tuberculosis
TDEM	Time Domain Electro Magnetic
TFR	Total Fertility Rate
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNPAC	Uganda National Programme of Action for Children
US$	U.S. Dollars
UShs	Uganda Shillings
VDC	Village Development Committee
VIP	Ventilated Improved Pit latrine
VWC	Village Water Committee

WAP	Water Action Plan for Water Resources Development and Management
WATSAN	National Water Supply and Sanitation Programme, UNICEF
WES	Water and Environmental Sanitation Programme, UNICEF
WES	Water Supply and Environmental Sanitation
WID	Women in Development
WUC	Water User's Committee
WVI	World Vision International (American-based NGO)

GLOSSARIES

mm	:	millimetre(s)
cm	:	centimetre(s)
m	:	metre(s)
km	:	kilometre(s)
mm^2 or sq.mm	:	square millimetre(s)
cm^2 or sq.cm	:	square centimetre(s)
m^2 or sq.m	:	square metre(s)
km^2 or sq.km	:	square kilometre(s)
l	:	litre(s)
lcd	:	litre(s) per capita per day
mm^3 or cu.mm	:	cubic millimetre(s)
cm^3 or cu.cm	:	cubic centimetre(s)
m^3 or cu.m	:	cubic metre(s)
km^3 or cu.km	:	cubic kilometre(s)
MCM	:	million cubic metre(s)
mg	:	milligramme(s)
g	:	gramme(s)
kg	:	kilogramme(s)
t or mt	:	metric tonne(s)
sec or s	:	second(s)
min	:	minute(s)
hr	:	hour(s)
day	:	day(s)
a or yr	:	annum or year
EC	:	electric conductivity (of water)
µS/cm	:	micro Siemens per centimetre; unit of EC
ohm	:	unit of electric resistivity

CHAPTER ONE : INTRODUCTION

1.1. Background

The coverage of water supply in the Republic of Uganda (hereinafter referred to as "Uganda") as of 1993 is 50 % in the urban area inclusive of Kampala, the capital of Uganda, and 33 % in the rural area.

In the Rehabilitation and Development Plan (1993/94-1995/96), the Government of the Republic of Uganda (GOU) set forth the strengthening of rural water supply as one of the major targets.

The GOU formulated the National Rural Water Supply Program in 1991. The program aims to achieve the supply of safe water to 75% of rural population and to decrease the water-borne diseases by the year 2000. The program has been implemented under the GOU's policy to realise the supply of water of 20 litres per capita per day (lcd) based on the self-reliance at rural community level.

The GOU has implemented the programme with the cooperation by UNICEF, DANIDA and other international agencies / NGOs to cover 38 districts except Kampala District in Uganda. But the achievement is now far below the target.

Under the said circumstances, GOU requested, in 1994, to the Government of Japan (GOJ) to extend its technical cooperation to the project study on rural water supply in Mpigi, Mubende and Kiboga Districts.

In response to the request, the Government of Japan dispatched, through Japan International Cooperation Agency, the official agency to implement the technical cooperation program of the Government of Japan (hereinafter referred to as "JICA"), preparatory study teams to Uganda to identify the facts and discuss the scope of work on the "Study on Rural Water Supply in Mpigi, Mubende and Kiboga Districts in the Republic of Uganda" (hereinafter referred to as "the Study") with the relevant agencies of the Government of Uganda. Both sides agreed on the scope of work of the Study (hereinafter referred to as "S/W", refer to Appendix 1.2.(1) in Volume Three of the Report) in April, 1995.

Based on the S/W, JICA organised the Study Team led by Mr. M. Yoshikawa and composed of experts of Sanyu Consultants Inc., Japan (refer to Appendix 1.1 in Volume Three of the Report); and dispatched the Team to Uganda to implement the Study in September 1995.

1.2. The Study

1.2.1. Objectives

The objectives of the Study are;

(1) to evaluate potential of water resources in the Study Area focusing on groundwater,
(2) to formulate sustainable water supply plan (mainly using groundwater) for 300 villages including six trading centres to the year 2005; and
(3) to pursue technology transfer to counterpart personnel in the course of the Study.

1.2.2. The Study Area

The Study is to cover Mpigi, Mubende and Kiboga Districts (refer to the "Location Map of the Study Area" attached).

1.2.3. Scope of the Study

The scope of the Study stipulated in the S/W are outlined as below:

(1) **Stage One: "Basic Study"**

a) Collection and analysis of the existing data and information,
b) Preliminary survey on the actual conditions of water resources,
c) Survey on village/trading centre inventory and the actual conditions of water supply,
d) Survey on the institutional aspects,
e) Evaluation of present conditions and identification of problems; and
f) Identification of potential areas for groundwater development and plan of detailed field survey.

(2) **Stage Two: "Detailed Study"**

a) Detailed Survey in the potential areas,
b) Pilot study on the community development and hygiene education; and evaluation of its effectiveness,

c) Analysis and evaluation of potential of groundwater and other water resources,
d) Water demand projection; and
e) *Classification of villages/trading centres by size, potential water source, easiness of* community development and other factors.

(3) Stage Three: "Formulation of Water Supply Plan"

a) Formulation of basic policies and strategies of water supply plans,
b) Water supply plan for each type of villages/trading centres,
c) Plan for community development and dissemination of hygiene education,
d) Guideline for providing sanitation facilities,
e) Operation and maintenance plan,
f) Monitoring plan of groundwater level and water quality,
g) Cost estimation and financial management plan,
h) Evaluation; and
i) Formulation of implementation program.

1.2.4. Work Flow of the Study

The Study was carried out in two steps and three stages. The flow of works in each stages is illustrated in Figure 1.1; and details are presented as below:

(1) Preparatory Works;

[1] Review of Existing Data and Information,
[2] Formulation of Plan of Operation; and
[3] Preparation of Inception Report.

(2) Stage One: Basic Study;

[4] Explanation and discussion on the inception report,
[5] Collection and review of existing data and information related to the Study,
[6] Study on institution and financial aspects,
[7] Hydrogeological survey,
[8] Meteo-hydrological survey,
[9] Geophysical soundings,
[10] Hydrochemical survey,
[11] Village inventory survey,
[12] Inventory survey on water supply facilities,

[13] Preparation of village inventory,

[14] Identification and evaluation of existing situation,

[15] Provisional evaluation of groundwater potential and selection of priority villages for further pilot study,

[16] Initial environmental examination,

[17] Formulation of guideline for pilot study; and

[18] Preparation and discussion on progress report.

(3) **Stage Two: Detailed Survey;**

[19] Geophysical sounding for priority villages,

[20] Test drilling,

[21] Test construction of borehole facilities,

[22] Pilot study,

[23] Supplemental survey for alternative water resources,

[24] Survey on environmental aspect,

[25] Classification of communities by type and evaluation of existing situation,

[26] Evaluation of water balance,

[27] Synthetic analysis of hydrogeology,

[28] Evaluation of groundwater potential,

[29] Design of planning components,

[30] Formulation of basic strategy for project planning,

[31] Preparation and discussion of interim report,

[32] Formulation of groundwater development plan,

[33] Plan formulation of facility and equipment,

[34] Examination of alternative water sources,

[35] Plan formulation of hygiene education,

[36] Formulation of guideline for sanitary facility,

[37] Plan formulation of operation and maintenance,

[38] Plan formulation on institutional strengthening,

[39] Plan formulation of groundwater monitoring,

[40] Estimate of project cost,

[41] Plan formulation of financial management,

[42] Financial evaluation,

[43] Institutional evaluation,

[44] Technical evaluation,

[45] Socio-economic evaluation,

[46] Environmental impact assessment,

[47] Synthetic project evaluation,

[48] Project packaging and prioritisation,

[49] Plan formulation of project implementation; and

[50] Preparation of draft final report.

(4) Reporting

[51] Explanation and discussion on draft final report,

[52] Workshop on strategy of improved project management; and

[53] Submission of final report.

The minutes of discussion on reports made by and between the Study Team and Directorate of Water Development (DWD) are as shown in Appendix 1.2.(2) to (4) in Volume Three of the Report.

CHAPTER TWO : UGANDA IN OVERVIEW

2.1. The Nation

2.1.1. Administrative Set-up

The Republic of Uganda is under the resistance council system at present to achieve democratic decentralization. This policy of democratic decentralization was conceived in the first half of 1980's when the National Resistance Movement (NRM) was in the bush.

Under the decentralization policy, Uganda sets two major sectors in the government system, namely the central and local governments.

The central government (GOU) is composed of the president, the vice president, the prime minister, three vice prime ministers and 19 ministers who are in charge of the Ministries of Finance and Economic Planning (MFEP), Natural Resources (MNR), Health (MOH), Local Government (MOLG), Gender and Community Development (MGCD) and others.

The present system of democratic decentralization started in 1986 with establishment of the resistance councils and resistance committees (now called as local councils, LC). Since then the Government has taken actions to develop institutions and procedures which allow for autonomous decision making by local councils. Accordingly, the Local Government Statute, 1993 is a refinement of the policy of decentralization since 1986 and a result of the desire to make local governments effective centres of local decision making, planning and development.

Uganda is divided into 39 Districts under four Regions. In rural areas, each District (LC5) consists of several Counties (LC4), and each County is composed of Sub-Counties (LC3). Under a Sub-County, there furthermore are other local communities domestically called as Parish (LC2). Villages, the smallest administration unit (LC1), are under the Parish.

2.1.2. *Administrative and Governmental Situations*

The establishment of the Republic of Uganda is the Resistance Council system at present for achieving democratic decentralization. This policy of democratic decentralization was conceived in the first half of 1980's when the NRM was in the bush.

