社会開発調査部報告書

No. 12

GOVERNMENT OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE OF ERITREA
MINISTRY OF LAND, WATER AND ENVIRONMENT

STUDY ON GROUNDWATER DEVELOPMENT AND WATER SUPPLY FOR SEVEN TOWNS IN SOUTHERN REGION OF ERITREA

FINAL REPORT

EXECUTIVE SUMMARY

JANUARY 1999

SANYU CONSULTANTS INC.

GOVERNMENT OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE OF ERITREA
MINISTRY OF LAND, WATER AND ENVIRONMENT

STUDY

ON

GROUNDWATER DEVELOPMENT AND WATER SUPPLY

FOR

SEVEN TOWNS IN SOUTHERN REGION

OF

ERITREA

FINAL REPORT

EXECUTIVE SUMMARY

JANUARY 1999

SANYU CONSULTANTS INC.

PREFACE

In response to the request from the Government of the State of Eritrea, the Government of Japan decided to conduct the Study on the Groundwater Development and Water Supply for Seven Towns in Southern Region of Eritrea and entrusted the study to Japan International Cooperation Agency (JICA).

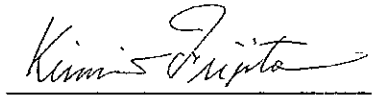
JICA sent to Eritrea a study team headed by Mr. Takao KUME, SANYU CONSULTANTS INC., from August 1997 to March 1998.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the State of Eritrea for their close cooperation extended to the team.

January, 1999



Kimio Fujita
President
Japan International Cooperation Agency

January 12, 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency (JICA)
Tokyo

Letter of Transmittal

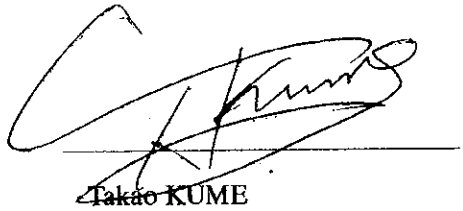
Dear Sir,

We are pleased to submit to you our Final Report on the Study on Groundwater Development and Water Supply for Seven Towns in Southern Region of Eritrea. This Report incorporates the findings and the development plans formulated, as well as advice and suggestions of the authorities concerned of your Agency and the Government of Japan.

The objectives of the Study are evaluation of water resources potential in focusing groundwater, formulation of development plans for water supply and sanitation, feasibility study for the water supply project, and technology transfer. Based on the Study, groundwater can meet the water demand of all target towns up to the Year 2005. Most towns will be sufficiently supplied with water from the test well(s) under the Study, or together with the existing wells. Facilities such as boreholes, well pumps, transmission/distribution pipelines, reservoir, booster pumps, pumping pits, control houses, service facilities, public latrines will be required for the Project. Although there are some conditions, the project is feasible and to promote the project was recommended.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Ministry of Foreign Affairs of the Government of Japan. We also wish to express our deep gratitude to the Ministry of Land, Water and Environment and the Ministry of Local Government of the Government of Eritrea for the close cooperation and assistance extended to us during our studies.

Very truly yours,



Takao KUME
Leader of the Study Team

List of Reports

This volume is part of the following reports:

Executive Summary

Debarwa	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Mendefera	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Adiquala	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Dekemhare	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Segeneiti	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Adi Keyih	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings
Senafe	Volume I	Main Report
	Volume II	Appendix
	Volume III	Drawings

