Nile Basin Capacity Building Network 'NBCBN'

Hydropower Development Research Cluster

GROUP I

SMALL SCALE HYDROPOWER FOR RURAL DEVELOPMENT

By

Eng. Leonard B. Kassana
Dr. D. Mashauri
Dr. D.J. Chambega
Dr. I.S.N. Mkilaha
Dr. C.F. Mhilu
Dr. James L. Ngeleja
Eng. Leonard R. Masanja
Dr. Ntungumburanye Gerard
Dr. Zelalem Hailu
Prof. Dr. Sibilike K. Makhanu
Dr. Museruka Casimir
Kizza Michael
Dr. Keneth Muniina

Coordinated By
Prof. Felix. Mtalo

Scientific Advisor
Prof. Bela Petry
UNESCO-IHE

2005

ACKNOWLEDGEMENT

The research group of Theme I is indebted to the following firms/persons for the provision of data and background information. Their comments as well, have been very helpful in preparing this report.

Tanzania

- Ministry of Energy and Minerals
- National Environment Management Council
- Tanzania Electricity Supply Company Limited
- Tanzania Traditional Energy Development
- University of Dar es Salaam

Burundi

- Geographic Institute of Burundi
- Ministry of Energy and Mines
- Director General of Hydraulics and Rural Energies

Kenya

- Kenya Power and Lighting Company Limited
- Kenya Generating Company Limited
- University of Nairobi

Ethiopia

- Ministry of Water Resources

Egypt

- NBCBN-RE Secretariat: Dr. Sherif El-Sayed

The Netherlands

- Scientific Adviser to the NBCBN-RE Hydropower Cluster: Prof. Dr. Bela Petry

Rwanda

- Kigali Institute of Science and Technology
- ELECTROGAS

Uganda

- Ministry of Energy and Mineral Resources
- Uganda Energy Transmission Company
- Directorate of Water Development, Uganda
- Energy Regulation Authority
- Business Uganda Development System-Energy for Rural Transformation

EXECUTIVE SUMMARY

Modern societies strongly depend on reliable, affordable and sustainable energy supplies. In fact, Energy is an obligatory input for most production processes and other economic activities and an essential component of our way of life. Many of the Nile Basin countries are among the least developed in the World in spite of their important potential in natural resources. They strongly depend on the development of their still very limited energy supply systems, using locally available, competitive and renewable resources--such as Hydropower-- to achieve further steps in their sustainable social and economic growth.

One important aspect of the development of the energy sector in most countries of the Nile Basin is the development of local capacities in planning, design, implementation and operation of Small Scale Hydropower systems and installations aimed at using water resources of moderate dimensions and providing solution at local and sub-regional scale (including development of rural areas). This is the general purpose of the Research Theme 1, established along the definitions given by the NBCBN-RE Conference (Cairo, January 2002) and the Hydropower Cluster launching event (Dar es Salaam, November 2002).

Theme 1 has received the contribution of the member countries Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda. In 1st phase of activities the research team has been focusing attention and activities on the following scope:

- Inventory of data bases and other sources of information related to Small Scale Hydropower in each member country
- Inventory of potentially interesting sites for the development of Small Scale Hydropower installations in each member country
- Inventory of Capacity Building needs related to Small Scale Hydropower in each member country.

A summarized account of the work done and results achieved so far is presented in the Theme 1--Report and corresponding country reports.
In a summary, major achievements so far are the following:

- An intensified collaboration between water professionals of the different countries of the Cluster region.
- For Burundi, about 15 sites were identified as small hydropower potentials suitable for development. These identified small hydropower potentials have about 3 Mw installed capacity. The Burundi report gives details of Hydrological and Meteorological study sources in the country.
- In Tanzania, searched reports and publications give an account of previous efforts by different institutions in the country studying and investigating hydropower potentials, small/micro/macro scale potentials inclusive. A total of about 56 new hydropower sites were found to have been studied at different levels ranging from reconnaissance to pre-feasibility and very few ones studied to a feasibility study level. In all these, an estimated total rough figure of about 200 Mw can be harnessed from small hydropower potential sites already identified. The report also gives a list of existing developed sites either publicly or privately owned.
- The report from Ethiopia shows that a total of 299 hydropower potential sites have been identified within 11 River basins. The largest river basin in terms of number of hydropower potential sites as well as technical energy potential is Abbay River basin. Abbay River basin has about 79000 GWh/year. This is about 49% of all river basin potential energy in Ethiopia.
- The report from Uganda shows a total of about 23 sites small hydropower sites of about 54MW potential. Most of these sites are located off the River Nile on Non-Nile Rivers scattered around the country (the Nile sites are all large hydro). Of these rivers, only about

25MW has been developed or is in progress of development, though this still represents the large hydro sites of 23 small hydro sites. The smaller ones are scattered all over the country, and potential private investors are being invited to develop them through the ERT program.

- Status for Rwanda and Kenya is contained in their respective country reports.

The following research objectives are planned in a continuation of Theme 1 activities:

- Completion of the inventories started in Phase 1.
- Publication of a Small Scale Hydropower Reference Booklet containing important data and information for every participating country in Theme 1.
- Development of a Design Manual for Small Scale Hydropower for use in the Nile Basin countries.
- Development of feasibility studies for the implementation of a small-scale pilot project in each of the Theme 1 member countries.
- Promotion of training activities within the scope of Theme 1.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

DGHER	General Director of Hydraulics and Rural Energies, Burundi
DRC	Democratic Republic Of Congo
DWD	Directorate of Water Development
MWLE	Ministry of Water, Lands and Environment, Uganda
ERA	Electricity Regulatory Authority, Uganda
ERT	Energy for Rural Transformation, Uganda
FBU	Burundi Francs
FDI	Foreign Direct Investment, Uganda
GWH	Giga Watt Hour
HP	Hydropower
IGEBU	Geographic Institute Of Burundi
IPP	Independent Power Producers
ITCZ	Intertropical Convergence Zone
KenGen	Kenya Generating Company
KPLC	Kenya Power and Lighting Company Limited
Km	Kilo Metre
kW	Kilo Watt
MP	Multipurpose
MW	Mega Watt
N/A	Not Applicable
NEDECO	The Netherlands Engineering Consultants
PCA	Principal Component Analysis
NBCBN-RE	Nile Basin Capacity Building Network For River Engineering
REGIDESO	National Light and Water Supply Company Limited, Burundi
RoR	Run Of River
SHP	Small Hydropower Project
Sid	Swedish International Development Agency
STD	Standard Deviation
TANESCO	Tanzania Electric Supply Company Limited
UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
UEB	Uganda Electricity Board
UNDP	United Nations Development Program
WAPCO	Water and Power Consultancy Services, India Based Firm
WS	Wabi Shebele Ethiopian River Basin

1 INTRODUCTION

1.1 BACKGROUND AND CURRENT STATUS

The Small Scale Hydropower Development Research Work as part of Nile Basin Capacity Building Network for River Engineering stemmed out of January 2002 Cairo Declaration on Nile Basin Initiative as one of the Regional Programs to build and strengthen professional and institutional capacity in the Nile riparian countries. This network was meant to be an open forum of national and regional capacity building institutions and professional organizations active in education, training and research. It had the following objectives:

- To make optimal use of existing capacities in the field of river engineering by connecting specialized institutions and experts/professionals
- To enhance and strengthen communication and collaboration among these experts
- To improve the accessibility of education and training in river engineering in the region
- To facilitate and regionalize research on river engineering in the Nile Basin riparian countries by offering opportunity to perform joint researchers

The January 2002 Cairo Declaration was followed by a series of launching seminars/workshops in different countries. Research clusters within NBCBN-RE are **Hydropower Development** hosted in Tanzania, River Morphology hosted by Sudan, Storage and Regulation Works by Uganda, River Intakes Works and Main Conveyance Systems for Water Supply hosted by Ethiopia and GIS and Modeling hosted by Egypt.
First workshop for Hydropower node was launched in Dar es Salaam, Tanzania as a host country in November 2002.During this workshop; two research topics were developed to be:-
 Theme I: Small-Scale Hydropower Development
 Theme II: Hydropower Regional Integration

Second Workshop on Hydropower was also organized in Dar es Salaam in March 2004. It looked at the progress of the research activities and prepared a mid Term report summarizing of all what has been taking place in Stage I. It is in this midterm report where we laid down a framework, which is the basis for this current report.

1.2 SCOPE

The project was intended to be executed in three Stages i.e. I, II & III:

Stage I: Period between 1st workshop held in Dar es Salaam, November 2002 and 2nd Workshop held in Dar es Salaam, March 2004. The following are main outlines of the Scope within this period of Stage I:

- Inventory of data bases and sources of Information
- Inventory of sites for small scale hydropower development
- Inventory of capacity building needs.

Stage II: This is the period between March 2004 (second Workshop held in Dar es Salaam) and June 14, 2004 Cairo Workshop. This phase was meant to intensify all research activities that were already underway in Stage I. It was also meant to consolidate the knowledge base. All these were to bring up a final report to be presented to the Cairo Workshop, June 2004. It is in this period that a progress report (Mid Term Report) was prepared and issued to the Secretariat of NBCBN-RE, which is based in Cairo, Egypt.

Stage III: The period beyond Cairo Workshop in June 2004: This is the period that will take over from where Stage II activity ended. It is at this Cairo workshop where assessment and evaluation of what extent of the objectives has been attained. The future and way forward for this NBCBN-RE network is expected be defined during the Cairo Workshop. Tentatively, the research group made the following deliberations for objectives beyond Cairo June 14, 2004 workshop:

- Each country should zero in on one prospective viable project candidate that has to be studied at all relevant stages for eventual implementation as a pilot project.

- Come out with customized design manuals that can be published for local use and Nile Basin as a whole.
- Come out with a definitive layout for strategies for mobilizing implementation funds.
- Publish a small-scale hydropower data for each Nile Basin participating country.

1.3 OBJECTIVES OF THE RESEARCH

Rural Electrification for countries within Nile Basin like any other countries in the Developing World is a major challenge for central and local governments and other investors. The major problem for the rural electrification from either thermal generators or electricity tapped from other distant major electric sources lies on **financial viability**. This is because consumers in our typical villages and rural towns have very low purchasing power thus casting doubts to the investors whether their investment costs shall be recovered on commercial terms. THE CHALLENGE OF TODAY IS HOW TO PROVIDE ELECTRICITY ON CHEAP MEANS FOR RURAL DEVELOPMENT HENCE ALLEVIATING POVERTY. One of the solutions for this problem is to identify small-scale hydropower potentialities in the rural areas and develop them to electrify the rural areas.

1.3.1 Uses of the Research Results

Consequences:

- Hydro-potentials that exist in rural areas shall be known for power harnessing possibilities for rural areas.
- Upon implementation of small hydro schemes in our rural areas, there will be a great reduction on deforestation as a result of cutting down trees for fire wood (this is a major source of energy in rural areas).
- Men and women in the rural areas shall have more time for farming
- Rural electrification shall be incentive for Agro based industry
- Employment opportunities shall be created in the rural areas
- Rural – town migration of people will be reduced as now people will see opportunities to get better life in the rural areas.
- End result of all these: POVERTY ALLEVIATION in the countries within Nile River Basin.

Users of Results:

Government energy planners/policy makers and local government authorities and other interested private parties

2 METHODOLOGY

2.1 ORGANIZATION AND COORDINATION OF THE PROJECT

Generally, Theme I: Small Hydropower Development Research Project as part of the Nile Basin Capacity Building Network for River Engineering has the following hierarchical levels as shown in figure 1:

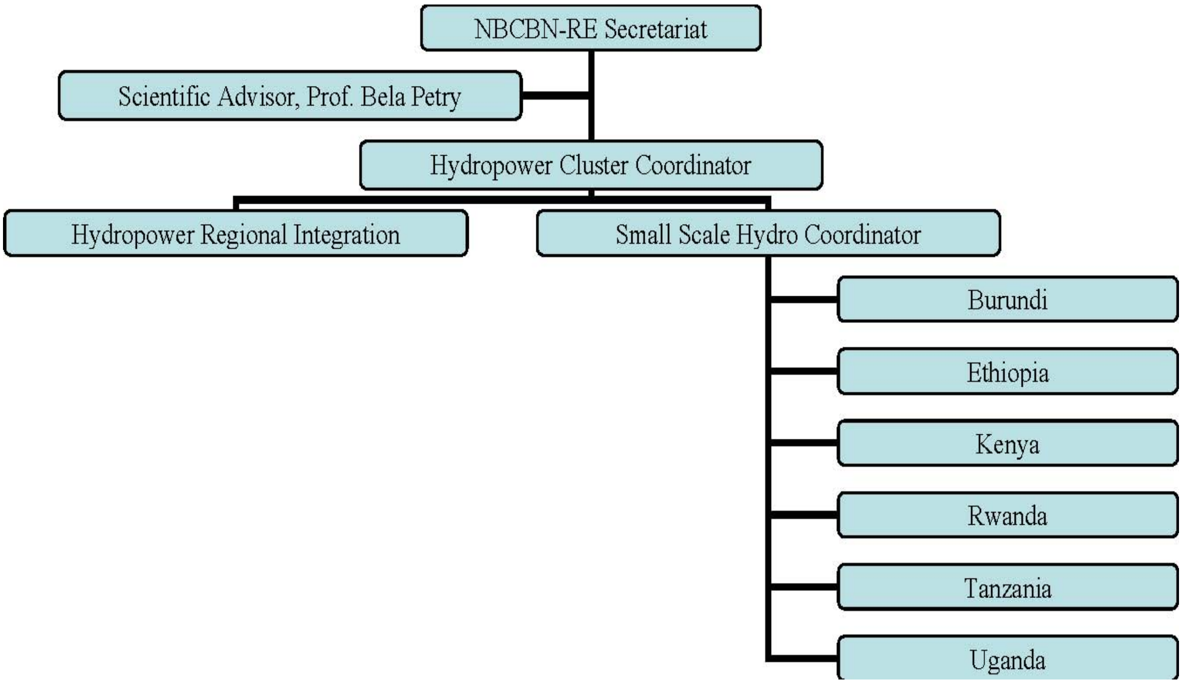


Figure (2-1) Organizational Chart for the Research Project

The above chart of organization shows the working relationship among the participating member countries and the way the reporting and information sharing was organized. The grassroots levels begin at the national nodes. The node is the basic unit of the network in each country. Its role is the identification and implementation of the agreed NBCBN-RE activities.

Coordinating roles were played by each theme coordinator together the hydropower cluster coordinator. Scientific Advisor had the role of overseeing the quality assurance of the research work.

The role of the NBCBN-RE Secretariat is coordination, facilitation, promotion and Monitoring of the NBCBN-RE activities. Final decision for finance and Workshop/Seminars logistics were being made at Cairo Secretariat Office where the Project Manager is based.

2.2 ORGANIZATION AND COORDINATION AT THE NATIONAL NODE LEVEL

As mentioned above in chapter 2.1, the national node, being the basic unit of the network is responsible for identifying and implementing NBCBN-RE activities for the particular cluster research work. It is important to make note that both NBCBN-RE Secretariat and national nodes share responsibilities in ensuring sustainability, mobilization of the resources and information management. Below is a summary of participating members in the Small Hydropower Development Research Group

RESEARCH TEAM IN PHASE 1:

Tanzania, the host country for Hydropower Cluster, has the following professionals in the team:

- Prof. Dr. F. Mtalo

- Eng. Leonard B. Kassana
- Prof. Dr. D. Mashauri
- Prof. Dr. D.J. Chambega
- Prof. Dr. I.S.N. Mkilaha
- Dr. C.F. Mhilu
- Eng. James L. Ngeleja
- Eng. Leonard R. Masanja

Burundi:	Mr. Ntungumburanye Gerard	- Burundi Coordinator
Ethiopia:	Dr. Zelalem Hailu	- Ethiopia coordinator
Kenya:	Prof. Sibilike K. Makhanu	- Kenya coordinator
Rwanda:	Dr. Museruka Casimir	- Rwanda coordinator
Uganda:	Mr. Kizza Michael	- Uganda coordinator
	Mr.Keneth Muniina	

2.3 EXECUTION FRAMEWORK

Phase I activities were based on three main components as mentioned below:

i. Inventory of Data Bases and Sources of Information
ii. Inventory of Sites for Small Scale Hydropower Development
iii. Inventory of Capacity Building Needs

The inventory of the potential sites for small-scale hydropower development was conducted based on the following approach:

Conducting desk study for the hydropower potentials
Review of existing documentations for identification of sites and their locations.
Data evaluation to establish the potential for each of the identified sites

3 PROJECT RESULTS

3.1 MAJOR FINDINGS

3.1.1 General

In a summary, through an intensified collaboration among multidisciplinary professionals from different countries under the Hydropower Cluster, it is all appreciated by all members that our countries, despite being poor from economical point of view, are endowed with enormous natural resources. These resources if sustainably and equitably managed, these countries should be able to alleviate if not eradicate completely, the poverty among our people. It is truly known that in all Nile Basin riparian countries, poverty is worse in rural and semi-urban areas than towns and cities. Therefore, cities and towns, being major load centers do attract investors of all categories i.e. public and private to invest in projects whose power would be transmitted to the load centers because their funds would be recovered quickly and with profits.

In view of the above, small scale hydropower projects seem to be giving one of the promising solutions for electrifying rural areas and hence increasing economic production. The SHP has the following advantages:

- It is quite simpler in design and construction than the larger Hydropower project.
- It is simpler to operate than the larger facility
- Has very minimal adverse impacts on environment
- Has minimum costs for transmission from the generation points to the load centers

By increasing economic activities in the rural areas would reverse the rural-urban immigration of the work force from the rural areas and hence alleviate poverty.

At this stage with efforts that have been done in the past, the research group has inventories data for:
- Potential sites for hydropower development in the rural areas
- Sources of such information regarding literatures, investigation reports etc

The group has attempted to identify the strength and weaknesses with respect to capacity Building in these countries as well.

For comprehensive understanding, the reader is kindly referred to attachments in Appendices A1 to A6 for country reports. In the appendices, an account for all 3 inventory issues namely potential sites, sources of information and capacity building needs is given country by country. Depth levels of these inventories are different from one country to another due financial limitations and different bureaucratic environments in each country.

3.1.2 Burundi

For Burundi, about 15 sites were identified as small hydropower potentials suitable for development. These identified small hydropower potentials have about 3 Mw potential capacities. BURUNDI has two major watersheds draining into the following regional basin as shown in figure (3-1).

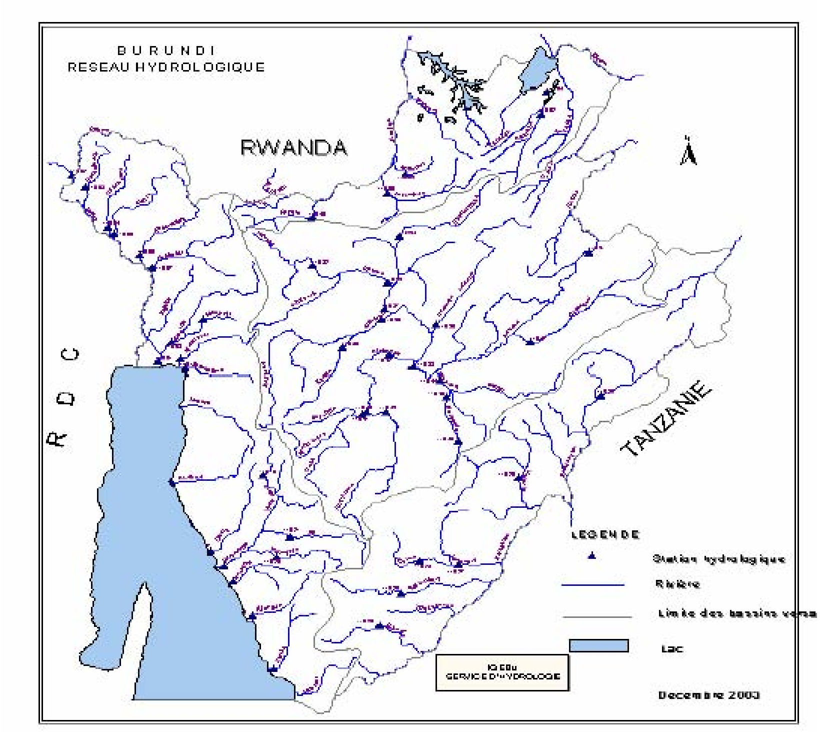


Figure (3- 1) Burundi map showing Hydrological basins

CONGO River Basin
NILE River Basin. Many tributaries flow into the Nile River through RUVUBU and KANYARU-KAGERA River inside BURUNDI and KAGERA River outside the country, which in return flows into Lake VICTORIA, feeding from there to the NILE River.

Table (3-1) The Burundi means Hydrological Balance of Water Resources

Watershed	Mean discharge National territory (m^3/s)	Imported discharge from Rwanda (m^3/s)	Imported discharge from Tanzania (m^3/s)	Exported discharge to Rwanda (m^3/s)	Exported discharge to Tanzania (m^3/s)
Ruvubu	108		4		-112
Kanyaru	21	25		-46	
Kagera	8	134			-142

The Inventory Work for Small Hydropower in the country indicates that a total amount of about 3 MW is potentially available for power production form 15 different sites. A list of small hydropower sites in Burundi is given in the table (3-2) below:

Table (3-2) Inventory of Sites for Small Scale Hydropower in Burundi

S/ n	Name of site	Responsible	Name of river	Installed power in mw	Start year
1 F	Gikonge	Regideso	Mubarazi	0.850	1982
2 0	Kayenzi	Regideso	Kavuruga	0.350	1984
3 r	Marangara	Regideso	Ndurumu	0.240	1986
4 f	Buhiga	Regideso	Ndurumu	0.240	1984
5 u	Sanzu	Regideso	Sanzu	0.072	1983
6 r	Butezi	Dgher	Sanzu	0.240	1990
7 t	Ryarusera	Dgher	Kagogo	0.020	1984
8 h	Nyabikere	Dgher	Nyabisi	0.139	1990
9 e	Murore	Dgher	Rusumo	0.024	1987
10 r	Mugera	Private	Ruvyironza	0.030	1962
11	Kiremba	Private	Buyongwe	0.064	1981
12 d	Teza	Private	Nyabigondo	0.360	1971
13 e	Kiganda	Private	Mucece	0.044	1984
14 t	Gisozi	Private	Kayokwe	0.015	1983
1 5 a	Burasira	Private	Ruvubu	0.025	1961

For additional details, please refer to the country report in Appendix A1.

3.1.3 Ethiopia

The report from Ethiopia shows that 299 hydropower potential sites have been identified within 11 River basins. The largest river basin in terms of number of hydropower potential sites as well as technical energy potential is Abbay River basin. Abbay River basin has about 79000 GWh/year. This is about 49% of all river basin potential energy in Ethiopia.

Figure (3-2) Map of Ethiopia showing Major River Basins

The desk study during this phase I of the research revealed that Ethiopia, a horn of African country is single major contributor of about 85% of the total Nile Water. The nation has 11 major River Basins with a total hydropower potential amounting to 7877 Mw including both large and Small Hydro potentials. A summary of energy potentials and other hydrological parameters are given in table (3-3) below.

Table (3-3) River Basins in Ethiopia with Areas, surface Water Resources and Potential Hydropower Sites

S/N	Name of Basin	Area (km2)	Techn. Potential (Gwh/yr)	75%Dependable Surface Water (Bm3)	HP Potential Sites
1	Abbay	201,346	78,820	51.48	132
2	Wabi Shebelle	202,697	5,440	2.34	18
3	Genale-Dawa	171,042	9,270	4.58	23
4	Awash	112,696	4,470	4.10	43
5	Tekeze	90,001	5,930	5.73	15
6	Omo-Ghibe	78,213	36,560	14.46	23
7	Ogaden	77,121	-	-	-
8	Baro-Akobo	74,102	18,880	8.51	39
9	Danakil	74,002	-		-

10	Rift valley Lakes	52,739	800	4.36	6
11	Aysha	2,223	-	0.57	-
	Total	1,136,182	160,170	97.20	299

Just as an illustration, three tables are extracted from the Ethiopian country report to indicate some of the small hydropower potentials in the following basins:

- Abbay River basin
- Wabi Shebel River basin
- Genale Dawa River Basin
- Awashi River basin

Table (3-4) Hydropower Identified Projects in the Abbay River Basin in Ethiopia Table

Power Scheme	**Code in the Models**	**Installed Capacity (MW)**	**Type of Project**
Aleltu	ALEL	418	Reservoir
Anger	ANGA	10	Reservoir
Beles Dangur	BELD	120	Reservoir
Chemoga Yeda	CHEY	630	Reservoir
Dabana	DABA	60	Reservoir
Fettam	FETT	125	Reservoir
Finchaa	FINC	100	Reservoir
Galegu	GALE	5	Reservoir
Gilgel B	GILB	5	Reservoir
Jemma	JEMA	2	Reservoir
Lah	LAHR	1	RoR
Lower Dabus	LDAB	7.5	RoR
Lower Didessa	LDID	300	Reservoir
Lower Dindir	LDIN	20	Reservoir
Lower Guder	LGUD	70	Reservoir
North Chagni	NCHA	5	Reservoir
Negeso	NEGE	10	Reservoir
Nekemte	NEKE	10	Reservoir
Neshe	NESHB	30	Reservoir
Rahad	RAHA	15	Reservoir
Tis Abbay	TANA	60	
Upper Beles	UBEL	382	
Upper Dabus	UDAB	40	Reservoir
Upper Didessa	UDID	100	Reservoir
Upper Dindir	UDIN	30	Reservoir
Upper Guder	UGUD	20	Reservoir
TOTAL		**1097**	

Table (3-5) Potential Hydropower sites in the Wabi Shebele River Basin in Ethiopia

No.	**Site Name**	**Power (MW)**	**Energy (GWH/yr)**
1	WS 1	24.8	217
2	WS 2	29.3	213
3	WS 3	26.5	232
4	WS 4	28.1	246

5	WS 5	39.4	256
6	WS 6	29.5	258
7	WS 7	29.7	260
8	WS 8	39.7	348
9	WS 9	39.8	349
10	WS 10	44.8	392
11	WS 11	53.7	490
12	WS 12	39.6	505
13	WS 13	74	655
14	WS 14	75	656
15	WS 15	98	859
16	WS 16	46.5	407
17	WS 17	84.4	430
18	WS 18	85.3	435
19	GL 1	2.6	14
20	GL 2	5.5	28
21	DK 1	40.6	207
Total		**936.8**	

Table (3-6) Small Hydropower Sites in Genale Dawa River Basin in Ethiopia

Stream and elevation		**Catchment's area (km2)**	**Mean annual runoff (m3/s)**	**Head m**	**Potential generating capacity (Mw)**
Logita	1800	716	14.4	45.5	0.400
Logita II	1800	716	14.4	16.5	0.200
Bonora	1650	438	12.3	30	0.320
Ababa	1550	371	12	29	0.320
Combolcha	2650	304	9.9	15	0.110
Total					**1.35**

Table (3-7) Hydropower potential in the Awash Basin in Ethiopia

Site	**Hydropower Potential**	
	Gross (GWh)	**Installed (MW)**
Melka Kunture	57	16
Awash III	165	32
Awash IV	167	34

Kesem	20	6
Kebena	12	3.8
Tendaho	69	6
Total		**97.8**

For further details, the reader is referred to the country report in Appendix A2.

3.1.4 Kenya

One of the major items that can be extracted from Kenya's report is an identification of a study done on River Nzoia that has the following hydropower potential characteristics as per the table 8 shown below. River Nzoia basin, which lies in The Lake Basin, has five significant hydropower potential areas.

Table (3-8) River Nzoia Hydropower Potentials in Kenya

N/s	River	Project	Installed Capacity (MW)	Firm Energy (GW.h/yr)	Avg Energy (GW.h/yr)
1.	Nzoia	Hemsted Bridge	60	297	307
2.	Nzoia	Rongai	12	52	72
3.	Nzoia	Lugari	15	62	86
4.	Nzoia	Webuye Falls	30	115	170
5.	Nzoia	Anyika	25	95	125
Subtotal Nzoia			60	297	307

More Details for Kenya will be contained in their respective country report. For some background, the reader is referred to Midterm Report issued in March 2004.

3.1.5 Rwanda:

Small Hydropower Potentials

The Rwandese study team has revealed that there are about 51 identified small hydropower sites that can be developed for power generation. The inventory shows that these sites may have up to 3.4 Mw potential. These potential sites are within two major river basins namely River Congo and River Nile. The inventory accounts that 60% of the sites belongs to the Nile River Basin and the rest belong to the Congo River Basin.

Inventory of required human resources in Hydropower

According to the Rwandese study team, there is no enough information on this issue. However, it is obvious that the needs in capacity building and draining of professionals are still very high in Rwanda. It can also be note that the genocide in 1994 destroyed among others a high number of infrastructure and human resources and even specific enterprises which where involved in installation or maintenance of small hydropower systems.

Emergence Needs for Rwanda

- Training the trainers and professionals
- Development of human resources in Water Resource Management and Hydropower sector
- Promotion of enterprises in hydropower sector
- Development of mechanisms to access to equipment and others facilities required for hydropower issues.

For details and comprehension, the reader is referred to Appendix A4.

3.1.6 Tanzania

Tanzania is currently estimated to have a hydropower potential of over and above 4700 MW largely concentrated in the following River Basins:

- **Rufiji** River Basin, this occupies about 20% of the National total land area. This contributes about 63% of the total hydro potential in the country.
- **Pangani** River Basin: This draws water from Northern highlands and peaks of Mount Kilimanjaro, Mount Meru and Pare Mountain ranges.
- **Kagera** River Basin, this drains into Lake Victoria, the largest lake in Africa, which is the source of Nile River.
- **Malagarasi** River Basin drains into the Lake Tanganyika, the deepest lake in the world.
- **Rumakali** River Basin: this drains into Lake Nyasa, a lake that is located at triple junction of the Great Eastern Africa Rift System.
- **Ruvuma** River Basin: This is a contiguous border river between Tanzania and Mozambique.

Out of all this huge hydropower potential in this nation, only 10% of the potential is tapped. Only 10% of the entire Tanzania population live in towns and cities and is able to access this existing power production whilst 90% of country's populations live in rural and semi urban areas and is able to access less than 1% of this clean energy.

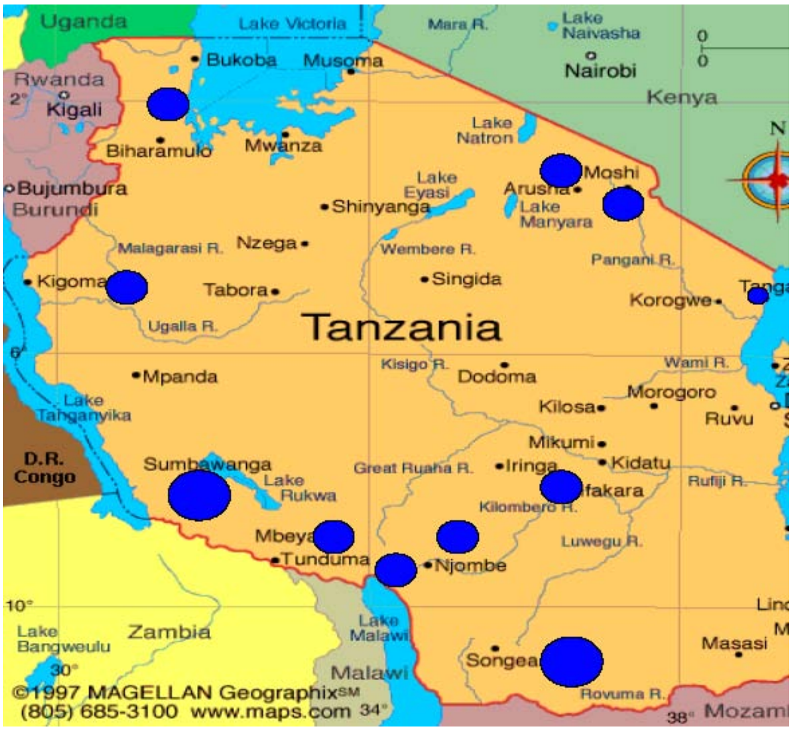
In Tanzania, reports and publications give an account of previous efforts by different institutions in the country studying and investigating hydropower potentials, small/micro/macro scale potentials inclusive. About 56 new hydropower sites were found to have been studied at different levels ranging from reconnaissance to pre-feasibility and very few ones studied to a feasibility study level. See table 9 below for the list of Tanzanian sites. In all these, an estimated total rough figure of about 300 Mw can be harnessed from small hydropower potential sites already identified. The report also gives a list of existing developed sites either publicly or privately owned.

Table (3-9) List of Small Hydropower Potential Sites in Tanzania

S/n	River Name	Location (Region)	Head for development in (m)	Installed capacity [kw]	Firm capacity (kw)	Average flow rate [m3/s]
1	Yungu River	Mbinga District (Ruvuma)	20	90	80kw	0.5
2	Mbawa River	Mbinga District (Ruvuma)	200	1800	1600	1
3	Luwika River	Mbinga District (Ruvuma)	200	1400	1200	0.8
4	Luaita River	Mbinga District (Ruvuma)	30	190	145	0.6
5	Upper Ruvuma River	Ruvuma	20	2000	1500	6
6	Hanga River	Songea District (Ruvuma)	40	550	420	5.2
7	Lilondo River (Mahanje Mission)	Lingatunda waterfail (Ruvuma)	150	1400	1100	0.75
8	Kibwaka River (Mhangazi River)	Njombe (Iringa)	50	5100	4000	35
9	Malisa River	Njombe (Iringa)	75	1250	1100	6
10	Mbaka River	Kyela (Mbeya)	200-300	8000	4-6	2.5
11	Kiwira River	Kyela (Mbeya)	285	25000	18	15.7

S/n	River Name	Location (Region)	Head for development in (m)	Installed capacity [kw]	Firm capacity (kw)	Average flow rate [m3/s]
12	Songwe River (Lake river)	Rukwa	20	1000	15.7GWh	10.6
13	Lupa River	Chunya (Mbeya)	50	2800	280	15.7
14	Lukwate River	Chunya (Mbeya)	60	900		1.8
15	Wuku River	Chunya (Sumbawanga	80	2500	2000	3
16	Yeye River		90	2500	1900	2.5
17	Rungwa River		108	50	9	35
18	Lukima River		120	4000	3000	4
19	Msadia/Mfwizi River		120	25000	215GWh	18
20	Mtozi River		40	2400	1700	12
21	Mbede River		50	1240	1080	0.3
22	Mamba River		50	155	135	0.1
23	Filongo River		150	415	360	0.3
24	Mpete River		200	55000	48000	0.03
25	Chulu River	Rukwa	300	850	720	0.3
26	Kirambo River		300	280	240	0.1
27	Muse River		200	520	450	0.2
28	Luiche River		200	1,100	800	0.5
29	Msofwe River		500	4500	3200	0.95
30	Milepa River	Rukwa	450			0.2
31	MBA River	Rukwa	300	1000	770	0.55
32	Kilemba River	Sumbawanga (Rukwa)	300	270	230	0.95
33	Kalambo River	Sumbawanga (Rukwa)	430	80000	58000	30
34	Kawa River	Rukwa	200	2000	1700	2.7
35	Luamfi River	Rukwa	40	1200	1000	9
36	Mtambo River	Mpanda (Rukwa)	40	2400	1700	8
37	Luegele River	Mpanda (Rukwa)	175	15000	11000	15
38	Ruchugi river	Kigoma River	20	1000	859	30
39	Mkuti River	Kigoma River	23	630	420	3.3
40	Himo l and ll	Kilimanjaro (Moshi)		945	190	3.3
41	Kihurio SHP 1 & ll	Seseni River, Same District, Kilimanjaro		1740	260	3.3
42	Ndungu	Goma River – Same (Kilimanjaro)		1740	260	3.3
43	Bombo/Gonja	Higilili River – Tanga (Tanga)				0.64
44	Mto wa Simba	Mto wa Mbu (Arusha)	210			2.4
45	Mbulu SHP	Mbulu (Arusha)	450	8100		1.75
46	Pinying river	Loliondo (Arusha)		450	221	0.9?
47	Njombe Falls	Njombe (Iringa)		2000		5.6
48	Kifunga Falls	Njombe (Iringa)		3.600		16
49	Hagafiro River	Njombe (Iringa)		5.000		
50	Kasongenye SHP	Biharamulo (Kagera)		420	840	1?
51	Kaonjuba SHP	Kamwana River – Muleba (Kagera)	90	800	200	1.2
52	Malagarasi SHP	(Kigoma)	80		7.600	16.00

S/n	River Name	Location (Region)	Head for development in (m)	Installed capacity [kw]	Firm capacity (kw)	Average flow rate [m3/s]
53	Uvinza	Ruchugi River (Kigoma)		1000	850	30
54	Nzovwe SHP	Sumbawanga (Rukwa)		3000	460	0.33
55	Nzovwe SHP	Songea (Ruvuma)	30	7500	2100	61
56	Hainu River SHP	Mbulu Babati (Arusha)	100		3.520	0.48



Legend:

General location of the Small Hydro potential Sites in Tanzania. NB:Size of the sphere represent relative number size of the sites in the region.