The present system of democratic decentralization started in 1986 with establishment of the now familiar Resistance Councils and Resistance Committees. Since then the Government has taken action to develop institutions and procedures which allow for autonomous decision making by local councils. Accordingly, the Local Government Statute, 1993 is a refinement of the policy of decentralization since 1986 and as a result of the desire to make local governments effective centres of local decision making, planning and development.

2.2. Socioeconomy

2.2.1. Population and Household

In these 26 years, population censuses of Uganda were conducted in 1969, 1980 and 1991. The 1980 population amounted 12,636 thousand on the increase by 3,101 thousand against 1969 population with an average annual growth rate of 2.59 %, and the 1991 population amounted 16,672 thousand on the increase by 4,036 thousand against the 1980 population with the average annual growth rate of also 2.55 %. The average annual growth rate during the period 1969 - 1991 showed 2.57 %.

On the other hand, a statistical data[1] reported a population projection. According to this data, the population as of 1995 was projected as 19,263 thousand.

The dependency ratio is high, as nearly half (about 9.6 million) as of 1995, the population is below 15 years of age. The life expectancy is 50.5 years for female and 45.7 years for male.

2.2.2. Ethnic Group

Uganda has over thirty ethnic communities, which can be divided into five (5) broad linguistic categories, namely the Bantu, the Atekerin, the Luo, the Highland Nilotics and others called as the Madi-Moru group.

The Bantu, which contributes to 50% or more of the population occupies the eastern, southern and western parts of the country. They are the earliest group to come to Uganda.

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[1] Background to the Budget 1995 - 1996 -Economic Performance 1994-1995 and Medium Term Strategy 1995/96 - 1997/98-, Ministry of Finance and Economic Planning.

The second group is the Atekerin, referred as the Para-Nilotics, the Lango or the Nilo-Hamites, which through migrations from Ethiopia, came to settle in the northern, the eastern and the north-eastern parts of Uganda.

The third group is the Luo, which originates from southern Sudan. They are found in the West Nile area and the northern and the eastern parts of Uganda.

The fourth group is the Highland Nilotics. This group of people is mainly concentrated in Kenya with the Kalenjin as the largest group. In Uganda, only the Sebei belongs to this group, which inhabit the present Kapchorwa District.

The last group is the Sudanic speakers of West Nile called as the Madi-Moru group.

2.2.3. Gross Domestic Product

In 1994, Gross Domestic Product (GDP) of Uganda grew to UShs. 4,776 billion at current market price at an average annual growth rate of 55.73 % for the period 1987 - 1994, while the real annual growth rate was 5.98 % on average during the same period.

Per capita GDP at current market price amounted to UShs. 255,657 in 1994 at the average annual growth rate of 51.35 % since 1987, and the real growth rate was 3.00 % for the period from 1987 to 1994. As seen in the above figures (5.98% vs. 3.00%), the growth rate of per capita GDP is showing a low rate compared with that of the total GDP. This was due mainly to a high growth in population.

2.2.4. Import and Export

Non-oil private imports increased by 57.4 % from US$450.2 million in 1993/94 to US$708.9 million in 1994/95. While the increment in non-oil private imports has been attributed to the coffee boom which has been much stronger during fiscal year 1994/95 as compared to 1993/94, the 57.4 % increment in private imports, in absolute terms, was less than for 1993/94, when the same imports increased by nearly 60.0 %. As a percentage of GDP, non-oil private imports increased from 11.9 % in 1993/94 to 13.4 % in 1994/95. The oil import bill increased by 22.3 % in 1994/95 as compared to a decline of 4.6 % in 1993/94.

In these two (2) years of 1993 and 1994, exports of merchandise goods increased by a large percentage comparing to those during the period 1987 - 1992. The amount of exports' value grew to US$402 million in 1994/95 from US$172 million. This good performance of exports' sector is mainly due to the dramatic improvement in terms of trade of coffee in the last two (2) years. Initially, the coffee price increased by 42 % (from US$0.80 per kg to US$1.14 per kg) between 1992/93 and 1993/94, and nearly tripled to US$3.20 per kg in mid-1994 due to the frost which hit the Brazilian coffee crop. This significantly reduced the supply of coffee on the international market.

Among the imported goods during these 14 years since 1981, the commodity group of machinery and transport equipment had the highest share rate. Especially, electrical machinery was constantly increased with 18.4 % of average annual growth rate, while the import amount of transport equipment was nearly flat with some fluctuation in some years.

Among the exported goods during the same period, the commodity group of food and live animals which were led by coffee export was the highest one through the period.

2.2.5. Industry

The agricultural industry contributes to the GDP about 25 % in monetary sector (when included the non-monetary sector, it contributes from 55 % to 60 % to the total GDP in Uganda) in every year since 1987. It means that the agricultural sector is the largest industry in Uganda.

There are several manufacturing commodity group in industrial sector in Uganda as food processing, tobacco and beverages, textiles and clothing, leather and footwear, timber, paper and printing, chemical, paint and soap, bricks and cement, steel and steel products, and vehicle accessories, plastic products, electrical products, etc. as miscellaneous commodity group.

The industrial sector, as measured by the index of industrial production, rose by 14.6 % annually from the base year of 1987 (=100.0) to 260.3 in 1994. The items which have shown strong growth include drinks and tobacco, chemicals, paint, soup, and steel products.

Production volume of almost of commodities except jerrycans were far from their installed capacity to produce. But, plastic jerrycans have a small room for more production considering their 41 % of the average annual growth rate. The jerrycans have a lot of ways to use for carrying liquid, especially for potable water in Uganda.

2.2.6. Consumer Price

According to statistic data, almost of whole country has an increasing ratio of price as about 22 % for the period from 1990 to 1994.

The highest increasing rates are that for sectors of food, beverage and tobacco, rent, fuel and utilities, transport and communication, and other goods and services.

Fluctuation range of Uganda's Shilling (UShs) currency was not so much wide during these three (3) years against US Dollar currency. Against US Dollar, UShs currency has appreciated gradually since the end of 1992 to March 1995 with a rate of around 1.0 %.

However, between December 1993 and December 1994, the UShs currency (weighted bureau average) appreciated by 21.4 % and this was on top of an appreciation that had occurred when the interbank market was established on November 1993. The interbank mid-rate appreciated by 18.9 % in the same period.

2.2.7. Education

Women in Uganda are impoverished and there are a large gender gap in education. The adult literacy rate is 48 % in males, but only 35 % in females. The total primary school enrollment was 56 % in 1980 but 47 % of these was girls (International Development Association (IDA), 1987). Today, it is about 70 %, 63 % of girls. The primary school attendance has increased, but drop out rate is high, especially for girls. Only 48 % of girls, but 72 % of boys enrolled in the primary school, graduate from P7 grade (MFEP, 1989).

About 12 % of children enrolled in the primary school enter into the secondary school. Only about 20 % of students graduating from the secondary school are female and only about 16 % of people with higher education are females.

2.2.8. Morbidity and Mortality

Leading causes of morbidity[2] are malaria, Acute Respiratory Infections (ARI), intestinal worms, diarrhoeal disease and trauma. The leading causes of mortality[3] are malaria, diarrhoeal diseases, HIV/AIDS, ARI and nutritional deficiencies. Most of this morbidity and mortality are preventable.

The HIV/AIDS pandemic has been spreading rapidly during the years of political instability. The HIV/AIDS epidemic is likely to have a major impact on the socioeconomy of Uganda, as a large segment of the population becomes infected in the early "productive age" (15 to 45 years of age), to suffer from severe and costly morbidity before dying young. The exact impact of the HIV pandemic on demography and socioeconomy in Uganda is, however, hard to estimate, due to the poor reliability[4] of data-collection on morbidity and mortality from HIV/AIDS. The sero-prevalence of HIV in Uganda is estimated to be high especially in urban areas (25% in Kampala) and among young women (15 to 20 years) of child bearing age. Almost six times as many females as males have HIV in the age group from 15 to 19 years, compared to only two times as many females as males in the age group from 20 to 24 years of age.

2.3. Natural Environment

2.3.1. Geography and Geomorphology

Uganda is a landlocked country which is surrounded by Sudan to the north, Kenya to the east, Zaire to the west and Rwanda and Tanzania to the south. The country has rectangular features and is located between lat. 1°28'S and 4°15'N and long. 29°34'E and 35°00'E. The average axis is approximately 470 km east-west and 530 km in the rest with the total area of 236,000 km^2.

Uganda's topographical features have a close relationship as the results of mountain-building movement in Cambrian time and rift movement formed the Western Rift Valley after late-Cretaceous. The latest stages of formation of the Rift gave rise to renewed

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[2] Out-patient data from health facility statistics (1988), MOH, 1992.

[3] In-patient data from health facility statistics (1988), MOH, 1992.

[4] Poor reliability mainly due to poor surveillance with use of health facility statistics, suffering from under-reporting, diagnostic bias and others.

volcanic activity and a general sag in the center of the country which produced the Lake Kyoga drowned valley system and Lake Victoria.

The plateau, which forms the major landscape element of the country occupies about 85 % of the land area, is directory underlain by gneisses and granitized rocks of Precambrian, and is mainly flat northern part of the country but produce hilly terrain in the peripheral parts of the country: in the south and south-west the generally less-metamorphose Precambrian formations give rise to a more incised topography. The surfaces of the plateau are remnants of an old dissected peneplain and three altitude levels of the surface have been identified.

These surfaces are of some importance to the occurrence of groundwater in weathered or fractured zones in Precambrian aquifers.

The sedimentary infill of the Western Rift Valley floor produces a low relief which is diversified in the south by the Pleistocene lava and ash crater fields. In the east the country is dominated by Miocene volcanoes in various stages of erosion.