Operation and Maintenance Manual for Water Supply Facility

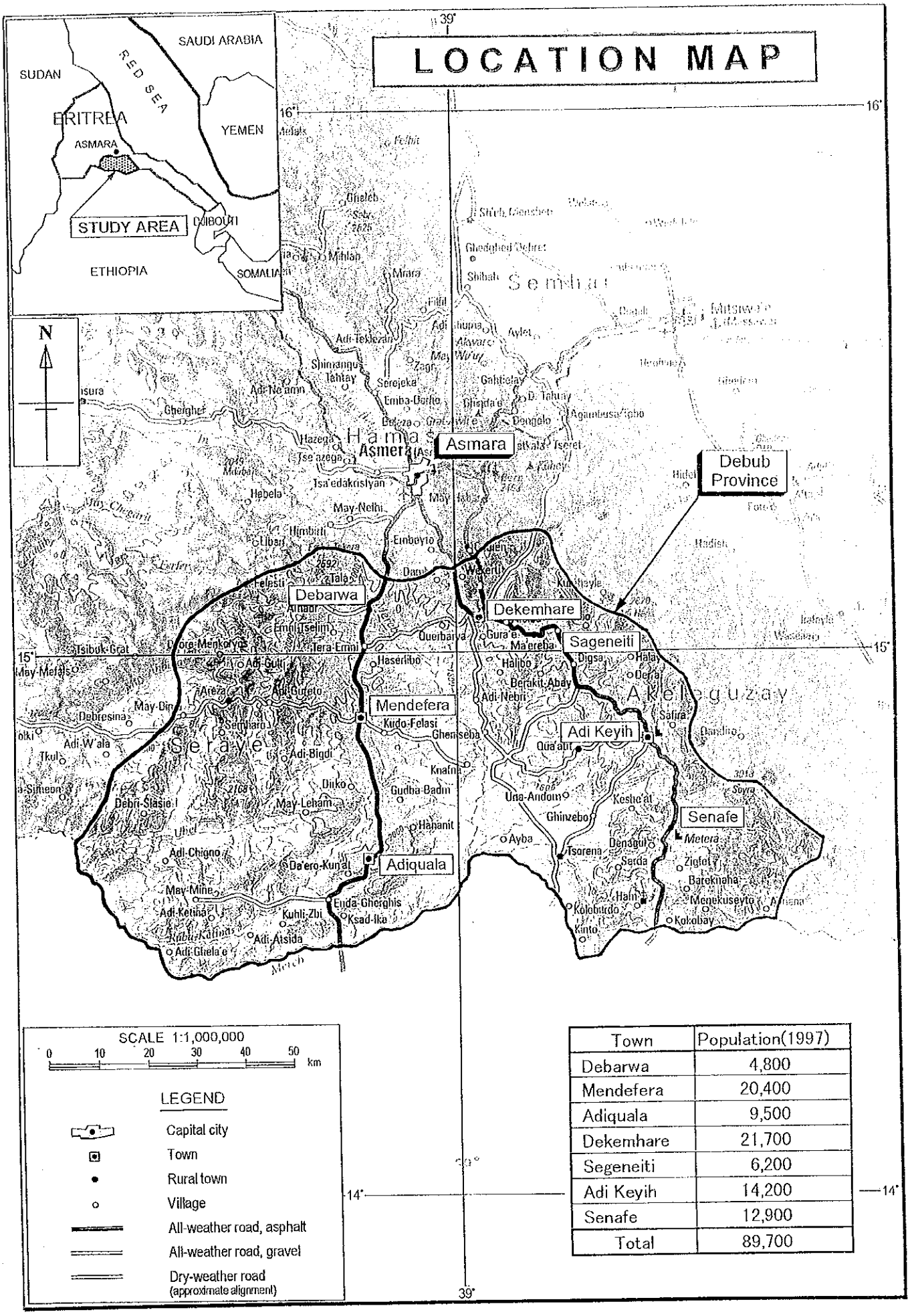
Hygiene Education Manual

Training Manual for Staff of WSA

Exchange Rate

1 US Dollar	=	7.0 Nakfa
1 US Dollar	=	135.0 Japanese Yen
1 Nakfa	=	19.3 Japanese Yen

March 1998



Town	Population(1997)
Debarwa	4,800
Mendefera	20,400
Adiquala	9,500
Dekemhare	21,700
Segeneiti	6,200
Adi Keyih	14,200
Senafe	12,900
Total	89,700

OUTLINE OF PROJECT PLAN

This Executive Summary briefs the objectives, strategy, development programs, project feasibility study, as well as conclusions and recommendations, along with the descriptive streams of the main reports.

Prior to the explanations, outline of the Plan such as the water demand projected, water resources development plans, planned facilities, cost estimates, and economic/financial evaluations on them, are summarized in tables to facilitate the comprehension of the frameworks of the plan formulated through the Study.

1. Current Situation of Seven Towns

This table shows the water-supply-related general indexes, i.e. population, household and numbers of existing water supply facilities together with annual rainfall of every town as a basic water resource.

Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total (Average)
Population	4,831	20,371	9,488	21,675	6,146	14,215	12,934	89,660
Household	1,224	5,613	2,500	5,820	1,777	3,829	4,094	24,857
Rainfall (mm/yr)	659	612	696	524	494	494	528	(572)
Nos. of W.S. facilities								
-House connection	15	650	263	431	105	677	315	2,456
- Communal w.p.*	5	5	2	-	6	2	3	23
- Water tanker	1	1	-	5	-	1	1	9

* : water point

2. Service Population and Water Demand

The table presents the projected service population, the planned service ratio for each town and each phase, and the estimated water demand derived from the mentioned basic figures.

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total (Average)
1. Service population								
2005	7,990	19,750	11,750	26,610	7,270	16,500	15,620	105,490
2010	12,460	33,270	16,490	37,950	11,500	25,500	21,810	158,980
2015	17,230	52,880	23,700	55,880	17,000	33,180	30,610	230,480
2. Service ratio (%)								
2005	84.2	60.9	76.2	77.4	68.1	74.5	76.8	(74.0)
2010	95.7	79.9	85.4	86.2	84.1	91.7	86.8	(87.1)
2015	100	100	100	100	100	100	100	(100)
3. Water demand (m^3/day)								
2005	411	1,001	532	1,320	344	849	698	5,155
2010	754	2,283	789	2,452	517	1,424	1,030	9,249
2015	1,318	3,761	1,322	4,962	785	2,095	1,697	15,940

3. Water Resources Development Plan

The table summarizes the current water resources as well as the water resources development plans of all target towns phase by phase. The water demand of most towns, except for Mendefera, can be covered by groundwater up to the final target year (2015). For Mendefera, surface water development would be required in 2015 to cover the deficit.

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
1. Existing water Resources (yield, m^3/day)	BH-12 (207)	BH-4, BH-5 (546.9)	Dug-wells (302)	BH-14,19 and others (553)	DW-1 (276)	DW-2 & BH-7 (415)	BH-9,10 (622)	2,921.9
2. Plan for 2005 (yield, m^3/day)	DEB-1 (411)	BH-4, 5 MEN-2, & nMEN-1,2 (1,001)	Dug-wells & Intake facility (532)	BH-14,& DEK-1, 2 (1,320)	SEG-2 (344)	DW-2, BH-7, & ADI-2 (968)	Above and, BH-14 (726)	5,302
3. for 2010 (yield, m^3/day)	DEB-1 (754)	Above and, nMEN-3 nMEN7 (2,283)	Above and, nADQ-1 (789)	Above and, BH-19, nDEK-1, and 2 (2,452)	SEG-2 (517)	Above and, BH-4, 5, ADI-1, nADI-1 (1,486)	Above and, nSEN-2, nSEN-3 (1,141)	9,422
4. for 2015 (yield, m^3/day)	DEB-1 & BH-12 (1,318)	Above and, Surface water source (3,761)	Above and, nADQ-2 (1,322)	Under-ground dam (4,962)	SEG-2 & DW-1 (785)	Above and, nADI-2,3 (2095)	Above and, SEN-1, & nSEN-1,4 (1,697)	15,940

4. Planned Facilities

This table lists the major facilities planned as well as the numbers and sizes of those facilities to be constructed in each town, by each target year.