River Basin

Figure (3-3) Tanzanian map showing some Major River Basins with Small Hydropower Sites concentrations.

Small hydro potential in the country as per the undertaken desk study, has been estimated to be about 300 MW drawn from 56 different sites within the above-mentioned river basins. If this cheap energy, which is found insitu i.e near or at rural load centers, is tapped and delivered to rural areas, the outcry of poverty in the rural areas will be greatly reduced. For further details, the reader is referred to country report in Appendix A3.

3.1.7 Uganda

The River Network (see figure 5) in Uganda can be separated into two major parts: the Nile River and the Non-Nile Rivers. So the study on hydropower potential in Uganda is substantially divided into:

• Those based on the use of the Nile River
• Those located elsewhere in Uganda (Non-Nile Rivers)

Though the potential of the later cannot in any way be compared to that of the Nile River. Nevertheless schemes have been identified (and some developed) for smaller schemes providing local supply.

Uganda's hydrological resources are estimated to have a power production potential of over 2500MW. The large power sites (over 2000MW) are mainly concentrated along the Nile River while sites for small Hydro (0.5 – 5.0MW) are scattered in many parts of the country. However, to-date up to less than 10% of this potential is exploited.

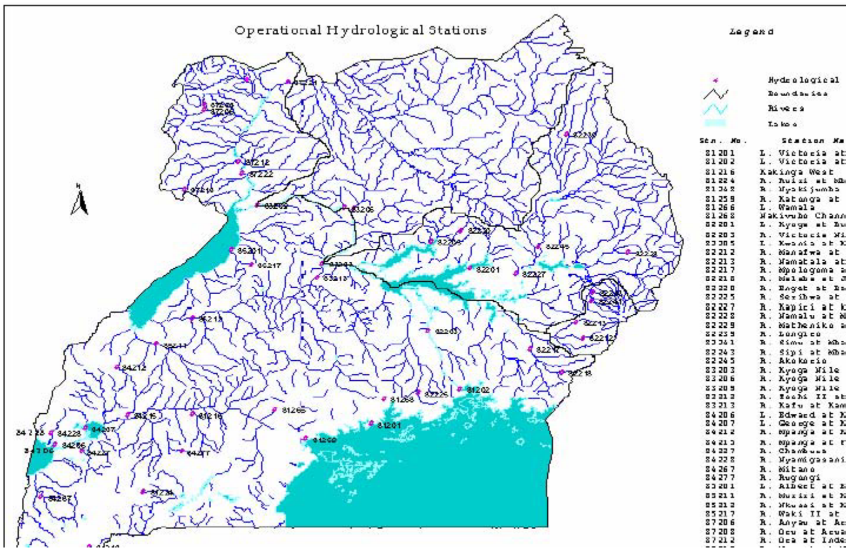


Figure (3-4) Uganda River Network System with Gauging Stations

Hydropower Potential on River Nile

As mentioned above, these sites represent some of Uganda's largest power potential sites of over 2000MW out of the full potential of 2500MW. Below is brief summary of the Nile River sites.

Table (3-10) Nile River Hydropower Potential Sites

Site	Location	Proposed Installed Capacity (Mw)	Status	Date Of Commissioning
Owen Falls	Jinja	180	In Operation	1954
Owen Falls Extension	Jinja	200	In Operation	2000
Bujagali	Jinja	250	Planning in Progress	N/A
Kalangala	Jinja	350	Feasibility study done	N/A
Kamdini (Karuma)	Masindi/ Apac	150	Feasibility study done	N/A
Ayago South	Gulu/Masindi	234	Preliminaries studies available	N/A
Ayago North	Gulu/Masindi	304	Preliminaries studies available	N/A
Murchision	Gulu/Masindi	642	Has adverse environmental Effects	N/A

Source: Ministry of Energy and Mineral Resources of Uganda

Hydropower Potential on the Non-Nile Rivers

It is known however that the potential for small-scale hydropower development exists in the following areas:

- Rivers draining the Mt.Elgon
- The extreme Southwest of Uganda
- Rivers draining West Nile, near Arua
- Rivers draining the Rwenzori Mountains.

The table (3-11) below gives the country's potential for medium, small and micro hydropower stations.

Table (3-11) Various Small Hydropower Sites of Uganda

Micro Hydro		
Site	**River**	**Estimated Capacity, MW**
Arua	Anyau	0.3
Heissesero	Bunyonyi	0.3
Kitumba	Nyakabuguka	0.2
Mpanga	Mpanga	0.4
Nyakabale	Nyakabale	0.1
Moyo	Ataki	0.2
Kisiizi	Kisiizi	0.2
Small Hydro		
Lake Bunyonyi	Bunyonyi	1.0
Nsongezi	Kagera	2.0
Paidha A	Nyagak	1.0
Paidha B	Nyagak	2.0
Ishasha A (West)	Ishasha	2.4
Ishasha B	Ishasha	3.6
Nyamabuye A	Kaku	1.5
Nyamabuye B	Kaku	0.7
Maziga Gorge	Maziba	0.5
Kaka	Ruimi	1.5
Mbarara	Muzizi	0.7
Sogahi A	Sogahi	2.7
Sogahi B	Sogahi	3.3
Medium Hydro		
Muzizi	Muzizi	10
Bogoye	Mubuku	7.5 (5MW in service)
Nengo bridge	Ntungu	12.0

In summary, about 23 small hydropower sites totaling about 54MW power potential. Most of these sites are located off the River Nile on Non-Nile Rivers scattered around the country (the Nile sites are all large hydro). Of these rivers, only about 25MW has been developed or is in progress of development, though this still represents the large hydro sites of 23 small hydro sites. The smaller ones are scattered all over the country, and potential private investors are being invited to develop them through the ERT program.

4 CAPACITY BUILDING NEEDS

4.1 INTRODUCTION

Most developing countries face water and energy scarcity problems in the future due to increasing demand resulting from population growth, improved standard of living and urbanization and industrial development. Most of Nile countries suffer from this situation because of the lack of adequate infrastructure for energy supply. In general, the per capita for electric consumption in the Nile Basin is one of the lowest in the world.

There are also a number of management problems such as lack of managerial and incentive measures, lack of personnel required for operation and maintenance and lack of associated research and development in
the energy sector.

Capacity building is a prerequisite to integrated water resources management in general and to rational energy systems in particular. Increasing the efficiency and effectiveness of the people working in the water and energy sector will be through active program of human resources development. Assessment, planning and use of energy resources in general and hydropower resources in particular require that people involved be of high caliber to address issues of the coming century.

A number of management problems has been recognized such as the lack of managerial and incentive measures, the lack of personnel required for operation and maintenance, lack of associated research and development activities, and the lack of coordination among energy concerned agencies.

4.2 CAPACITY BUILDING

Capacity building is a prerequisite to integrated water resources management. Technical solution will not achieve the objectives of development on their own without suitable attention to the human factor. The national and local institutions tend to be inefficient and ineffective for many reasons such as:

- Inadequate funding and human resources,
- Inadequate working environment for the individuals responsible for implementing the energy policies.
- A lack or inadequate opportunities for education and training for upgrading skills, and
- Lack of positive programs to ensure the involvement and commitment of the communities and the public in general.

The correction of these inadequacies has come to be known as "Capacity building" which is a long-term continuing process that consists of four basic elements:

- The creation of an enabling environment that has appropriate policy and legal framework;
- Institutional strengthening and development, including local participation;
- Human resources development, including the strengthening of managerial system and energy Users interest; and
- Awareness building and education at all levels of society

4.3 NEEDS FOR CAPACITY BUILDING IN THE ENERGY SECTOR

Capacity building is needed to implement the integrated approach to the development, management and use of energy resources. The solutions should begin with capacity building in the area of energy resources assessment. The term "energy resources assessment" is often used not only for inventory of the available hydropower and other renewable resources but it should include the capabilities a country has to satisfy its energy requirement and how to match supply with demand.

Since hydropower study requires a multi-disciplinary team participation, it is essential to have capacity building not only in the area of engineering but also in a spectrum of other relevant disciplines. Since such a strong inter-disciplinary team lacks in most cases, authorities of developing countries are forced to depend on external support. Technical and feasibility studies of hydropower resources projects are often done by foreign agencies as external support while executions of these projects are implemented by huge companies with just a little involvement of the national experiences. Many of the external supports are spent on studies whereas very little are allocated to capacity building and human resources development.

4.4 HUMAN RESOURCES DEVELOPMENT

In many cases in our countries, the proportion of University graduates is less than 10% and roughly, more than 0% of the employees have less than a high school degree. The percentage of University graduates is a low proportion of the total employees.

Therefore, given these conditions, the only means is to increase the efficiency of the energy sector staff in responsiveness, development and management through active programs of human resources development. Tailor made short-term as well as long-term trainings are essential to meet the need in human capacity requirements. Training is an important management tool for motivating staff and improving organizational performance. Training improves performance by strengthening employee knowledge and improving procedures, structures and management. The tailor-made training should aim at improving employee wellbeing and satisfaction through benefits, long term education, staff incentive programs, career ladder and succession planning.

4.5 LACK OF PROPER VOCATIONAL TRAINING

In spite of the effort being made to expand University education in the area of water resources, vocational education for assistants is not adequate .Also; it is obvious that there is a shortage in the number of assistant engineers. The number of vocational training is limited. It appears that there is a need for technicians (assistant engineers) in the area of operation and maintenance of power plants.

5 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS AND RECOMMENDATIONS

Lack of low cost and reliable sources of energy for rural and semi-urban areas is a major hindrance to social and economical development in the Nile Basin countries.

Nile Basin Countries are among the least developed countries in the World though endowed with huge hydropower potential resources totaling more than 12 GW. There exist enough small hydropower potentials near or at rural and semi-urban areas, if exploited can change developmental equation of the rural areas.

There is a need of intensified training/capacity building in the areas of manufacturing technology for equipment related to SHP schemes. Designing and Manufacturing industries for SHP lack footing in our countries and therefore need sustained efforts. These efforts should be coupled with equal efforts for markets within the basin counties.

The relevant authorities in these countries should take a number of measures to address these techno-economic constraints to give way to exploit these abundant energy sources that are quite close to the rural communities. Among others, the following are measurers that are recommended:

- Government policies to better support SHP development
- Developing Capacities in organizations and institutions mandated to undertake SHP development e.g. training
- Involvement of local expertise wherever they are available, to carry out studies on SHP development.
- In some of the Nile Basin countries there exist, operating small hydro plants and it is therefore recommended to learn and gather skills from them.
- Explore possibilities of cooperation among the Nile basin countries for manufacturing SHP equipments. This cooperative venture could improve market potentials.

5.2 THE WAY FORWARD BEYOND CAIRO JUNE 2004 WORKSHOP

The following research objectives are recommended for continuation of Theme I beyond Cairo June 14, 2004:

- Completion of the inventories started in Phase 1.
- Publication of a Small Scale Hydropower Reference Booklets containing important data and information for every participating country in Theme 1.
- Development of a Design Manual for Small Scale Hydropower for use in the Nile Basin countries.
- Development of feasibility studies for the implementation of a small-scale pilot project in each of the Theme 1 participating member country.
- Promotion of Training activities within the scope of Theme I.

6 REFERENCES

Local country reports from the NBCBN-RE participating member countries as submitted by Theme I country members, 2004.

Petry, Bela (2002-2004): Personal Communication

APPENDIX A1

BURUNDI REPORT

CONTENTS

1 WATERSHED CHARACTERISTICS IN BURUNDI NILE BASIN.

1.1 LOCATION.

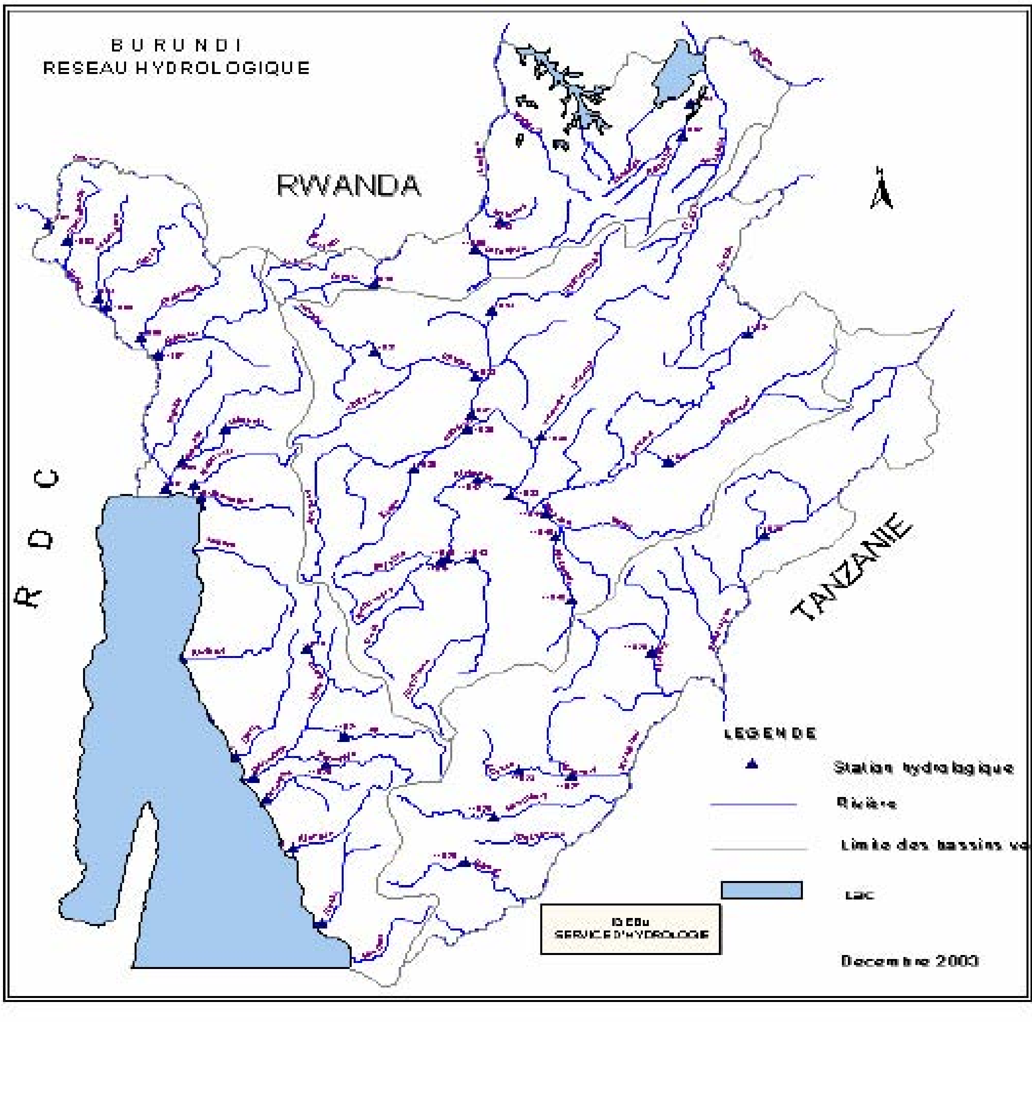
The burundi Nile basin watershed lies between 2°15'S and 3°55'S of latitude and 29°30 E and 30°35E of longitude. It is located in the central plateaux and depressions of north of BURUNDI of which altitude ranges between 1000m up to 2300m.

1.2 RELIEF.

The borders of the watershed are: -to the North, North West, and North-Est: peneplains of Rwanda and Tanzania natural region; altitude 1250m up to 1600m, -to the West: foothills of eastern parts of the Congo-Nile crest; altitude 1600 up to 2300m. These foothills lead to the massifs and ranges of mountains making up the crest; altitude 2000 up to 2500m, -to the South: foothills (altitude 1800m-2000m) of the BURURI-RUTOVU massif; altitude 2000m-2200m, -to the South-East and East: narrow old peneplains; altitude 1250-1500m resulting in the valleys of eastern (altitude 1200m-1600m).

1.3 HYDROGRAPHY.

BURUNDI has 2 major watersheds: one of CONGO basin and another for NILE basin. many tributaries flow into the Nile river through RUVUBU and KANYARU- KAGERA river inside BURUNDI and KAGERA river outside the country which in return flows into Lake VICTORIA, feeding from there to the NILE river.



Hydrological balance mean of water resources per year.

Watershed	Mean discharge National territory (m3/s)	Imported discharge from Rwanda (m3/s)	Imported discharge from Tanzania (m3/s)	Exported discharge to Rwanda (m3/s)	Exported discharge to Tanzania (m3/s)
Ruvubu	108		4		-112
Kanyaru	21	25		-46	
Kagera	8	134			-142

This table shows that the mean discharge of the Nile basin in the part of Burundi territory is around 137 m3/s which the equivalent is 355.1 hm3 of mean per month. Also, we have 112 m3/s (290.3 hm3 of the mean per year) which pass through the exutory point of the basin of Ruvubu per month.

1.4 CLIMATE.

The Nile basin in Burundi have a tropical climate but moderate by altitude. The following characteristics are:

- The mean annual temperature is a function of topography and ranges between 18^{o}c and 20^{o} c,
- The annual rainfall amounts reach 1000m up to 1200m. The rainfall regime is characterized by two rainy seasons, the small and long rainy season. These two rainy seasons lasts from mid-September to December immediately followed by January which is generally a small dry season.
- The long rainy season starts in February to May followed by a long dry season from June to around mid-September.

1.5 SOIL AND VEGETATION.

The soils are either rocky, lateritic, lithogenic, clay or sandy. The schisto-quartz rocks are characteristic of the basin. The Nile basin occupies first of all the northern part of Burundi, southern and western part of KIRIMIRO central natural region and characterized by the presence of wood savanes. Thus, most of these soils are favourable to agriculture. The main crops matching with these soils are, among others, maize, beans, bananas, manihoc , collocate and coffee.

1.6 POPULATION DISTRIBUTION.

The average population in the Nile basin area is 115 habitants per square km; the high population density is found in areas with fertile soils.
During the dry season, the population practices farming activities in the marshlands to get subsistence food and other needs. Bananas local brew and coffee are the essential sources of population income.

General data

- Total Population: 6,3 millions inhabitants from which about 95 % in rural area.
- Number of customers in hydropower in 2002: 31 454 from which 30 079 are in urban centers and 1375 in rural area.
- Rate of national electrification: 2%
- Consumption of hydropower per capita : 20 KWh/year
- Total consumption 2002 : 119 961 MWh

2 INVENTORY OF DATA BASES AND SOURCES OF INFORMATION

2.1 INVENTORY OF HYDROLOGICAL DATA BASE AND SOURCES OF INFORMATION

Hydrological Data

Nº	Name of Site	Hydrological Station	Location	Format	Availability	Date of Reference
1	GIKONGE	MUBARAZI	All hydrological National database is located in Geographic Institute of BURUNDI (IGEBU)			1975-1997
2	KAYENZI	KAVURUGA				-
3	MARANGARA	NDURUMU				1979-1993
4	BUHIGA	NDURUMU		Electronic data in computer in ACCESS 2000	Accessible on official demand at a fee	
5	SANZU	NYAKIJANDA				1974-2002
6	BUTEZI	NYABAHA				1974-2002
7	RYARUSERA	-				1973-2002
8	NYABIKERE	-				-
9	MURORE	-				-
10	MUGERA	RUVYIRONZA				-
11	KIREMBA	BUYONGWE				1974-2002
12	TEZA	-				1986-1993
13	KIGANDA	MUBARAZI				-
14	GISOZI	-				1975-1997
15	BURASIRA	RUVUBU				-
						1975-1997

All Hydrological Stations have gauge height, discharge measurements and rating curves parameters

Hydrological Studies

Nº	Description	Location	Format	Availability	Date of Refe.
1	Hydrological year books	Geographic Institute of BURUNDI (IGEBU)	Documents in 12 volumes. Hard copy	Accessible on official demand at a fee for photocopies.	1978-1990
2	Hydrology of Imbo Region		Documents in 50 pages and 184 annexes. Hard copy	Accessible on official demand at a fee for photocopies.	1974
3	Provisional Hydrological Report on Imbo Region		Documents in 120 pages. Hard copy .	Accessible on official demand at a fee for photocopies.	1969-1971
4	NYAMUSWAGA Development Study		Documents in 99 pages, 3annxes, 64 tables and 33 figures. Hard copy.	Accessible on official demand at a fee for photocopies.	1986
5	Hydrological Basins Directory of BURUNDI		Documents in 210 pages. Hard copy .	Accessible on official demand at a fee for photocopies.	1988

2.2 INVENTORY OF METEOROLOGICAL DATA BASE AND SOURCES OF INFORMATION

Nº	Name of Site	Meteorological Station	Location	Format	Availability
1	GIKONGE	MURAMVYA[1]	All Meteorological National database is located in Geographic Institute of BURUNDI (IGEBU)	Electronic data Accessible official computer in ACCESS 2000	Accessible on official demand at a fee
2	KAYENZI	MUYINGA[3]			
3	MARANGARA	MULEHE[1]			
4	BUHIGA	KARUZI[3]			
5	SANZU	BUTEZI[2]			
6	BUTEZI	BUTEZI[2]			
7	RYARUSERA	BUGARAMA[1]			
8	NYABIKERE	MUTUMBA[2]			
9	MURORE	MURORE[1]			
10	MUGERA	MUGERA[1]			
11	KIREMBA	KIREMBA[2]			
12	TEZA	TEZA[3]			
13	KIGANDA	KIGANDA[1]			
14	GISOZI	GISOZI[3]			
15	BURASIRA	BURASIRA[3]			

Legend

1. Station with Rainfall data only
2. Station with Rainfall and Temperature data
3. Station with all Meteorological parameters

2.3 INVENTORY OF ENERGY DATA BASE AND SOURCES OF INFORMATION

N°	Description	Location	Format	Availability	Date of reference	Evaluation
1.	Hydropower Resources Development Study in BURUNDI. LAHMEYER Int..1983	Ministry of Energy and Mines. General Direction of Water and Energy	Document in 156 pages available. Main document + Annexes. Hard copy.	Accessible to authorized officers on demand at a fee for photocopies.	1980-1983	The study has to be updated because of many changes up to now.
2.	National Electrification Master Plan revised by SOGREAH in 1995.	Ministry of Energy and Mines. General Direction of Water and Energy	Document in 124 pages available. Hard copy.	Accessible to authorized officers on demand at a fee for photocopies.	1994-1995	The first document of Master Plan has been done by EDF (France) in December 1988.
3.	Annual reports of REGIDESO (National Light and Water Supply Company in Urban Area)	General Direction of REGIDESO BUJUMBURA	Documents in 110 page each, including annexes available. Hard copy.	Accessible on official demand at a fee for photocopies.	1990-2002	Annual report for 2003 will be soon ready.
4.	National Rural Electrification Master Plan. By ICM, 1993	General Direction of Hydraulics and Rural Energies (DGHER)..	Document in 110 pages , including annexes is available. Hard copy.	Accessible on official demand at a fee for photocopies.	1991-1993	The document has to be updated because of many changes up to now.
5.	Annual Reports of General Direction of Hydraulics and Rural Energies.	General Direction of Hydraulics and Rural Energies (DGHER).	Document in 80 pages each, with annexes is available. Hard copy.	Accessible on official demand at a fee for photocopies.	1990-2003	-
6.	Assessment Study of Energy Sector in BURUNDI. By BEROCAN Int. ;1998	Ministry of Energy and Mines. General Direction of Water and Energy	Document in 148 pages, with annexes is available. Hard copy.	Accessible on official demand at a fee for photocopies.	1997-1998	Study aimed on all forms of Energy with special accent on Hydropower.

2.4 INVENTORY OF SITES FOR SMALL SCALE HYDROPOWER

S/N	NAME OF SITE	RESPONSIBLE	NAME OF RIVER	INSTALLED POWER IN MW	START YEAR
1	GIKONGE	REGIDESO	MUBARAZI	0.850	1982
2	KAYENZI	REGIDESO	KAVURUGA	0.350	1984
3	MARANGARA	REGIDESO	NDURUMU	0.240	1986
4	BUHIGA	REGIDESO	NDURUMU	0.240	1984
5	SANZU	REGIDESO	SANZU	0.072	1983
6	BUTEZI	DGHER	SANZU	0.240	1990
7	RYARUSERA	DGHER	KAGOGO	0.020	1984
8	NYABIKERE	DGHER	NYABISI	0.139	1990
9	MURORE	DGHER	RUSUMO	0.024	1987
10	MUGERA	PRIVATE	RUVYIRONZA	0.030	1962
11	KIREMBA	PRIVATE	BUYONGWE	0.064	1981
12	TEZA	PRIVATE	NYABIGONDO	0.360	1971
13	KIGANDA	PRIVATE	MUCECE	0.044	1984
14	GISOZI	PRIVATE	KAYOKWE	0.015	1983
15	BURASIRA	PRIVATE	RUVUBU	0.025	1961

APPENDIX A2

ETHIOPIA REPORT

CONTENTS

1 INVENTORY OF SMALL HYDROPOWER SITES IN ETHIOPIA

1.1 INTODUCTION

There are a few small, mini and micro hydro plants in operation, and numerous potential sites. The following report makes inventory of the potential sites as identified by previous investigations. About 10 per cent of the economically feasible potential is thought to be suitable for small scale developments. Three small hydropower plants are part of the self contained system of power supply in the country.

Small hydro could provide considerable help to the country, by meeting the power deficit in the main interconnected grid system, substituting thermal plants in the main grid or isolated grids, helping reduce fuel imports and electrifying remote rural areas.

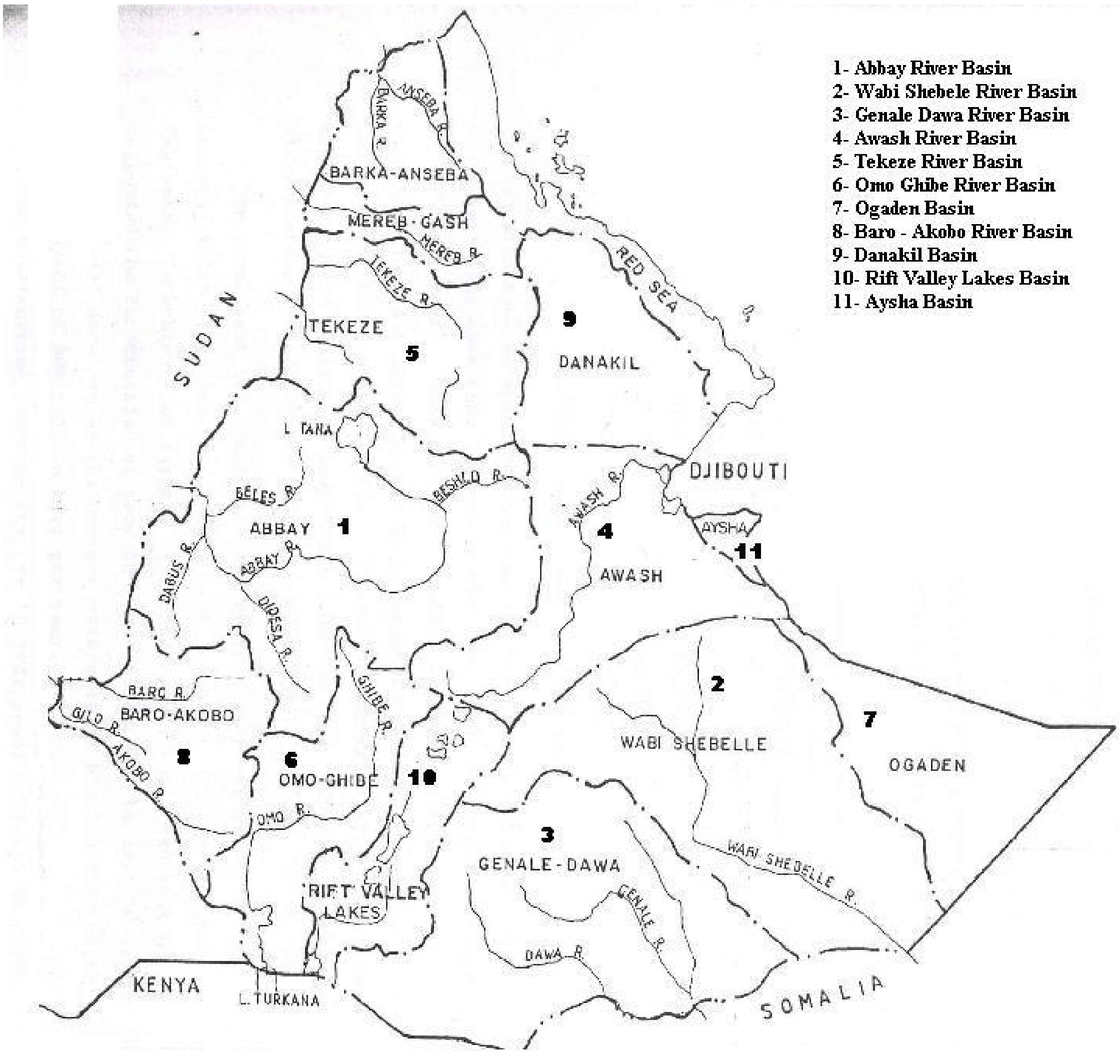


Figure (1- 1) Basins in EThiopia

1.2 ABBAY BASIN

The French Consultant BCEOM in association with BRGM and iSL consulting Engineers conducted a master plan study for integrated development of the Abbay River Basin in 1999. BCEOM identified about 26 potential hydropower sites, which are indicated in Table 2 and Fig 3

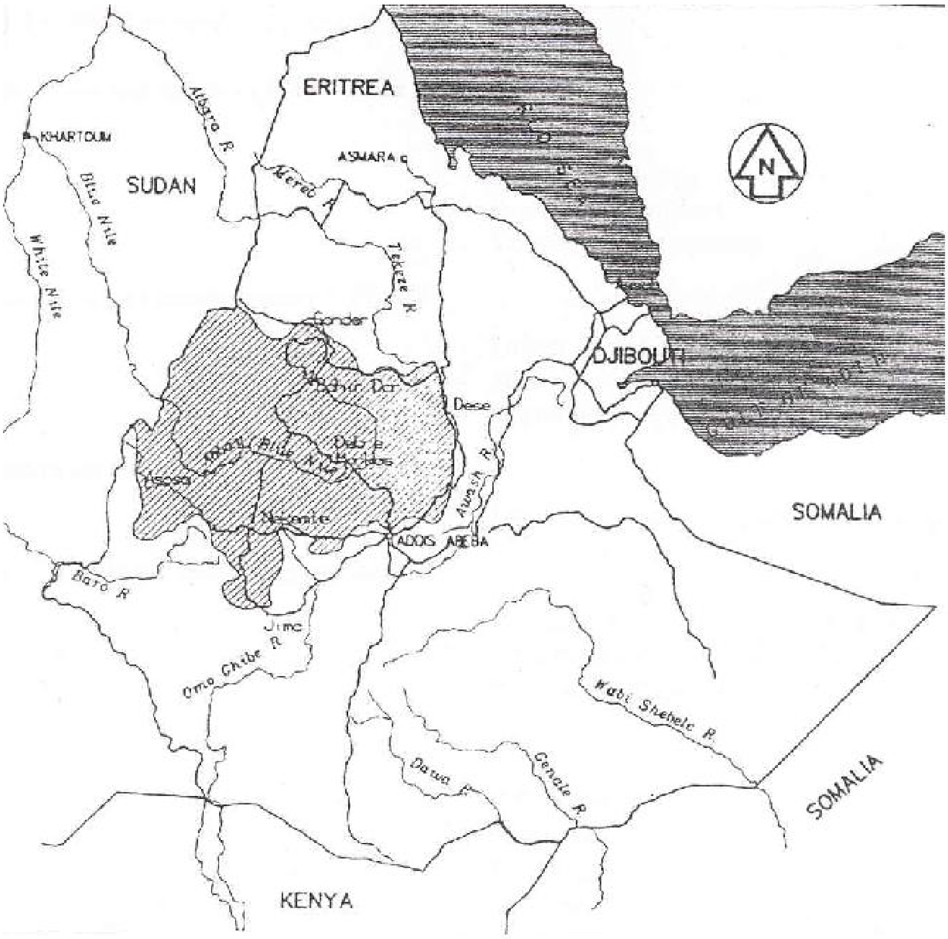


Figure (1- 2) Location Map

Source: Abbay River Basin Integrated Development Master Plan Project, Phase 3 Executive Summary, BCEOM, April 1999

Table (1-1) Small Hydropower Sites in the Blue nile basin (BCEOM)

Name of Power Scheme	Installed Capacity (MW)	Type of Project
Anger	10	Reservoir
Galegu	5	Reservoir
Gilgel B	5	Reservoir
Jemma	2	Reservoir
Lah	1	RoR
Lower Dabus	7.5	RoR
Lower Dindir	20	Reservoir
North Chagni	5	Reservoir
Negeso	10	Reservoir
Nekemte	10	Reservoir
Rahad	15	Reservoir
Upper Guder	20	Reservoir

Table (1-2) Small Hydropower Sites in the Blue Nile Basin (Chinese Study Team)

Name of Site	Power (kW)	Name of Site	Power (kW)
Gilgal Abay	196	Belo	65
Kiltie	15	Kiltie	122
Andassa1	89	Andassa1	236
Andassa2	89	Ardie	92
Andassa3	89	Dura	519
Temie	122	Gumbi	122
Azwari 1	29	Uke	58
Azwari 2	122	Endris	167
Asher	167	Negesso	278
Andassa Branch	89	Gefere	90
Koga	45		
Suha Shet	167		
Muga Hayk	167		
Gula (1)	26		
Gula (2)	40		
Temecha	60		
Gedab (1)	167		
Gedab (2)	222		
Lahi	60		
Birr	14		
Fetam (3)	434		
Fetam (2)	224		
Fetam (1)	278		

1.3 THE WABI SHEBELE RIVER BASIN

The Master Plan Study for the Integrated Development of the Wabi Shebele River Basin is currently being made the Water Works Design Enterprise. Currently the Master Plan study has identified 21 potential hydropower sites, with 5 new sites identified apart from the 16 potential hydropower sites earlier identified by WAPCO.