Most of Uganda lies within the upper part of the White Nile basin, which consists of seven major catchment. About 17 % of Uganda is covered by lakes and swamps. The present drainage pattern is largely the result of upwarping and faulting along the Rift. This caused a reversal of flow in many of the originally westward-flowing rivers as wells impeding the flow of rivers draining the plateau to form extensive swamp areas and lakes.

2.3.2. Meteorology, Hydrology and Water Resources

(1) Meteorology

Most of Uganda has fairly well-marked wet and dry seasons related to the movement of the sun across the equator and the influence of South-East and North-East Monsoons which tend to move with the sun.

The mean annual rainfall ranges from more than 1,600 mm along the coastal line of Lake Victoria to less than 500 mm in the north-eastern part.

Rainfall of about 1,200 to 1,500 mm occurs in the northern area of Lake Victoria and along the western boundary of Uganda. The Lake Victoria zone is characterized by flat topped hills of uniform height, extensive swampy lakes and valleys. The central and eastern area of Mpigi District includes in this zone. The primary vegetation is short grass on the hill top and forests in the valley, giving way to papyrus swamps. The climate of this zone displays comparatively small seasonal variations of temperature, humidity and wind throughout the year. The western boundary zone is fairly described as a transition zone between the Zaire forest and Uganda savanna climates. The rainfall increases with height.

Rainfall in north-east zone (Karamoja) ranges from 400 to 1,000 mm/year, intense dry and hot season comes from November to March when the streams dry up.

The southern Lake Kyoga zone which includes Mubende and Kiboga District is hilly region, with flat topped hills in the southern parts and largely flat in northern parts. The rainfall ranges from 800 to 1,200 mm falling on 140 to 170 days per year.

The mean temperatures over the whole of Uganda show no great variation, apart from those of the mountainous districts of western area and around Mt. Elgon. The highest temperatures occur generally in February but occasionally in January or March, and the lowest temperature in July or August. In the south and in Karamoja the temperatures reach 32 to 35°C during the dry season and 27°C during rain season.

(2) Hydrology

The country's hydrology is dominated by the extensive lake system. The total surface area of Uganda and the proportions covered by open water and swamps are as follows (Atlas of Uganda, 1967):

-Land area of Uganda:	235,810 km^2	
-Area covered by open water:	36,278 km^2	(15%)
-Area covered by swamps:	5,183 km^2	(2.2%)

Most of southern part of the country drains into Lake Victoria from where it escapes over the Owen Fall Dam into the Victoria Nile and so by way of Lake Kyoga to Lake Albert; it then flows out of Lake Albert, as the Albert Nile, at the same end as it flows in. All of the country's rivers ultimately reach to the White Nile. Because of upwarping and faulting of the land surface, many of the perennial streams of the plateau clogged with swamps. The length of Victoria Nile in Uganda is 459 km.

(3) Water Resources

Surface water sources are used for urban water supply and hydropower.

Untreated surface water sources including artificial storage are used locally for domestic supply by rural people and more predominantly for livestock use. The potential for rural people usage is limited on account of development costs, if treatment is required. The most favorable sources are upland regions with high duration and volume, and treatment is generally not necessary. The economics of treated surface water for rural people becomes more acceptable in areas of high population density.

Groundwater represents the main source of domestic water supply for the rural people and is important for livestock use, particularly in the regions. Development is from springs or boreholes and dug wells.

2.3.3. Geology, Hydrogeology and Groundwater

(1) Geology

Geology of Uganda consists of Precambrian rocks distributed in the whole country, Karoo shales of Paleozoic in very limited area, volcanic rocks of Tertiary to late-Cretaceous in the western Rift Valley, and volcanic rocks distributed in western and eastern volcanic activity areas and sediments of Quaternary in the whole country.

Precambrian rocks are largely divided into three formations: cover formation, gneissose formation and mobilized and intrusive granites.

The gneissose formation called Gneiss Complex overlies the country extensively. The rocks is mainly composed of granitized and metamorphosed gneisses including elements of cover formation.

The cover formation is found widespread in the southern region including the study area. The formation is divided into eight formations and three of them are distributed in the study area: Mityana Series, Singo Series and Buganda-Toro System. Cover formation in the study area predominates in metamorphosed sedimentary rocks such as sandstone, conglomerates, schist, phyllite and quartzite. Mityana and Sigo Series are distributed in limited area, but Buganda-Toro System is extensively distributed. In the study area, schist, shale and phyllite predominate.

Intrusive granites are found in north-west region including the study area. These rocks are in general medium to coarse grained, and porphyritic granites occur in Mubende District.

The Mesozoic and Cenozoic rocks are composed chiefly of Rift Valley Sediments, volcanic formations and more recent alluvial overburdens and are affected by structural movement. Alluvial deposits are broadly distributed along valleys.

The major geological structures of Uganda was formed by orogenic fold and shear in Precambrian, rift movement of late-Cretaceous to Tertiary. By the rift movements the Western Rift Valley was formed and filled with sediments, 1,800m in places. The latest stage of the rift movements gave rise to renewed volcanic activity in the center of the country which produced the Lake Kyoga drowned valley system and Lake Victoria.

(2) Hydrogeology

Gneiss Complex is distributed over some 75% of the country and forms the principal source of groundwater supplies.

Cover Formation such as Mityana Series and Buganda-Toro System the depth of weathering extends to 100m deep in some places, and borehole success rate is low. The rocks, however, have opportunities to obtain water when fresh rock is encountered.

Tuffs and some agglomerates form very poor aquifers. The lavas of the Western Rift Valley are also considered to be a poor aquifer and often contain saline water.

Groundwater in the rocks occurs in weathered zone and fractures as local and discontinuous system. The occurrence of groundwater in the main water bearing horizon (less weathered zone and fissures) is rather variable but related in a general way to topography, that is, 27% of borehole unsuccessful rate in plane and 75% unsuccessful rate in watershed (World Bank - UNDP report, 1989).

(3) Groundwater

The main urban centers (Kampala, Jinja and Entebbe) and majority of the district centers obtain supplies from surface water sources. Borehole abstraction may be used to supplement these supplies. In the rural areas water supplies are obtained from natural sources, such as lakes or springs, valley dams, dug wells or shallow water holes, and boreholes. Some 10,000 boreholes have been drilled in the country. More than 90% are fitted with handpumps for rural water supplies. In the high rainfall areas around Lake Victoria and above 1,500m there are abundant sources of alternative supplies, and there is a low ratio of boreholes to population in such areas.

2.3.4. Soils, Land Use and Vegetation

(1) Soils

Red or yellowish sand to sandy clay loams, representing various stage of tropical weathering of the crystalline rocks, are found over the country. Kaolinite minerals form the clay of these soils. Black cotton soils are common in the broad valley of eastern Uganda and may restrict infiltration. Fine deposits in the swamp areas have a similar effect and may have high levels cation saturation. Locally, these can be saline, such as around Lake Kyoga, which can affect groundwater quality. Other more localized soil types contain abundant soluble salts, such as in the Western Rift Valley where there is high evaporation.

(2) Land Use

About 92%, or 180,000 km^2, of the land area is considered to be arable (Atlas of Uganda). The area of cultivation is about 67,000 km^2, the major crops being coffee and cotton. Livestock rearing is practiced, particularly in Karamoja. A large percentage of the land area, some 15% or 31,000 km^2, is allocated to forest and game reserves, mainly in the western part of the country.

(3) Vegetation

Grassland savanna occurs extensively over most of northern Uganda and a large part of the south-west. Forest savanna occurs in the higher rainfall area bordering Lake Victoria and dense forest is extensive in the mountainous areas. Seasonal and permanent swamp vegetation border the lakes and major rivers except in the drier northern part of the country.

2.4. Development Plans

Three nationwide development plans are now on-going in Uganda, namely (1) the Rehabilitation and Development Plan, (2) the Water Action Plan and (3) the National Planning Strategy - Rural Water Supply Programme. The former 2 plans present targets and/or policies for socioeconomic development and water resources management respectively, and the last one presents a guideline for making clear volume of works and necessary fund in case of implementation of water supply projects in district level. Hereinafter, subjects of the plans are given briefly.

2.4.1. Rehabilitation and Development Plan[5]

(1) Introduction

In the Rehabilitation and Development Plan (1993/94 - 1995/96) (RDP), GOU set forth an overview of the outcome in the previous Economic Recovery Programme (1987/88 - 1992/93) (ERP), a comprehensive statement of the Medium Term Structural Adjustment Programme for 1993/94 - 1995/96 and a review of main features of the Public Expenditure Programme for the plan period as summarized below:

(2) Economic Recovery Programme (ERP)

The GOU implemented ERP (1987/88 - 1992/93) aiming to rehabilitate the economy and play the foundations for sustained economic growth. The immediate objectives of the programme were to rehabilitate the productive sectors, in particular critical infrastructure, to reduce inflation primarily by tackling imbalances in the budget and to address the balance of payments' crisis. During the plan period, the main elements of the strategy to address these problems were; (a) export promotion, (b) reform of agriculture policy, (c) foreign investment promotion, (d) reform of the Government budget and (e) reduce the level of inflationary pressure. The performance of the economy in this period was impressive. An average real GDP growth exceeded 6%/annum, inflation was reduced from a level of 207% in July 1987 to 0.5% for a twelve month period to June 1993, and significant progress was made to reduce imbalances in the fiscal and external accounts.

(3) Medium Term Structural Adjustment Programme

The economic programme of the Government for 1993/94 - 1995/96 will built on the progress made under the previous ERP to achieve accelerated economic growth and a sustained improvement in social welfare of the Ugandan population. The programme aims to increase the tempo of economic growth whilst continuing to reduce macroeconomic imbalance in the economy and eliminate distortions in relative prices in the market for inputs, outputs and financial resources. The Government has set a number of macroeconomic targets to quantify progress toward these objectives; (a) an annual growth rate of at least 5%/annum, (b) a reduction rate of inflation of 7.5% by the end of 1993/94,

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[5] Source: MFEP, 1993.

(c) an improvement in the economy's external credit worthiness and (d) a substantial improvement in the economic and social prioritisation of public expenditure. The strategy to achieve these objective focuses on; (a) the development and diversification of the economy's export base, (b) the mobilization of domestic saving, (c) investment promotion, (d) implementing a debt reduction strategy, (e) reform of the Government budget and (f) providing incentives for the use in agricultural production.

In the social sector of the programme, the Government will intensify its efforts to address the needs of the most vulnerable groups with a view to alleviating poverty in general and mitigating the social costs of adjustment in particular. Sustainable poverty reduction requires greater efforts to achieve accelerated and broad based economic growth while at the same time improving human resources through better health and education, and, in the short term, targeted intervention to alleviate poverty particularly amongst the vulnerable groups.

The children of Uganda, whose number is more than 50% of the total population, will benefit from the implementation of the Uganda National Programme of Action for Children (UNPAC). Resources will be concentrated on the provision of basic education, health services and safe drinking water.

(4) **Public Expenditure Programme**

The recommended 327 projects are in the new RDP Priority List.

Total RDP expenditure in the plan period is estimated at UShs.1,980 billion or US$1.98 billion in 1993 constant price. The total annual expenditure is projected to increase from the 1993/94 budget total of UShs.606 billion or US$606 million to UShs.713 billion or US$713 million in 1994/95 and UShs.616 billion or US$616 million in 1995/96.

In the sectoral distribution, the social infrastructure sector accounts for the largest proportion of planned expenditure within the RDP with 30.7%.

The external assistance of the order of US$1.6 billion is required to sustain Uganda's economy recovery during the period 1993/94 - 1995/96. The assistance is particularly for debt relief some of burden of Uganda's US$2.6 billion external debts.

2.4.2. National Strategy in Rural Water Supply Sector

To coordinate the activities of the various agencies involved in the WES sector, the DWD has developed a draft to a National Water Supply Policy, the Water Action Plan for Water Resources Development and Management (WAP). In addition a Water Statute was tabled by Parliament in 1995. Presently the WAP and the Water Statute form the main guiding framework for planning and implementation of activities in the water sector.

(1) Water Action Plan[6]

The WAP has been formulated by GOU in the light of following seven certain principles about water resources management that were derived in the meetings that led up to the United Nations Conference on Environment and Development, convened in Rio de Janeiro in 1992:

- Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.
- Land and water resources should be managed at the lowest appropriate level.
- The Government has an essential role as an enabler in a participatory, demand-driven approach to development.
- Water should be considered as a social and economic good, with a value reflecting its most valuable potential use.
- Water and land use management should be integrated.
- Women play a central part in the provision, management and safeguarding of water.
- The private sector has an important role in water management.

The WAP recommends (1) institutional and management structure, (2) management functions and its levels, (3) functions, potentials and constraints for water resources management, (4) short term management functions, (5) rapid water resources assessment, (6) comments on international aspects, (7) key issues from the districts studies, (8) management procedures, (9) action programme and (10) timing of implementation.

The WAP sets an implementation schedule as the action programme with 3 stage strategy in which 39 actions will be undertaken. Stage One is expected to be completed after 2 years, Stage Two after four(4) years, and Stage Three after six(6) years. The criteria used in

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(6 Source: Uganda Water Action Plan, July 1994.

determining the schedule has been a balancing of considerations such as clustering actions that are best dealt with together, and following the logic of the overall Water Action Plan: firstly creating the enabling environment, then building the institutional structures, and, finally, producing and using the needed management procedures and tools.

According to this implementation schedule, the WAP is now on going to enable the management environment as the Stage One.

(2) Rural Water Supply Programme[7]

The National Planning Strategy - National Rural Water Supply Programme - (RWP) was formulated by DWD in 1991.

The RWP presents;

(a) outlines of the demand for water in the rural area of Uganda,
(b) description of the water supply potential of the country,
(c) review of the technical options available for the provision of water from improved sources for the rural areas,
(d) determinations of the order of magnitude of the investment required to provide respectively 50%, 75% and 100% of the rural population with safe water by the year 2000,
(e) estimation of a realistic level of investments in the rural water supply sector for the next five(5) years taking into account the absorptive capacity of both local communities and Government structures, and
(f) a model for the preparation of district-based plans which will make the local communities full-fledged partners in the planning process.

The RWP thus provides the general framework within which planning and implementation of the rural water supply and sanitation activities will take place.

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[7] National Planning Strategy - Rural Water Supply Programme - (Final Report), July 1991.

2.5. Water Supply and Environmental Sanitation (WES) Sector

2.5.1. Community Based Maintenance System (CBMS)

DWD used to have regional Borehole Maintenance Units (BMU) responsible for Operation and Maintenance (O&M) of water sources. In the 1980's the GOU shifted its policy to the CBMS. The main strategy of CBMS is that the O&M of the improved rural water schemes, including all costs, are the responsibility of the users. All minor repair is to be done by locally trained Hand Pump Mechanics (HPMs).

Major repairs, which are non-affordable to the local authorities, are also often non-affordable to the GOU. Consequently the issue of preventive O&M of boreholes (BHs) are crucial for the longevity of BHs. GOU therefore presently recommend the use of a "demand driven approach". This is done to ensure that the limited resources only are invested into communities with willingness and ability to maintain their own water source. The philosophy is that; communities who demand a clean water source and willingly contribute to it, are more likely to feel its ownership and become responsible users. Responsible use will minimize the need for O&M, enhance sustainability and maximize the health benefits.

The CBMS is a GOU's approach, which put large demands on the community's capacity to independently manage their improved water facilities. Hence, institutional and human resource capacity building is essential for success. Presently the CBMS is only fully operational in a minority of the communities where it has been established. Still more need to be learned about:

(a) the user's willingness and capacity to take responsibility for their own water,

(b) the capability of the government extension workers to provide the necessary support to the CBMS as facilitators; and

(c) the ability of the private sector in rendering the necessary services for supporting the communities.

2.5.2. Institutional Set-up

(1) National Level

The MFEP is responsible for national economic planning, approves and coordinates externally and GOU funded projects. The technical support to the WES sector by the central GOU is through the MNR, the MOH, the MOLG and the MGCD.

The MNR through the DWD is responsible for water resource management. The DWD facilitates the construction of improved water facilities, by establishing the strategies, which guide and coordinate the nation wide implementation with the assistance of Donors and NGOs. The DWD operates BH construction by four percussion and 22 rotary drilling rigs; and 142 drilling staff.

The MOH is through the Health Inspectorate responsible for rural sanitation, spring protection and a few institutional water schemes to health facilities. District health staff are responsible for Primary Health Care (PHC) and environmental health in the district, hence promote rural WES activities and assist in the construction of improved sanitation and protected springs.

MGCD is responsible for policy formulation, planning, monitoring and HRD within gender issues and community development District staff under the directorate for Community Development is responsible for community involvement in rural development projects, such as WES. District staff under the Directorate for Gender are responsible for gender issues.

MOLG is responsible for implementing and monitoring the decentralization process.

The two national training institutions most important for the WES sector are; (a) Mbale and Nakasero School of Hygiene under the MOH, which train HIs and HAs, and (b) Nsamizi Training School in Mpigi district, under the MGCD, which train Community Development Officer (CDO) and Community Development Assistants (CDAs).

Further the GOU is presently embarking on privatisation and DWD, therefore, increasingly recommend the use of the private sector for implementation (e.g. private drilling companies, local masons or HPMs). The capacity of the private sector to render services within the WES activities has grown substantially during the recent years, but also enhanced the need for quality control, training and capacity building.

(2) Local Council Level

In the district (LC5) level, the WES staff consist of a District Health Inspector (DHI) and a District Community Development Officer (DCDO), a District Water Officer (DWO) and a Borehole Maintenance Supervisor (BMS).

Other important district staff to assist the WES staff to achieve their targets are members of the District Health Team (DHT) headed by a District Medical Officer (DMO). The key members are the DMO, the DHI the District Health Educator (DHE) and the District Health Visitor (DHV). The DHT work as a team and they are therefore all important for the success of the WES activities in the district.

The DHE plays a very important role in community mobilisation, education, training and development. Further the DHV, a nurse specialized in preventive maternal child health, has a large impact on mobilisation, education training and development of, especially women.

The district based WES staff use the LC system, from LC4 to LC1, extensively for all their activities, but especially for mobilisation. The LC system fast and efficiently reach community level to inform them of plans of water improvement in their area. The LC system also efficiently raise a demand of water from the communities to the district WES staff.

At the user level, a Water User's Committee (WUC) is established by each water facility. Two of the WUC members are caretakers (it is recommended that one of these be a woman). Further the WUC consists of a chair person, a treasurer, a secretary and one more member. WUCs are responsible for O&M of the water source. The caretakers oversee the water source on daily basis, e.g. is it used properly, are the jerrycans clean. The Caretaker is responsible for keeping the water source clean. The WUC can assist by calling in community assistance. The WUC plans for O&M of the water source by requesting for community assistance in form of labour or fees to be used for general maintenance and repair.

(3) Hand Pump Mechanics (HPM)

The maintenance of water sources equipped with HPs are done by local HPM under a contract with WUCs. HPM are mainly men with former technical experience (e.g. in bicycle repair). They are selected by the WES committee in LC3 which also pays for the training. Most training of HPM takes place at one of the technical training institutions and takes from one to four weeks. After graduation the HPM get a bicycle and tools.