Table (1- 3) Small Hydropower Sites in the Shebelle Basin

No.	Power (MW)	Energy (GWH/yr)
1	2.6	14
2	5.5	28

Figure. (1-3) Location Map Wabi Shebelle River Basin

Source: Preliminary Water Resources Development Master Plan for Ethiopia Final Report, WAPCO, June 1990

1.4 THE GENALE DAWA RIVER BASIN

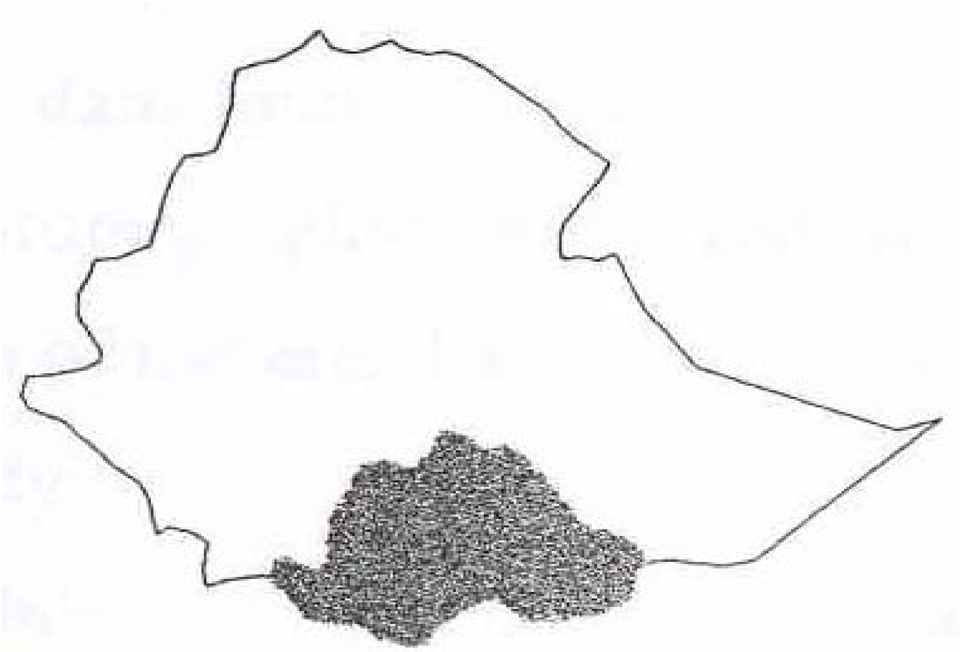


Figure (1- 4) Location Map of the Genale Dawa Basin

The Reconnaissance Phase Genale Dawa River Basin Integrated Development Master Plan Study was made by the Ministry of Water Resources in the year 2000 which incoorporated the Dam and Hydropower aspects. The report reproduced investigations by ***(ACRES, 1982) Power planning study, Ministry of Agriculture and Small Hydropower Investigation Team. P.R.C (1989 and WA****PCOS Preliminary Water Resources Development Master Plan for Ethiopia.*

Table (1-4) Small Hydropower Study Team Investigation Sites(Genale Dawa)

Stream and levation		**Catchment area (km2)**	**Mean annual runoff (m3/s)**	**Head m**	**Potential generating capacity (Kw)**
Logita	1800	716	14.4	45.5	400
Logita II	1800	716	14.4	16.5	200
Bonora	1650	438	12.3	30	320
Ababa	1550	371	12	29	320
Combolcha	2650	304	9.9	15	110

The study identified an altogether 31 potential dam sites for irrigation, hydropower and integrated development.

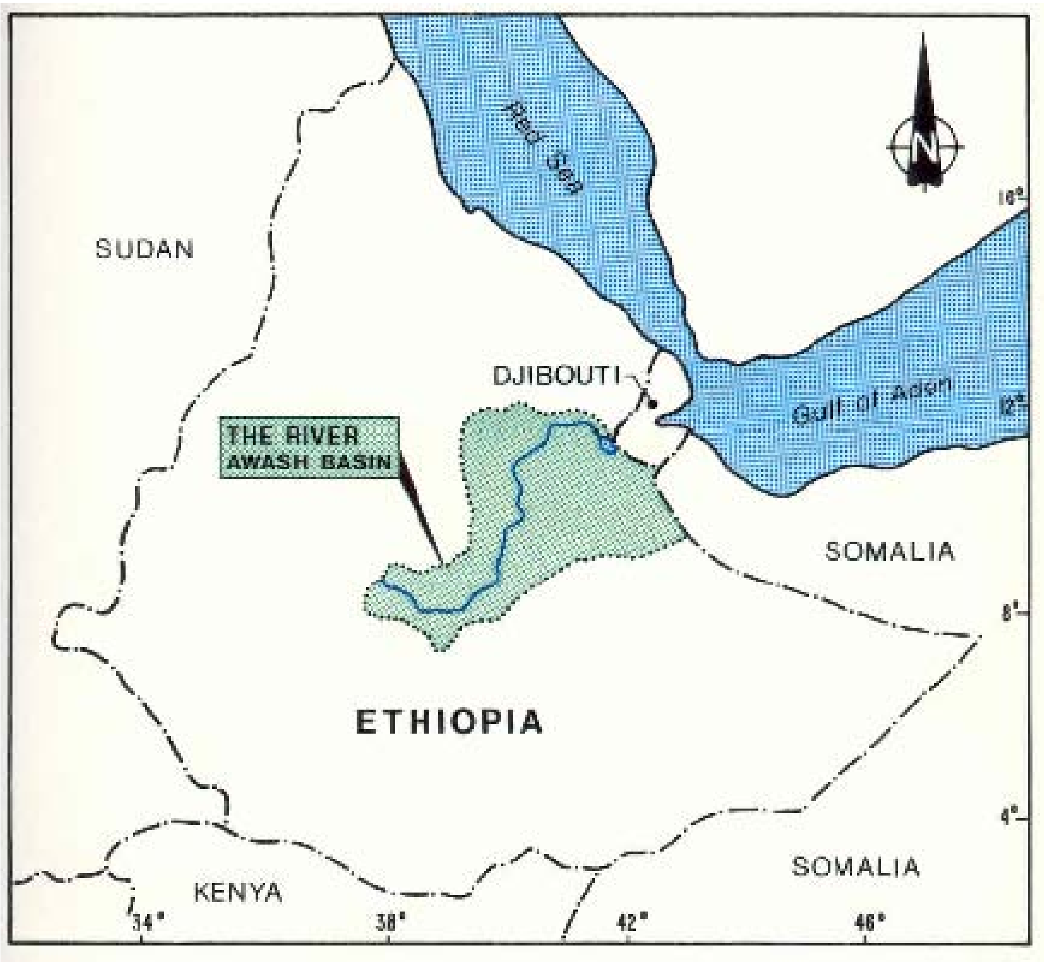


Figure (1-5)Location Map of Awash Basin

Source: The Awash River Master Plan Study, Sir Williams Halcrow & Partners Ltd plan ag cap

The identified potential small hydropower projects are shown in Table 6, however the master plan reports that hydropower potential of the basin is 50% more than what is indicated in the table.

Table(1- 5) Small Hydropower potential in the Awash Basin

Site	Hydropower Potential	
	Installed (MW)	**Gross (GWH)**
Melka Kunture	16	57
Kesem	6	20
Kebena	3.8	12
Tendaho	6	69

1.5 TEKEZE RIVER BASIN

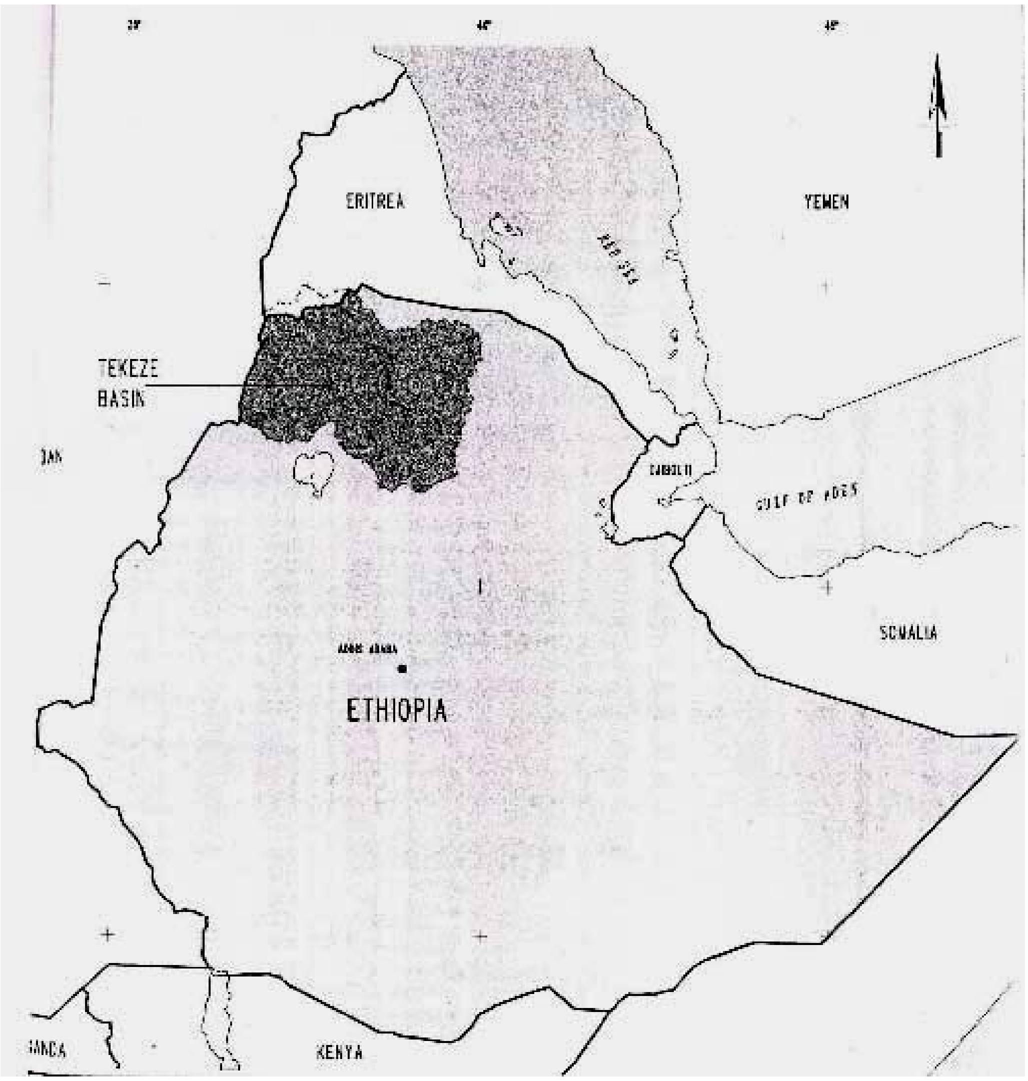


Figure (1-6) Location Map of Tekeze Basin

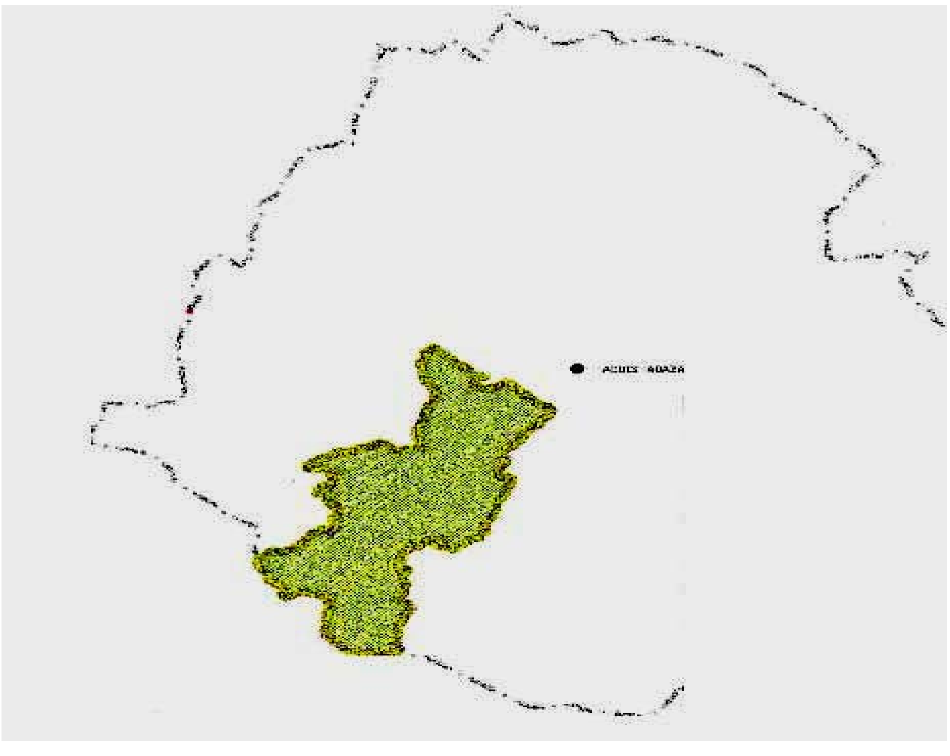
Source: Tekeze River Basin Integrated Development Master Plan Project Executive Summary, the Netherlands Engineering Consultants (NEDECO), February 1998

Table (1- 6) Small Hydropower Sites Identified in the Tekeze Basin

Teknr	Source	River	Coordinates		Near by town	Power (MW)	Map/photo numbers	
			Easting	Noting			1:250,000	1:100,000
							(Map	
1	TK-11	Hamu	507.832	1435.934	Finerawa	9.1	ND-37-15	ND37-115
2	TK-12	Tserare	517.183	1416.127	Sekota	16.0	ND-37-15	ND37-115
3	TK-13	Tserare	529.866	1395.558	Korem	6.0	ND-37-15	ND37-127
4	TK-14	Tserare	547.964	1397.426	Korem	2.0	ND-37-13	ND37-127
5	TK-15	Goang	288.393	1423.989	-	4.6	ND-37-13	ND37-111
6	TK-16	Goang	273.886	1420.107	-	4.4	ND-37-13	ND37-110
7	TK-17	Goang	254.874	1419.191	-	5.7	ND-37-13	ND37-110
8	TK-18	Goang	235.839	1416.136	-	3.4	ND-37-13	ND37-110
9	TK-19	Goang	224.071	1416.25	Metema	2.1	ND-37-13	ND37-109

The Netherlands Engineering Consultants, NEDECO inassociation with DHV consult made the Iegrated Master Plan Study Of the Tekeze River Basin in 1998. The consultant selected 5 sites, which are considered the most feasible ones in terms of physiography, of which tow were finally evaluated as the best ones (TK4, 85 MW and TK7, 221 MW). The consultant selected 10 sites out of the 15 potential sites identified by WAPCO and made ground checking for these sites.

1.6 THE OMO GHIBE RIVER BASIN



Figure(1-7) Location Map of Gibe-Omo basin

The Omo Ghibe river basin has the second largest hydropower potential of all the river basins next to the Abbay river basin.

The potential to develop a hydropower network on individual rivers with schemes situated downstream of a regulating reservoir is shown in table 8 below.

Three types of hydropower projects, varying in scale, have been identified to supply electricity in the Basin: large - scale (>100 MW): medium - scale (up to 100 MW); and small-scale developments (up to 15 to 20 MW) Mini-hydro and very small-scale development up to 1 MW are feasible, technically, at the headwaters; small-scale plants are practical along the highland plateau.

Table (1-7) Small Hydropower Sites in the Gibe Omo basin (Chinese Study Team)

Site	Power (kW)
Weshy	168
Menessa	123
Weyibo	444
Dekonu	89
Fato	58
Welga	125
Wunkie	122
Degosa	124
Ameka	222
Gombra	42
Gemena	126
Gemesha	26

1.7 THE BARO AKOBO RIVER BASIN

Figure (1- 8) Location Map of Baro-Akobo Basin

Source: Baro-Akobo River Basin Integrated Development Master Plan Study,Final Report Executive Summary by TAMS and ULG Consultants LTD, May 1997

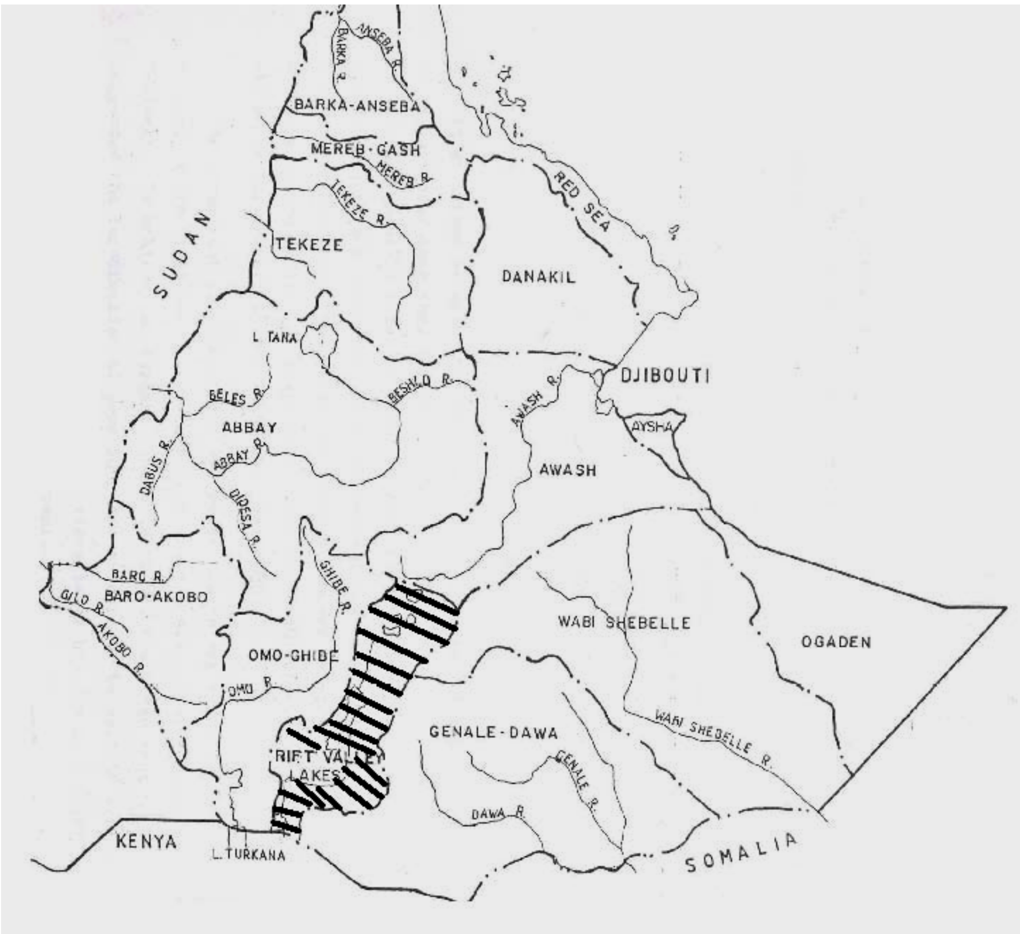
According to the countrywide master plan study by WAPCO, the basin is the third in terms of abundant surface water and hydropower potential. The TAMS (New York)-ULG (UK), who made the Master Plan Study of the basin, Executive Summary report describe the basin as being endowed with plentiful potential hydropower resources more than sufficient to meet the projected demands of the entire nation for many decades to come.

Table(1- 8) Small Hydropower Sites in the Baro-Akobo Basin

Site	Power (kW)
Kile	89
Keto	356
Sor	667
Uka	22
Awetu	122

1.8 THE RIFT VALLEY LAKES BASIN

Reconnaissance Master Plan For the Development of the natural resources of the Rift Valley Lakes Basin was made Sir William Halcrow & Partners Ltd and the reports compiled in August 92.



Figure(1- 9) Location Map of Gibe Omo Basin

Source: Preliminary Water Resources Development Master Plan for Ethiopia Final Report, WAPCO, June 1990

Halcrow referred to the major power planning studies by Acres, UNDP and Cesen, for the basin being notably only for the absence of potential for hydropower development. Cesen report suggested an energy potential in the Bilate-Sagan-Dana basin of some 50,000 GWH without regard to the potential location of power plants. Halcrow's report states other sites in the other basins are far more economically attractive.

Table(1- 9) Small Hydropower Sites in Rift Valley Lakes Basin

Site	Power (kW)
Shope	40
Shalle	183

Water resource potential of these basins as the WAPCOS report indicates is almost negligible. The Reconnaissance phase Master Plan Study of these so-called dry basins was made from June 1999 to May 2000 by the basin development study department of the Ministry of Water Resources itself.

It was reported that Dam site selection was not possible because of the absence of a large-scale map, 1:50,000 for these basins, the currently existing topographic map being a 1:250,000 scale map. The report states that because of the short field visit made and the absence of useful topographic maps, it is not possible to make confirmative conclusion on the absence of suitable dam sites. However, due to shortage of water, sedimentation problem and unavailability of suitable dam sites development of hydropower in these basins seems unlikely.

2 POWER SECTOR FRAMEWORK

2.1 CURRENT POWER SECTOR POLICY AND INFRASTRUCTURE IN ETHIOPIA

Policy

The Ethiopian government's formal policy in the energy sector was issued in May 1994. The key features of this policy included the creation of the Ethiopian Electricity Agency (EEA) and the promotion of the role of the private sector in electricity generation. The Agency was successfully created in the year 2000 and has begun to create the conditions that will help attract private investment.

Another important component of the 1994 policy was the focus on hydropower and, particularly, small-scale hydropower. This remains the main formal Government policy statement today though a range of policies have been clarified or refined through subsequent legislation such as the Investment Law.

Interconnected system

The Ethiopian Electric Power Corporation (EEPCo) was established as a corporation by Proclamation 18/1997. EEPCo is currently owned by the Ministry of Infrastructure and is responsible for generating, transmitting and distributing electricity.

Investment legislation (Proclamations Nos 37/1996 and its amendment Proclamation 116/1998) took a step toward the liberalisation of the electricity market and allowed domestic and foreign investors to invest in hydropower without any size restriction and domestic investors to invest in non-hydro generation below 25 MW. Non-hydro generation above 25 MW was to remain the sole domain of the state.

The revised Proclamation 280/2002, together with the associated Regulation 84/2003, relaxes the last remaining restrictions on investment in power generation but confirm EEPCo's monopoly in the transmission and distribution of electricity for the interconnected system (ICS). Power generation that supplies the ICS may therefore be undertaken either by EEPCo or by private companies selling electricity to EEPCo.

Presently the Corporation maintains two different power supply systems; namely, the Interconnected System (**ICS**), which is mainly supplied from hydropower plants, and the Self-Contained System (**SCS**), which consists of mini-hydropower plants and a number of isolated diesel generating units that are widely spread over the country. While Table 1 and Table 2 show the features of various mixes of power sources in the ICS and SCS, Figure 2-1 shows the coverage of the ICS in the country.

Table (2- 1) ICS Power Supply in Ethiopia

NAME	HYDRO	DIESEL	GEOTHERMAL	TOTAL	COMYR G.C.
Koka	43.2	-	-	43.2	1960
Awash II	32.0	-	-	32.0	1966
Awash III	32.0	-	-	32.0	1971
Finchaa	128.0	-	-	128.0	1973,2002
Melka Wakana	153.0	-	-	153.0	1988
Tis Abay I	11.4	-	-	11.4	1964
Tis Abay II	73.0	-	-	73.0	2001
Aluto Langano	-	-	7.3	7.3	1999
Alemaya	-	2.3	-	2.3	1958
Dire Dawa	-	4.5	-	4.5	1965

Adigrat	-	2.4	-	2.4	1992,93,95
Axum	-	1.3	-	1.3	1975, 92
Adwa	-	3.0	-	3.0	1998
Mekele	-	3.3	-	3.3	1984, 91, 93
Shire	-	1.0	-	1.0	1975, 91, 95
Lalibela	-	1.0	-	1.0	1975, 91, 95
Nekempt	-	2.3	-	2.3	1984
Ghimbi	-	1.1	-	1.1	1962, 84
Grand Total	***472.6***	***22.2***	***7.3***	***502.1***	-

Table(2- 2) SCS Power Supply in Ethiopia

Plant Name	Hydro	Diesel	Total	COMYR G.C.
Yadot	0.35	-	0.35	1991
Sor	5.00	-	5.00	1992
Dembi	0.80	-	0.80	1994
Sub Total	***6.15***	-	***6.15***	-
Dubti	-	1.00	1.00	1991, 92, 95
Bonga	-	1.32	1.32	1972, 74, 76, 94, 98
Asayita	-	0.94	0.94	1970, 71, 88, 95
Negele Borena	-	0.87	0.87	1975, 84
Asosa	-	0.85	0.85	1991, 94, 95, 98
Others	-	8.88	8.88	'67-'98
Sub Total	-	***13.86***	***13.86***	-
Grand Total	6.15	***13.86***	***20.01***	

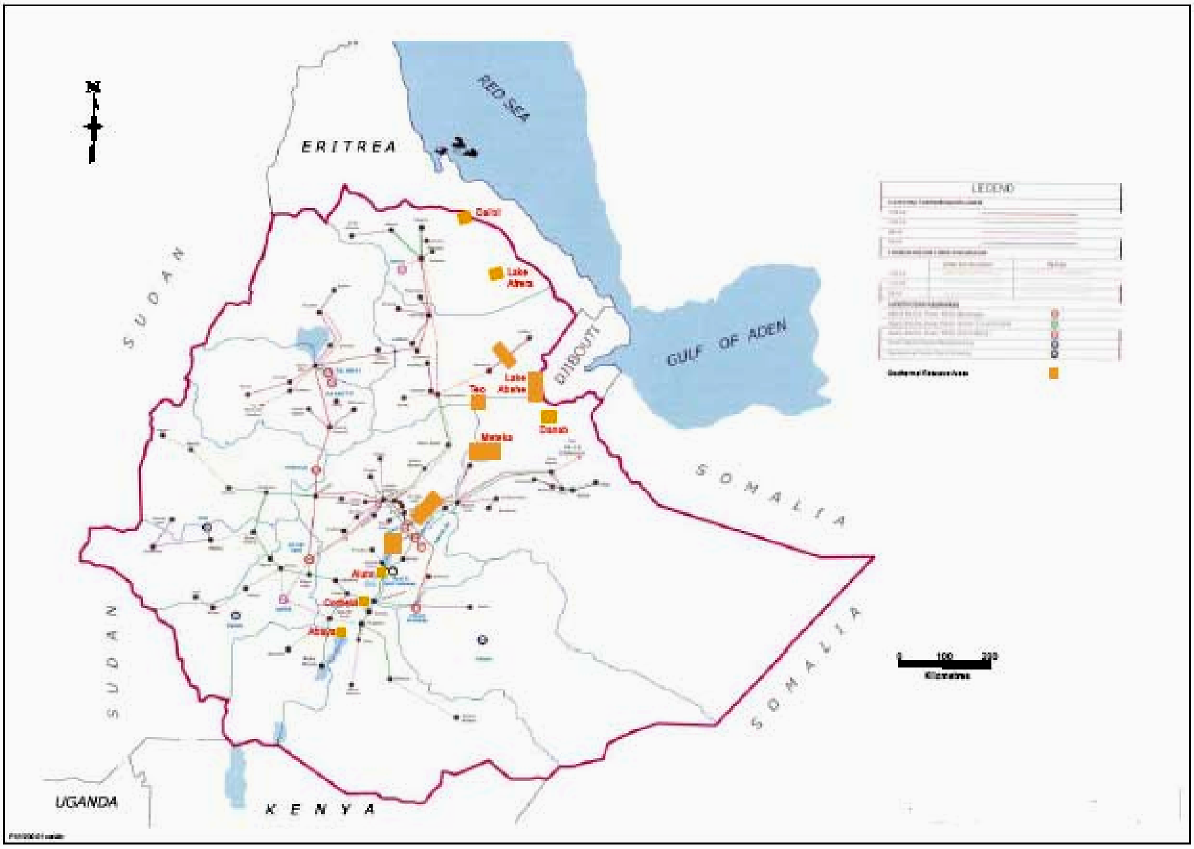


Figure (2-1) Interconnected System of Ethiopia

Isolated networks

For isolated networks, the private sector is permitted to invest in generation and distribution. A Rural Electrification Strategy has been adopted by the Ministry of Infrastructure and issued in May 2002 which allows for grid extension by EEPCo but also the development of isolated grids by the private sector, local communities and electric supply cooperatives. The strategy calls for the design of an institutional structure for rural electrification including a Rural Electrification Board (REB), a Rural Electrification Secretariat (RES) and a Rural Electrification Fund (REF).

Proclamation no. 317/2003 - the Rural Electrification Fund Establishment Proclamation - was passed in 2003 which established the REB with the Ethiopian Rural Energy Development and Promotion Center (EREDPC) as the secretariat.

2.2 INVESTMENT CLIMATE IN THE POWER SECTOR IN ETHIOPIA

The climate for foreign investors in the electricity sector improved with the passing of the new Ethiopian Investment Law in 2002. Ethiopia is taking steps to reduce the burden of business licensing and to reform the investment code to make it more investor friendly. There are no restrictions on the local content or technology transfer requirements of foreign investment or restrictions on the repatriation of foreign earnings or capital though the IMF did mention that a number of barriers continue to exist that it recommended should be eliminated. These barriers included:

- a tax certification requirement for repatriation of investment income;
- restrictions on repayment of legally entered into external loans and supplied and foreign partner’s credits;
- rules for issuance of import permits; and
- the requirements to provide a clearance certificate from the National Bank of Ethiopia (NBE) to obtain import permits.

Strict foreign exchange controls are administered by the National Bank of Ethiopia such that an importer is required to apply for a permit and obtain a letter of credit for 100% of the value of imports before an order can be placed.

2.3 REGULATORY AND POLICY FRAMEWORK

Independent electricity regulators exist throughout the world because of the need for independent *economic* regulation. Historically, independent regulators only occurred where utilities are privately owned. Before the 1990s, virtually the only country with independent regulators was the US where investor-owned utilities were the norm. Since the late 1980s, independent regulators have been established to perform economic regulation in countries that have privatised their utilities and/or introduced competition.

The primary function of an economic regulator is to set prices for monopoly activities. Related activities may include

- market creation and governance (where competition is possible),
- performance (cost efficiency and service quality) of the utility, and
- regulation of abuses of monopoly power in semi-competitive electricity markets.

EEA (Ethiopian Electric Agency) has a much wider responsibilities than many economic regulators elsewhere. The role of EEA and other institutions in relation to each of the regulatory or other functions that EEA is, or could be, involved with, including: policy making

- the electricity market (its development and governance)
- cost efficiency
- national standards for electrical products and equipment
- worker protection and public safety
- building installations

- certification of professionals
- natural resources
- environment
- demand-side energy efficiency
- complaint handling
- investment approval
- rural networks

It is a matter of scrutiny how the EEA fits into the wider framework of regulation in Ethiopia and how it can harmonize the role of the different regulatory and policy making institutions including:

- the Ministry of Infrastructure
- the Ethiopian Investment Authority
- the Ministry of Water Resources
- the National Standards body (QSAE)
- the Environment Protection Agency
- the Rural Electrification Board
- the Regional Governments
- the Ministry of Labour
- the Society of Ethiopian Electrical Engineers
- the Ministry of Mines
- National Bank of Ethiopia (NBE)

Main matters of scrutiny include:

- a review of the powers and responsibilities of EEA and other regulatory agencies under existing legislation,
- identification of gaps or overlaps in regulatory responsibilities,
- recommendations on roles and responsibilities of EEA in relation to other agencies.

Policy making

The Ministry of Infrastructure is designated by Proclamation 256/2001 as the Ministry with responsibility for policy making in the electricity sector. In particular, the Ministry shall:

- initiate policies and laws, prepare plans and budget and, upon approval, implement same;
- ensure the enforcement of laws, regulations and directives of the Federal Government;
- undertake studies and research; collect and compile statistical data;
- give assistance and advice, as necessary, to Regional executive organs;
- enter into contracts and international agreements in accordance with the law.

This Proclamation, combined with Proclamation 86/1997, properly allocates responsibility for policy making to the Ministry and regulation to the Agency.

Electricity market regulation

There is often overlap between the role of an anti-trust regulator and that of the economic regulator for electricity. Not all economic regulators in all countries have a role in the governance of the electricity market. In some countries, such as Germany and New Zealand, the anti-trust regulator is given responsibility for regulating the market. In others, such as the UK, the anti-trust regulator shares responsibilities with the economic regulator and when the market becomes competitive the responsibility passes to the anti-trust regulator. However, in most countries the economic regulator does play a role in regulating the market.

There is currently no anti-trust legislation and no anti-trust agency in Ethiopia and there is, therefore, no overlap with EEA. It is therefore recommendable that the regulator's role include responsibilities in relation to the creation and governance of the market relationships.

Cost efficiency regulation

Electricity prices should clearly be regulated by the economic regulator but, because prices are linked to costs, the economic regulator should be keen to encourage cost efficiency in utilities.

The cost efficiency of *privately*-owned, monopoly utilities *must* be regulated by the independent regulatory agency. This is because costs are passed through to customers and, without pressure from regulators, utilities would have no direct incentive to keep costs low. Cost efficiency must therefore be regulated and an independent regulator is the only body able to do this.

For state-owned utilities, the situation is not so clear and for such utilities, cost efficiency can be regulated in any one of the following ways:

- a Government audit office,
- by the Ministry that owns the utility (there are several variants of this option, including a national audit office or a 'contract' as formerly practiced in France with EdF),
- by the Governing Board of the utility, by the independent regulator.

Current responsibilities of cost-efficiency regulation in Ethiopia

There are three bodies, in addition to the Agency, that have some responsibility for ensuring cost efficiency of EEPCo and other state-owned utilities:

- the Auditor General
- the EEPCo Board
- the Ministry of Infrastructure

The Auditor General is charged with monitoring the cost efficiency of Government offices and organizations, such as EEPCo. Its responsibilities include the auditing of accounts, conducting efficiency audits and performance audits.

The Ministry of Infrastructure as owner of EEPCo has responsibilities that include approval of investment plans of EEPCo and the approval, in consultation with the Board, of the annual and long-term corporate targets of the enterprise.

EEPCo's governing Board also has responsibilities for budgeting and, implicitly or explicitly, for ensuring the cost efficiency of EEPCo. The Board of any Public Enterprise, including EEPCo, comprises between three and twelve members of which not more than one third can be elected by the workers. The remainder are appointed by the Supervising Authority which, in the case of EEPCo, is the Ministry of Infrastructure.

EEA is mandated in Proclamation 86/1997 with responsibility "*..to promote the development of efficient, reliable, high quality and economical electricity service*" but the Proclamation does not mention further the role of the Agency in relation to monitoring the cost and management efficiency of EEPCo and other electricity companies.