(4) Handpumps and Spareparts Distribution

The DWD recommends the U2/U3 Handpump (HP) for BHs and deep wells. U2/U3 is a local adoption of the India Mark II or Mark III. The U2/U3 HP is manufactured in Uganda.

National Standards have been submitted to the Uganda National Bureau of Standards. Most water programmes and projects in Uganda use the U3 HP for BHs and deep wells. The DWD is presently assessing the NIRA, TARA, U-3 and Consallen pumps for use on shallow wells.

Corrosion of galvanised iron raiser main is a major problem for many communities throughout Uganda. Hence, the use of stainless steel AISI 316 is recommended, to decrease the recurrent cost of O&M.

The standardised use of the U3 HP facilitate the capacity building of institutional and human resources for O&M and the availability of spareparts. Presently all spareparts can be purchased directly from the local pump-manufacturer in Kampala. Further most spareparts are available at district level, either at subsidised prices from district based Water and Environmental Sanitation Programme(WES)-UNICEF depots or from whole sale hardware dealers. The spareparts, which wear the fastest (e.g. rubber parts) can often be obtained from local hardware dealers or the HPM.

2.5.3. External Support in Water Sector

The main rural water supply projects in Uganda at present are Rural Water and Sanitation (RUWASA), Eastern Uganda Project by DANIDA and WES-UNICEF. RUWASA provides water, sanitation and hygiene education to eight districts in Eastern Uganda with technical and financial assistance from DANIDA. WES-UNICEF provides support to all other districts with financial assistance from Swedish International Development Authority (SIDA), Canadian International Development Agency (CIDA) and Norway and technical assistance through UNICEF Uganda.

Further multiple international NGOs support projects in the WES sector. Some of these include; Lutheran World Federation (Northeastern Uganda), Water Aid (Eastern and Western Uganda), Plan International (Luwero district, Central Uganda), Care International (West Nile), World Vision International (WVI, Mubende and Kiboga) and International Service Volunteer's Association (AVSI, Mpigi, Hoima and Kitgum).

The WES-UNICEF project is an umbrella programme providing assistance to district staff within the WES sector. Districts under WES might have none, one or more NGOs working in close cooperation with the district WES staff and UNICEF in the implementation of local WES-projects.

UNICEF's involvement in the water and sanitation sector started as an emergency programme during the civil war. Through 1980's UNICEF rehabilitated old and provided new water schemes. From 1982 to 1984 UNICEF supported a drilling programme in Northern and Eastern Uganda. This was interrupted by the civil war. From 1986 to 1987 a rehabilitation programme was run with focus in Luwero district. At the end of the civil strife, the emergency aid transformed into a development programme.

The South West Integrated Health and Water Project (SWIP) was started in 1987 in the initial eight later ten, south western districts of the country. In early 1990's National Water Supply and Sanitation Programme (WATSAN) was added to the UNICEF programme to extend the support to all areas outside SWIP and RUWASA.

SWIP was a "self-contained", resource rich project, with a strong organisation and emphasis on BH drilling,

WATSAN worked with district staff, through technical advisors and coordinators from DWD, MOH and MGCD, in close cooperation with NGOs. WATSAN's focus was on rehabilitation of BHs, protection of springs and environmental sanitation. The project's performance was, however limited due to the management structure and the wide geographical coverage. WATSAN's scarce resources progressively covered up to 20 districts in 1994.

By first of January 1996 SWIP was integrated with WATSAN into the so-called WES project. WES is based on a strategy very similar to the former WATSAN project. The aim is district capacity building for management of WES resources. The national technical support team consists of four people seconded from the GOU; two from MNR, one from MOH and one from MGCD. These four people are responsible for supervision and training of all districts. UNICEF gives backup support to the national coordinators and financial and material support to the district's plan for improved WES. All districts are responsible for development of their own annual plan. Further monitoring and reporting on how the allocated resources were spent are also district responsibility. All plans and reports are to be submitted to UNICEF, Kampala. The main constraints in WES are the large geographical area covered and the limited national based staff for technical support. Further the management capacity at most districts is still in their earliest development phase. Districts receiving administrative and technical assistance form NGOs are therefore often gaining more from the UNICEF's WES project, than those, which do not have any NGO's.

2.5.4. Sanitation and Environmental Hygiene

The Health Inspectorate in the MOH has developed standardized National Sanitation Guidelines. The guidelines include general recommendations and detailed designs for sanitation plat-forms (san-plats), slab and ventilated improved pit-latrines (VIP). These guidelines are presently being revised and adapted to decentralisation. The main strategy is promotion of improved latrines and environmental sanitation through health education. The chosen approach should ensure community participation and fully utilise the potential community resources.

The main pre-fabric designs for sanitation are; (1) ferro-cement sanitation plat forms (san-plats) and (2) concrete slabs. Both have a small squat holes, "foot steps" and a lid. Both san-plats and slabs are easy to clean, safe for even small children and re-useable. The small squat hole prevents children from falling into the pit. The "foot-steps" enable the visitor to "hit the hole" even in darkness. The lid prevent flies from entering the pit. The technology has been found to be in agreement with traditional technology.

Due to their lighter weight and lower production costs, san-plats are recommend, as the most appropriate technology for household sanitation.

Slabs are properly more durable than san-plats, but expensive to produce and difficult to transport, due to a much higher weight. Hence, they are mainly recommended for use in VIP for institutional latrines. These VIPs has a ventilation pipe.

The GOU has encouraged privatisation of the manufacturing and selling of san-plats and slabs, but san-plat and slab production is heavily subsidized. It is the aim to eliminate all subsidies by year 2000.

CHAPTER THREE: THE STUDY AREA AND TARGET COMMUNITIES

3.1. Natural Environment

3.1.1. *Geography and Geomorphology*

The study area is situated in the south-western part of Uganda, and average axes are approximately 110 km east-west and 135 km north-south with a total area of 17,102 km^2. The altitude of land ranges from 700 to 1,800 m above sea level.

The topographical features of the study area are represented by flat topped plateau like hills rising generally to the same height, broadly rounded plateau and valleys which are filled by papyrus swamps, high grass or forests.

Although there are few major rivers as, for instance, the Mayanja, Katonga and Kafu, they flow the boundaries of the study area. There are very many tributaries of moderate size with valleys narrower than the major water courses. Most of the valleys are dry in hot season. The valleys display comparatively little flat ground consisting of swamps or seasonally flooded forest or grassland. Many valleys are markedly rectilinear, or only slightly curved, and water-courses and swamps do not show the sinuosity and meander in low valley gradients. In general the river network bears little relation to geological structure in the area of sedimentary rocks, but in gneiss and granite areas rectilinear character of the streams are well structurally controlled.

In the south there is a large swamp filled depression known as Lake Wamala. The drainage in the south area is towards Lake Victoria, either directly or by way of Lake Wamala and River Katonga. The drainage in the north belongs to the Victoria Nile catchment and towards River Kafu.

3.1.2. Meteorology and Hydrology

(1) *Meteorology*

(a) Meteorological Stations

Nine meteorological stations are in the study area; Entebbe, Mubende, Kawanda, Namulonge, Nabbingo, Kiboga, Vuuma, Naluggi and Lunnya. Entebbe station has recorded rainfall, air temperature, relative humidity, sunshine hours, wind velocity and pan evaporation.

(b) Rainfall

The monthly rainfall at Entebbe station varies 54.8 mm in February to 289.3 mm in May, and an average annual rainfall is 1,556 mm. There is a relatively dry season between December and March, and another in June and July. The consequence is a pattern with rainfall well-distributed throughout the year and peaks in March-April-May, and October-November, the earlier one being the principal one. The rainfall occurs on 160 to 170 days each year. The central and southern area of Mpigi District belong to same rainfall pattern.

The record of Kiboga and Mubende stations show similar rainfall pattern. The areas are hilly regions and the altitude of both stations are 1,130 and 1,200 m above sea level. The annual average rainfall is 1,197 mm at Kiboga station and 1,166 mm at Mubende station. Two peaks associated with the Equatorial Through are evident, one during March-May, the other September-November. Two dry seasons occur in June-July, and the other between December and February. The rain falls on 90 to 130 days per year. The western area on Mpigi District and most of Mubende and Kiboga Districts belong to this climatic pattern. However, a much drier zone with mean annual totals below 875 mm extends from west of Mpigi to near Lake Wamala. The area id Maddu in Mpigi, Kiganda, Myanzi and southern Kitenga in Mubende (Atlas of Uganda, 1969).

(c) Air Temperature and Relative Humidity

The mean maximum and minimum temperatures in the study area show no great variation. The maximum monthly temperature ranges from 25.0 to 26.8°C at Entebbe and from 26.2 to 28.6°C at Mubende. The highest monthly mean temperatures occur during dry season in January or February. The minimum temperature ranges from 16.1 to 17.9°C at Entebbe and from 14.7 to 15.7°C at Mubende. The lowest minimum temperatures occur in June or July. The daily variation of temperature is about 7°C in average at Entebbe station, while about 11°C in average at Mubende.

Humidity Records at Entebbe and Mubende stations indicate that Entebbe located on the shore of the Lake maintain high percentage of humidity, reaching a high of 90% in June. In most months humidity is reaching 80% at Mubende, however, in the afternoon during dry season lowered near 50% in Mubende. The difference in humidity during dry season is reaching about 10% between Entebbe and Mubende.

(2) Hydrology

The major rivers in the study area are the Kafu, Mayanja, Mpongo, Katonga, Kibimba and Nabakazi. The Mayanja and Mpongo are the tributaries of the Kafu which is in the Victoria Nile catchment area and flow to the north. The Nabakazi is a tributary of the Katonga which is in the catchment area of Lake Victoria and flows to the south. These tributaries originate in the hill region except the Kibimba which originates in Lake Wamala.

In the study area, river gauging stations are located only for the Katonga, and no station for the Kafu. River discharge of the study area is largely affected by the presence and scale of swamps which function as storage reservoir. Runoff coefficients of two stations at the Katonga which were estimated by UNDP are as shown below:

Station No.	Catchment Area	Runoff Coefficient
81324	3,870 km^2	11.24 %
81359	13,930 km^2	0.64 %

3.1.3. Geology and Hydrogeology

(1) Geology

The study area is underlain by cover formation, Gneiss Complex and intrusive granites of Precambrian, and sediments of Pleistocene to recent. Major cover formation distributed in the area is Mityana Series and Buganda-Toro System.

The Mityana Series predominates in silicified sandstone, but shale and conglomerate beds are alternating. The rocks are normally hard and massive, and many springs are found along faults. They are underlain by the Buganda-Toro System.

The Buganda-Toro System is broadly distributed in the study area, but very poorly exposed. The rocks consist of schists, phyllites, shales, sandstones, conglomerates and quartzites. Weathered formations are normally deep, in some places in Mubende District reaching 100m. Fresh formations of argillites are soft and have scarce fissures. Argillites predominate, and sandstones and conglomerates are frequently thinly bedded. In throughout much of the area, quartzite separates Buganda-Toro System from underlain Gneiss Complex. The thickness of the System has been estimated of the order of 900m or less in the south of Mpigi District (The Geology of Southern Mengo, Geological Survey of Uganda, 1959), but it is presumed from the existing borehole records that the System is thick in western region more than in eastern region.

Gneiss Complex is mainly composed of fine to coarse grained gneiss of granitic composition and granitic gneiss with bands of quartz-feldspar pegmatite. The highly weathered formations are normally thin, 20m or less, and fresh formations are hard and have large fissures, especially the area along faults.

Intrusive granites are distributed in the west and north of Mubende District. The granites are usually coarse and porphyritic, but fine and medium grained varieties occur. The rock is hard and has usually scarce fractures.

(2) Hydrogeology

Aquifer system in the study area lie only of fractures in rocks of which size and extent vary in location due to weathered conditions and grain size of rocks, geological structures etc. Information on aquifer characteristics in each hydrogeological unit are not available except of personal experience. The discontinuous fractures and incomplete drilling records give difficulty in siting and construction of successful boreholes.

The major hydrogeological units are Mityana Series, Buganda-Toro System, Gneiss Complex and Intrusive Granites.

Mityana Series is distributed around Lake Wamala and predominates siliceous sandstone and conglomerates. Many boreholes are drilled in Mityana town and its surrounding villages. A large scale fault runs from north to south through Mityana town area for about 20 km, and small faults crossing the major fault are detected by aerophotograph. Groundwater is expected along the faults and successful existing boreholes are extracting water from the fractures resulting from the faults. The average yield is 2.2 m^3/hr and greatest within the major hydrogeological units. The existing boreholes in the Mityana town are affected by drawdown of groundwater table due to overpumping of them.

Buganda-Toro System predominates in schists and phyllites, and the average yield is 1.3 m^3/hr. Some boreholes drilled in the area, however, have high yield, and it is considered from the evaluation of the existing borehole records that those penetrated the System and are drilled into underlain Gneiss Complex. Those boreholes are mostly found in east and north areas where the System is not deep.

Gneiss Complex is most reliable aquifer in the area, and fractures are able to detect easily as high peak of conductivity by geo-magnetic survey. The average yield is 2.0 m^3/hr, however, in Kiboga District only 1.0 m^3/hr. In the north-east region of Mpigi District it is more than 3.0 m^3/hr.

Intrusive granites is distributed in the limited area and average yield is 1.3 m^3/hr. The granites are normally hard and massive. High yield is not expected because of few fractures and topographical features forming hilly land.

3.2. Socioeconomy

3.2.1. Population and Household

As shown in APPENDIX D-3 in the previous sub-clause, a total population in Kiboga, Mpigi and Mubende Districts amounted 1,557 thousand in total as of 1991 with the average annual growth rate of 2.82% during the period from 1969 according to the 1991 Population and Housing Census. This population growth rate is slightly higher comparing with that (2.57%) of the whole Uganda.

These three Districts are called Buganda in the former time indicating that most people are the Baganda, the largest single ethnic group in Uganda.

According to the said population census, the average family size per household in these three Districts is reported as 4.39 persons that is rather small scale comparing with that (4.85 persons) of Uganda.

3.2.2. Socioeconomic Perspective of the Districts Related to the Project

The study area consists of three districts, namely Kiboga District, Mpigi District and Mubende District. As mentioned above, these areas form a Baganda society. This Society has classes, but no fixed social divisions and any person with talent can rise to a position of their social importance.

Socioeconomic perspectives are given below.

(1) **Kiboga District**

Kiboga District borders with the districts of Mubende in the South, Masindi and Hoima in the North, Kibale in the West and Luwero in the East with area of 4,004 km^2. It was formerly a part of Mubende District. The district has moderate rainfall and temperatures well enough for the growth of a number of crops.

Kiboga Town is its headquarters, and the District has 2 counties as Kiboga East County and Kiboga West County with a total of 10 sub-counties.

Main economic activity is agriculture with an emphasis on:

(a) Food crops : maize, beans, groundnuts, bananas, finger millet, soya beans, sim-sim, sweet potatoes, and Irish potatoes.
(b) Cash crops : coffee, cotton, tea.
(c) Fruits and vegetables : pineapples, tomatoes, onions, passion fruits, and cabbages.
(d) Ranching with cattle : about 35,000 heads, goats : 8,500, sheeps : 2,000 and pigs : 8,300 in total as of 1992.

(2) **Mpigi District**

The District borders with districts of Mubende, Kiboga and Luwero in the North, Kampala District in the East, Masaka District in the South and Lake Victoria in extreme south with area of 6,222 km^2. They have about 36,000 ha of forest. Mpigi District lies at approximate altitudinal range of 1,982 m - 1,341 m above sea level receiving heavy and reliable rainfall together with relatively high temperatures. The Municipality Entebbe gets 1,513 mm of rain per annum.

The headquarters is Mpigi Town, and the District has Entebbe Municipality where it has an international airport, Buwama Town and Matuga Town with a total of 30 sub-counties.

Main economic activities are agriculture with a bias in:

(a) Food crops : sweet potatoes, beans, cassava, maize, bananas, groundnuts, sorghum, soya beans, and Irish potatoes.
(b) Cash crops : coffee and cotton.
(c) Fruits and vegetables : Tomatoes, onions and cabbages.

(d) Dairy farming with about 125,000 head of cattle, 32,300 heads of goats and 11,500 heads of sheeps.
(e) Fishing.

Major industries in Mpigi District are those of manufacturing of jaggery, foot wears, furniture, printing, brick making, stone quarrying, and processing of coffee, tea, and bakeries. Maganjo Maize Millers is the highest single employer with 117 employees as of 1992.

(3) **Mubende District**

The District borders with the districts of Kiboga and Luwero in the North, Mpigi in the South, Kibale in the North, Kabarole in the West and Masaka in the South with its area of 6,536 km^2. It lies at altitude of 1,372 m - 1,448 m above sea level with high temperature and remarkably low rainfall.

Mubende Town is the headquarters, and there is a Mityana Town too as one more town level. Counties of Busujju, Buwekula, Kassanda and Mityana belong to this District with 22 sub-counties under those counties.

Main economic activities are agriculture with an emphasis on:

(a) Food crops : maize, beans, sweet potatoes, Irish potatoes, groundnuts, bananas, finger millet, sim-sim, soya beans and yams.
(b) Cash crops : coffee, cotton and tea.
(c) Fruits and vegetables : Tomatoes, pineapples, passion fruits, onions and cabbages.
(d) Cattle ranching and dairy farming with cattle : 283,800 heads, goats : 5,700 heads, sheep : 26,800 heads as of 1992.

Major industries in the District are processing of coffee and tea, bread making, maize milling, brick making, printing and manufacturing of jaggery. Wamala Growers Union is the highest single employer with 120 employees as of 1992.

3.3. Water Resources

3.3.1. Surface Water

(1) Water Balance

(a) General

Inadequate data base on surface water and groundwater makes any assessment for the global water balance more or less questionable, especially lack of data for change of groundwater storage. Simplified, but fundamental water balance equation which applies the climatological and hydrological water balance, can be expressed as follows:

$$P = R + E + \delta_s \quad \text{...(1)}$$

Where: P = Precipitation

R = Runoff

E = Evapotranspiration

δ_s = Change in storage of surface and groundwater

An initial calculation of the water balance study is tried by monthly basis in the drainage where large scale swamps are not included, that is, River Mawokota Kato in Mpigi District, River Katabaranga in Mubende District and River Nakayenga in Kiboga District (see VOLUME TWO, Figure 1.2.1). The areas are topographically composed of gentle sedimentary and crystalline rock hills, plain and broad extended river floors which are filled by soils. The drainage areas are 91.7 km^2 in River Mawokota Kato, 198.3 km^2 in River Katabaranga and 59.5 km^2 in River Nakayenga.

(b) Calculation of Parameters

Precipitation of Entebbe station on 1990 is estimated 10 years recurrence intervals of annual rainfall from 1985 to 1994, and data of Kiboga station on 1959 is estimated 35 years from 1943 to 1977. The data can be used for the calculation.

River Kakinga, which is a tributary of River Katonga, has similar topographical conditions with the three areas. The flow record from 1970 to 1977 is applied to estimate a runoff coefficient. The rainfall record of Entebbe station is applied for the calculation. Calculated average annual runoff coefficient is 21.4% as shown in the following table.