Who should have responsibility for cost efficiency regulation?

Who *should* have responsibility for regulating the cost efficiency of the state-owned EEPCo? The options are:

- EEA, or
- Government through the Auditor General, the EEPCo Board and the Ministry of Infrastructure?

If the Ministry of Infrastructure and the EEPCo Board continue to have responsibility for regulating cost efficiency, then cost-plus pricing methodology would be appropriate (rate-of-return regulation). EEA's role would be to accept the costs submitted to it by EEPCo and set/approve prices that cover costs, service debts and earn a reasonable return on investment. The Ministry and/or the Board would monitor costs, ensure EEPCo's efficiency and approve its investments and budgets.

An important concern is whether EEA has any effective sanction over EEPCo to encourage cost efficiency. As a state-owned company, EEPCo is not motivated by profit and therefore price setting is unlikely to be an effective tool to encourage efficiency. For similar reasons, monetary sanctions (fines) are unlikely to be effective.

If there were more private companies that needed to be regulated then there would be a good argument in favour of giving responsibility for regulating cost efficiency in the entire sector (including EEPCo) to EEA; but this is not yet the case

2.4 INDEPENDENCE OF REGULATION

We note that toward the end of 2003, the Agency has drafted a new Proclamation that provides many of the characteristics of regulatory independence. However, it is doubtful whether a genuine independence of regulation is attainable

Is EEA independent?

Independence essentially means that regulation is distanced from policy making. EEA reports to the Ministry of Infrastructure, as does EEPCo, and cannot be considered independent of policy makers. The Agency is accountable to the Ministry and its General Manager is appointed by the Government on the recommendation of the Minister and the General Manager does not have a fixed term and could be replaced at the discretion of the Minister. EEA does have limited authority to issue Directives, including Directives on pricing methodology, but generally has limited power to issue Directives independently of the Ministry. These are all key areas where independence needs to be introduced.

The EEA budget is a mix of Government funding, license fees and “monies from other sources”. There is currently only one electricity company (EEPCo) and even when small distributors are licensed their license fees will be relatively low. It is unlikely that licence fees will cover EEA’s budget and it will not be easy to introduce financial independence of EEA.

Importance of independence

Independence is an important quality for a regulator who regulates prices of privately owned utilities; it gives assurance to the private companies and investors that revenues will cover costs and provide a reasonable return on investment. A dependent regulator is likely to be influenced by short-term political factors, usually to maintain low prices, that often over-ride the interests of investors and ultimately lead to a long-term decline in investment and deterioration in the electricity supply system.

Independence is less important where the utility is state-owned and where the state is the shareholder of the utility though it does remain of considerable importance to commercial banks that need assurance that their loans will be serviced. In the absence of an independent regulator, such banks will seek sovereign guarantees. Independence is also less important to private investors if their revenues are guaranteed through long-term Power Purchase Agreements (PPAs) though again they will wish assurance that EEPCo will have the revenues to meet their contractual commitments in the PPAs and will therefore normally require sovereign guarantees.

An independent regulator is also important where the transmission or distribution company is obliged to offer third-party access to independent producers. This is not the situation today in Ethiopia but it is possible that it will be introduced in the future.

For the independence to be valuable, other conditions need to exist:

- effective political and economic institutions;
- separation of powers, particularly between the executive and the legal system;
- a well functioning legal system and sound courts;
- a good commercial law framework and some competition policy basis;
- a supply of well qualified staff able to carry out the various functions;
- a functional commercial framework

2.5 INTERNATIONAL INTERCONNECTIONS

The Ethiopian Power System, when expanded as planned, will have energy continually available that is surplus to Ethiopia's needs. The amount of surplus energy available will vary through time, declining from higher values immediately after new generation is added to relatively low values, as domestic demand grows, just before the next generating station is added. This surplus energy provides an opportunity for export sales if there is a suitable market for it, thereby reducing the average unit cost of energy through a higher level of utilization of the Ethiopian plant from its inception. The neighboring states of Sudan and Djibouti may provide such a market. The following provides an overview of these prospects

The Sudan Market

Sudan's National Electricity Corporation (NEC) power system in 1999 generated about 2290 Gwh, this being about 60% hydro energy and 40% thermal (1100 Gwh). Of the thermal generation, about 74% was from steam plant (33- and 60-MW units), 9% from 10.5-MW diesel units and the 11-3 remainder from an assortment of gas turbines (10-, 13.4-, 15- and 20-MW units). The steam and diesel units operated with an overall plant operating capacity factor of about 33%.

The current NEC generation expansion plan calls for net thermal plant capacity additions (new plant less retired plant) totaling 580 MW by 2005 followed by the 1000-MW Merowe hydroelectric power project in 2006 and 2007. Subsequent plans for installation of a 300-MW steam station in each year from 2011 to 2014 and ongoing retirements would bring the total net system thermal additions to 1680 MW by 2015. These additions would bring the system thermal capability from the current level of about 1100 Gwh per year to about 2775 Gwh in 2007 and about 5960 Gwh in 2014, assuming an overall plant operating capacity factor of 33% for all thermal plant as experienced in 1999.

The closest connection points between the Ethiopian and the Sudan system are in excess of 400 km distant, and reinforcements beyond this point from Roseires to the main load center in Khartoum would be required within Sudan to be able to effect imports from Ethiopia.

It is clear that by 2007 and beyond to 2012, Sudan will have 'displaceable' thermal generation far in excess of the hydro energy surpluses expected to be available from the Ethiopian system in each year of that time frame

The Djibouti Market

In 1999, the Electricité de Djibouti system experienced suppressed demand. Recent study, however, provides estimates of an unconstrained demand for 2001 of 255 to 260 Gwh at a load factor of about 61%. Recent study, however, provides estimates of an unconstrained demand for 2001 of 255 to 260 Gwh at a load factor of about 61%. The same study projects this demand to grow to between 330 to 360 Gwh by the year 2007 and to between 360 to 425 Gwh with a load factor of about 63% by the year 2010. Forecasts beyond this horizon are not available.

As Djibouti has no hydroelectric power resources, its year 2000 generation was all-thermal, comprising 16 diesel units ranging from 2.5 MW to 12 MW capacity. Future generation additions to 2010 were planned to be 2 x 6 and 4 or 5 x 15 MW units to provide a total system installed capacity of 102 or 114 MW. This corresponds to an annual energy production of 450 to 500 Gwh/yr at 63% load factor and 80% unit availability.

The closest connection points between the Ethiopian and Djibouti systems are about 300 km apart, although reinforcement of the transmission system within Djibouti beyond this point may be required to be able to effect imports from Ethiopia.

Djibouti clearly represents a relatively limited market potential for Ethiopian surplus energy with its total demands in the time frame in which energy would be available from Ethiopia being of the same order of magnitude as the Ethiopian surplus.

Potential Benefits to Participating Parties

The most obvious and direct benefits of interconnection between Ethiopia and Sudan and/or Djibouti would be

- revenues to Ethiopia from otherwise under utilized capability which would lower Ethiopia's long term unit energy costs and
- lower unit energy costs for the receiving system(s) from displacement of more expensive thermal energy generation.

A less obvious and indirect energy benefit is the potential for deferral of investment in new generation in the participating systems through agreement for energy exchanges via the system interconnection(s). In the period 2007 to 2012, the surplus Ethiopian energy would permit deferral of installation of new thermal plant in the receiving system(s). Sudan and/or Djibouti would then plan to have new plant in place to meet not only their own needs immediately thereafter but also the thermal generation needed by Ethiopia in 2013 and 2014 to be able to defer investment in new hydro generation in its system.

Ethiopia would eliminate the need for an early investment in thermal plant, and the participating system(s) would realize more economic energy over the long term as a consequence of delayed investment in thermal plant in their system(s). This cycle of exchanges could repeat indefinitely into the future with investments alternating between new thermal plant in Sudan and/or Djibouti and new hydro generation in Ethiopia until Ethiopia's economic hydro resources are all developed.

It is clear that the energy exchange option would require a very serious commitment to international cooperation in the power sector, including both coordinated planning for generation expansion, coordinated investment programs and coordinated system operation.

3 CAPACITY BUILDING NEEDS

3.1 INTRODUCTION

Most developing countries face water and energy scarcity problems in the future due to increasing demand resulting from population growth, improved standard of living and urbanization and industrial development. Ethiopia suffers from this situation because of the lack of scarcity adequate infrastructure for energy supply. The per capita electric energy consumption in Ethiopia is shown in Figure 1 below. It is one of the lowest in the world. Even though there is slight increase of installation capacity through addition of new power plants, there will not be substantial increase because of a high rate of population growth (3% annually).

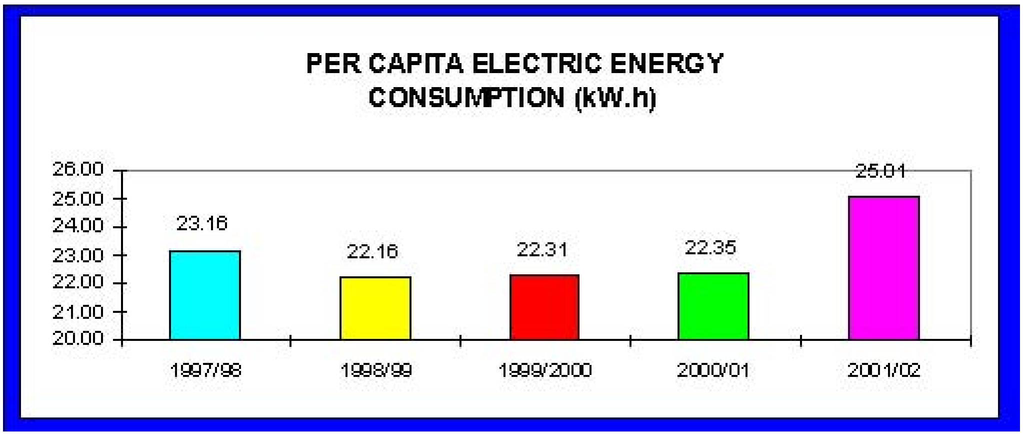


Figure (3-1) Per Capita Energy Consumption in Ethiopia

There are also a number of management problems such as lack of managerial and incentive measures, lack of personnel required for operation and maintenance and lack of associated research and development in the energy sector.

Capacity building is a prerequisite to integrated water resources management in general and to rational energy systems in particular. Increasing the efficiency and effectiveness of the people working in the water and energy sector will be through active program of human resources development. Assessment, planning and use of energy resources in general and hydropower resources in particular require that people involved be of high caliber to address issues of the coming century.

A number of management problems has been recognized such as the lack of managerial and incentive measures, the lack of personnel required for operation and maintenance, lack of associated research and development activities, and the lack of coordination among energy concerned agencies.

Capacity Building

Capacity building is a prerequisite to integrated water resources management. Technical solution will not achieve the objectives of development on their own without suitable attention to the human factor. The national and local institutions tend to be inefficient and ineffective for many reasons such as:

- inadequate funding and human resources,
- Inadequate working environment for the individuals responsible for implementing the energy policies.
- a lack or inadequate opportunities for education and training for upgrading skills, and
- Lack of positive programs to ensure the involvement and commitment of the communities and the public in general.

The correction of these inadequacies has come to be known as "Capacity building" which is a long term continuing process that consists of four basic elements:

- The creation of an enabling environment that has appropriate policy and legal framework;
- Institutional strengthening and development, including local participation;
- Human resources development, including the strengthening of managerial system and energy users interest; and
- Awareness building and education at all levels of society

Needs for Capacity Building in the Energy Sector

Capacity building is needed to implement the integrated approach to the development, management and use of energy resources. The solutions should begin with capacity building in the area of energy resources assessment. The term "energy resources assessment" is often used not only for inventory of the available hydropower and other renewable resources but it should include the capabilities a country has to satisfy its energy requirement and how to match supply with demand.

Since hydropower study requires a multi-disciplinary team participation, it is essential to have capacity building not only in the area of engineering but also in a spectrum of other relevant disciplines. Since such a strong inter-disciplinary team lacks in most cases, authorities of developing countries are forced to depend on external support. For instance, in assessing hydropower resources, the Ministry of Water Resources as well as the Ethiopian Electric Light and Power Corporation find themselves to be at the mercy of external support of agencies and organizations. Most of the water Master plans studies are often done by international organizations (France, Germany, Norway, Holland …). Technical and feasibility studies of hydropower resources projects are often done by foreign agencies as external support while executions of these projects are implemented by huge companies with just a little involvement of the national experiences. Many of the external supports are spent on studies whereas very little are allocated to capacity building and human resources development.

Human Resources Development

In many cases the proportion of University graduates is less than 10% and roughly more than 70% of the employees have less than a high school degree. Figure 3-2 shows the degree of qualification of the employees of the electric enterprise in Ethiopia which has monopoly of Power Generation and distribution in the country. The percentage of University graduates is a low proportion of the total employees. This clearly shows why EEPCo is totally dependent on foreign support for hydropower investigation and implementation. The same is the case with the Ministry of Water Resources.

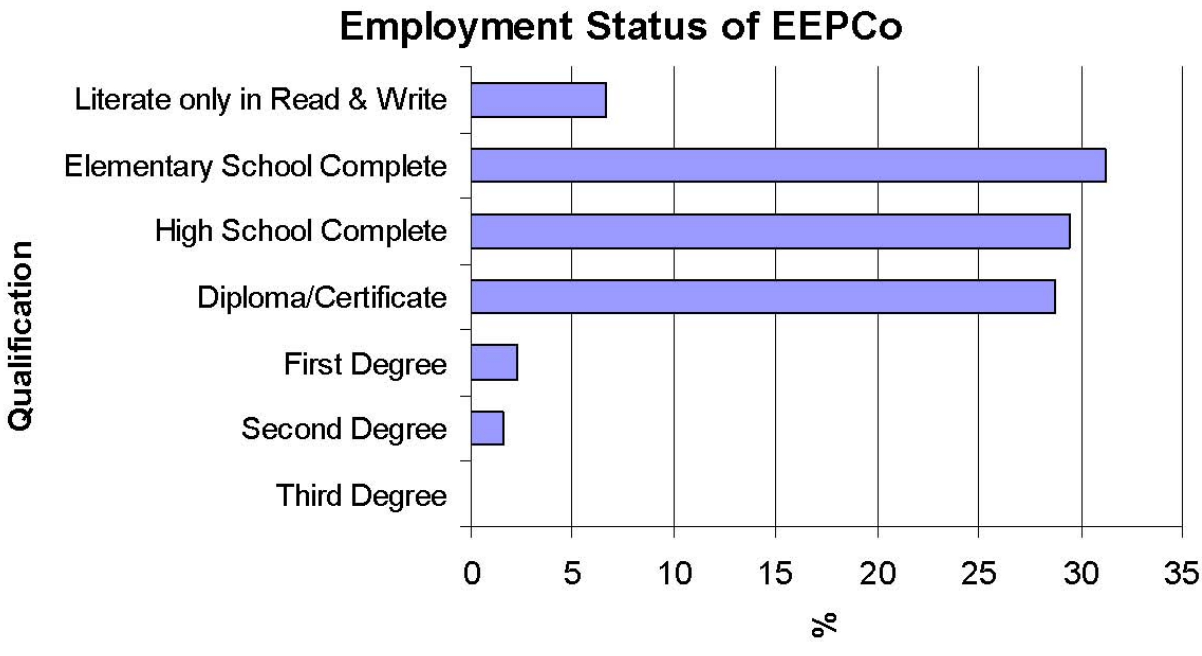


Figure (3- 2) Status of Employment in EEPCo

Therefore, given these conditions, the only means is to increase the efficiency of the energy sector staff in responsiveness, development and management through active programs of human resources development. Tailor made short-term as well as long-term trainings are essential to meet the need in human capacity requirements. Training is an important management tool for motivating staff and improving organizational performance. Training improves performance by strengthening employee knowledge and improving procedures, structures and management. The tailor-made training should aim at improving employee well-being and satisfaction through benefits, long term education, staff incentive programs, career ladder and succession planning.

Lack of Proper Vocational Training

In spite of the effort being made to expand University education in the area of water resources, vocational education for assistant is not adequate.

On the other hand, it is obvious that there is a shortage in the number of assistant engineers. The number of vocational training is limited. It appears that there is a need for technicians (assistant engineers) in the area of operation and maintenance of power plants.

Necessary Actions to be taken

The future national capacity building in the power sector in general and in Hydropower development in particular should concentrate to the development, management and reuse of the water resources. It should take into consideration the following actions: Development of energy related institution at the river-basin level taken into account the need for accelerated Hydropower as well as renewable energy development.

1. Review of the legislative and regulation level of energy resources assessment and facilitate the close collaboration among water agencies, particularly between information producers and users.
2. Include capacity building measurers as a major program in the organization that provides external support to any country.
3. Encourage national universities and higher education institutes to participate in national capacity building efforts in the power sector.
4. Encourage inter agency coordination and establish energy resources council in each country which will be in charge with responsibility of implementing reforms and policies.
5. Creating awareness on the part of public and decision makers of the importance of energy issues, magnitude of problems and the need for action and conservation measures.
6. Strengthening policy development and energy resources planning capabilities.
7. Reviewing and strengthening of the organizational structures, functional relationship and linkages among agencies that are involved in the power sector.

4 INVENTORY DOCUMENTS

S.N.	Reference	Evaluation & Summary
1	**Title:** Abbay River Basin Integrated Development Master plan **Date:** September 1998 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** MoWR **Consultant:** BCEOM,BRGM, iSL **Availability:** Freely accessible with recommendation letter	Investigation of basin resources is made. Hydropower potential sites are indicated.
2	**Title:** Master plan for the development of surface water resources in the Awash basin **Date:** December 1989 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** MoWR **Consultant:** Sir William Halcrow & Partners **Availability:** Freely accessible with recommendation letter	Investigation of surface water resources of the basin is made. Hydropower potentials are indicated.
3	**Title:** Preliminary Resources Development Masterplan for Ethiopia **Date:** June 1990 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** MoWR **Consultant:** WAPCOS **Availability:** Freely accessible with recommendation letter	Hydropower and Irrigation sites allover the country are determined at a preliminary level
4	**Title:** Tekeze River basin Integrated Development Masterplan Project **Date:** May 1998 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** MoWR **Consultant:** NEDECO, DHV **Availability:** Freely accessible with recommendation letter	Resources in the Tekeze basin are investigated. Hydropower sites are indicated.

S.N.	Reference	Evaluation & Summary
5	**Title:** Baro-Akobo River Basin Integrated Development Masterplan Study	Resources in the Baro Akobo basin are investigated. Hydropower sites are indicated.
	Date: May 1997	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: MoWR	
	Consultant: TAMS, ULG	
	Availability: Freely accessible with recommendation letter	
6	**Title:** Omo-Gibe River Basin Integrated Development Masterplan Study	Resources of the basin are investigated. Hydropower Potential Sites are indicated.
	Date: December 1996	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: MoWR	
	Consultant: Richard Woodroofe &Associates	
	Availability: Freely accessible with recommendation letter	
7	**Title:** Electricity Tariff Study	
	Date: March 2003	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: EEPCo	
	Consultant: Scott Wilson	
	Availability: Freely accessible with recommendation letter	
8	**Title:** Ethio-Sudan Transmission	A perspective of economic feasibility of the 580 km long 230 kV single circuit interconnection is made.
	Interconnection	
	Date: January 1984	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, EREDPC	
	Client: EELPA	
	Consultant: Acres International	
	Availability: Freely accessible with recommendation letter	

S.N.	Reference	Evaluation & Summary
9	**Title:** Ethopian Power System Expansion Masterplan **Date:** March, 2001 **Place:** A.A. **Format:** Hard Copy **Location:** Library, EREDPC **Client:** EEPCo **Consultant:** Acres International **Availability:** Freely accessible with recommendation letter	
10	**Title:** Djibouti-Ethiopia Interconnection Study **Date:** February 1989 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** EEPCo **Consultant:** Acres International, Electicitate de France **Availability:** Freely accessible with recommendation letter	
11	**Title:** Energy Policy of the Transitional Government of Ethiopia **Date:** March 1994 **Place:** A.A. **Format:** Hard Copy **Location:** Library, EREDPC **Client: ---** **Consultant: ---** **Availability:** Freely accessible recommendation letter	Contents: 1) Preamble 2) Rational for Policy 3) Policy Objectives 4) General Policy 5) Priority of Policy 6) Main Policy Issues and Strategies
12	**Title:** Genale Dawa River Basin Integrated Development Masterplan Project **Date:** August 1998 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** **Consultant:** **Availability:** Freely accessible with recommendation letter	Reconnaissance Level Investigation of Resources of the basin are made. Hydropower sites are indicated.

S.N.	Reference	Evaluation & Summary
13	**Title:** Gojeb Medium Hydropower Project Feasibility Study	Feasibility study of the Gojeb hydropower plant is investigated. Dependable power of 69 MW and installed capacity of 153 MW is suggested.
	Date: August 1997	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: MoWR	
	Consultant: Howard Humphreys, Coyne et Belle, Rust Kennedy & Donkan	
	Availability: Freely accessible with recommendation letter	
14	**Title:** Geba Hydropower Project Feasibility Study	Two sites are identified i.e. Geba 1 and Geba 2 with estimated dependable capacity of 154 and 100 MW respectively.
	Date: May/1999	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: MoWR	
	Consultant: Norplan A.S.	
	Availability: Freely accessible with recommendation letter	
15	**Title:** Guder Hydropower Project pre-feasibility study	Pre-feasibility level study has estimated dependable capacity of 79.3 MW and installed capacity of 100 MW.
	Date: April 1999	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: MoWR	
	Consultant: Norplan A.S., Norconsult International	
	Availability: Freely accessible with recommendation letter	
16	**Title:** Feasibility study of Beles, Chemoga-Yeda and Halele-Werabassa Hydropower Project	Feasibility study estimated the potential of Beles to be 220 MW, Chemoga Yeda, Stage I 2x59 MW Stage II 82 MW Halele Werabessa Stage I 2x48 MW Stage II 294 MW Aleltu 3x62 MW
	Date: September 2000	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, MoWR	
	Client: EEPCo	
	Consultant: Lahmeyer International, Electroworth Eng'g Services, Knight Piesold	
	Availability: Freely accessible with recommendation letter	

S.N.	Reference	Evaluation & Summary
17	**Title:** Feasibility Study of Chemoga-Yeda Stage I Hydropower Project **Date:** August 2000 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client**: EEPCo **Consultant:** Lahmeyer International, Electroworth Eng'g Services, Knight Piesold **Availability:** Freely accessible with recommendation letter	Feasibility Study of Stage I estimated the potential to 118 MW.
18	**Title:** Baro Hydropower Project Pre-feasibility Study **Date:** March 1999 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** MoWR **Consultant:** Norplan A.S., Norconsult International A.S. **Availability:** Freely accessible with recommendation letter	Pre-feasibility level study identified two alternatives i.e. Baro 1 and Baro 2 for which dependable capacity of 151.8, and 482.5 MW respectively is identified.
19	**Title:** Report of Small Hydropower Investigation in Gojam **Date:** April 1989 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** Rural Infrastructure Department of the Ministry of Agriculture **Consultant:** Small Hydropower Investigation Team from China **Availability:** Freely accessible with recommendation letter	The study identified 25 sites in the region out of which 11 were considered suitable for short-term development.
20	**Title:** Report of Small Hydropower Investigation in Sidamo, Kefa, Gamo-Goffa, Illubabor **Date:** April 1989 **Place:** A.A. **Format:** Hard Copy **Location:** Library, MoWR **Client:** Rural Infrastructure Department of the Ministry of Agriculture **Consultant:** Small Hydropower Investigation Team from China **Availability:** Freely accessible with recommendation letter	

S.N.	Reference	Evaluation & Summary
21	**Title:** Rural Electrification Fund final Project Operations Manual	The purpose of the project operation manual is to provide guidance for staff in day-to-day operations of Federal Rural Electrification Fund.
	Date: December 2003	
	Place: A.A.	
	Format: Hard Copy	
	Location: Library, EREDPC	
	Client:	
	Consultant:	
	Availability: Freely accessible with recommendation letter	

APPENDIX A3

KENYA REPORT

TABLE OF CONTENTS

1 INVENTORY OF DATA BASES AND SOURCES OF INFORMATION

1.1 INVENTORY OF DATA BASES ON METEOROLOGICAL INFORMATION FOR RIVER NZOIA

S/N	Reference	Evaluation and Summary of contents
1.	**Description**: Small Scale Hydroelectric Schemes in South West Kenya. April 1981. I: Preliminary Survey Report: **Location:** Library, Ministry of Energy ***Format*:** Printed Report*Date of Reference*: April 1981 *Availability*: Free	The report is quite descriptive with detailed data. It contains data on flood in Nzoia Basin, rainfall data, mean monthly rainfall, and mean monthly temperatures, annual minimum temperature data between the years 1969 to 1979.
	Note:	The most current meteorological and hydrological data can be obtained from the Office of the Chief Hydrologist, Ministry of Water Development, Head Office, at a cost of KSh. 600.00 for any two-year period data. Another means of obtaining the data is by a letter addressed specifically to the Permanent Secretary, through the Chief Hydrologist.

1.2 INVENTORY OF DATA BASES ON HYDROLOGICAL INFORMATION FOR RIVER NZOIA

S/N	Reference	Evaluation and Summary of contents
1.	**Description:** Water Resources Study for the Kerio Valley Basin **Location:** Library, Ministry of Energy ***Format*:** Printed Report ***Date of Reference*:** November, 1981 *Availability*: Free	The data contained in this document is old. The data is from six stations within the River Nzoia basin and includes: the catchment areas for the stations, the run offs, the rainfall, the mean monthly discharge coefficients, the dry months of 5year return period, the solid transport, evaporation.
2.	**Description:** Small Scale	The report is quite descriptive with detailed data. It contains data on flood in Nzoia Basin. Hydrological data such as months of high and low river discharges, stream flow, mean monthly discharges, daily discharges (maximum

	Hydroelectric Schemes in South West Kenya. April 1981. I: Preliminary **Survey** **Report:** **Location:** LibraryMinistryof Energy ***Format*:** Printed Report ***Date of Reference*:** Aprilr, 1981 *Availability*: Free	and minimum), for seven gauging stations, for the period between the year 1969 to 1979.
	Note:	The most current meteorological and hydrological data can be obtained from the Office of the Chief Hydrologist, Ministry of Water Development, Head Office, at a cost of KSh. 600.00 for any two-year period data. Another means of obtaining the data is by a letter addressed specifically to the Permanent Secretary, through the Chief Hydrologist.

1.3 INVENTORY OF ENERGY POLICIES, AGREEMENTS AND PLANNING STUDIES FOR KENYA

The broad objective of the energy policy is to ensure adequate, cost Effective and affordable supply of energy to meet development needs, while protecting and conserving the environment.

S/N	Reference	Evaluation and Summary of contents
1.	**Description:** National Energy Policy, Draft 2003 **Location:** Library, Ministry of Energy **Format**: Printed Report **Date of Reference**: February 2003 *Availability*: Free	The national Energy Policy contains the Government Policy for the energy sector. The energy policy contained in the document are: 1. Least Cost Power Development Plan Policy, which was prepared in 1986 as a joint effort between KPLC and the Government. The updates of the policy rely on inadequate information on economic costs for developing both geothermal and hydro projects. The policy is elaborate and outlines the Government's commitment to support the efforts to generate power continuously and at a lower cost 2. Principal Taxation Policy in the Energy Sector 3. Hydropower policies under which the government expresses its support and incentives for private investors: pre-feasibility and feasibility studies of identified potential sites, land availability and resettlement activities, guarantee of purchase of electric power 4. Policies on Geothermal energy. The Governments commitment and strategies in developing the geothermal resource; sources of funding for the projects 5. Rural Electrification Policies. The Governments objectives for rural electrification programmes, funding and administration arrangements, supply options e.g. small hydros and hybrid systems; regulatory framework and cost effective tariff structure to facilitate

		market entry by IPPs. 6. Fiscal policies, which detail Governments strategies to encourage private sector participation in the power sub-sector: tax holidays, 7. Environmental policies. The requirements of the Environment Management and Coordination Act, 1999. The roles of environmental authorities such as National Environmental Management Authority (NEMA) are contained in the policies 8. Legal and Regulatory Framework Policies. Developments undertaken by the Government to encourage Private sector participation. The policy elaborates the amendments to be incorporated into the Electric Power Act, 1997, to provide incentives to private sector 9. Financial Resources Mobilization Policy. Outlines the Governments commitment to provide financial support for IPPs, to develop regional electric power interconnector projects. 10. Electricity Accessibility and Consumer Connections policy Outlines the consumers responsibilities in power generation, the Government's flexible and financially sustainable strategies to provide electricity to consumers; 11. Policies on Consumer Tariffs Outline the Government's commitments, and objectives of setting consumer tariffs and their administration, 12. Energy policies and strategies in Petroleum sector 13. Hydrocarbon Exploration, supply and distribution Policies The energy policies are well designed to create the private investors into the energy industry. They are detailed and updated to the current.
2.	**Description:** Study on Kenya's energy demand, supply and policy strategy for households, small-scale industries and services establishment. Final report, September 2002 **Location:** Library, Ministry of Energy **Format:** Printed Report **Date of Reference:** September 2002 **Availability**: Free	Treaty for East African cooperation, 1998

3.	**Description:** Economic Survey 2003; Central Bureau of statistics. Ministry of Planning and Economic Development **Location:** Library, Ministry of Planning and Economic development Central Bureau of Statistics Library **Format:** Printed Report **Date of Reference:** 2003 *Availability*: Free	Document for national resource planning. Contains an overview of the energy sector. The planning details for Petroleum; Electricity; Wood fuel and Resources; alternative energy resources; wind power and household energy survey highlights Well elaborated Government Plans and Strategies: Rural electrification programmes; encouragement of private participation in power generation, transmission and distribution; upgrading of Kenya-Uganda transmission lines from present 132kV to 220kv.
4.	*Description:* Kenya National Power Development Plan (1986–2006) Appendix Volume 2, June 1987. Prepared by Acres International Limited *Location:* Library, KPLC *Format*: Printed Report *Date of Reference*: 1987 Availability*: Free*	Detailed documentation of the hydropower potential in Kenya by drainage basins. Cost estimates for the projects; Reconnaissance studies for different basins. The power and energy capabilities of existing, committed and potential hydroelectric sites are given
5.	**Description:** Small Scale Hydroelectric Schemes in South West Kenya. April 1981. Preliminary Survey Report: Booklet Location: Library, Ministry of Energy *Format*: Printed Report *Date of Reference*: *Availability*: Free	The study report contains the potential small-scale hydroelectric sites in South West Kenya, which also encompasses the Nzoia Basin.
6.	*Description:* National Power Development Plan (1991-2010), Final Report, 1992 Acres International Limited Location: Library, KPLC *Format*: Printed Report	The report identifies the status of existing and committed system. The identified underdeveloped hydroelectric resources in Kenya total over 1400MW. The distribution is given per drainage basin, with the Lake Victoria being the second with 30%. Lists the Candidate hydro projects, their location and characteristics

	Date of Reference: April 1981 *Availability*: Free	
7.	Description: National Power Development Plan (1986 - 2006), Final Report, June 1987. Acres International Limited Location: Library, KenGen, Ministry of Energy and KPLC *Format*: Printed Report *Date of Reference*: June1987 *Availability*: Free	The National Power Development Plan document can reliably be used for orderly and economic expansion of generation and transmission facilities within the plan period. The information and data on power demand projection, on annual growth basis, and load projection up to the year 2010. The document contains detailed description of the projects that are promising for supply of electricity to the interconnected transmission system; The projects that have been advanced to the pre-feasibility and reconnaissance levels of studies. Recommendations for further study. The details are given for each drainage basin The dominant recommendations of the plan document are; to carry out the full feasibility study of the promising hydropower projects; consideration of the other hydropower sites projects which may be attractive if considered multipurpose or comprehensive regional development context and studies to be carried out of promising economic interconnectivity with neighboring countries.
8.	Description: Water Resources Sector Strategy: Strategic Directions for World Bank Engagement, February 2003 Location: Library, World Bank *Format*: Printed Report *Date of Reference*: *Availability*: Free	The document assesses the water related infrastructure, such as, transport and hydropower. It highlights the benefits of private sector involvement. Outlines the options of working with partners and finding new sources of financing for water resources infrastructure
9.	*Description:* Sector reform and Power Development Project. Last updated January 28th 2004 Location: Library, World Bank *Format*: Printed Report February 2004 *Date of Reference*: *Availability*: Free	The project was carried out to assist the Government of Kenya in implementing power policies, institutional reforms and sub-sector restructuring
10.	*Description:* Sector reform and Power Development Project. Last updated January 28th 2004 Location: Library, World Bank *Format*: Printed Report February 2004 *Date of Reference*:	The project was carried out to assist the Government of Kenya in implementing power policies, institutional reforms and sub-sector restructuring

	Availability: Free	
11.	Description: Kenya Energy Reform and Power Development Project. Development credit agreement, Kenya and International Development Association (IDA) April 3rd 1998 Location: Library, World Bank *Format*: Printed Report *Date of Reference*: April 1998 *Availability*: Free	The document contains details of the strategies by the GoK to contact; European Investment Bank (EIB), Overseas Economic co-operation fund and a German based credit bank for a loan to assist in financing the project.
12.	Description: Staff Appraisal report, Kenya. Energy sector reform and power development project, May 21st 1997 Location: Library, World Bank *Format*: Printed Report *Date of Reference*: May 1997 *Availability*: Free	The report contains details on energy sector and the macroeconomic context, energy sector organization, energy markets and pricing. It also contains the financial analysis, implementation arrangements and justification and economic analysis of the project
13.	Description: Ministry of Energy, Energy Sector Reform and Power Development Project Implementation Plan (PIP), January 1997. Location: Library, Ministry of Energy *Format*: Printed Report *Date of Reference*: January 1997 *Availability*: Free	The document contains detailed information regarding the implementation of energy sector reform and power development project, which the Government of Kenya (GoK) intended to implement in order to reduce the current and projected electricity supply shortfalls. The funding was from International Association Development (IDA). The objectives of the project were: to undertake the investment needed to arrest the electricity supply shortfall; to formulate and implement key policies and institutional reforms with a view to developing an efficient and vibrant energy sector capable of meeting growing energy needs of the domestic economy. The reforms included: (1) Restructuring the power sector with a view to enhancing the operational efficiency through prudent improvements in both financial and technical capacity; (2) Mobilization of resources required to supplement external borrowing in financing the power sector investment programme and to encouragement of prudent utilization of electricity through tariffs restructuring/adjustments; (3) Creation of an efficient legal and regulatory environment to facilitate private sector participation in the generation of electricity and promote competition in the petroleum sector The document contains the strategies designed to implement the above reforms.
14.	Description: Update Study on electricity Tariffs in Kenya, April 2002, by: The Ministry of Energy, KPLC, and KenGen.	The study was carried out following the introduction of the new retail tariffs in August 1999. An Interim Power Purchase Agreement (IPPA) was introduced to define the cost of KPLC of the electricity it purchased from KenGen and other IPP. The study was carried out to review the KenGen bulk supply tariff and to review the retail customer tariffs.