The DWD Entebbe has estimated the base flow of River Kakinga with 3.33 mm/year and 38.1% of runoff by the record from 1969 to 1978 (see Appendix A.7.).

Monthly evapotranspiration is calculated from the data of Entebbe and Namulonge stations.

Each parameters are shown in VOLUME TWO, Table 1.2.4.

Table 3.3.1. Runoff Coefficient in River Kakinga

Catchment Area	(km^2)	996
Annual Rainfall	(mm)	1,559
Total Rainfall	(MCM)	1,506
Total Discharge	(MCM)	322
Runoff Coefficient	(%)	21.4

(c) Calculation of Groundwater Budget

The result of calculation of groundwater budget in the selected areas are shown in VOLUME TWO, Table 1.2.4. The table shows that change in storage of groundwater in the Mawokota Kato catchment area is estimated at 478 mm/year which is 31% of total rainfall. In the Katabaranga and Nakayenga area, the change is estimated at 433 mm/year which is 28% of total rainfall.

Groundwater recharge to the areas can be estimated by the following equation:

GR = δ , x catchment area =

Mawokota Kato = 478.4 mm x 91.7 km^2 = 43.87 MCM

Katabaranga = 432.8 mm x 198.3 km^2 = 85.82 MCM

Nakayenga = 432.8 mm x 59.5 km^2 = 25.75 MCM

Major part of recharge induced during the month of March, April and May and it takes out during dry season from December to February. Base flow discharge may probably compensate deficient. Major component of runoff in the selected areas is a surface runoff because clayey soils and rocks underlain.

(2) Surface Water

Small scale dams are proposed for the low groundwater potential villages. Inflow to dams

per unit catchment area is calculated as follows:
The data of mean monthly rainfall, runoff coefficient and evapotranspiration evaluated in above paragraph, 3.3.1. (1) Water Balance, are employed for the estimation of mean inflow (see Table 3.3.2.). Runoff coefficient is 21.4%. The results of calculation of inflow are shown in Table 3.3.2. The table shows that the peak of inflow are during March-May and August-November.

Table 3.3.2. reveals that cumulative inflow from unit catchment area to a dam reaches 171,000 m^3/year.

Table 3.3.2. Inflow per Unit Catchment Area

Month	Rainfall in Kiboga (mm)	Evapotranspiration in Kiboga (mm)	Inflow ($1000m^3/km^2$)	Cumulative Inflow ($1000m^3/km^2$)
Jan.	5.8	7.0	0	0
Feb.	82.3	23.0	12.69	12.69
Mar.	98.8	26.4	15.49	28.18
Apr.	116.8	46.2	15.11	43.29
May.	276.4	61.9	45.90	89.19
Jun.	19.3	18.4	0.19	89.38
Jul.	82.3	22.3	12.84	102.22
Aug.	117.3	43.1	15.88	118.10
Sept.	74.7	36.5	8.17	126.27
Oct.	109.7	58.4	10.98	137.25
Nov.	226.8	64.1	34.82	171.53
Dec.	5.3	6.4	-0.24	171.29
Jan.	5.8	7.0	-0.26	171.03
Total	1215.5	413.6		

(3) Rainwater Resources

A study of the rainwater balance was carried out in order to evaluate the potential of rainwater harvesting in the study area.

The daily rainfall records in the selected consecutive years which include the most drought year at Entebbe (1985 to 1987), Mubende (1983 to 1984) and Kiboga-G (1969 to 1971) stations were used for the study. The effective daily rainfalls were estimated as 0.9 of rainfall more than 1.0 mm/day.

The water consumption and roof area of typical household were assumed to be 0.10 m^3/day (5 person x 0.02 m^3/day) and 40 m^2 respectively.

The capacities of rain-tanks per typical household reach to 13 m^3 in Entebbe, 9 m^3 in Mubende and 15 m^3 in Kiboga. The figures show that the rainwater harvesting system is to be applied to a supplemental measure but not to the substantial rural water supply system.

3.3.2. Groundwater

(1) Hydrogeology

The summary of the existing borehole records in each hydrogeological unit and their distributed areas is shown in the following table.

Table 3.3.3. Summary of Existing Borehole Record

Hydrogeological Unit	Location	Existing Borehole Record		
		Avg. Depth(m)	Avg. Yield (m^3/hr)	Avg. SWL (m)
Mityana Series	Mubende	80.2	2.2	25.6
Buganda-Toro System	whole Districts	91.7	1.3	25.3
Gneiss Complex	whole Districts	72.8	2.0	22.2
Granites	Mubende	70.1	1.3	26.4

The average yield is highest in Mityana Series distributing in Mubende District and lowest in Buganda-Toro System in whole districts and Granites in Mubende.

In Kiboga District, Buganda-Toro System ranges from 0.9 to 2.1 m^3/hr in the average yield and Gneiss Complex from 0.5 to 1.5 m^3/hr. The remarkable hydrogeological characteristics of the district are low static water level and deep pump setting location: average static water level is 31.1 m and pump setting depth is 48.7 m. deep.

In Mubende District, the average highest yield, 3.2 m^3/hr, is in Myanzi which faces Lake Wamala and is underlain by Mityana Series consisting of sandy rocks, and lowest in Butayunaja underlain by schists. Argillites of Buganda-Toro System are broadly distributed in the district and the potential of the formation is low. The average yield is lower in west than central and east region. The average total depth is 90 m and static water level is 25 m deep. The district is also characterized by low groundwater level and deep borehole depth: average total depth is 90m and static water level is 25 m deep.

In Mpigi District, hydrogeology is clearly divided into two areas: western area composed mainly of argillites of Buganda-Toro System has low potential ranging from 0.6 to 1.0 m^3/hr in average yield, and eastern area distributed by Gneiss Complex has comparatively high yield ranging from 1.1 to 2.9 m^3/hr. Total borehole depth and groundwater level are shallower in eastern area than western area.

(2) Geophysical Prospecting

(a) Purpose and Methodology

Geophysical sounding was performed in the potential areas selected by preliminary hydrogeological survey. The purpose and method of sounding are as below:

- to detect the fracture zone by the electro-magnetic magnetic (EM) sounding,
- to detect depth to the fracture zone by the resistivity sounding,
- to detect thickness and litho-facies of overburden and highly weathered layers of bed rocks by the resistivity sounding using Wenner method,
- to study geophysical conditions in the study area through above sounding.

(b) Electro-magnetic Prospecting

The detail of the survey results are shown in VOLUME TWO and APPENDIX. The geophysical conditions revealed by the survey are as follows:

Quaternary deposits and Buganda-Toro System have not shown typical peaks which indicate fractures in rocks. High peak of conductivity is detected at survey points in Mityana Series and Gneiss Complex. The values of high conductivity are generally more than 20 μ S/cm.

(c) Results of Resistivity Prospecting

Resistivity prospecting was conducted at 65 sites to cover the study area, and detail of the survey are given in the VOLUME TWO, Chapter 1.1.4. and APPENDIX A 6.
Buganda-Toro System shows low resistivity less than 2,000 ohm-m and crystalline rocks such as Gneiss Complex and Granites are high ranging 50 to 4,000 ohm-m. The resistivity of aquifers of Mityana Series predominated in siliceous sandstone ranges from 40 to 1,800 ohm-m, but other formations from 40 to 1,000 ohm-m.

(d) Test Borehole Siting

Geo-physical prospecting for the test boreholes is conducted at 15 villages of the three districts. The detail of the survey is shown in VOLUME TWO and APPENDIX.

In Kiboga District, four lines of EM and seven points of resistivity are surveyed. Three resistivity layers are identified and aquifers are estimated at 20 to 25 m and 70 to 80 m deep in JA-2, Ssinde.

Twenty lines of EM and 34 points of resistivity are conducted in Mubende District, and the resistivity of successful borehole drilled at JA-5, Bekina, divided into five layers. The aquifers are expected at 20 to 55 m deep. In Mpigi District, five line and six points are performed and the geology is divided into four resistivity layers.

(3) Drilling of Test Borehole

(a) Outline of the Work

Ten test boreholes were drilled and pumping facilities of five boreholes out of ten, two in each of Mpigi and Kiboga Districts and one in Mubende District, were constructed. The objectives of work were for the pilot study in the community participation and to obtain the hydrogeological conditions of the study area, including:

- to compare the effect of community participation, hygiene and O/M of five villages, which recieved a borehole each, with and without further intervention,
- to obtain aquifer characteristics and potential, and to obtain groundwater quality.

Rotary and air hammer drilling rigs were used for the test borehole construction, and water-based fluid with polymer is applied during the drilling procedure.

Total ten boreholes were drilled, five struck on aquifers, four in Mubende District were dry, and one in Kiboga District was capped due to high iron concentration of water.

Three types of borehole logging covering spontaneous potential, resistivity and gamma-ray were performed to identify aquifers and aquicludes after the drilling completed.

After the completion of the drilling of successful five boreholes, PVC casing of five inche diameter and screen with 1-1.5 mm slot opening, are installed in the boreholes. The opening ratio of the screens is about 10%.

Three kinds of pumping test, step drawdown, constant discharge and recovery were performed to identify aquifer characteristics.

(b) Drilling Capacity of DWD and Local Contractor

The borehole construction is contracted with a local drilling contractor in Uganda. The contractor, Drillcon Ltd., has been established two years ago as a link of privatization. Drilling rigs, supporting equipment and crews which are employed by the contractor belong to DWD, and the contractor hires and maintains them during the contract work.

DWD has four (4) percussion type drilling rigs and twenty two (22) rotary type drilling rigs with DTH hammer which are procured mostly in mid 1980th, and those are operating well according to the report by DWD. The rigs are normally working for DWD own projects and donors such as RUWASA and SWIP. The DWD has limited capacity and limited budget for the maintenance and repair of rigs and supporting equipment. Some of equipment are maintained and repaired by the donor's supports or private workshops.

Truck mounted rotary and air hammer drilling rigs were used for the test borehole drilling of the study. Water-based fluid with polymer was applied during the drilling procedure. Mud circulation method was not applied because of lack of equipment in the country. The lack of mud drilling technique is losing opportunities to extract water from soft layers composed of highly weathered rocks and recent deposits.

Screens are usually not used because soft layers are cased by blank work casing, and water is extracted only from hard rocks without casing. The DWD and the contractor have limited borehole siting and logging equipment. The borehole design is decided by hydrogeologist/driller.

(c) Results of Drilling

The detail of drilling and pumping tests are shown in Table 1.1.14. of VOLUME TWO.

<Kiboga District (Ssinde JA-2 and Kawawa JA-7)>

In Ssinde three boreholes are drilled: the first is failed by drop of a drilling bit, the second JA-2 is capped because of high iron concentration of water and the third JA-7 successful. JA-2 has large yield of 5.4m^3/hr, and it is presumed that the high iron concentration is caused by lateritic soil which is located just above screens. JA-7, Ssinde-2, is stopped drilling at the boundary between the formations, but more large yield will be expected when drilled more deeper into Gneiss Complex. All boreholes are located in Buganda-Toro System.

Kawawa, JA-3, is drilled in Buganda-Toro System sheared by a fault and underlain by deep weathered layer. The drilling stopped at 27 m deep and borehole bottom is set at 13.9 m deep because of the borehole wall collapse by soft layer and poor drilling technique. The yield is 1.0 m^3/hr in JA-7 and 0.6 m^3/hr in JA-3.

<Mubende District (Manyogaseka JA-1, Kitebere JA-4, Bekina JA-5, Namyeso JA-6 and 10)>

Five boreholes are drilled and four are dry hole. The rocks of failed boreholes are composed of Buganda-Toro System and Mityana Series. Fractures in the rocks are detected by geophysical prospecting, but these bear few or no water. The successful borehole of Bekina consists of phyllite, granite and quartzite of Buganda-Toro System. The quartzite is highly weathered and bears large quantity of water, but finally yielded only 0.6 m^3/hr due to very poor drilling technique.

<Mpigi District (JA-8 Seeta and JA-9 Magere)>

The geology of the boreholes drilled in Mpigi District consists of alluvium, quartzite of Buganda-Toro System and granitic gneiss of Gneiss Complex. The area is located near the boundary between the System and Complex, and a lineament extending for N.N.E. is interpreted by aerophotographs. In Seeta two boreholes drilled and the first is failed because of borehole wall collapse by poor drilling technique. The yield is 7.2 m^3/hr in Seeta and 0.78 m^3/hr in Magere.

(d) Water Quality of Test Boreholes

The water quality of test boreholes is analyzed by in-situ and a laboratory test. Water samples from all successful boreholes are taken at the final stage of the constant discharge test.

The values of sample from JA-2, Ssinde-1, are above the recommended National Guideline values of 2.0 mg/l for iron and 20.0 NTU for turbidity, respectively. Although these poor features are not a health hazard, nevertheless they make the water less appealing to users and the borehole is likely to be abandoned by the community. JA-7, Ssinde-2, is newly drilled near JA-2 from the above reason.

The samples from JA-3, Kawawa, and JA-9, Seeta, are slightly acidic with low bicarbonate alkalinity. These features may enhance corrosion of steel pipes. Other samples have also low bicarbonate alkalinity, and these low values are a disadvantage for steel pipes. Otherwise the samples are good for drinking water.

(4) Water Quality

Water quality of 102 water sources are surveyed by in-situ test and 58 samples taken from springs, boreholes and rivers are analyzed by the DWD Entebbe laboratory.

(a) Results of Field Test

pH, electric conductivity, temperature and contamination by coliform/bacteria were tested by using field test kits. Facility and sanitary conditions and yield are also checked.

pH values of the boreholes range from 5.65 to 7.65 and springs from 4.98 to 6.16.

Electric conductivity (E.C.) ranges from 91 to 2,420 μ S/cm, and in Kiboga it shows high value of which taste is slightly salty. These boreholes are drilled in Gneiss Complex.

Simple paper tests for the investigation of biological contamination were performed, and the results show that 45% of the boreholes and 67% of the springs are contaminated biologically.

Color of water is rusty or milky in 52% of boreholes and 32% of springs. The color of many boreholes reduces after short or long time pumping.

Sanitary conditions are generally bad except few facilities, that is, no fence, scatter of rubbish and stay of waste water around the facility. The quality of facilities is also poor, many of them have cracks and no maintenance by communities.

(b) Results of Laboratory Test

Forty eight (48) samples are taken from boreholes, nine samples from springs and one from river. Total 25 items are analyzed which are standard test items of DWD except coliform. Many samples from boreholes exceed permissible limit of National Guideline in color, turbidity and total iron. Other items are mostly in the permissible limit.

Color; 34 out of 48 samples are colored in yellowish to brownish and many of them include iron precipitation and silts,

Turbidity; 25 out of 48 samples are more than 20 NTU and maximum is 200 NTU,

Total iron; 31 out of 48 samples are more than 2.0 and maximum is 46.0 mg/l,

Electric conductivity (E.C.); the values are generally high ranging from 51 to 2,440 μ s/cm,

Chlorides; high in Kiboga ranging from 5 to 507 mg/l,

There is a relationship between color, turbidity and total iron, that is,

water colored ⇔ turbidity large ⇔ total iron large.

Water quality of springs is mostly in the permissible limit, but some are muddy color. Two samples exceed the permissible limit of total iron, but slightly.

(c) Evaluation

The results of the laboratory test reveal that more than 70% of the existing boreholes exceed the permissible limit of drinking water quality guideline of Uganda in the value of total iron, turbidity and color. It is considered that the reason of high iron concentration is derived from the corrosion of galvanized steel casing using in the study area.

Corrosion can be prevented through the deposition of a protective coating of calcium carbonate. Saturated Index (Langelier Index) calculated from pH, calcium and bicarbonate indicates difficulty of the deposition of a protective coating. The index calculated reveals that the groundwater in the study area does not deposit a coating which protects steel and corrodes it. High electric conductivity accelerates corrosion of steel.

The biological pollution is a big problem in the study area. 45% of the existing boreholes and 67% of the springs are contaminated by bacteria and or coliform. It is considered that the reasons are poor construction of borehole facilities and poor sanitary conditions. The quality of cement grouting and platform of many boreholes is poor, and waste water flows and infiltrates into the boreholes through concrete cracks and from ground. The contamination of the springs is derived from infiltration of waste water from houses located on the slope above the springs.

(5) Evaluation of Aquifer Potential

(a) Aquifer System

Aquifer system of the study area lie only of the fractures in rocks of which size and extent vary in location due to geological structures, weathered conditions, grain size etc. Information on aquifer characteristics of hydrogeological units are not available except borehole records reported by drillers. The lack of hydrogeological information give difficulty to evaluate aquifer systems.

Major hydrogeological units in the area are composed of Mityana Series, Buganda-Toro System, Gneiss Complex and Granites. Unconsolidated deposits are broadly distributed in rivers, however, these consist of limited extent of sand and gravel, and water quality is normally less accessible as drinking water.

<Mityana Series>

In the area where the Series is distributed, many boreholes have been drilled. The rocks are siliceous, hard and massive, but in the area where fault is detected boreholes are generally successfully drilled. The yield of existing boreholes is 2 m^3/hr in average.

<Buganda-Toro System>

The system predominates in schist and phyllite which are aquicludes and highly weathered layer is deep. Yield is expected when a borehole is encountered hard rock and Gneiss Complex underlain. The average yield is 1.3 m^3/hr.

<Gneiss Complex>

The unit consisting of gneiss is most reliable aquifer in the area, and fractures are able to detect as high peak of conductivity by geo-magnetic survey. The average yield of the study area is 2.0 m^3/hr, however, in the north of Kiboga District it is 1.0 m^3/hr. The north-east area of Mpigi District, Kiziba, Kyambogo and Nangabo, has more than 3.0 m^3/hr in average yield.

<Granites>

The distribution of the unit is limited in Mubende District. The rock is generally hard and massive, and weathered layer less than 20 m. The average yield is 1.3 m^3/hr.

(b) **Groundwater Quality**

Seventy (70)% of the samples taken from the existing boreholes exceed permissible limit recommended by National Guideline for Drinking Water Quality in the values of total iron, turbidity and color. Those high values are derived from corrosion of galvanized steel casing using in the area. Saturation Index calculated reveals that groundwater in the area does not deposit protective coating against corrosion. In the study area introduction of corrosion resistant materials is recommended.

Forty five (45)% of boreholes and 67% of springs are contaminated biologically. The contamination comes from poor facility construction and poor maintenance. Strengthening of supervise for contractor and education of hygiene and O/M for users are recommended.

(c) Low Groundwater Potential Area

Twenty eight (28) low groundwater potential communities are listed through the analysis of topographical and hydrogeological conditions. The communities are recommended alternative water sources.

3.4. Target Communities

3.4.1. Community Inventory

A village inventory survey was conducted for 300 target communities (villages and trading centres) in the Study Area, which were originally defined in the list attached to the Scope of Work (S/W) agreed by and between MNR and JICA.

The survey was conducted to identify the locations of the communities in the original list and to enquire the relevant information covering the following subjects to the chairpersons of the target communities and to the heads of the sampled households;

(1) Socio-economy
(2) Land use
(3) Health and Sanitation
(4) Present condition of water supply and utilisation
(5) On-going and programmed projects
(6) Village organisation
(7) Women in Development (WID) related information, policy and institution