	Location: Library, Ministry of Energy *Format*: Printed Report *Date of Reference*: April 2002 *Availability*: Free	The document has invaluable information for planning.
15.	Description: The Study on the National water Master plan, Sectoral Report (1): Power Development Plan. The Ministry of Water Development: A study by JICA, July 1992 Location: Library, World Bank *Format*: Printed Report *Date of Reference*: July 1992 *Availability*: Free	The report reviews the existing power supply in Kenya including the hydro-electric power schemes, and an overview of the power Market in Kenya, including energy production, sales, electricity tariffs applied. The document contains details on hydropower development plan, which includes power demand projection, system expansion plan and hydroelectric power schemes. The information is detailed enough to be used for hydropower schemes planning and projects.

1.4 INVENTORY OF MARKET EXPANSION PROJECTION FOR KENYA

S/N	Reference	Evaluation and Summary of contents
1.	Description: National Energy Policy, 2003 Location: Library, Ministry of Energy *Format*: Printed Report *Date of Reference*: February 2003 *Availability*: Free	The National Energy policy contains the details on the social and economic indicators of energy development level. This is compared in detail with other regional countries. The document also has elaborate information on the demand and supply of energy in Kenya. The information given in the document is reliable for the prediction of future trends, planning and developments in the energy industry. Per Capita GDP Relative to Per Capita Commercial Energy Consumption for Kenya is given. Comparison for the years between the years 1971 and 1994. Demand Projections for Electric Power and Energy for the period between 1998 and 2003. Much information is for the energy sources: Biomass energy, Petroleum fuels, coal and other renewable which is a reflection of many organizations, NGOs and private companies, involved in studies on these energy sources. Challenges for each source well elaborated Energy supplies -Primary energy sources for electricity generation are detailed. For Hydropower energy, details on both developed and undeveloped potential. Data given based on the drainage basins in the country. The challenges and constraints are well outlined. For Geothermal energy, the Geographical locations, the potential developed and undeveloped resources in the country are given. For Nuclear energy, the general costs of nuclear energy developments and the country's preparedness in investing in this sector. For Solar and wind energy, the Current estimates of the tapped solar resources and the future development plans. The challenges and constraints.

		In addition, for Fossil fuels: the Exploration, sources, supply and distribution of the fossil resources. The challenges and constraints. The Governments Acts that require revision and harmonization to take account of the market dynamics.
2.	Description: *KPLC, Annual report 2001/2002* Location: Library, KPLC *Format*: Printed Report *Date of Reference*: 2002 *Availability*: Free	Power system operation statistics for 6 years; 1997 – 2003. The installed and effective capacities for KenGen Hydros, thermal, geothermal and Wind; and for the GoK thermal Rural Electrification Sites, the five Independent Power Producers, emergency power producers and Uganda imports. The report also gives the KPLC and REF system sales, annual growth rates in generation and sales.
3.	Description: Inventory of Energy Research Activities in Kenya Zakayo M. Karimi. July 1988 Location: Library, National Council for Science and Technology *Format*: Printed Report *Date of Reference*: July 1988 *Availability*: Free	The document details the status and funding of energy research and development activities in Kenya and the organization involved

1.5 INVENTORY OF PLANNING OF ELECTRICAL INTERCONNECTIVITY

S/N	Reference	Evaluation and Summary of contents
1.	Description: Arusha –Nairobi Power Transmission Line Study. Ministry of Energy, Final Report. Volume 1 –Main Report, November 2002 Location: Library, Ministry of Energy *Format*: Printed Report *Date of Reference*: November 2002 *Availability*: Free	Review and update of: the loads forecast for Tanzania, Kenya and Uganda; available generation data have been outlined and; proposed regional sub-Saharan African grid interconnection. The document also includes: Preparation of outline definition of selected major interconnection alternative, planning of the system expansion, investment costs estimates and economic analysis of the interconnection

2 CASE STUDIES OF THE RIVER NZOIA BASIN

2.1 HYDROPOWER POTENTIAL

<table>
<tr><th>S/N</th><th>Reference</th><th>Evaluation Summary of contents</th></tr>
<tr><td>1</td><td>Description:
Kenya National Power Development Plan (1986 – 2006), Appendix Volume 2. June 1987. Prepared by Acres International Limited

Physical Location:
Library, Kenya Power and Lighting Company (KPLC)

Format: Printed Report

Access Fee: Free</td><td>The National Power Development Plan (NPDP) gives, in detail, the potential sites for hydropower in Kenya according to drainage basins.

River Nzoia basin, which lies in The Lake Basin, has five significant hydropower potential areas.
<table>
<tr><th>No.</th><th>River</th><th>Project</th><th>Installed Capacity (MW)</th><th>Firm Energy (GW.h/yr)</th><th>Average Energy (GW.h/yr)</th></tr>
<tr><td>1.</td><td>Nzoia</td><td>Hemsted Bridge</td><td>60</td><td>297</td><td>307</td></tr>
<tr><td>2.</td><td>Nzoia</td><td>Rongai</td><td>12</td><td>52</td><td>72</td></tr>
<tr><td>3.</td><td>Nzoia</td><td>Lugari</td><td>15</td><td>62</td><td>86</td></tr>
<tr><td>4.</td><td>Nzoia</td><td>Webuye Falls</td><td>30</td><td>115</td><td>170</td></tr>
<tr><td>5.</td><td>Nzoia</td><td>Anyika</td><td>25</td><td>95</td><td>125</td></tr>
<tr><td colspan="3">Subtotal Nzoia</td><td>60</td><td>297</td><td>307</td></tr>
</table>
The Plan document recommends a reconnaissance level study of the Hemsted Bridge and Webuye Falls projects on the river Nzoia. The document also contains information on the pre-feasibility study of the Nzoia-Kerio Water transfer scheme.</td></tr>
<tr><td>2.</td><td>Description:
Water Resources Study for the Kerio Valley Basin. November 1981. Report submitted by Kerio Valley Development Authority

Physical Location:
Library, Ministry of Energy

Format: Printed Report

Access Fee: Free</td><td>The reason for the Kerio Valley Development Authority (KVDA) to further their research on Nzoia River was the rivers upper region potential for hydropower generation. The upper region of River Nzoia is adjacent to the Kerio Valley. The upper Nzoia River, because of the available flow and its geographical situation above and alongside the Elgeyo Escarpment, could contribute to the generation of hydropower. This was if the interbasin transfer, diversion of the upper Nzoia River flow, was to be found economically justifiable, notably by using the fall from the Elgeyo Escarpment for energy generating purposes. The report also gives the mean monthly discharge co-efficients and the discharge co-efficients for the dry months of 5-year return period for various gauge stations within the Nzoia Basin.</td></tr>
<tr><td>3.</td><td>Description:
Small Scale Hydroelectric Schemes in South West Kenya. April 1981. I: Preliminary Survey Report:

Physical Location:
Library, Ministry of Energy</td><td>The identified plant sites of the Nzoia River basin and the tributaries are as shown below:
<table>
<tr><th>River</th><th>Site code</th><th>Catchment area (km^2)</th></tr>
<tr><td>Nzoia</td><td>42
41</td><td>3840
8340</td></tr>
<tr><td>Kuywa</td><td>4A1</td><td>138</td></tr>
<tr><td>Kapkateny</td><td>4A2</td><td>28</td></tr>
<tr><td>Moiben</td><td>4B1</td><td>240</td></tr>
</table></td></tr>
</table>

	Format: Printed Report Access Fee: Free	<table><tr><td></td><td>4B2</td><td>170</td></tr><tr><td></td><td>4B3</td><td>66</td></tr></table>
4.	Description: Small Scale Hydroelectric Scheme in South-West Kenya; I: Preliminary Survey Report, April 1981. By Imatran Voima Oy Ivo Consulting Engineers and Finconsult Consulting Engineers Physical Location: Library, Ministry of Energy Format: Printed Report Access Fee: Free	The information contained in the document is old and some of it could be outdated. However, the information and data can be used in the planning studies and in the development of hydropower projects in the Basin. Ten rivers in the Lake Basin and Kerio Valley, Arror, Muruny, Perkerra, Nzoia, Yala, Nyando, Sondu, Kuja, Mara and Migori. The selected hydropower potential sites were evaluated. The feasibility of the plant sites was evaluated basing on the Technical factors, Infrastructural factors and economical factors. Teremi falls/kuywa, in Nzoia Basin, was one of the selected plant sites. This was based on the duration of the flow, total available head, accessibility and construction possibilities, the present power consumption potential, economic parameters and multi-purpose possibilities. The plant site was recommended for feasibility study. The socio-economic environment of the regions and the hydrological information of the plant sites are also given. The hydrological information given in the document include: -Extreme and observed values of river discharges, maximum discharge, mean of annual maximums, mean discharges, mean of annual minimums, minimum discharges, frequency of minimum and maximum discharges, maximum and minimum discharges and their return periods, duration of flow, and design flood.
5.	Description: Water Resources Study for the Kerio Valley Basin. November 1981. Report submitted by Kerio Valley Development Authority Physical Location: Library, Ministry of Energy Format: Printed Report Access Fee: Free	
6.	Description: Small Scale Hydroelectric Schemes in South West Kenya. April 1981. Preliminary Survey Report: Physical Location: Library, Ministry of Energy	

	Format: Printed Report Access Fee: Free	

2.2 DAM SITES

S/N	Reference	Evaluation Summary of contents
1.	Description: The Study on the National Water Master Plan. Sectoral Report, Integrated Water Resources Planning. July 1992 Physical Location: Library, Ministry of Water Development Format: Printed Report Access Fee: Free	The potential and existing dam sites along the River Nzoia Basin are as follows EXISTING DAM SITES AT: Twin Rivers; Ellegirini POTENTIAL DAM SITES AT: Kipkaren; Kiboro; Mukulusi; Moiben; Lower Moiben; Moi's Bridge; Hemsted Bridge
2.	Description: Lake Basin Development Authority: Five Year Development Plan, 1983-1988, Republic of Kenya Physical Location: Library, Ministry of Water Development Format: Printed Report Access Fee: Free	The document contains information on Hydropower projects that were planned to be undertaken within the planning period. These projects are Sondu/Miriu lower dam, Webuye falls, Teremi Falls and Mau Forest in order of priority. Both Webuye and Teremi falls lie in River Nzoia basin. It was found out that Webuye falls project was to have considerable effect on not only on power generation, but also contribute greatly to flood amelioration downstream of River Nzoia. The projects were to impact on promotion of rural electrification, agro-industries and Irrigation. Complete feasibility study of Teremi falls had been done and funds earmarked for the implementation. The power by the project was not to be fed into the national grid, but attest to the viability of mini-hydros and their effects on rural community. A summary of the cost estimates, for Sondu/Miriu and Webuye projects, and cost estimates for feasibility studies of Teremi and Mau Forest are given. Also the estimated plant investment cost for Teremi falls and Nzoia/Kuywa have been given. The data and information contained in the document, though old, can be used in the future planning.
3.	Description: The Study on the National Water Master Plan. Sectoral Report (H), Dam Development	The information given in the report about the dam sites in the River Nzoia basin is sufficient for future planning and development of the sites. The document contains the details on the existing dam sites, the on-going dam sites and potential dam sites. The potential dam sites and

<table>
<tr>
<td></td>
<td>Plan. By JICA, July 1992

Physical Location: Library, Ministry of Water Development

Format: Printed Report

Access Fee: Free</td>
<td>their status are as given in the table below:
<table>
<tr><th></th><th>Dam site</th><th>River</th><th>Catch't area (km^2)</th><th>Purpose</th><th>Responsible agency</th><th>Develop't stage</th></tr>
<tr><td>1</td><td>Moiben</td><td>Moiben</td><td>188</td><td>W</td><td>MOWD</td><td>Pre-F/S</td></tr>
<tr><td>2</td><td>Lower Moiben</td><td>Nzoia</td><td>644</td><td>P</td><td>KVDA</td><td>M/P</td></tr>
<tr><td>3</td><td>Hemsteds</td><td>Nzoia</td><td>3752</td><td>I, P</td><td>KPC, LBDA</td><td>M/P</td></tr>
<tr><td>4</td><td>Moi's bridge</td><td>Nzoia</td><td>858</td><td>W</td><td>MOWD</td><td>Pre-F/S</td></tr>
<tr><td>5</td><td>Rongai</td><td>Nzoia</td><td>4709</td><td>I, P, W</td><td>LBDA</td><td>M/P</td></tr>
<tr><td>6</td><td>Sergoit (1)</td><td>Sergoit</td><td>390</td><td>W</td><td>MOWD</td><td>M/P</td></tr>
<tr><td>7</td><td>Sregoit (2)</td><td>Sergoit</td><td>659</td><td>W</td><td>MOWD</td><td>M/P</td></tr>
<tr><td>8</td><td>Kerita</td><td>Kerita</td><td>104</td><td>W</td><td>MOWD</td><td>M/P</td></tr>
<tr><td>9</td><td>Kisongoi</td><td>Kisongoi</td><td>119</td><td>W</td><td>MOWD</td><td>M/P</td></tr>
<tr><td>10</td><td>Webuye Falls</td><td>Nzoia</td><td>8420</td><td>P, I</td><td>LBDA</td><td>M/P</td></tr>
<tr><td>11</td><td>Lugari</td><td>Nzoia</td><td>830</td><td>I, P</td><td>LBDA</td><td>M/P</td></tr>
<tr><td>12</td><td>Teremi</td><td>Kuywa</td><td>138</td><td>P</td><td>LBDA</td><td>F/S</td></tr>
<tr><td>13</td><td>Rambula</td><td>Nzoia</td><td>11849</td><td>I, P</td><td>MOWD</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
Where, W: Water Supply, I: Irrigation, P: Hydropower, M/P: Master Plan, Pref-F/S: Pre-Feasibility Study, F/S: Feasibility Study</td>
</tr>
<tr>
<td>4.</td>
<td>Description:
The Study on the National Water Master Plan, Sectoral Report (K): Topographic Survey of Dam Sites. Republic of Kenya, Ministry of Water Development, JICA, July1992

Physical Location: Library, Ministry of Water Development

Format: Printed Report

Access Fee: Free</td>
<td>Rambula dam site, on River Nzoia was covered in the Survey. The survey was carried out between August and December 1990, which involved (1) arrangement to sub-letting the work to local survey or contractor, (2) aerial photography and control point survey for photogrammetric mapping, profile survey and leveling survey for establishment of site datum, (3) Supervision of survey work executed by contractors.</td>
</tr>
</table>

2.3 EXISTING HYDROPOWER SITES

2.4 RECONNAISSANCE STUDIES

S/N	Reference	Evaluation Summary of contents
1.	Description: Pre-investment Study for Water management and development of the Nyando and Nzoia River Basin, Nzoia River Basin Pre-Investment	The description of the Nzoia river catchement basin in terms of administrative set-up, population, Labour and Agriculture. The description of the sub-areas: the Boundaries, climate and soil details from the Agronomic standpoint, the lower and upper Nzoia sub-sector.

	Report. By Interconsult, Rome, October 1983 Physical Location: Library, Ministry of Water Development Format: Printed Report Access Fee: Free	
	Description: The National Water Master Plan, Main report, Volume III, Part 2: Action Plan by Province/District. By JICA, July 1992 Physical Location: Library, Ministry of Water Development Format: Printed Report Access Fee: Free	The document contains information on the potential water source for future development for each district. It details the following issues: - 1. Teremi Dam: Which is proposed for Hydropower development project 2. Description of Nzoia/Yala basin and the executing agency being The Lake Basin Development Authority 3. The Water resources study for Nzoia Basin and the executing agency is Ministry of Water Development 4. The potential water sources for future development: Mushangumbo dam, Hemsted Bridge Dam, and Webuye falls dam.
	Description: Lake Basin River Catchement, development River profiles Studies and Water Supply Plan. Basin Water Balances and Inter-Basin Transfer Studies Report. Volume III, March 1985 Physical Location: Library, United Nations Environmental programme (UNEP) Format: Printed Report Access Fee: Free	The document contains detailed information on the Rivers in the Lake Basin region. The description of the river catchments and the potential water projects that can be developed within the basin is done in detail. The information and data contained in the document is reliable enough to be used for the planning and development of the water related projects within the Lake Basin.

2.5 DESCRIPTION FOR RIVER NZOIA BASIN

COUNTRY: Kenya

BASIN: River Nzoia Basin

LOCATION
River Nzoia lies in the western region of Kenya. The catchment area is bounded by latitudes 1^{o} 30'N and 0^{o} 30'S and Latitude 34^{o} E and 35^{o} 45'E. The catchment area may be divided into two sub-catchments, Lower Nzoia and Upper Nzoia sub-basins.

Lower Nzoia:
Latitude: 0^{o} 04'N and 0^{o} 11'S
Longitude: 33^{o} 57'E and 34^{o} 14'E

Upper Nzoia
Latitude: 0^{o} 04'N and 0^{o} 55'S
Longitude: 34^{o} 55'E and 35^{o} 10'E

BRIEF DESCRIPTION OF THE RIVER NZOIA BASIN
River Nzoia flows into Lake Victoria just North of Yala swamp and rises from Cheranganyi hills in the East with tributaries feeding it from mount Elgon in the North. The basin covers an area of about 12000km^2 and a total length of 275km. River Nzoia basin transgresses many regions thus land use will vary accordingly. In the lower regions of Budalangi the soils are poorly drained and mainly of clay type due to the frequent flooding. Thus, agriculture is not very prevalent in the area. However, note that in the agro-ecological zones Budalangi area is marked LM4, the marginal cotton zone.

Lower Nzoia
Lower Nzoia is of 125.4 km^2 in area and lies at the altitude of 1,130m to 1225m Above Sea Level. The area is generally flat and swampy. The permanent swamps cover a total area of 25 km^2.

Main Land Use
Livestock rearing and fish farming are common activities. Agro-economic conditions are generally poor throughout the sub-area with exception of Bunyala pilot irrigation scheme. Cotton is practically the only crop produced for the market. Maize farming is done on small scale for the local market only. Sugar-cane farming is practiced on small farms.
Most roads are not tarmacked, which poses a serious problem in the communication network.

Upper Nzoia
Upper Nzoia basin covers a total area of 170.5 km^2. The landform is hilly with steep slopes. The sub-basin lies between the altitudes of 1625metres and 1825metres Above Sea Level. The minimum and maximum elevations are 1917m ASL and 4300 ASL.

Main Land Use
Crops are generally grown on scattered hill-side plots separated by extensive rangeland. Main crop grown is hybrid maize, followed by sunflower. Other crops are beans and cassava. A cattle rearing is also practiced. The roads in the upper Nzoia basin are in fair conditions making communication fair.

THE HYDROLOGY OF RIVER NZOIA BASIN
The mean monthly rainfall trend represents two maxima and minima over the year. The First and Second maxima occur from April to May and July to November respectively. The minimum and maximum mean monthly rainfall is 20mm and 200mm respectively. The mean annual rainfall is between 1000 to 1500mm. The isohyets are 45 inches on entering Lake Victoria, 60 inches at Mount Elgon and 50 inches around Cherangani hills 50 inches.

The highest river discharges occur between May and September while the lowest river discharges occur between January and March. Annual Runoff: 310mm and Runoff ratio; 21.7%

The rivers within the river Nzoia basin are River Nzoia, River Kuywa and River Moiben. Both rivers Kuywa and Moiben drain into River Nzoia, which drains into Lake Victoria. Moiben River has a catchment of 262 km^2, the upper and lower river Nzoia have 1470 and 8420 km^2 catchement areas respectively. The middle Nzoia river, Nzoia at Moi's bridge has a catchement area of 1470 km^2.

OTHER FEATURES

Floods

River Nzoia is characterized with flooding in its lower reaches. The river floods frequently, annually. This is due to the large catchment area versus one river to let the water into the lake. There is intense erosion in the upstream region due to deforestation. The soil blocks the channel or fills it, hindering the free flow of water. Deposition of the material eroded in the upstream takes place in the downstream. The deposition is intensive due to the low gradient of the riverbed. The deposition reduces the depth and thus the capacity of the river, which eventually results into flooding. Dykes have been constructed over 32 km stretch in the downstream of the river Nzoia to contain the flood problem

Design Flood: Flood discharge of $117m^3/s$ is obtained from the flood envelope curve applicable to the Lake Basin. One of the stations within the basin is considered favorable since it has an automatic stage recorder and lies downstream of the River Basin covering an area of $1180km^2$. The 25 and 50 year return period peak discharges from the station are $1100m^3/s$ and $1360m^3/s$ respectively. It is considered that these values can be taken as valid for the end reaches of the Nzoia where periodic flooding occurs. It is evident that discharges of this order are likely to result in floods involving several hundred millions cubic meters thus flooding very large areas.

In Reference (LBDA) the development of the Webuye falls project was a to be implemented as a multi-purpose project: for hydropower generation and for amelioration of the flood in the downstream of River Nzoia.

Erosion and Sedimentation

Erosion in the upper catchment area of the basin is due largely to deforestation. Erosion in the lower reaches of the basin is caused by the progressive movement of the meanders causing bank materials to be moved downstream. Erosion in the upper catchment area leads to mass sedimentation in the lower areas. The solution lies largely in the control of erosion in the upper catchement.

Annual sediment delivery in river Nzoia is between 158,400 to 326,350 tonnes (Dunnes, 1974).

2.6 REFERENCE MATERIALS AND THEIR SOURCES

1. Angwenyi George, 1979: Water Resources of the Lake Basin, a Research Paper. University of Nairobi. *Location: Nairobi University Library*

2. Dunnes Thomas, 1974: Suspended sediment data for the rivers of Kenya US department of Geological Sciences, University of Washington. *Location: Nairobi University Library*

3. Interconsult, 1980: Pre-Investment Study for Water Management and Development of Nyando and River Nzoia Basins. *Location: Library, Ministry of Water Development*

4. Republic of Kenya, Lake Basin Development Authority: Fiver Year Development Plan, 1983-1988

5. MOWD, 1981: Western Province Annual Report

6. MOWD, 1980: Gauge height and Flow records. *Location: Library, Ministry of Water Development*

7. MOWD, 1979: National Water Master Plan Stage 1. March 1979. Tibbets Abbert McCarthy Stratton. *Location: Library, Ministry of Water Development*

8. MOWD, 1976: Report on Nzoia River Flood Protection, Bunyala Location

9. MOWD, 1973: Surface Water Resources in Kenya, June 1973. *Location: Library, Ministry of Water Development*

10. Proposal for a pre-investment study for water management and development of the Nyando and Nzoia River Basin July 1978. Ministry of Water Development: *Location: Library, Ministry of Water Development*

11. Water Resources Study for the Kerio Valley Basin. November 1981. Report submitted by Kerio Valley Development Authority. *Location: Library, Ministry of Energy*

3 INVENTORY OF CAPACITY BUILDING NEEDS

3.1 INVENTORY OF EXISTING HUMAN RESOURCES IN HYDROPOWER DEVELOPMENT

<table>
<tr><th>S/N</th><th>Reference</th><th>Evaluation Summary of contents</th></tr>
<tr><td>1.</td><td>Description:
Annual KenGen Report, 2001/2002

Physical Location:
Library, KenGen

Format: Printed Report

Access Fee: Free</td><td>The Kenyan hydropower development sector is majorly controlled by KenGen, which does the work of generating, and KPLC, which buys from KenGen and other IPPs and distributes the power.

The staff existent at KenGen is as shown in the Table

<table>
<tr><th></th><th>2001/2002</th><th>2000/2001</th></tr>
<tr><td>Technical</td><td>1096</td><td>1129</td></tr>
<tr><td>Non-Technical</td><td>452</td><td>458</td></tr>
<tr><td>Management</td><td>540</td><td>531</td></tr>
<tr><td>Total</td><td>1548</td><td>1587</td></tr>
</table>
</td></tr>
</table>

3.2 INVENTORY OF REQUIRED HUMAN RESOURCES IN HYDROPOWER DEVELOPMENT

S/N	Reference	Evaluation Summary of contents
1.	Description: National Water Master Plan Stage 1, Volume IV: Organization, Manpower and Training. By Tippets – Abbet, et., al, Engineers and Architects. Physical Location: Library, Ministry of Water Development Format: Printed Report Access Fee: Free	The document details the need of skilled human resource in water resources. Hydrometrists, Hydrological Experts/Hydrologists, and Water Resource Engineers are required. The document also contains the duties of the required persons. The local institutions, Universities, Polytechnics, Technical institutes, that train manpower relevant for water and energy sectors are also included in the document. The courses offered and level of training are also included. There is no specialized training for the hydropower sub-sector.

3.3 INVENTORY OF HUMAN RESOURCES CAPACITY DEVELOPMENT NEEDS IN HYDROPOWER NEEDS: TRAINING NEEDS, FACILITIES, MASTER PLANNING AND COOPERATION ARRANGEMENTS

S/N	Reference	Evaluation Summary of contents
1.	Description: National Energy Policy, 2003 Physical Location: Library, Ministry of Energy, KPLC Format: Printed Report Access Fee: Free	The document only gives a general situation for need of manpower in the energy industry. It does not give specific skilled human resource required in the energy sector. Technologies and policy issues in the energy sector are highly dynamic. There is therefore a need to continuously train and upgrade human resource capacity to keep up with these dynamics. In Kenya's energy sector, specialized research and consultancy services have largely been internationally sourced due to inadequate domestic capacity to undertake such tasks. In addition, specialized training programmes on energy are not available in the country's institutions of higher learning.(NEP)
2.	Description: Kenya National Power Development Plan (1986-2006). Appendix Volume 2, June 1987. Acres International Limited Physical Location: Library, Ministry of Energy Format: Printed Report Access Fee: Free	The power plan document indicates the areas where skilled human resource is required. The following recommendations are proposed in the document: - 1. Increase the staff numbers in the planning department of KPLC and provide through training in power system planning and analytical methods 2. Increase the number of staff hydrologists at the Ministry of Water and Development and provide computer training advancements for all professional staff 3. Ministry of energy and regional development should build up a small cadre of staff skilled in the review and assessment of feasibility levels of future generating plants in thermal, geothermal and hydroelectric power fields.
3.	Description: KenGen Annual Report and Accounts 1999 Physical Location: Library, KenGen Format: Printed Report Access Fee: Free	The document only gives the general statement of the company concerning the need for training and development of the specialized human resource. The company continues to focus on enhanced training and development and the creation of a good working environment in order to desire the best performance from its staff. The company's staff consists of both locally and internationally trained

APPINDEX A4

RWANDA REPORT

CONTENTS:

1 INTRODUCTION

The main task of this phase I in NBCBN research activities is as follows:

a. Inventory of Databases and Information

- Meteorological;
- Hydrological;
- Cartographical;
- Softwares;
- Documentation and Literature;
- Hydropower Studies.

b. Inventory of Operational and Potential Sites

- Past Studies;
- Existing Data;
- Micro and Minihydropower Sites.

c. Inventory of Capacity Needs

- Emergency of needs;
- Manufactures;
- Access to equipments;
- Human resources Capacity.

2 BASIC INFORMATION AND DATA

2.1 METHANE GAS (CH4) / KIVU LAKE

- Rwanda "Superficies" = 26 338 km^2
- Kivu Lake: S_{area} = 7 000 km^2
  Depth / maximum = 485 m
- Methane gas in Kivu Lake:
  - Below a depth of 300 m
  - Area of the lake containing the gas: 2 400 m^2
  - Total potentialities = 250 x 10^9 Nm^3
  - Exploitable = 40 x 10^9 Nm^3
  - Actual Production = 10^6 Nm^3/year
  - (Extraction since the year 1963)
  - Formation of the gas = 120 x 10^9 Nm^3/year
- Project of increase the production:
  - Name = SOCIGAZ
  - Expectation = 109 Nm3/year

This project target is an installation of a thermal-electric power plant of 30 MW by the end of 2007 and of 90 MW by the end of 2010

2.2 NATIONAL PRODUCTION OF HYDROPOWER

- REGIDESO = National utility: November 1939 – April 1976
- New National Utility: ELECTROGAZ
  - (Etablissement Public de Production, de Transport et de Distribution d'Electricité, d'Eau et de Gaz)
  - Period: Nov 1939 – 1976: REGIDESO
  - Monopole = Contract of 99 years since April 1976
  - Potential end of monopole = year 2075
  - But a process of Privatisation is expected to occur

- Total installed hydropower in Rwanda = only about 26 MW (covering only about 63 % of the current demand)

Station	River	Basin	Year of Installation	P [MW]	Remark
Ntaruka	Mukungwa (Nyabarongo)	Nile	1959	11.25	Rehabilited In 1997
Mukungwa	Mukungwa	Nile	1982	12	
Gisenyi	Sebeya	Congo	1980	1.2	Minihydro
Gihira			1985	1.8	minihydro

Note that since 1985 there is not yet any new installation of power plant

- Shared Production: Rusizi I = 28.2 MW ; Rusizi II = 26.6 MW
- Total importation = 15 MW through the SINELAC interconnected line (110 kV): Rwanda, RDC, Burundi

Sources of importations

Source	River	P [MW]	Remark
SINELAC	Rusizi	9.5	
SNEL		3.5	
UEB		2	

SINELAC = Société Internationale d'Energie des Grands Lacs

- Evolution of maximum power after 1994:

Period	1995	1996	1997	1998	1999	2000	2001	2002	2003
P [MW]	28.3	34	36.2	37					

- Energy loss over the distribution line: About 35 % too high/comparison with an average of 17 % in a number of Sub-Saharan Countries
- Annual Consumption: an average of 19 kWh/capita
- Rate of access: < 3 % of the population

2.3 MAIN HYDROPOWER PROJECTS

A number of hydropower projects is planned
Source: HydroQuébec International: Dec 1999 ; Kigali.

S/N	Station	River/ Basin	P [MW]	E [GWh]	Year of Construction	Cost in 1991 $\$ \times 10^6$	Cost per kWh in 2002 $\$ \times 10^6$
1	Mukungwa II	Mukungwa/ Nile	2.2	16.3	1996	16.5	0.15
2	Keya Gisenyi		2.5				
3	Rugezi Near Ntaruka	Rugezi/ Nile	2.5	10.6	2001	7.73	0.13
4	Base Ruhengeri	Base/Nile	2.8				
5	Akanyaru	Akanyaru/ Nile	3.87	25.2	2001	17.4	0.10
6	Rukarara III	Rukarara/ Nile	9.45	41.3	2000	35.5	0.12
7	Rusumo Falls(*)	Akagera	20	137.6	2001	50.3	0.07
8	Rusizi IV	Rusizi/ Congo	27	136.3	2004	52	
9	Nyabarongo Near Mwaka	Nyabarongo/ Nile	27.5	146.6	2003	58	0.082
10	Nyabarongo Near…/…	Nyabarongo/ Nile	43.2	231	2003	80.4	0.07
11	Rusizi III (*)	Rusizi/ Congo	32.3	159.8	2004	61.7	0.062

10 = Plant without a reservoir while 9 = Hydropower Plant “au fil de l’eau”
(*) Rusumo = 60/3 = 20 ; Rusizi III = 97/3 = 32.3
All these projects remain uninstalled as none of them has been executed
Low rentability for lower Power Stations

According to the same source of documentation, the standard reference is the diesel generation plant system for which the unit cost is about 0.11 x106 $ per kWh production.

Hence: Low rentability for lower power stations as indicated above in this table (Mukungwa, Rugezi, Akanyaru)

2.4 HYDROPOWER PRODUCTION IN RWANDA [SOURCE: ELECTROGAZ, KIGALI]

Year	Po [MW]	E $\left[\frac{GWh}{Yr}\right]$	L_{BT+HT} [km]
1978	8.3	48.5	1041
1979	9.8	53.5	1117
1980	12.3	58	1180
1981	14.3	64	1333
1982	16.1	73.5	1410
1983	17.1	75.5	1457
1984	18	84	1687
1985	19.4	92.5	1935
1986	21.8	95	2153
1987	24.85	105	2418
1988	28.6	121	2586
1989	33.3	137.5	2801
1990	35.6	149	32.8
1991	36	140.5	3183
1992	37	182	
1993	37	171	
1994	20	74	
1995	28	113	
1996	34	155	
1997	36	183	
1998	37	187	
1999	40	197	

3 MAIN MICRO HYDROPOWER SITES

Province	SN	Main Site (District)	River Basin	Date of Construction	H [m]	P [kW]	Q [m^3/s]	Remarks
Gisenyi	1	Gihira (Rubavu)	Congo	(ELECTROGAZ)				Minihydro
	2	Sebeya (Rubavu)	Congo	(ELECTROGAZ)				Minihydro
	3	Nkora (Rubavu)	Congo	1981 (OCIR)		150		
	4	Pfunda (Kanama)	Congo	1971 (OCIR)	14.65	130	0.9	
Ruhengeri	5	ETIRU (Kigombe)	Nile	1952 (ETIRU)		295		Private plant (3 sites)
	6	Mutobo (Nyakinama)	Nile		100	25	0.05	Potential
	7	Nyabeshyaza (Nyakinama)	Nile		150	44	0.03	Potential
	8	Nyamyotsi II (Nyamutera)	Nile		50	77	0.15	Potential
	9	Nyamyotsi I (Nyamutera)	Nile		70	108	0.15	Potential
	10	Mukingo (Ruhondo)	Nile		50	65	1.1	Potential
	11	Mazinga (Cyabingo)	Nile		10	136	1.4	Potential
Byumba	12	Kavumu (Kisaro)	Nile	1988 (BORDA)	44	53	0.245	Destroyed in 1994 (genocide period)
	13	Bungwe (?)	Nile	1983 (AIDR)		3		
	14	Rutare (Rutare)	Nile	1988 (SNV)		14		
	15	Kinyami (Kinyami)	Nile	1988 (COFORWA)		12		Destroyed
	16	Cyungo (Cyungo)	Nile					
Gitarama	17	Nyakabanda (Ndiza)	Nile	1989 (?) (IEPF)	30	75	0.294	Belong to rural communities; still operational since 1986 ; survived the genocide-year 1994
	18	Ntongwe (Rubyiro)	Nile		10	100	2	Potential
	19	Rutongo (Kayumbu)	Nile		39	20	0.13	Potential
Kibuye	20	Musasa (Itabire)	Nile	1984 (DISTRICT)		8		Pumping System only
	21	Ndaba (Gisunzu)	Congo		163	137	0.17	Potential Site; 12 km from Electrogaz
	22	Rufungo (Budaha)	Nile	1993 (AIDR)				Destroyed in 1994 (genocide period)
	23	Kigara (Itabire)	Nile	1984 (Private)		8		Pumping Water only
	24	Rukopfu (Budaha)	Congo	1992 (Private)		12		

	25	Kirinda (Budaha)	Nile	1973 (EPR Church)	16	175	1	Destroyed in 1994 (genocide period)
	26	Murunda (Rutsiro)	Congo	1979 (Catholic Church)	70	100	0.2	Private (Rural Cooperative) ; Very near the National grid Electrogaz (400 m)
	27	Muhungu (Itabire)	Nile	1984 (DISTRICT)		8		Pumping Purpose
	28	Gisovu (Gisovu)	Congo	1989 (ARDI)		11		Pumping Purpose
	29	Kivumu (Budaha)	Nile	1991 (ARDI)		11		Pumping Purpose
	30	Nyabahanga (Itabire)	Nile	1884 (DISTRICT)		8		Pumping Purpose
	31	Gasesa I (Budaha)	Nile					Potential
	32	Gasesa II (Budaha)	Nile		30	17	0.09	Potential
	33	Secoko (Budaha)	Nile		25	75	0.31	Potential
Gikongoro	34	Runyombyi (Nshili)	Nile	1973 (EPR Church)	30	140	0.55	Operational and survived the genocide event
	35	Kigembe	Nile		5.5	18	0.65	Potential
	36	Mwogo (Mudasomwa)	Nile		26	97	0.4	Potential
	37	Mazimeru (Kivu/R)	Nile		60	168	0.3	Potential
	38	Maruruma (Kivu/N)	Nile		50	161	0.5	Potential
Cyangugu	39	Mushaka (Gishoma)	Congo	1974 (AIDR)		0.5		Pumping Purpose
	40	Gishoma (Gishoma)	Congo	1991 (CARE)				
	41	Rwongo (Gafunzo)	Congo		5	5	0.1	
	42	Gasumo II (Gisuma)	Congo		10	9	0.1	
	43	Gasumo I (Gisuma)	Congo		10	10	0.1	
?	44	Mpenge			8	30	0.76	Potential Site ; close to Electrogaz
	45	Gatobwe			15	110	0.3	Potential Site ; far from Electrogaz (10 km)
	46	Gasumo			25	40	0.2	Potential Site ; close to Electrogaz
	47	Kabahendanyi			20	100	0.8	Potential Site ; very far from Electrogaz
	48	Karundura III				250		Potential
	49	Karundura V			12	370	3.15	Potential

4 ACCESSIBILITY OF OTHER DATA [SOURCE: MININFRA]

SN	Parameter/Data	Sources	Availability & Accessibility	Format	Duration / Period	Evaluation & Remarks
1°	Flow Rate Q [m3/s]	MINAGRI MINITERE				
2°	Head H [m]	MINAGRI MINITERE				
3°	Rainfall P [mm]	MINAGRI MINITERE				
4°	Cartographic/Topographic	MININFRA (Dpt of Energy) UNR (Centre of GIS)				
5°	Previous Studies of identification of sites	MININFRA (Dpt of Energy) ELECTROGAZ UNDP (Kgli) WORLD BANK (Kgli)				
6°	Electric (Market) Projections in Rural Areas	ELECTROGAZ (Dpt of Energy)				
7°	Geological maps	MININFRA (Dpt of Geology)				
8°	Demographic data	MINALOC (Dpt of Human Resource) MINIFINANCE (Dpt of Planning)				

5 INVENTORY OF CAPACITY NEEDS

See Pages 3-16 to 3-30
Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in Burundi, Rwanda and Western Tanzania.

Draft Report N° 1, May 2004, ANC-LAVALIN International in collaboration with HydroQuébec International. 015718-0000-40TR-0002-00. WORLD BANK.

6 FUTURE PLAN AND ACTIVITIES BEYOND JUNE 2004

Capacity Building and Training:
Training Locally about 20 Technicians and Water Professionals ever year;
In fact there is crucial lack of qualified human resources in water issues, due to mainly the genocide in 1994 and its consequences.

Research:
Assessment of SSHP potentialities;
Mapping and provision of a SSHP booklet;

Feasibility studies:
SSHP and renewable energy resources (solar, …)/feasibility of combination of such various options for rural electrification.

SSHP Pilot projects:
A viable pilot project to support applied research activities and to promote rural electrification (poverty alleviation, …).
Manuals:
Publishing design manuals (turbine and local materials …).

Collaboration:
NBI projects; other clusters …

APPINDEX A5

TANZANIA REPORT

CONTENTS

1 ELECTRICITY AND HYDROPOWER DEVELOPMENT IN TANZANIA - OVERVIEW

The Tanzania electricity generation, transmission and distribution system is managed by TANESCO, a vertically integrated Government owned Power Company. TANESCO's existing interconnected grid system has an installed capacity of 768.7MW of which today, 557MW is hydro based generation and the remaining is thermal. The few remote and isolated areas which have power supply are supplied from isolated diesel stations which amount to a total of 17MW.
As a result of the liberalisation of the sector, an Independent Power Producer (IPP) of 100MW installed capacity generates and supplies bulk power to the national grid.

Hydropower is currently the back bone of the Tanzanian Power Generation System. The country has a high hydropower potential (4.78GW) of which about 10% is exploited today from the two major rivers basins of Rufiji and Pangani, where all the existing big hydropower stations and some of the small hydropower potentials are located

1.1 HYDROPOWER RIVER BASINS IN TANZANIA

The backbone of the hydropower generation in Tanzania is located within the existing two major river basins namely Rufiji and Pangani where all the hydropower stations which produce most of the total country generation capacity are constructed.

1.1.1 Rufiji Basin and the Great Ruaha River System

This is the major source of Tanzania hydropower, producing about 82% of the total hydro generation. There are two reservoirs in the Rufiji Basin and the Great Ruaha River System namely Mtera and Kidatu reservoir. Mtera Dam/reservoir with a live storage capacity of 3,200Million M3 was originally designed as a storage and flood control facility for downstream Kidatu dam/reservoir which is a regulation dam (live storage 125 Million M3) with power generating capacity of 204MW. Latter a hydropower station of 80MW was installed at Mtera.

On the Kilombero River tributary known as Kihansi river lies a Hydropower station, a run of the river plant with 180MW installed capacity. Kihansi station has a provision to increase its generation capacity to 300MW in the future.

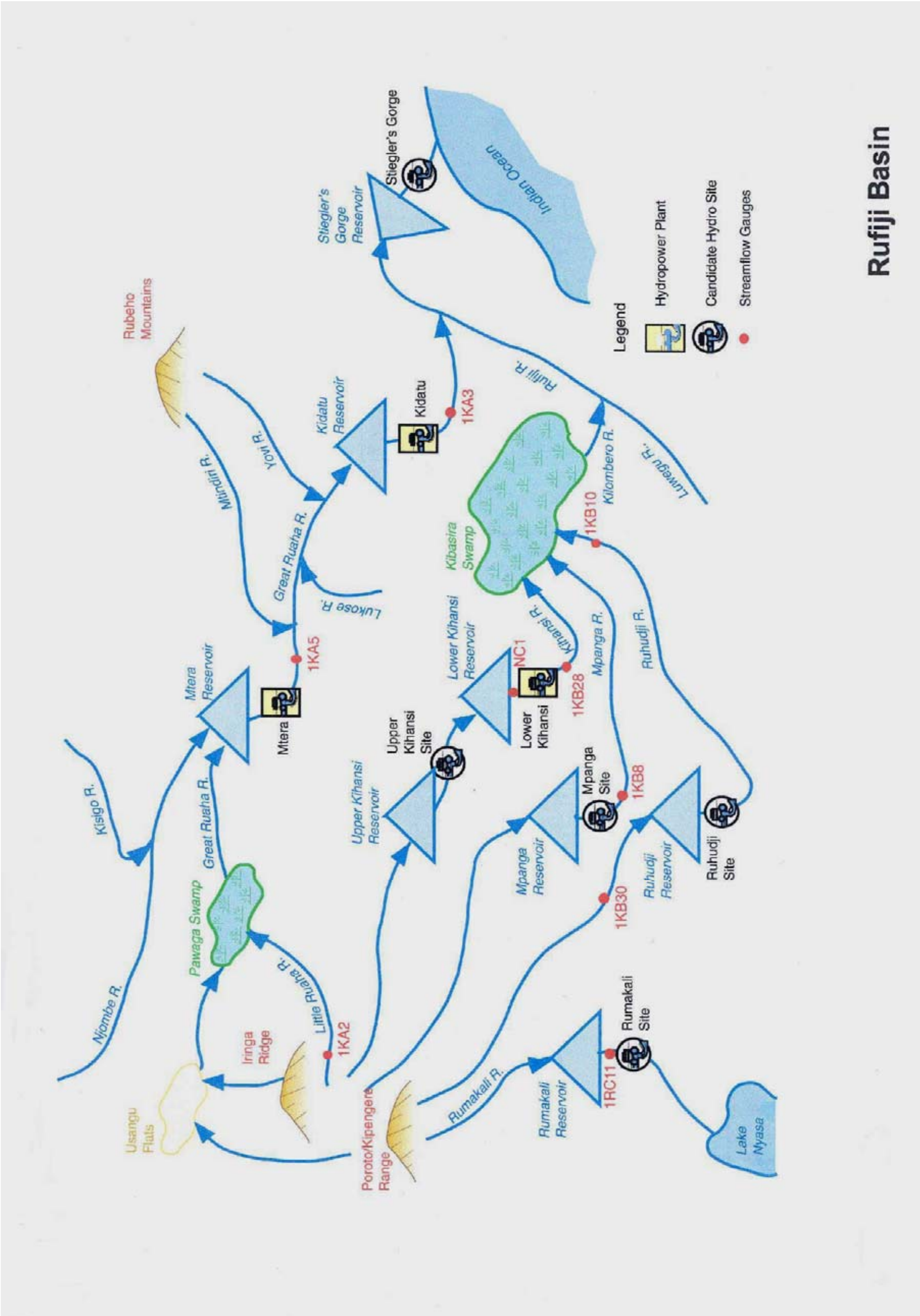

Rufiji Basin
Legend
Hydropower Plant
Candidate Hydro Site
Streamflow Gauges
Indian Ocean
Stiegler's Gorge
Stiegler's Gorge Reservoir
Rufiji R.
Rubeho Mountains
Mtandiri R.
Yovi R.
Kidatu Reservoir
Kidatu
1KA3
Luwegu R.
Kilombero R.
Kibasira Swamp
1KB10
Great Ruaha R.
Lukose R.
1KA5
Mtera Reservoir
Mtera
Kisigo R.
Lower Kihansi Reservoir
NC1
Kihansi R.
Mpanga R.
Ruhudji R.
1KB28
Upper Kihansi Site
Lower Kihansi
Upper Kihansi Reservoir
Mpanga Site
1KB8
Mpanga Reservoir
Ruhudji Reservoir
Ruhudji Site
1KB30
Pawaga Swamp
Little Ruaha R.
Njombe R.
Iringa Ridge
1KA2
Rumakali Site
Rumakali Reservoir
1RC11
Rumakali R.
Usangu Flats
Poroto/Kipengere Range
Lake Nyasa

Figure (1-1)

1.1.2 Pangani River Basin

The Pangani river basin has only one storage dam/reservoir, Nyumba ya Mungu with a capacity of about 875 Million M3. It is a reservoir that regulates water for power generation at Nyumba ya Mungu (8 MW), Hale (21MW) and New Pangani Falls (68 MW) power stations.

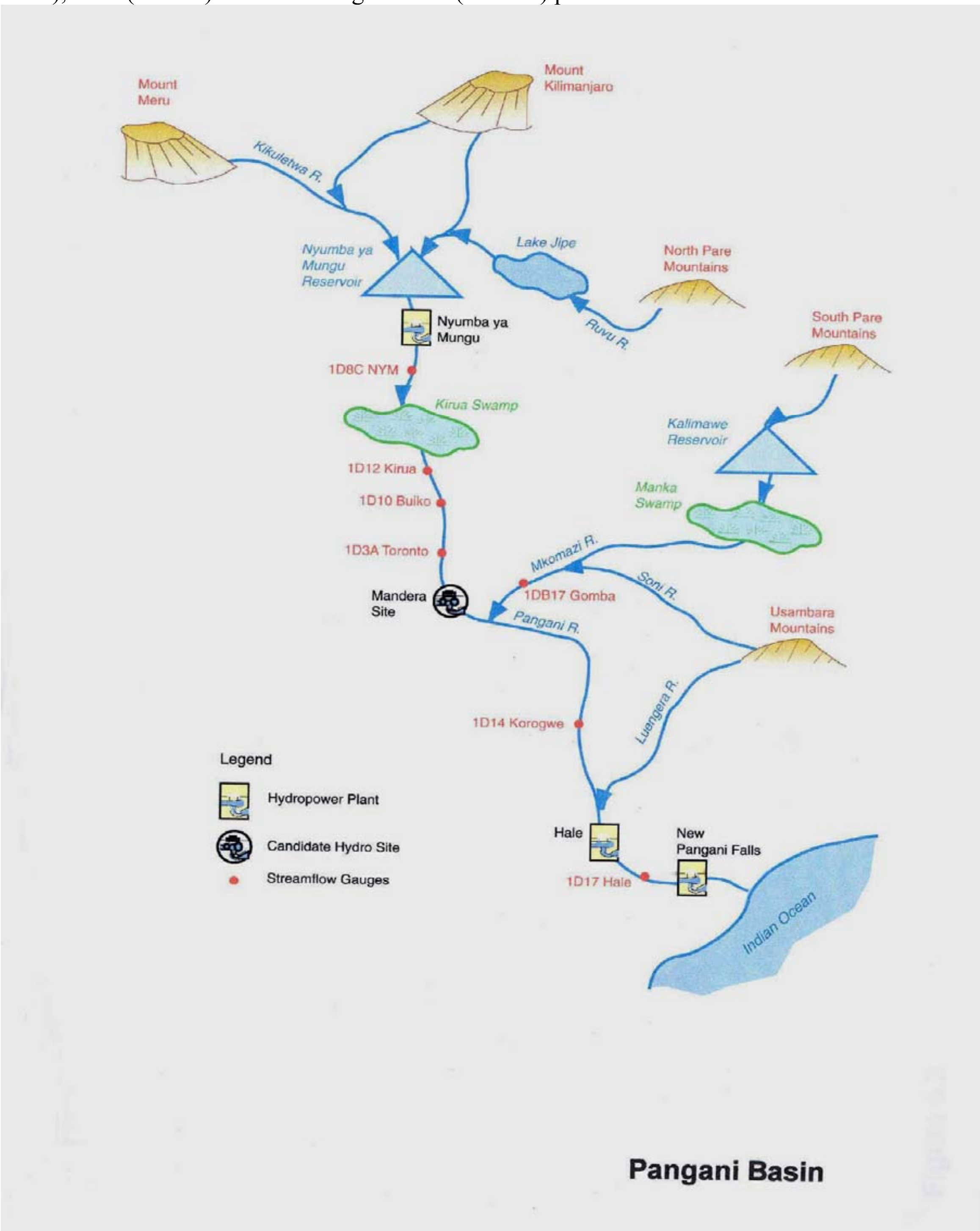


Figure (1-2)

1.2 OPPORTUNITIES (IDENTIFIED HYDROPOWER POTENTIAL)

Tanzania has extensive undeveloped hydroelectric resources mainly located in the Rufiji and Pangani river basins as well as Lake Nyasa. It is estimated that the total potential is 4.78GW out of which only about 10% is already developed. Identified sites that have been studied include Rumakali (222MW) in Rumakali sub-basin that flows to Lake Nyasa, Ruhudji (358MW), Mpanga (160MW), Upper Kihansi (120MW) and Stiegler's Gorge (2100MW) in Rufiji Basin. The Pangani Basin has Mandera (21MW) as a site studied to a feasibility level. All these are non-Nile River potentials.

For Nile Basin, it is estimated that about 300 Mw potential do exist on the Kagera River. However, Small Scale Hydro-potential is quite limited in hydro site numbers as well as head and hydrology.

Extensive work has been done to study the numerous existing small scale hydropower potentials, which are scattered in most parts of the country where over the past many years a number of reconnaissance and pre-feasibility studies have been carried out on both mini and small hydropower potential sites. A few of them have been studied up to feasibility level.

Small hydropower potentials are situated in remote isolated areas, their development will definitely serve as an engine towards economical and social development of the remote/local Tanzanian communities which some of them now are supplied with power by making use of isolated diesel stations. The majority of the Tanzanians have no access to electricity; only about 10% of the entire Tanzanian population enjoys the supply of electricity services. The remaining go for a locally available traditional energy (biomass) which accounts to 90% of energy consumption in the country.

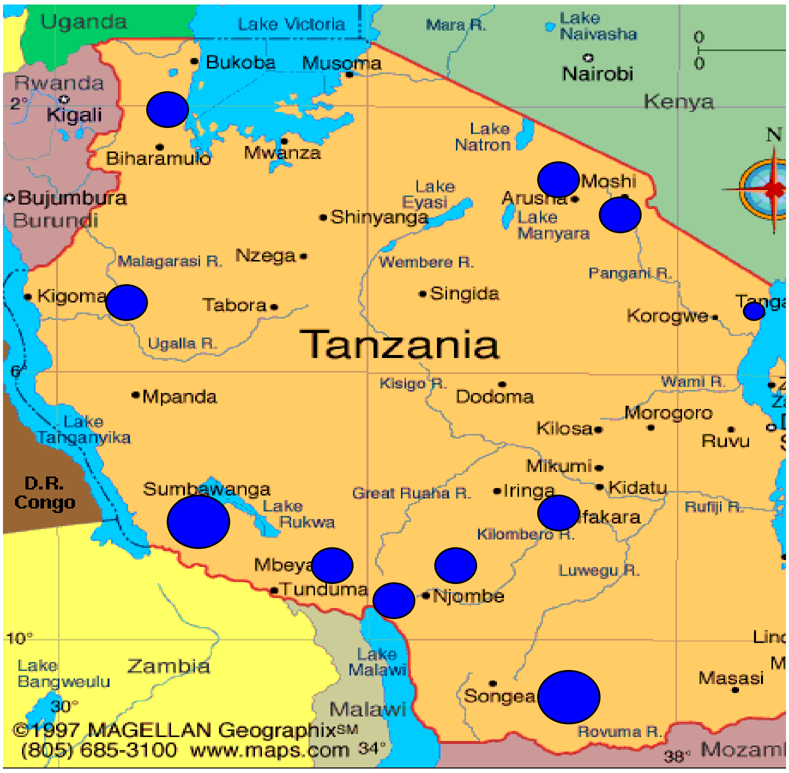
Operation of diesel stations in the remote isolated systems depends on the imported expensive fuel which is a cost to the national economy. This fact opens a challenge to develop Small hydropower to supply cheap and environmentally friendly electricity to the isolated communities.

The Government underscores the advantages of investing in hydro electricity generation for those sites which have been evaluated and proved to be viable. Following the recent/on-going reforms of the power sector (trade liberalization, opening doors to private investors, privatisation of public utilities, etc) it is anticipated that private firms will also increase their interest to invest in hydroelectricity generation. The table below shows the existing listing of identified Small hydropower potentials.

Table(1-1) List Small Hydropower Potential sites in Tanzania – see also graphical presentations in next pages

No.	**River Name**	**Location (Region)**	**Head in metres**	**Installed capacity [kw]**	**Firm capacity (kw)**	**Average flow rate [m3/s]**
SMALL HYDRO-POTENTIALS WITHIN NILE RIVER BASIN						
1	Kasongenye SHP	Biharamulo (Kagera)		420	840	1?
2	Kaonjuba SHP	Kamwana River – Muleba (Kagera)	90	800	200	1.2
SUBTOTAL				1220		
SMALL HYDRO-POTENTIALS IN NON-NILE RIVER BASINS						
3	Yungu River	Mbinga District (Ruvuma)	20	90	80kw	0.5
4	Mbawa River	Mbinga District (Ruvuma)	200	1800	1600	1
5	Luwika River	Mbinga District (Ruvuma)	200	1400	1200	0.8
6	Luaita River	Mbinga District (Ruvuma)	30	190	145	0.6
7	Upper Ruvuma River	Ruvuma	20	2000	1500	6
8	Hanga River	Songea District (Ruvuma)	40	550	420	5.2
9	Lilondo River (Mahanje Mission)	Lingatunda waterfail (Ruvuma)	150	1400	1100	0.75
10	Kibwaka River (Mhangazi River)	Njombe (Iringa)	50	5100	4000	35
11	Malisa River	Njombe (Iringa)	75	1250	1100	6
12	Mbaka River	Kyela (Mbeya)	200-300	8000	4-6	2.5
13	Kiwira River	Kyela (Mbeya)	285	25000	18	15.7
14	Songwe River	Rukwa	20	1000	15.7GWh	10.6
15	Lupa River	Chunya (Mbeya)	50	2800	280	15.7
16	Lukwate River	Chunya (Mbeya)	60	900		1.8
17	Wuku River	Chunya (Sumbawanga)	80	2500	2000	3
18	Yeye River		90	2500	1900	2.5
19	Rungwa River		108	50	9	35
20	Lukima River		120	4000	3000	4
21	Msadia/Mfwizi River		120	25000	215GWh	18
22	Mtozi River		40	2400	1700	12
23	Mbede River		50	1240	1080	0.3
24	Mamba River		50	155	135	0.1
25	Filongo River		150	415	360	0.3
26	Mpete River		200	55000	48000	0.03
27	Chulu River	Rukwa	300	850	720	0.3
28	Kirambo River		300	280	240	0.1
29	Muse River		200	520	450	0.2
30	Luiche River		200	1,100	800	0.5
31	Msofwe River		500	4500	3200	0.95
32	Milepa River	Rukwa	450			0.2
33	MBA River	Rukwa	300	1000	770	0.55
34	Kilemba River	Sumbawanga (Rukwa)	300	270	230	0.95
35	Kalambo River	Sumbawanga (Rukwa)	430	80000	58000	30
36	Kawa River	Rukwa	200	2000	1700	2.7
37	Luamfi River	Rukwa	40	1200	1000	9
38	Mtambo River	Mpanda (Rukwa)	40	2400	1700	8
39	Luegele River	Mpanda (Rukwa)	175	15000	11000	15
40	Ruchugi river	Kigoma River	20	1000	859	30
41	Mkuti River	Kigoma River	23	630	420	3.3
42	Himo l and ll	Kilimanjaro (Moshi)		945	190	3.3
43	Kihurio SHP l & ll	Seseni River, Same District, Kilimanjaro		1740	260	3.3
44	Ndungu	Goma River – Same		1740	260	3.3

		(Kilimanjaro)				
45	Bombo/Gonja	Higilili River – (Tanga)				0.64
46	Mto wa Simba	Mto wa Mbu (Arusha)	210			2.4
47	Mbulu SHP	Mbulu (Arusha)	450	8100		1.75
48	Pinying river	Loliondo (Arusha)		450	221	0.9?
49	Njombe Falls	Njombe (Iringa)		2000		5.6
50	Kifunga Falls	Njombe (Iringa)		3,600		16
51	Hagafiro River	Njombe (Iringa)		5,000		
52	Malagarasi SHP	(Kigoma)	80		7,600	16.0
53	Uvinza	Ruchugi River (Kigoma)		1000	850	30
54	Nzovwe SHP	Sumbawanga (Rukwa)		3000	460	0.33
55	Nakatuta SHP	Songea (Ruvuma)	30	9000	2100	61
56	Hainu River SHP	Mbulu Babati (Arusha)	100		3.520	0.48



General location of the Small Hydro potential Sites in Tanzania. NB:Size of the sphere represent relative number size of the sites in the region.

River Basin

Figure (1-3) Tanzania map showing rivers rich in Hydropower Potentials and some small hydro potentials locations

1.3 EXISTING SMALL HYDROPOWER PLANTS

The history of Mini/Small hydropower development in Tanzania dates back during the colonial period where Mini/Small hydropower plants were developed to supply power to specific communities like religious centres (Missionaries). The table below shows existing Mini/Small hydropower station.

Table (1-2) Existing Mini/Small hydropower Stations

Location	Turbine Type/Manufacturer	Installed capacity (kw)
	TANESCO	
Tosamaganga (Iringa)	Gilkes & Gordon/Francis	1220
Kikuletwa (Moshi)	Boving & Voith Reaction	1160
Mbalizi	Gilkes & Gordon/Francis	340
Missions		
Kitai (Songea)	Gross Flow/Ossberger	45
Nyagao (Lindi)		15.8
Isoko (Tukuyu)		15.5
Uwemba (Njombe)		800
Bulongwa (Njombe)		180.0
Kaengesa (S'wanga)		44.0
Rungwe (Tukuyu)		21.2
Nyangao (Lindi)		38.8
Peramiho (Songea)		34.6
Isoko (Tukuyu)		7.3
Ndanda (Lindi)		14.4
Ngaresero (Arusha)	Gilbsk	15.0
Sakare (Soni)	Geiselbrecht	6.3
Mabarari (Mbeya)	Chinese	700.0
Ndolage (Bukoba)	B. Maler	55.0
Ikonda (Njombe)	CMTIP	40.0

1.4 ONGOING INITIATIVES TOWARDS DEVELOPMENT OF MINI/SMALL HYDROPOWER PROJECTS

The government policy on Small Hydropower is to develop small hydro potential sites existing in areas which are not supplied with power from the National grid or to replace diesel generation in isolated areas. Based on this policy, several SHP development activities have been initiated by the government in cooperation with local and foreign agencies. On-going development activities in SHP development range from sites identification, pre-feasibility/feasibility studies and personnel training. Through financing from Sida, Wino and Kasulu projects are in implementation status

Table(1- 3)Development status of some small hydro sites in Tanzania

Name of the river	Site Location	Potential capacity in KW	Supplying/Expected to supply	Development status
Ruvuma	Sunda	3,000	Tunduru (D)*	Feasibility study
Ruvuma	Nakatuta	9,000	Songea/Mbinga	Feasibility study
Ruvuma	Lupilo	1,400	Songea ®+	Feasibility Study
Luaita	Mbiga	300	Mbinga	Feasibility Study
Luwika	L. Nyansashore	1,400	Mbamba Bay	Reconnaissance
Ruhudje	Njombe	3,000	Njombe (D)	Prefeasibility
Lupa	Rukwa valley	3,800	Chumya (D)	Reconnaissance
Malagarasi	Uvinza	6,400	Kigoma ®	Reconnaissance
			Kasulu (D)	Reconnaissance

			Uvinza	Feasibility
Luiche	Nkungwe	4,000	Uvinza	Prefeasibility
Biharamulo	Game Reserve	200	B'mulo (D)	Prefeasibility
Ngono	Kalebe	2,500	Bukoba ®	Prefeasibility
Hainu	Mbulu	1,500	Mbulu (D)	Feasibility
Mto wa simba	Mto wa mbu	1,500	Babati (D)	Prefeasibility
Hagafiro	Uwemba	800	Uwemba	constructed

* (D) = District Headquarters
\+ ® = Regional Headquarters

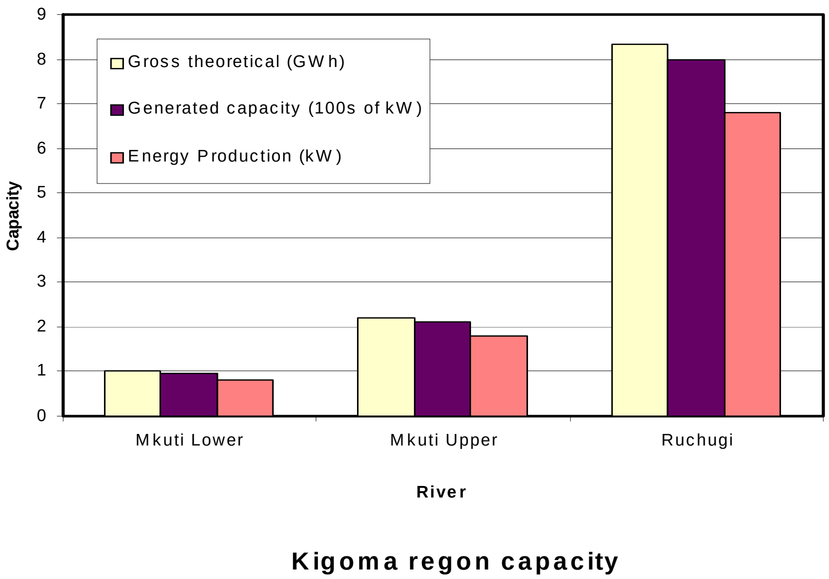


Figure (1-4)

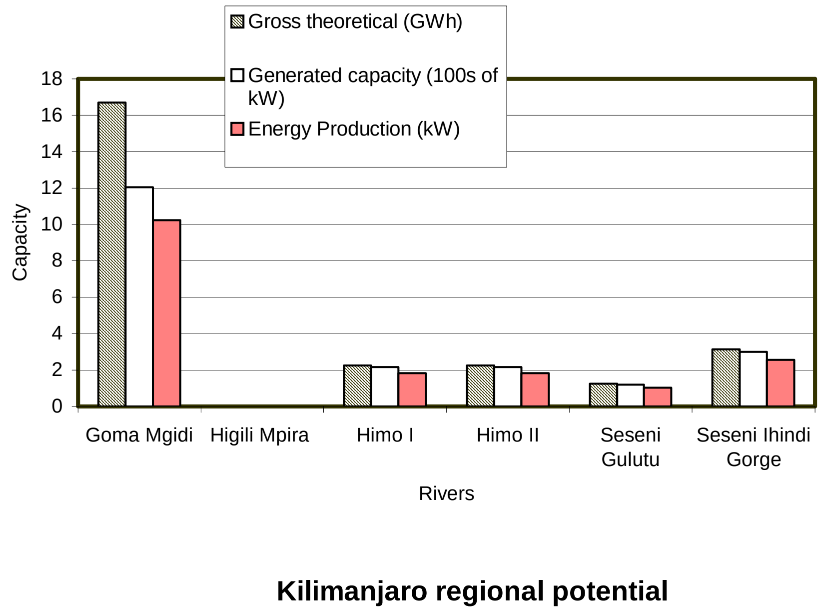
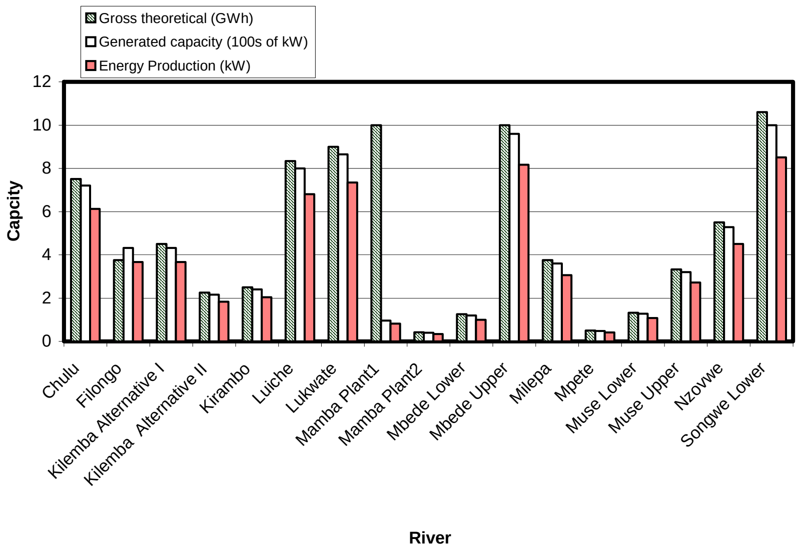
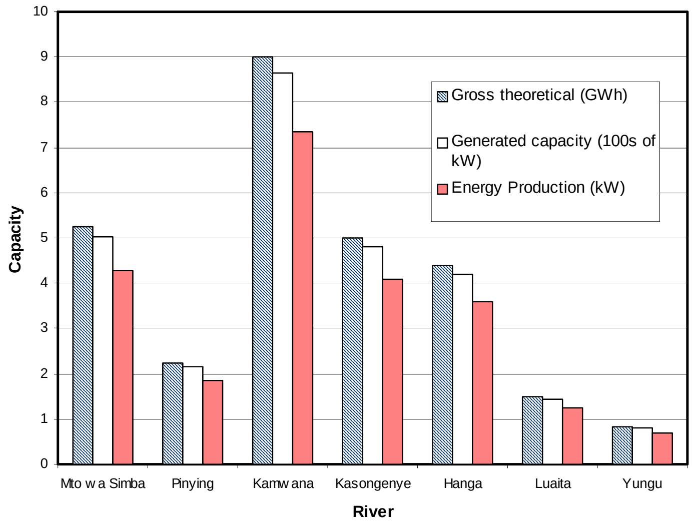


Figure (1-5)



Rukwa region potential

Figure (1-6)



Arusha, Kagera and Ruvuma regions potentials

Figure (1-7)

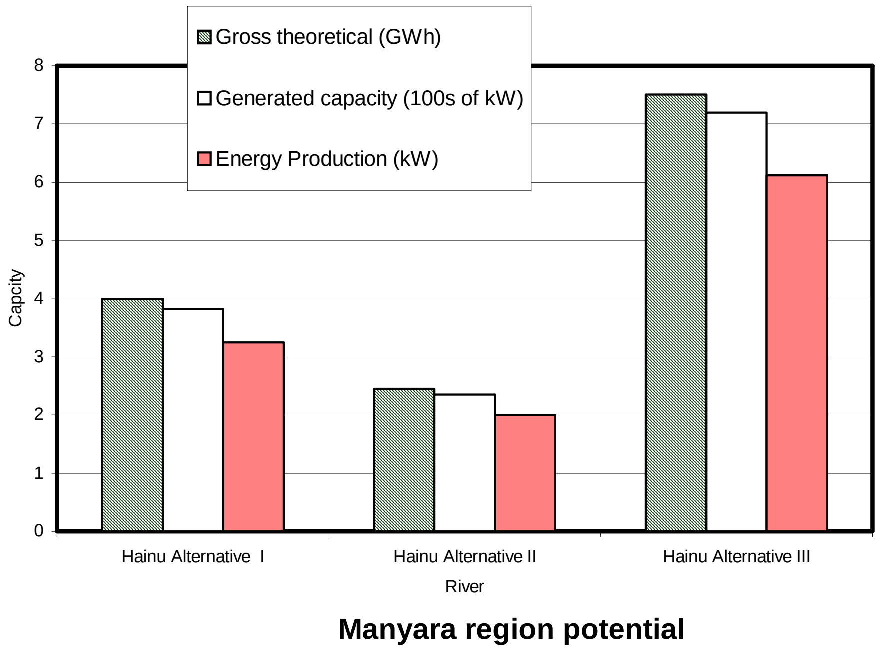

Gross theoretical (GWh)
Generated capacity (100s of kW)
Energy Production (kW)
8
7
6
5
4
3
2
1
0
Capcity
Hainu Alternative I
Hainu Alternative II
Hainu Alternative III
River
Manyara region potential

Figure (1-8)

2 INVENTORY OF CAPACITY BUILDING NEEDS

2.1 LOCAL TRAINING CAPACITY BUILDING

The rationale on the need for small hydropower systems has been explained in the previous section. Factors such as low electrification levels in rural areas, wider participation through cooperatives, equity, and environment management – all combined influence on the development of Small Hydropower Systems in Tanzania. Correspondingly, the challenge to overcome all these factors is a long term process that requires capacity building in form of training.

A small hydropower system has mainly 5 components. These are; civil works, the turbine, the generator, control systems and transmission/distribution. The respective training to these components is discussed as follows:-

2.1.1 Civil Works

Civil engineering training in the design and construction of dams; weir; settling tanks; canals; spill ways; trash rack that filters out debris e.g. leaves and branches; fore bay tanks; penstocks; power house this contains the turbine, generator and control systems. Knowledge on “river engineering” will compliment in the design of the civil works.

2.1.2 Turbine

There are two main families of turbines thus, impulse and reaction.Knowledge on the types of turbine is a pre-requisite e.g. on the choice of turbine. The choice of turbines depend on several factors such as power demand and its characteristics, the head, annual range of water flow in the river, the efficiency of the turbine at any point within the flow range, installation and maintenance costs.

2.1.3 Generator

Knowledge on ac synchronous generators both single and 3phase is necessary. Linked to this is knowledge in power drives and transmissions. Briefly in-depth training in electro/Mechanical engineering related to hydropower is needed.

2.1.4 Control Systems

Water turbines vary is speed whenever load is applied or relieved. This has effects on the generator frequency and output voltages which in turn affect the efficiencies of the load centres be it motors, equipment that may be powered.

Capacity building in form of training is needed in “control systems”. There exists modern “electronic load control” (ELC) that control supply of electrical power by a given water flow. There are also modern Induction Generator controls (IGC) that control voltage and frequency and which specialized training is needed.

2.1.5 Transmission and Distribution

Transmission and distribution from the small hydropower plant should be kept at short distances in the context of minigrids.” This is in order to minimize transmission losses and in the use of many transformers. Therefore knowledge on transmission and distribution in the context of minigrids is necessary.

2.2 CAPACITY BUILDING IN THE CONTEXT OF POWER SECTOR REFORMS

The power sector reforms that were initiated in early 1990s allow the involvement of the private sector in general to invest in the power sector. Consequently there has been independent power producers (IPPs) in areas of power generation that otherwise used to be exclusively TANESCO role. To date there are IPPs generating power from “fossil based fuels and “biomass fuels. These include the 100MW IPTL (Independent Power Tanzania Ltd) that uses heavy fuel oil (HFO) and TANWAT that uses biomass fuel. The 6MW Kiwira Coal mine is another IPP using coal. IPTL is connected to the national grid. TANWAT and Kiwira are connected to local minigrids. To date there are no IPPs using hydro-sources. There are however individual micro hydropower plants that are mostly owned by missionaries that generate power for their own uses e.g. for hospitals and schools.

The development of smaller hydropower plants to cater for minigrids should be encouraged and that necessary capacity building in form of training is needed.

IPPs in small hydro systems in rural areas are likely to be fully operated as “utilities. Being a utility is to have unique responsibilities towards consumers. A utility must supply power as needed and where needed, continuously and at minimum cost to consumers. Breakdowns in operation are totally unacceptable as they can have catastrophic effects on the communities receiving power and energy from the plants. Therefore when small hydropower plants enter into contracts as utilities they must be ready to assume the unique responsibilities. Therefore tailored made training courses are needed to cover such subjects or topics on meter reading, maintenance of power lines, reactive power, energy, dispatchability, maintenance coordination, capacity in terms of peak demands and normal demands e.t.c.

Small hydropower systems as local utilities will be catalysts in the formation of ESCOs (Energy Supply Companies) and IPDs (Independent Power Distributors) in the energy trade or business at community or district levels.

Tailored made training courses could be arranged to support small hydro systems as local utilities. Table 4, 5 & 6 shows Training/Professional Resource institutions in Tanzania that could be platforms for capacity building in form of training. Exchange programme with other countries in the Nile River Basin Initiative would be highly encouraged.

Table(2-1) Possible Technical Institutions for Training Platforms for Capacity Building

S/No	Institutions	Training courses	Awards
1.	University College of Engineering (UDSM-pCoE)	Civil Engineering River engineering, Water Resources Engineering, Electric Engineering, Energy Systems	Degrees Diploma
2	UCLAS	All matters of Survey & Mapping	Degree, Diplomas, Certificate
3.	Dar es Salaam Institute of Technology (DIT)	- Civil Engineering - Electro/Mechanical	Diploma, FTC - do -
4	Arusha Technical College	- Civil Engineering - Electro/Mechanical	FTC
5	Mbeya Technical College	- Civil Engineering - Electro/Mechanical	FTC
6	Water Resources Institute, Rwegalulila	- Water Resources Engineering	FTC
7	TANESCO Training Institute	Power transmission and distribution - meter reading - billing - power line maintenance, etc	Certificate
8	Dodoma Rural Development Institute	- Energy Market Identification - Energy business entrepreneurship	Certificate

Table (2-2) Other Professional Resources Institutions

S/n	Institutions	Services offered
1	Water Laboratories, Ministry of Water & Livestock Development	Physical, chemical and Bacteriological analyses of water & soils
2	National Environmental Management Council	Matters concerning Environmental Protection in Tanzania
3	Ministry of Energy and Minerals	All maters regarding Energy policies for the Government
3	Department of Research & Development of Tanzania Electric Supply Company Ltd	All matters related to Hydropower Development
4	National Land Use Planning Commission	Principal Advisory organ on all matters related to land use
5	Various private Consulting firms e.g Norplan, Norconsult, Cowi Consult, e.t.c	Hydropower Development, e.t.c

Table(2-3) Some Manufacturing Industries

S/N	ORGANISATION/ INSTITUTION	ACTIVITY/Products	Location
1.	TANELEC	Transformers, Electric equipment	Arusha
2.	PEMACO-BEVI	Electric motors, Generators	Dar es Salaam
3.	KIDC	motors	Dar es Salaam
4.	NYUMBU Automobile Company	Engines, motors	Kibaha
5.	DAESUNG	Motors/cables	Dar es Salaam
6.	IMAC	motors	Dar es Salaam
7.	SIDO	motors	Dar es Salaam

3 INVENTORY OF DATA BASES AND SOURCES OF INFORMATION

Table (3-1) Inventory of data bases and sources of information

S/ N	SOURCE	DATA FORMAT	POSTAL ADDRESS
1	Ministry of Water and Livestock Development	Raw & Semi - processed	-
2	Ministry of Energy and Minerals	Raw & Semi - processed	
3	Tanzania Electric Supply Company Limited	Raw	
4	Tanzania Meteorological Agency	undefined	-
5	University of Dare s salaam	Map sheets	Dodoma
6	Tanganyika Wattle Company (TANWAT)	undefined	Dar es Salaam

Ministry of Local Govt. & Administration Tanzania Meteorological Agency TANESCO, NEMC, GTZ, UNDP – TZ,
Geology Department (University of Dar es Salaam) MADINI Agency (TG Survey)
Ministry of Lands & Human Settlement Training Centres, Schools, Health Centres
Ministry of Lands & Human Settlement
Bureau of Statistics University of Dar es Salaam

APPENDIX A6

UGANDA REPORT

CONTENTS

1 INTRODUCTION

The definition of *small-scale hydro* is somewhat arbitrary from a technical standpoint. In United States small hydro projects were defined as systems of 15 MW or less. Though in recent developments, the definition has been increased to projects of 30 MW or less.

Mini and Micro hydro projects can be defined in much in the same fashion. Mini hydro projects are taken to refer to projects of 1 MW or less, and Micro hydro projects to be 100 KW or less. Though, these definitions are used for purposes of quantifying different projects.

Hydro-electric sites are divided into three different categories by head: low, medium and high. Low Head (2 to 20m head), Medium (20 – 150m head), High (more than 150m).

Uganda, on paper is said to have a hydropower potential of 2000MW, with an installed capacity of about 248 MW. Most of this is at the Owen Falls (180MW) on the River Nile. The Owen Falls has undergone an extensive upgrading, which addition of a 200 MW Kira Station. This Hydropower is said to provide about 98% of the country's utility power supply.

In Uganda, electricity is primarily generated from the Owen Falls Dam at Jinja in the South Eastern Uganda. In smaller, remote urban centers, electricity is produced using Diesel-Oil Generators. Although 40% of Uganda lives in the area covered by Uganda Electricity Board (UEB) system, only 6% of Uganda's population has access to electricity, 5% in the Urban and 1% in the rural areas. The 94% of the population represents a potential market for increased electric power generation, transmission and distribution.

The Government has embarked on a 10 year innovative programme, known as the Energy for Rural Transformation (ERT) programme under the assistance of the WORLD BANK to promote rural electrification through grid extension, mini-grid development based on local generation, solar installations for isolated settlements and renewable energy based power generation.

In Uganda, the Ministry of Energy and Mineral Resources is responsible for Uganda's energy. The Uganda Electricity Board is responsible electricity generation and supply in Uganda, and has been exercising monopoly since the 1964 Act which has undergone reform and is in the process of privatization. The Utility Company UEB has been unbundled into four entities:

a) The Uganda Electricity Generation Company Limited(UEGCL)
b) The Uganda Electricity Transmission Company Limited(UETCL)
c) The Uganda Electricity Distribution Company Limited(UEDCL)
d) The Uganda Electricity Board(Remnant)

2 HYDROPOWER REFORM IN UGANDA

The mission of the Ministry of Energy and Mineral Development is to promote, develop and strategically manage and safeguard the rationale and sustainable utilization of Energy and Mineral resources for social and economic development. The Government's overall policy objectives in the energy sector are to:

- Improve the quality and quantity of energy supply through appropriate sector reforms and establishment of an enabling legislation.
- Promotion of efficient utilization of energy resources and execution of rural electrification programs.

In 1997, the Government of Uganda embarked on an ambitious reform program for the Power Sector. This process started with the formulation of a compressive and detailed Strategic Plan fro Transforming the power sector into a financially viable electricity industry which can make its full contribution to economic and social development, by being able to supply reasonably priced and reliable power. It was followed by the enactment of the Electricity Act 1999 whose main objective was to liberalise the Power Sector.

In expanding access to energy services, the government policy is to promote private sector participation in the development of both conventional and renewable energy resources. Also, another objective is to maximize opportunities fro export of power to neighbouring countries once the internal demand is adequately met. This led to Independent Power Producers (IPPs) to develop several hydropower sites in Uganda under BOOT management structure.

In 1999 October, the Electricity Act became law in Uganda. This law removed UEB's monopoly in the Generation, Transmission and Distribution of power and established the Electricity Regulatory Authority (ERA) to regulate the industry, in addition to privatising UEB.

Given the capital intensity of the power investments and in line with government's commitment to attract private capital and expertise in the provision of utilities, the sector has been opened to private investment. Two initiatives are being planned to open up the sector to Foreign Direct Investment (FDI): - Independent Power generation projects and privatisation of elements of the UEB.

3 RURAL ELECTRIFICATION

Uganda is currently pursuing two rural electrification projects. The purpose of first project is to subsidize private investment in the rural network expansion – Energy for Rural Transformation (ERT) program. This is a World Bank funded project with a goal to increase rural access to electricity from 1% to 10% in a period of 10 years (a target of 70MW). It is intended that this will be done by the private sector, with grant support from various multilateral and bilateral agencies. This grant will provide "smart subsidies" so that resulting tariffs may be affordable. The program allows for low cost recovery and cost-based tariffs to facilitate private sector initiatives.

The second program is a three year pilot program aiming at connecting 2,000 customers with off grid solar. Solar power is useful for low consumption areas that are far from the existing grid.

The third program of Uganda's strategy is to increase low cost hydro power generation. The Bujagali project is fundamental to make the first two programs successful. The power from Bujagali will meet the core demand for Uganda's energy needs as well as support the rural electrification strategy.

In parallel, minihydro's further away from the grid are also being developed with investments from the private sector to reach distant local markets. The isolated grid mini-systems will serve the relatively concentrated areas with a potential for use of electricity by rural enterprises. This can be done for both renewable and conventional sources.

4 THE HYDROLOGY OF UGANDA

Most of Uganda lies within the upper part of the White Nile Basin, which consists of seven major catchments. The most prominent hydrological feature is Lake Victoria, which is the second largest fresh Water Lake in the World and covers an average area of 67,000 km^2. The only outflow from the lake is that down the Nile and since 1954 it has been through the Owen Falls Dam.

Nearly 1/5 of the country is composed of lakes and swamps, occurring principally in southern Uganda and the Western Rift valley. After flowing out of Lake Victoria, the Nile also flows through lakes Kyoga and Mobutu. Lake Kyoga is a shallow sheet of water lined with swamps varying in area between 3,500 km2 and 4,000 km2, while Lake Mobutu covers an area of about 5,600 km2.

One of the key hydrological issues in Uganda is the Water Balance of Lake Victoria. The level determines the flow down the Nile and heavily influences the water resources projects in a series of countries downstream. The level of the lake rose dramatically in the years 1961-64 and since then has only occasionally dropped below the pre-1961 recorded maximum.

5 RAINFALL DISTRIBUTION IN UGANDA

Uganda extends from latitude of 1.5 ˚S to 4.0 ˚N; it therefore experiences a truly equatorial climate. Broadly speaking, it is well watered throughout and vegetation is correspondingly lush. It has very small annual variations in temperature and humidity. The rainfall pattern is bimodal almost everywhere, with peaks from March to May and again from August to November. Many regions have a relatively dry season from December to February. Local variations in climate are dominated by topographic influences, particularly due to Lake Victoria in the South-East and Lake Mobutu to the West, and also the mountains, particularly the Rwenzori Range to the South-West and Mount Elgon to the East.

Variations of temperature, humidity, cloud cover and prevailing wind all contribute to the climate as it affects hydrology (through evaporation), agriculture and many other human activities. However, the variation of these parameters through the seasons is closely correlated with that of rainfall, so that this is most generally useful descriptor of the climate.

The Rainfall climate in Uganda may be linked to the mean position of the Inter Continental Convergence Zone (ITCZ). It is the double passage of the ITCZ, north and south over the country, which produces the characteristic bimodal pattern. The total annual rainfall and size of seasonal variation are governed by topography as by latitude.

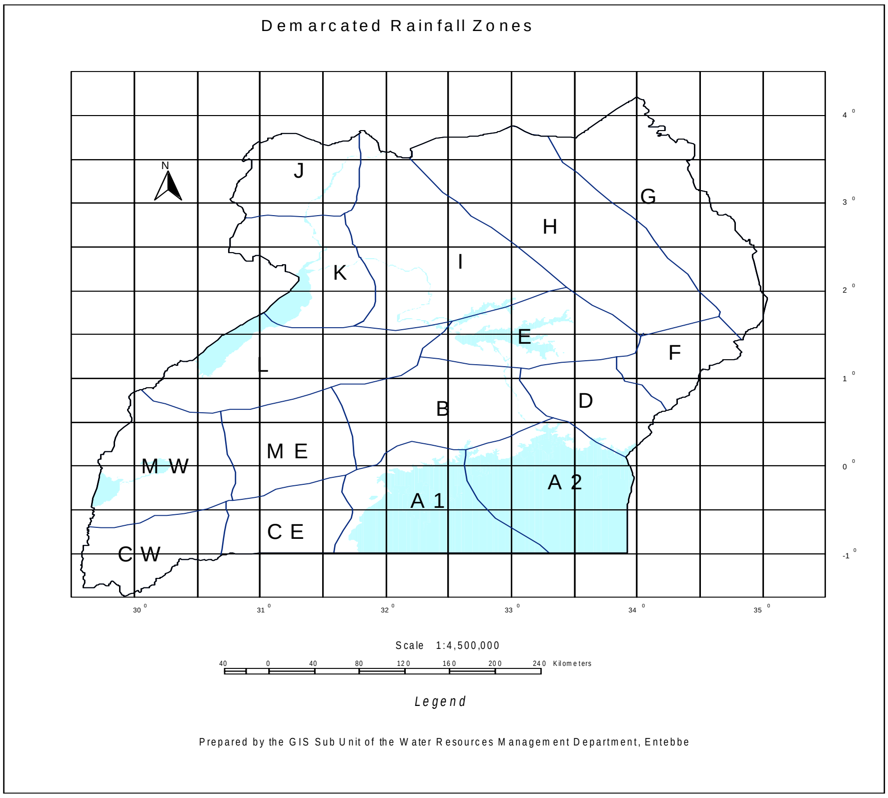


Figure 1 Rainfall Climatical Zones of Uganda

Figure below shows a map for annual rainfall in Uganda, based on data 1931-1960 previously regarded as a standard period. This map gives a clear picture of the rainfall distribution over the territory Uganda.

The spatial rainfall distribution of Uganda has been delineated into climatical zones which receive almost the same pattern of rainfall. Then for each climatical zone, the temporal distribution is explained. (This research was carried out Basalirwa Brenda et al, in 1993).

The zones adapted in the hydroclimatic study were delineated by Basalirwa et al (1993) in her study of the Design of a Regional Minimum rain gauge network. The method used was based on the Principal Component Analysis (PCA). The spatial patterns of the dominant principal components were used to classify Uganda into 14 homogeneous zones. The zones were delineated following the analysis of monthly rainfall records at 102 rain gauges for the period 1940-75.

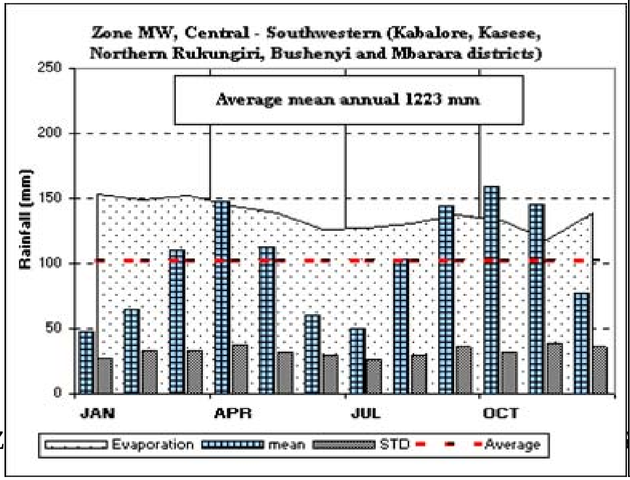
Table (1)ZONAL AVERAGE RAINFALL, STD AND EVAPORATION ANALYSIS

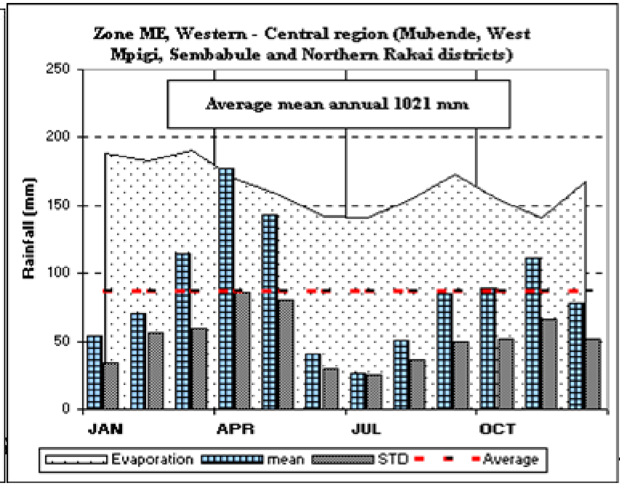
Zone	Districts, 2000 boundaries	Annual Rainfall and its zonal variability	Main rainy seasons	Main dry seasons	Evaporation verses rainfall
NORTHEASTERN TO NORTH CENTRAL AREAS					
G	Moroto, Kotido and Northeastern Kitgum	Average of 745 mm, STD 145 mm. High variability, from ~ 600 over the north and northeastern parts to ~ 1000 mm over the southern and western parts.	One rainy season of about 5½ months, from April to early September with the main peak in July/August and a secondary peak in May.	One long dry season of about 6 months, October to March. Driest months December to February.	Evaporation > rainfall by a factor of over 10 during the driest months, December to February. During the rainy season evaporation is slightly > rainfall.
H	Kitgum, Eastern Lira, South Kotido, Western Moroto and Katakwi	Average of 1197 mm, STD 169 mm. Moderate variability, from ~ 1000 over the north and northeastern parts to ~ 1300 mm over western and southern parts	One rainy season of about 7 months, April to late October with the main peak in July/August and a secondary peak in May.	One long dry season of about 4 months, mid-November to late March. Driest months December to February.	Evaporation > rainfall by a factor of over 10 during the driest months, December to February. During the rainy months, May; July and August rainfall is slightly > evaporation.
I	Adjumani, Gulu, Apac, Western Lira and Eastern Masindi	Average of 1340 mm, STD 155 mm. Moderate variability, from ~ 1200 over northwestern and western parts to ~ 1500 mm over the southern parts.	One rainy season, about 7½ months, April to about mid November with the main peak in August to mid October and a secondary peak in April/May.	One long dry season of about 4 months, mid-November to late March. Driest months December to February.	Evaporation > rainfall by a factor of up to 10 during the driest months, December to February. During the rainy months of May, August and September rainfall > evaporation.

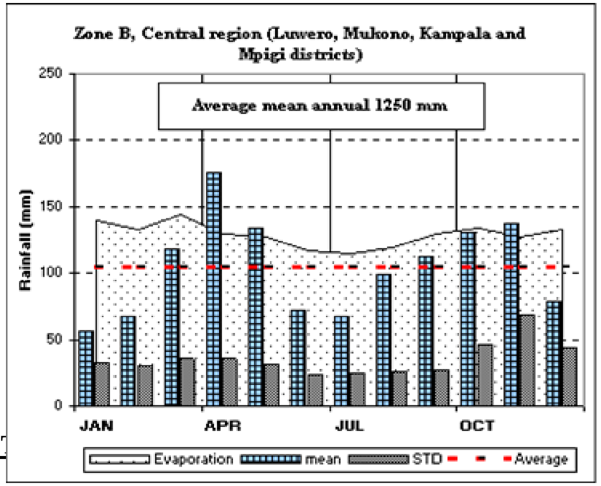
NORTHWESTERN TO CENTRAL WESTERN AREAS					
J	Moyo and Arua	Average of 1371 mm, STD 185 mm. Moderate variability, from ~ 1200 over the eastern parts and highest ~ 1500 mm over the western parts.	One rainy season of about 7½ months, April to about mid November with the main peak August to October and a secondary peak in April/May.	One long dry season of about 4 months, late November to late March. Driest months December to February.	Evaporation > rainfall by a factor of ~ 10 during the dry months, December to March. During the rainy season, July to October, rainfall > evaporation.
K	Nebbi, Southwestern Gulu and Western Masindi	Average of 1259 mm, STD 195 mm. High variability, from ~ 800 within the Lake Albert basin to ~ 1500 mm over the western parts	Mainly one rainy season of about 8 months, late March to late November with the main peak August to October and a secondary peak in April/May.	One long dry season of about 3½ months, December to about mid March. Driest months December to February.	Evaporation > rainfall by a factor of ~ 6 during the driest months, December to March. During the rainy season, July to October, evaporation > rainfall.
L	Hoima, Kiboga, Western Luwero, Kibale, North Kabarole and Bundibugyo	Average of 1270 mm, STD 135 mm. High variability, from ~ 800 over eastern L. Albert parts to ~ 1400mm over the western parts.	Two rainy seasons, main season August to November with peak in October and secondary season March to May with peak in April.	Main dry season December to about mid March, secondary dry season is June to July.	Evaporation > rainfall by a factor of ~ 5 during the dry months, December to March. During the rainy months, March and August to November rainfall > evaporation.

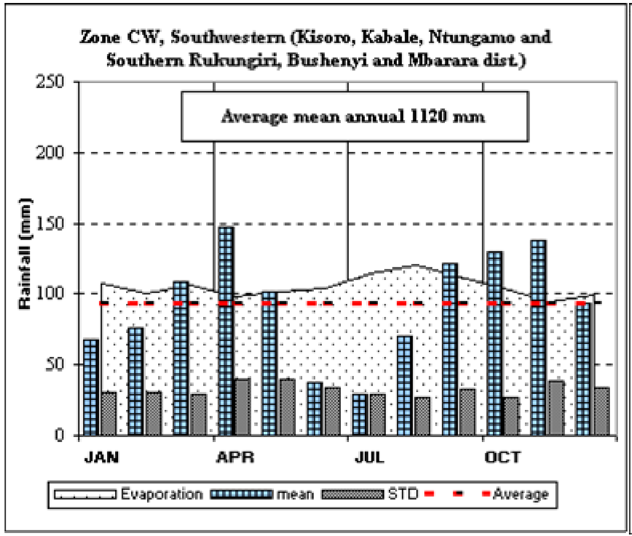
ZONAL AVERAGE RAINFALL, STD AND EVAPORATION ANALYSIS					
Zone	**Districts, 2000 boundaries**	**Annual and its zonal variability**	**Main rainy seasons**	**Main dry seasons**	**Evaporation verses rainfall**
CENTRAL WESTERN AREAS TO CENTRAL REGION					
MW	Kabarole, Kasese, Northern Rukungiri, Bushenyi and Mbarara	Average of 1223 mm. High variability, lowest ~ 800 mm Kasese Rift Valley, highest over slopes of Rwenzori mountains, over 1500mm.	Two rainy seasons, main season August to November with peak in September to November and secondary season March to May with peak in April.	Main dry season December to late March, secondary dry season is June to July.	Evaporation > rainfall by a factor of ~ 5 during the dry months, December to March. During the rainy months, March, and August to November rainfall > evaporation.
ME	Mubende, West Mpigi, Sembabule, and Northern Rakai	Average of 1021 mm.	Two rainy seasons, main season March to May with peak in April and secondary season September to December with a modest peak in November.	Main dry season June to August, secondary dry season is January to February.	Evaporation > rainfall by a factor of ~ 6 during the dry months, June to August. During the main rainy months, April and May rainfall ~ evaporation.
B	Luwero, Mukono, Kampala, and Mpigi.	Average of 1250 mm.	Two rainy seasons, main season March to May with peak in April and secondary season August to November with a modest peak in October/November.	Main dry season December to February, secondary dry season is June to July.	Evaporation > rainfall by a factor of ~ 2 during the dry months, December to February. During the peak of the rainy seasons rainfall is greater and or equal to evaporation.
SOUTH WESTERN AREAS TO WESTERN SHORES OF LAKE VICTORIA BASIN					
CW	Kisoro, Kabale, Ntugamo, Southern Rukungiri Bushenyi and Mbarara	Average of 1120 mm.	Two rainy seasons, main season September to December with peak in October/November and secondary season March to May with a peak in April.	Main dry season June to August, secondary dry season is January and February.	Evaporation > rainfall by a factor of ~ 3 during the dry months, June to August. During the rainy seasons rainfall is greater and or equal to evaporation.
CE	Rakai, West Masaka, and East Mbarara	Average of 915 mm.	Two rainy seasons, main season March to May with peak in April and secondary season September to December with a peak in October/November.	Main dry season June to August, secondary dry season is January and February.	Evaporation > rainfall by a factor of ~ 5 during the dry months, June to August. During the main rainy season rainfall is greater and or equal to evaporation.
A1_W	Western shores of Lake Victoria and Western Masaka.	Average of 1057 mm.	Two rainy seasons, main season March to May with peak in April and secondary season October to December with a peak in November.	Main dry season June to September, secondary dry season is January and February.	Evaporation > rainfall by a factor of ~ 3 during the dry months, June to August. During the main rainy season rainfall is greater and or equal to evaporation.

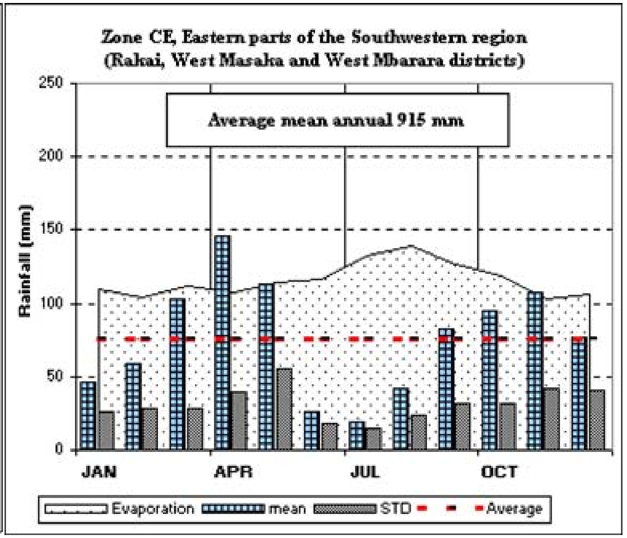
ZONAL AVERAGE MEAN MONTHLY RAINFALL, STD AND EVAPORATION FOR CENTRAL WESTERN TO CENTRAL AREAS

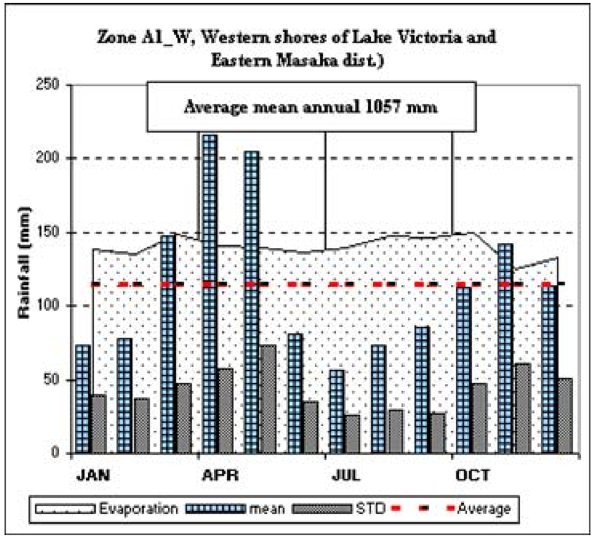






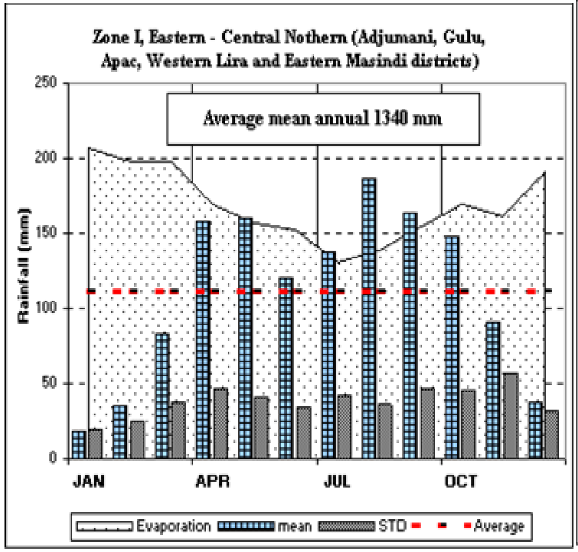


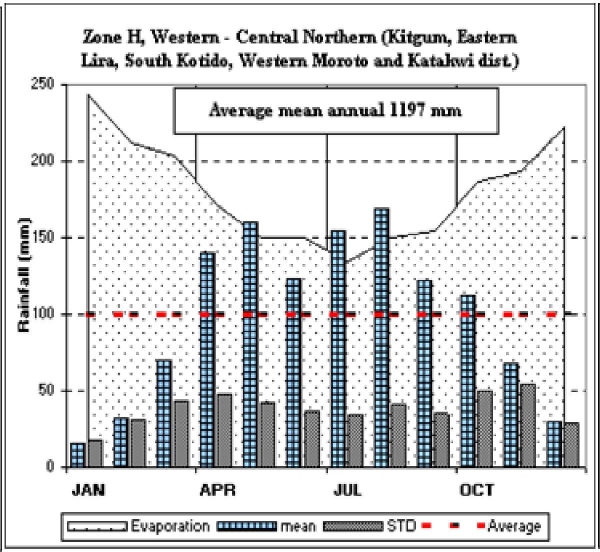


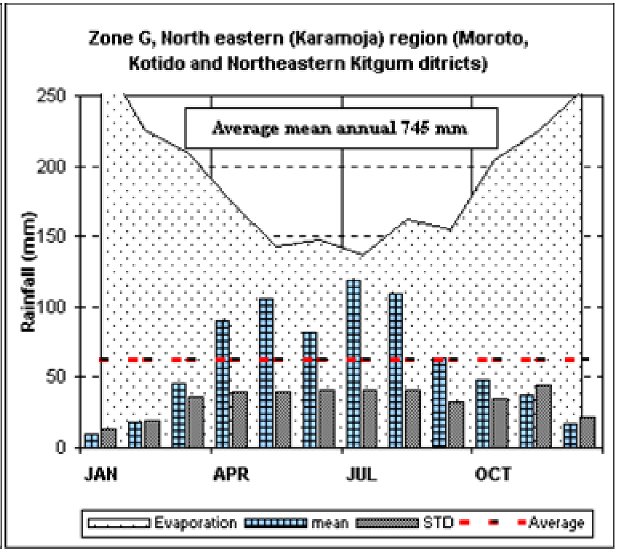


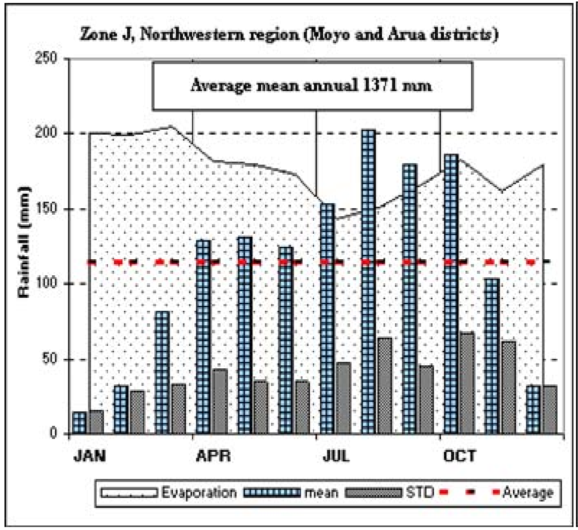
ZONAL AVERAGE RAINFALL, STD AND EVAPORATION ANALYSIS					
Zone	**Districts, 2000 boundaries**	Annual and its zonal variability	Main rainy seasons	Main dry seasons	**Evaporation verses rainfall**
EASTERN PARTS OF LAKE VICTORIA BASIN TO SOUTH EASTERN AREAS					
A1_E	Kalangala, South Mpigi and South Kampala	Average of 1414 mm.	Two rainy seasons, main season March to May with peak in April and secondary season October to December with a peak in November.	Main dry season June to August, secondary dry season is January and February.	Evaporation > rainfall by a factor of ~ 3 during the dry months, June to August. During the main rainy season rainfall is greater and or about equal to evaporation.
A2	South Mukono, Jinja, South Iganga, South Bugiri and South Busia	Average of 1443 mm.	Two rainy seasons, main season March to May with peak in April and secondary season October to December with a peak in November.	Main dry season June to August, secondary dry season is January and February.	Evaporation > rainfall by a factor of ~ 2 during the dry months, June to August. During the main rainy season rainfall is greater and or about equal to evaporation.
D	Central and north Iganga, South Kamuli, Tororo and north Busia	Average of 1316 mm.	Two rainy seasons, main season March to May with peak in April and secondary season August to November with a peak in October/November.	Main dry season December to February, secondary dry season is June and July.	Evaporation > rainfall by a factor of ~ 3 during the dry months, December to February. During the main rainy season rainfall is greater and or about equal to evaporation.
CENTRAL EASTERN TO CENTRAL LAKE KYOGA AREAS					
F	Kapachorwa, Mbale, Pallisa and Kumi	Average of 1328 mm.	Virtually one rainy season, March to October, with the main peak in April and a secondary peak in August.	One dry season December to about mid March.	Evaporation > rainfall by a factor of ~ 8 during the dry months December to February. During the main rainy season rainfall is greater and or about equal to evaporation.
E	Nakasongola, North Kamuli, South Soroti, Lira and Apac	Average of 1215 mm.	Virtually one rainy season, March to November, with the main peak in April/May and a secondary peak in August/September.	One dry season December to about mid March.	Evaporation > rainfall by a factor of ~ 7 during the dry months, December to February . During the peak of the rainy season rainfall is greater and or about equal to evaporation.

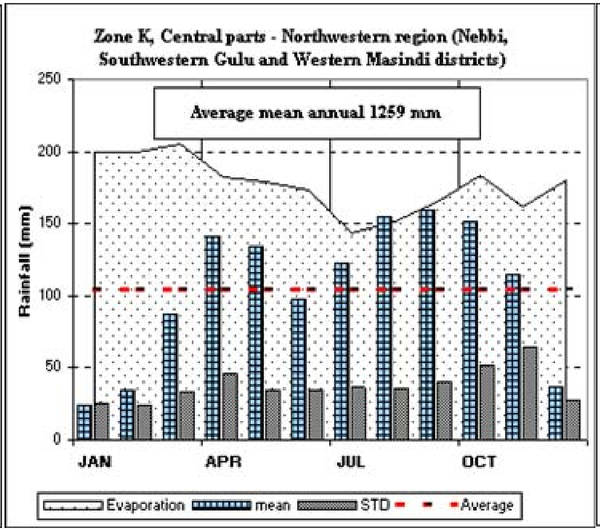
ZONAL AVERAGE MEAN MONTHLY RAINFALL, STD AND EVAPORATION FOR NORTHEASTERN TO NORTH CENTRAL AREAS

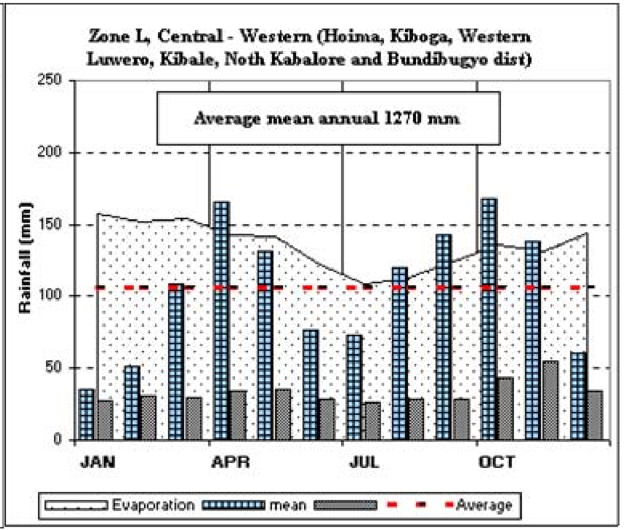




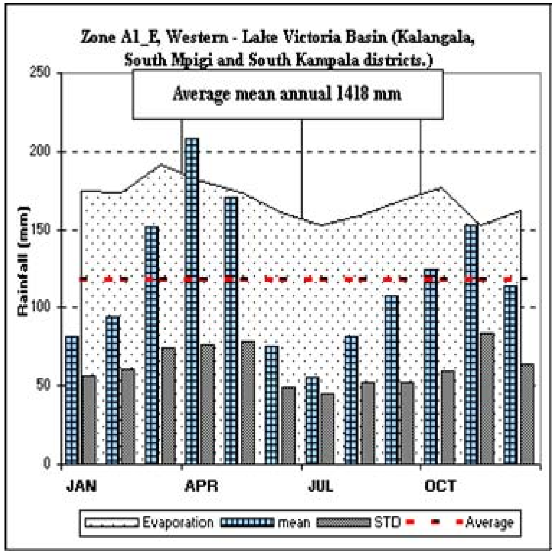


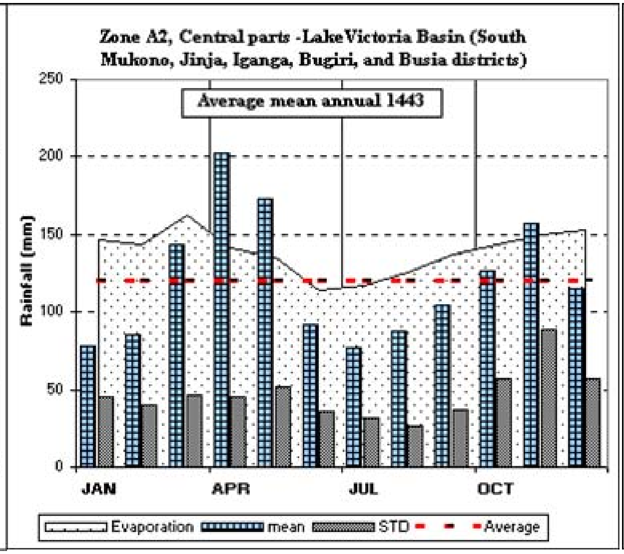


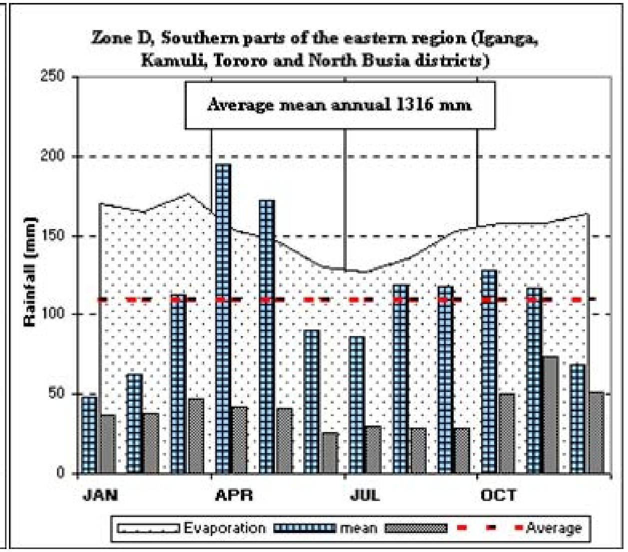




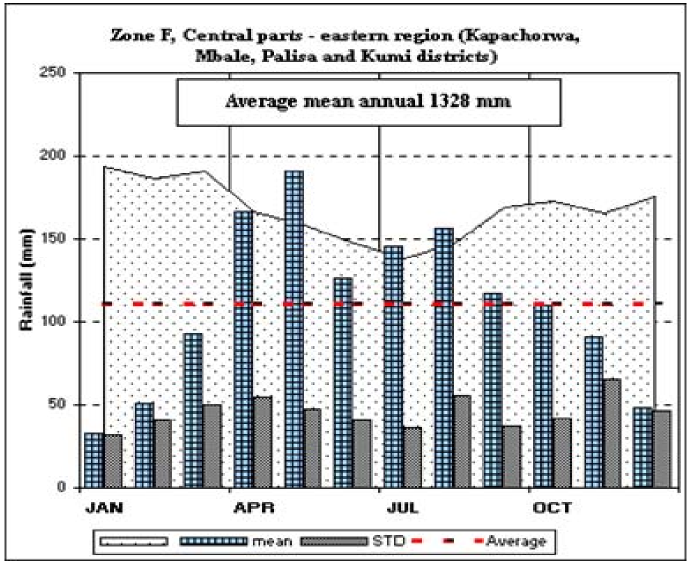
ZONAL AVERAGE MEAN MONTHLY RAINFALL, STD AND EVAPORATION FOR NORTHWESTERN TO CENTRAL WESTERN AREAS

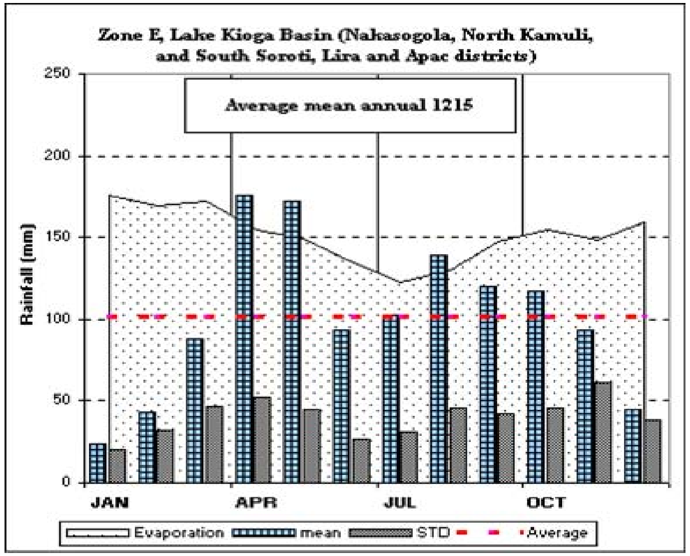






ZONAL AVERAGE MEAN MONTHLY RAINFALL, STD AND EVAPORATION FOR CENTRAL EASTERN TO CENTRAL LAKE KIOGA AREAS





6 RIVER FLOW NETWORK IN UGANDA

Most of Uganda forms part of an interior plateau, the surfaces of which comprise the major landscape element in Uganda. They are lower in the North and centre of the country, and are higher in the south and south-west. 84% of Uganda lies at the altitude band of 3000-5000ft (915-1525m), and the only mountainous areas are on the borders of Uganda, as follows:

- Mt.Elgon the Eastern border with Kenya
- The Rwenzori mountains on the western border with DRC
- Mufumbiro Mountains on the Rwanda/DRC borders in the South-West corner of Uganda.
- Several abrupt volcanoes in Karamoja, the north-eastern part of Uganda.

The country's hydrology is dominated by the extensive lake system, namely;

- Lake Victoria to the South
- Lake Kyoga and its associated system of small lakes in the Centre of Uganda
- Lake Edward and Mobutu (Albert) on the western borders,
- Numerous small lakes in the south-western part between Lake Victoria and Lake Edward.

The total surface area of Uganda and the proportions covered by open surface water and swamps are as follows,

- Area of Uganda 235,810 km^2
- Area covered by open water 36,278 km^2 (15.0%)
- Area covered by swamps 5,183 km^2 (2.2%)

The lakes are interconnected by a river system which has an interesting history of development as shown in figure 2 below.

.

(a) In former geological times, rivers flowed westwards across Uganda to DRC originating from somewhere in the region of Lake Victoria's eastern watershed in Kenya.

(b) A period of upwarping and faulting occurred along the western along the western rift, transverse to the direction of river flows. This severed the river flows to the west, caused a reversal of flows, and a ponding-up of waters which led to the gradual filling of the basin which is now Lake Victoria.

(c) Lake Victoria gradually filled, until it began o overflow, initially to the south, but eventually to the north through what is now the Nile. The outlet at Jinja was created by a river which cut along the rift a shatter zone until the northern rim of the lake was breached.

Much of southern Uganda drains into Lake Victoria. From Lake Victoria, water passes through the Owen falls Dam into the Victoria Nile, which flows north o Lake Kyoga.
The Kyoga Nile emerges from Lake Kyoga and flows north and west of Lake Albert. From Lake Albert, the Albert Nile flows north to Sudan.

The main river basins of Uganda are shown in the Figure 2 below. All of Uganda's rivers ultimately reach the Nile. Because of warping of the landscape, many of the perennial streams of the plateau are clogged with swamp. In the north-eastern part of the country, many of the water courses are seasonal.

The Directorate of Water Development (DWD) is the lead government agency for the water and sanitation sector under the Ministry of Water, Lands and Environment (MWLE). Among its functions, is the responsibility of water resources management of all water resources in the country, with rivers included. As such it operates 136 river gauging and take-level gauges, of which about 40 are equipped with automatic water level recorders.

These gauges gave the following **flow characteristics** for various Non-Nile Rivers of Uganda, as shown in the Table below.

Table (2) Non-Nile Rivers' Flow Characteristics

Site ID	Site Name	Mean	Median	St Dev	CV	Min	Max
81222	*R. Kagera at Kyaka Ferry*	247.489	227.031	115.805	0.468	16.000	473.969
81224	*R. Ruizi*	45.167	38.691	32.428	0.718	10.727	154.727
81228	*R. Mpamujugu*	8.711	6.915	7.743	0.889	1.383	34.929
81233	*R. Kibale Lower*	8.100	4.246	9.157	1.130	0.802	32.450
81248	*R.Nyakijumba at Maziba*	24.353	23.629	10.735	0.441	3.999	44.773
81250	*R. Kiruruma South*	34.622	29.721	30.863	0.891	3.385	127.911
81258	*R. Bukora*	9.886	7.782	9.013	0.912	1.162	39.769
81259	*R. Katonga at Kampala - Masaka Road*	8.639	6.440	5.612	0.650	2.404	22.118
81262	*R. Katonga at Nkonge First Bridge*	8.146	5.264	7.014	0.861	0.276	23.415
82212	*R.Manafwa*	52.938	52.173	23.790	0.449	10.563	120.437
82213	*R. Namatala*	29.620	25.633	17.460	0.589	5.506	71.288
82217	*R. Mpologoma*	83.938	63.950	72.070	0.859	4.404	297.598
82218	R. Malaba	52.218	48.419	14.812	0.284	31.298	96.697
82220	R.Enget	4.592	3.079	2.790	0.608	1.553	12.000
82221	R. Agu	33.609	22.277	41.404	1.232	2.714	173.142
82222	R. Abuket	10.840	6.070	11.136	1.027	1.193	45.786
82223	R. Kapiri 1	42.252	24.006	62.393	1.477	3.403	293.026
82225	Sezibwa	9.564	8.666	4.056	0.424	5.315	15.821
82226	R. Kami	21.632	17.962	15.004	0.694	0.271	67.893
82227	R. Kapiri 11	27.424	18.490	21.886	0.798	2.127	69.115
82228	R. Namalu	4.072	2.372	5.822	1.430	0.092	23.000
82231	R. Greek (Kelim)	56.338	41.867	40.022	0.710	5.589	161.207
82240	R. Siroko	26.397	26.322	13.737	0.520	7.486	57.165
82241	R. Simu	13.452	12.023	7.080	0.526	5.453	39.000
82243	R. Sipi	14.413	13.568	7.535	0.523	4.085	35.000
82245	R. Akokorio	53.263	48.449	42.292	0.794	4.593	121.196
83212	R. Tochi 11	30.001	29.721	13.179	0.439	10.752	60.033
83213	R. Kafu	74.618	66.856	41.858	0.561	15.229	208.919
84212	R. Mpanga	19.776	17.225	8.480	0.429	8.292	42.994

84215	R. Mpanga at Kiburara	44.775	44.315	19.415	0.434	9.356	89.338
84217	R. Hima	3.579	3.227	3.027	0.846	1.204	14.000
84218	R. Kanyampara	15.186	13.249	5.837	0.384	7.287	26.246
84221	R. Rwimi	36.277	30.496	23.532	0.649	8.476	78.573
84222	R. Mubuku	75.594	62.642	57.108	0.755	12.000	182.738
84223	R. Sebwe at Bugoye	50.148	26.322	48.242	0.962	8.925	169.095
84224	R. Rukoki	89.194	85.193	71.168	0.798	5.082	239.948
84227	R. Chambura	30.881	28.551	11.078	0.359	8.749	63.699
84228	R. Nyamugasani	51.173	43.958	24.854	0.486	11.284	99.439
84264	R. Ntungwe	47.937	37.220	32.453	0.677	4.272	117.172
84265	R. Ishasha	41.697	37.915	18.848	0.452	11.000	83.954
84267	R. Mitano	45.325	44.076	13.985	0.309	12.994	69.497
84270	R. Chiruruma	14.273	12.017	6.706	0.470	6.186	34.000
84275	R. Ruhezanyenda	8.232	9.907	3.022	0.367	3.524	10.339
85205	R. Semuliki at Bweramule	267.128	262.493	83.052	0.311	22.000	496.762
85211	R. Muzizi	31.305	23.884	23.676	0.756	2.208	91.564
85212	R. Nkussi	19.578	18.496	6.661	0.340	9.795	30.061
85217	R. Waki 11	10.299	9.736	4.359	0.423	3.912	18.679
86201	R. Aswa 1	96.161	95.372	50.727	0.528	28.878	208.278
86202	R. Aswa 11	441.179	328.219	410.428	0.930	30.000	1822.630
86213	R. Agago	39.584	32.882	33.545	0.847	7.789	134.758
86217	R. Okura at Agoro	5.733	3.826	3.812	0.665	1.467	11.452
87201	R. Nyarwodo	42.024	28.862	29.235	0.696	12.263	124.497
87202	R. Ala	49.698	42.982	26.716	0.538	14.454	94.111
87205	R. Kochi	189.994	165.080	133.138	0.701	20.000	591.647
87206	R. Anyau	72.982	60.674	50.697	0.695	2.374	253.396
87208	R. Oru	118.265	77.469	136.625	1.155	7.303	567.127
87212	R. Ora 11	122.101	126.379	45.372	0.372	35.000	234.371
87218	R. Nyagak	23.803	21.317	9.378	0.394	14.562	54.972
	Max	441.179	328.219	410.428	1.477	35.000	1822.630
	Min	3.579	2.372	2.790	0.284	0.092	10.339
	mean	54.141	46.131	35.894	0.666	8.490	154.788
	st dev	73.78935	62.16519	58.63339	0.273414	8.028295	260.1421

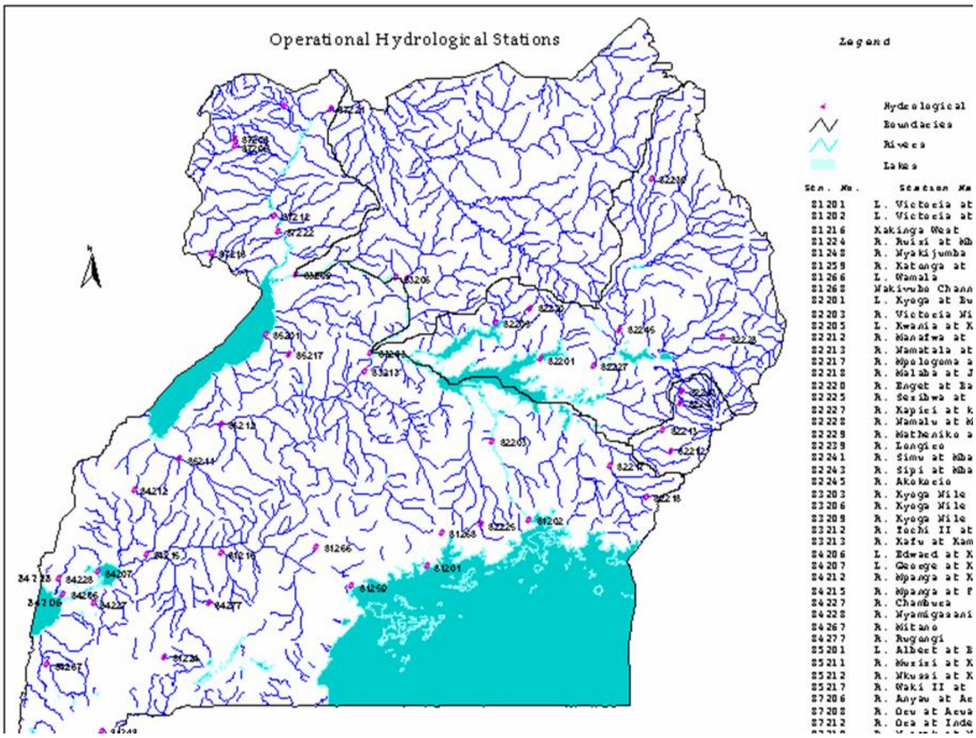


Figure (2) River Network of Uganda with the gauging station locations

7 SMALL POWER DEVELOPMENT POTENTIAL

The River Network in Uganda can be separated into two major parts: the Nile River and the Non-Nile Rivers. So the study on hydropower potential in Uganda will be substantially also divided into

- Those based on the use of the Nile River
- Those located elsewhere in Uganda (Non-Nile Rivers)

Though the potential of the later cannot in any way be compared to that of the Nile River. Nevertheless schemes have been identified (and some developed) for smaller schemes providing local supply.

Uganda's hydrological resources are estimated to have a power production of over 2500MW. The large power sites (over 2000MW) are mainly concentrated along the Nile River while sites for small Hydro (0.5 – 5.0MW) are scattered in many parts of the country. Though, to-date up to less than 10% of this potential is exploited.

8 HYDROPOWER POTENTIAL ON RIVER NILE

As mentioned above, these sites represent some of Uganda's largest power potential sites of over 2000MW out of the full potential of 2500MW. Below is brief of the Nile River sites.

Site	Location	Proposed Installed Capacity (Mw)	Status	Commissioning Date
Owen Falls	Jinja	180	In Operation	1954
Owen Falls Extension	Jinja	200	In operation	2000
Bujagali	Jinja	250	Planning in Progress	N/A
Kalangala	Jinja	350	Feasibility study completed	N/A
Kamdini(Karuma)	Masindi/Apac	150	Feasibility study complete	N/A

Ayago South	Gulu/Masindi	234	Preliminaries studies available	N/A
Ayago North	Gulu/Masindi	304	Preliminaries studies available	N/A
Murchision	Gulu/Masindi	642	Has adverse environmental effects	N/A

Source: Ministry of Energy and Mineral Resources
This is covered in more detail in the first part of the research.

9 HYDROPOWER POTENTIAL ON THE NON-NILE RIVERS

It is known however that the potential for small-scale hydropower development exists in the following areas:

- Rivers draining the Mt.Elgon
- The extreme Southwest of Uganda
- Rivers draining West Nile, near Arua
- Rivers draining the Rwenzori Mountains.

The table below shows the country's potential for medium, small and micro hydropower stations.

Table(3)Various Small Hydropower Sites of Uganda

Micro		
Site	**River**	**Estimated Capacity (MW)**
Arua	Anyau	0.3
Heissesero	Bunyonyi	0.3
Kitumba	Nyakabuguka	0.2
Mpanga	Mpanga	0.4
Nyakabale	Nyakabale	0.1
Moyo	Ataki	0.2
Kisiizi	Kisiizi	0.2
Small		
Lake Bunyonyi	Bunyonyi	1.0
Nsongezi	Kagera	2.0
Paidha A	Nyagak	1.0
Paidha B	Nyagak	2.0
Ishasha A(West)	Ishasha	2.4
Ishasha B	Ishasha	3.6
Nyamabuye A	Kaku	1.5
Nyamabuye B	Kaku	0.7
Maziga Gorge	Maziba	0.5
Kaka	Ruimi	1.5
Mbarara	Muzizi	0.7
Sogahi A	Sogahi	2.7
Sogahi B	Sogahi	3.3
Medium		
Muzizi	Muzizi	10
Bogoye	Mubuku	7.5(5 MW in service)
Nengo bridge	Ntungu	12.0

There has been very little development of small, mini or micro hydro in Uganda. Approximately 8MW has been developed at four sites. Estimates of potential capacity equals 46 MW identified 16 sites. UEB has developed sites and private developers another two. These include;

- Mubuku II (5 MW)
- Maziba (1 MW)
- Kisizi (0.075 MW)
- Kikagati Power Station (1.25MW)

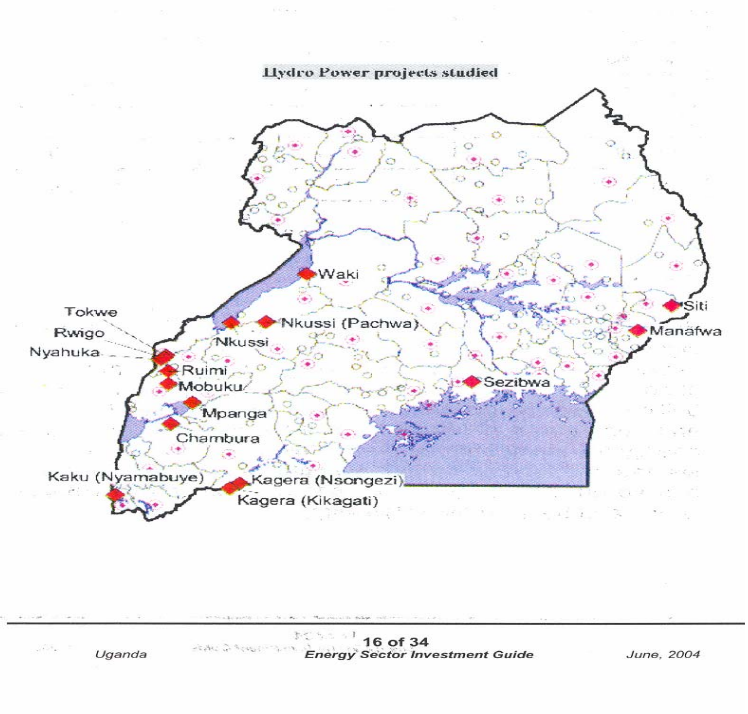
Other Hydropower sites have been previously developed and connected to the grid:

- Muzizi (10MW)
- Paidha (7.5MW)
- Ishasha (4.5MW)
- Nyagak (3.3MW)

The Energy for Rural Transformation program is planned to have three arms (two concerned with hydropower) renewable energy components, and these include;

- Renewable Energy Power Generation for Sale via the Main Grid – this has led to a number of small hydropower sites to be studied and get linked to the grid. These are Nyagak (3.3MW) in West Nile, Musizi (10MW) and Ishasha (4MW) in Western Uganda.
- Isolated Grid Mini-Systems far from the National Grid – here one hydropower generation project has been identified: Kisizi mini-hydro plant is to be upgraded from 60KW to 125KW with a distribution network serving nearby trading centres.

There are numerous potential micro hydro stations throughout the country; however external funding agencies consider these too small or uneconomic to develop, so many are still awaiting funding.



Figure(3)Some of the Small Hydropower Sites of Uganda (Source: Uganda Energy Sector Investment Guide, 2004)

10 HYDROPOWER CAPACITY OF UGANDA

No study has been carried in the country to determine the institutional, human resource; Legal institutional and financial or economic capacity of Uganda as far as Small Hydropower development is concerned. The views presented in this report are based on discussions made with some key players in this sector of Uganda.

- **Human Resource Capacity**

In Uganda, so far there are two registered Universities that offer undergraduate degrees in Engineering. These universities produce about 150 graduates per year in this field. Though, there is no institute that specializes in providing education on Energy Management and Development in the country. Most of the Key players, if not all, in this sector of the country have been trained from overseas.

- **Institutional Capacity**

The Energy Sector of Uganda is managed by both the Public Sector and Private Sector. It involves the following institutions:

1. **Ministry of Energy and Mineral Development -** is responsible for policy formulation of the Energy sector in Uganda.
2. **Electricity Regulation Authority** – is responsible for the regulation of the generation, transmission, distribution, distribution, sales, import and export of Electricity.
3. There are now different business entities, out of the national utility company UEB, responsible for the generation, transmission, and distribution of electricity as: **Uganda Electricity Generation Company Limited** (UEGCL), Uganda **Electricity Transmission Company Limited** (UETCL), and the **Uganda Electricity Transmission Company Limited** (UEDCL) respectively. Generation and Distribution business were leased to private operators on a long-term concession while Transmission will remain a public function in the medium term.
4. **Uganda Investment Authority (UIA)** – this is a one-stop centre for investors that facilitate investors with the necessary information about the possible investment opportunities in the country.
5. **Private Sector Foundation - ERT -** this is an arm of UIA, which manages and regulates the ERT project in Uganda. Its responsibility is to avail investors in the private sector with enough contingencies to attract them to invest in this sector.
6. **Rural Electrification Agency -** this was established by the Ministry of Energy and Mineral Development to carry out the Minister’s responsibilities with regard to Rural Electrification. It’s responsible for Policy Analysis of Rural Electrification issues, planning in collaboration with the System Operator, monitoring of Rural Electrification nationally and information dissemination.

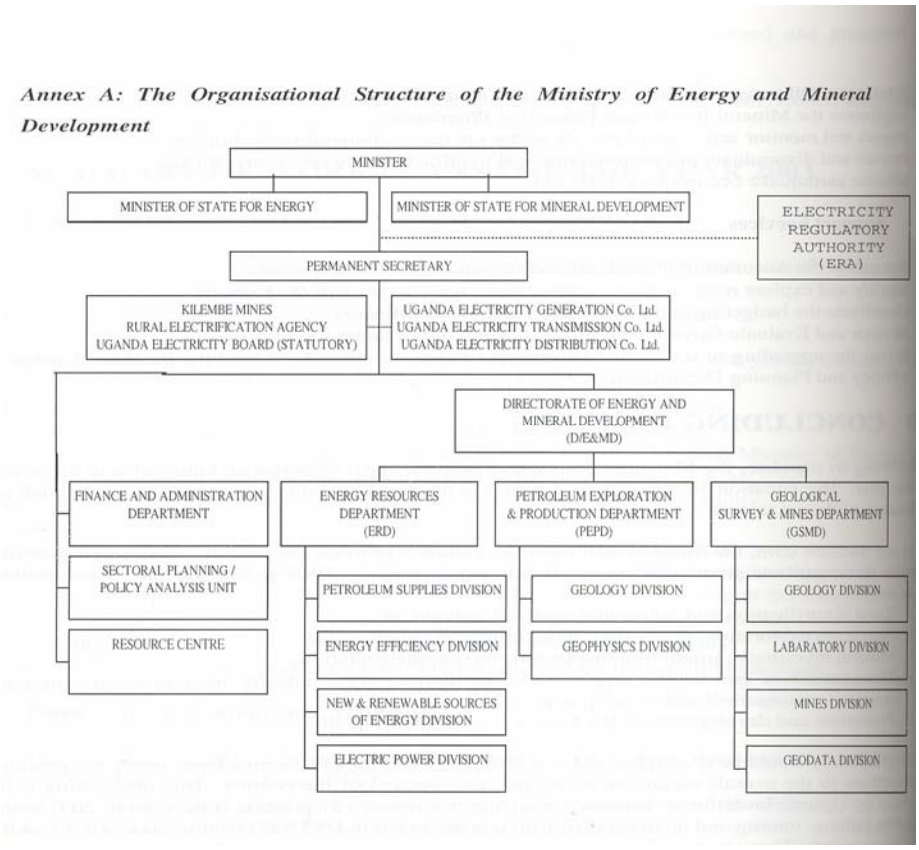


Figure (4) The Organisational Structure of the Ministry of Energy and Mineral Development

- **Technical Capacity**

In terms of machinery for small hydropower development, Uganda as a country has no specialized manufacturing industry to produce turbines, generators etc as required for hydropower development. Most of the machinery used is imported. However, for micro hydropower development, the Private Sector Foundation is creating a project to involve the local community in making micro turbines for micro power projects.

- **Legal Framework**

This sector of small hydropower development is apparently the most advanced, especially it being the first step in national power development. Numerous policies and statutes have been set up by the Government to regulate the development of small hydropower in the country. The legal framework in the country as far as small hydro is concerned is well equipped to handle any development of hydropower in the country. It involves the availability of laws, statutes, and policies; courts all levels of the country, Judges and Lawyers are well available.

- **Economic and Financial Capacity**

In terms of economic capability of Uganda as far as small hydropower development is concerned, the Economy is not yet strong enough to handle private sector investment in small hydropower development. This is because the tariff that the investor would charge for an optimal recovery period would high above what an average rural Uganda can afford. However, the Government of Uganda through the ERT project has regularized this.

In conclusion, according to the Ministry of Energy and Mineral Development, Rural Electrification Strategy Plan (2001-2010), the Government has noticed the need for capacity building in order for its programs to succeed. And as such, the Strategy includes a long term capacity Building and intensive awareness raising and promotion.

11 CONCLUSION

Unlike many other countries in the world, Uganda's grid electricity is wholly derived from renewable hydropower. The on going power sector reform will certainly increase the connection of more hydropower to the grid from the IPP's. Since the ERT program mainly targets the small hydropower generation, the small hydropower sector is bound to grow. So in a few years the whole scenario of small hydropower potential in Uganda will be put to use.

Though, the major challenge for Uganda would be to make sure that the grid is strengthened to have the necessary capacity to handle the additional power.

12 REFERENCES

1. Professor Bela Petry, "*Preliminary Studies in Hydropower, Methodologies and Procedures*", March 2004.
2. Ministry of Energy and Mineral Development, *"Energy Sector Investment Guide",* June 2004
3. Ministry of Energy and Mineral Development, "*Annual Report 2002*".
4. Ministry of Energy and Mineral Development, *"Rural Electrification Strategy and Plan (2001-2010)",* February 2001
5. Ministry of Energy and Mineral Development, *"The Energy Policy for Uganda",* September 2002
6. Uganda Electricity Board, ***"****Hydropower Development Master Plan (Part 1), Volume 7, Hydrology and Hydropower Potential of Non-Nile Rivers"* , July 1996.
7. Hon. Syda Bbumba (Mrs.), *"Uganda's Strategy for Accelerating Grid Based Renewable Power Generation for a Clean Environment"*, 2000.
8. Lori Pottinger (International Rivers Network), "*Bujagali Dam: A Case study in Corporate Welfare.*" September 2000.
9. http://www.small-hydro.com//, "Uganda Country Brief" , 2004
10. Joan Kyokutamba, "*Energy Services for Small Scale Enterprises in Uganda*" , 2000.
11. The World Bank, *"Uganda-Energy for Rural Transformation, Project Report"* , November 2001.

GROUP MEMBERS

S/N	NAME	ORGANISATION/ INSTITUTION	COUNTRY	POSTAL ADDRESS	TELEPHONE	FAX	E-mail
1	Prof. Sibilike K. Makhanu	Western University College Of Science & Technology	KENYA	Box 190-50100 KAKAMEGA,	+254-(0)56-20724	+254-(0)56-30153	k_s_makhanu@yahoo.com
2	Prof. D. Mashauri	UDSM/CEBE/WRED	TANZANIA	Box 35131, D'Salaam	2410500/8	2410029	dmashauri@yahoo.com , mashauri@wre.udsm.ac.tz
3	Prof. D.J. Chambega	UDSM/ECSE	TANZANIA	Box 35131, D'Salaam	2410454	2410454	chambega@ee.udsm.ac.tz
4	Dr. C.F. Mhilu	UDSM/Energy	TANZANIA	Box 35131, D'Salaam	2410754		cfmhilu@hotmail.com
5	Prof. F. Mtalo	UDSM/CEBE/WRED	TANZANIA	Box 35131, D'Salaam	022-2410029 0748-780387	022-2410029	mtalo@wrep.udsm.ac.tz
6	Ntungumburanye Gerard	Geographic Institute Of Burundi (IGEBU)	BURUNDI	B.P 34 GITEGA -	257-402625-257-402275	257-402625	igebu@cbinf.com
7	Kizza Michael	Makerere University, Dept. Of Civil Engineering	UGANDA	Box 7062 KAMPALA,	256-77-614580		mkizza@tech.mak.ac.ug
8	Mr.Keneth Muniina	Makerere University, Dept. Of Civil Engineering	UGANDA	Box 7062 KAMPALA,	25641543152		kmuniina@yahoo.com
9	Dr. Museruka Casimir	K.I.S.T (Kigali Institute of Science & Tech.)	RWANDA	BP 3900 KIGALI	(250) 08524311		muserukac@yahoo.com
10	Dr. Zelaleni Hailu	Addis Ababa University	ETHIOPIA	Box 385 Addis Ababa	00259-09-635994		zelalemhgc@yahoo.com
11	David Ngula	TANESCO	TANZANIA	Box 9024 - DSM	255-22-2451210	2451223	nguladep@tanesco.co.tz, nguladep@yahoo.co.uk
12	Eng. James L. Ngeleja	NEMC	TANZANIA	Box 63154 - DSM	255-222127056		ngeleja@hotmail.com
13	Prof. I.S.N. Mkilaha	UDSM – MECHE/Energy	TANZANIA	Box 35131 – DSM	022-2410754 0744-758285	022-2410029	mkilaha@udsm.ac.tz
14	Leonard Kassana	TANESCO	TANZANIA	Box 9024 - DSM	+255 741-246775		leokassama@yahoo.com kassana@nbcbn.com
15	Leonard R. Masanja	Ministry of Energy & Mineral	TANZANIA	Box 2000 - DSM	0741-309237	2120799	masanja@mem.go.tz, kitola@hotmail.com
16	Prof. Bela Petry	UNESCO-IHE	NETHERLANDS	WESTVEST 7 2601 DA DELFT,	+31-15-2151838	+31-15-2122921	b.petry@unesco-ihe.org