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
2005								
Submersible P.	1 unit	5 unit	1 unit	3 unit	1 unit	3 unit	3 unit	17 unit
Transmission P.L.	690 m	9,647 m	2,851 m	7,767 m	5,253 m	5,886 m	2,126 m	34,220 m
Distribution P.L.	20,658 m	28,066 m	14,297 m	43,774 m	11,082 m	19,393 m	17,139 m	154,409 m
Reservoir	1 unit	1 unit	2 unit	2 unit	1 unit	1 unit	1 unit	9 unit
Booster Pump	-	2 unit	1 unit	2 unit	1 unit	2 unit	-	8 unit
Pump Pit	-	2 unit	-	1 unit	1 unit	2 unit	-	6 unit
Control House	1 unit	7 unit	2 unit	5 unit	2 unit	5 unit	3 unit	25 unit
Communal w.p.	12 set	13 set	8 set	20 set	10 set	9 set	8 set	80 set
School Latrine	2 unit	5 unit	3 unit	6 unit	3 unit	3 unit	3 unit	25 unit
Public Latrine	3 unit	5 unit	3 unit	5 unit	3 unit	5 unit	3 unit	27 unit
2010								
Submersible P.	1 unit	5 unit	1 unit	5 unit	1 unit	6 unit	2 unit	21 unit
Transmission P.L.	-	12,100 m	5,100 m	8,100 m	1,500 m	9,660 m	8,800 m	45,260 m
Distribution P.L.	15,052 m	35,809 m	5,133 m	16,693 m	12,374 m	12,811 m	8,645 m	106,517 m
Reservoir	1 unit	1 unit	2 unit	1 unit	1 unit	1 unit	-	7 unit
Booster Pump	-	3 unit	4 unit	2 unit	3 unit	6 unit	1 unit	19 unit
Pump Pit	-	3 unit	4 unit	1 unit	2 unit	4 unit	1 unit	15 unit
Control House	-	8 unit	5 unit	3 unit	1 unit	8 unit	3 unit	28 unit
Communal w.p.	6 set	13 set	5 set	9 set	5 set	7 set	3 set	48 set
School Latrine	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	7 unti
Public Latrine	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	7 unit
2015								
Submersible P.	2 unit	-	1 unit	1 unit	2 unit	2 unit	5 unit	13 unit
Transmission P.L.	1,170 m	43,000 m	1,900 m	11,200 m	400 m	5,000 m	6,100 m	68,770 m
Distribution P.L.	23,348 m	37,742 m	3,190 m	47,892 m	17,772 m	10,065 m	2,320 m	142,329 m
Reservoir	1 unit	4 unit	3 unit	4 unit	1 unit	1 unit	1 unit	15 unit
Booster Pump	-	5 unit	4 unit	2 unit	3 unit	2 unit	2 unit	18 unit
Pump Pit	-	5 unit	-	1 unit	-	2 unit	1 unit	9 unit
Control House	1 unit	5 unit	1 unit	2 unit	1 unit	4 unit	4 unit	18 unit
Communal w.p.	6 set	19 set	7 set	22 set	10 set	5 set	4 set	73 set
School Latrine	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	7 unti
Public Latrine	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	1 unit	7 unit

P.: Pump, P.L.: Pipeline, w.p.: Water point

5. Cost Estimation

This table shows the results of cost estimates individually for water supply facilities, sanitation facilities, and annual O&M cost, for each target year, each town and total.

(Unit: Thousand USD)

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
2005								
Water Supply	1,165	3,840	1,691	4,215	1,911	2,731	1,423	16,977
Sanitation	60	120	72	132	72	91	72	624
Total	**1,225**	**3,960**	**1,763**	**4,347**	**1,983**	**2,822**	**1,495**	**17,601**
Annual O&M cost	43	121	61	134	58	107	67	592
2010								
Water Supply	891	6,271	2,987	3,330	1,478	7,986	2,901	25,845
Sanitation	32	32	32	32	32	32	32	225
Total	**923**	**6,303**	**3,019**	**3,362**	**1,510**	**8,018**	**2,933**	**26,070**
Annual O&M cost	80	307	124	223	95	198	837	1,140
2015								
Water Supply	2,410	18,672	2,441	9,454	2,413	4,011	3,039	42,443
Sanitation	43	43	43	43	43	43	43	301
Total	**2,453**	**18,715**	**2,484**	**9,497**	**2,456**	**4,054**	**3,082**	**42,744**
Annual O&M cost	132	628	222	435	136	299	194	2,045

6. Economic and Financial Evaluation

This table presents the results of water tariff analysis, cost analysis, and economic/financial evaluations based on such tariffs, costs, and benefits. A few towns show rather low EIRR's but the project was concluded as economically and financially sound based on the computed average EIRR.

6.1. Proposed Water Tariff (Unit: Nfa/m³)								
Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Average
House Connection	7.5	9.0	7.5	7.0	10.0	8.0	7.0	8.0
Yard Connection	4.0	6.0	5.0	5.0	8.0	6.0	4.0	5.4
Communal w.p.	2.0	2.0	2.0	2.0	4.0	2.0	2.0	2..3
6.2. Economic Evaluation								
NPV (Thousand Nfa)	1,804	-1,046	2,876	3,551	-2,277	2,957	7,296	2,395
B/C	1.24	0.95	1.62	1.14	0.78	1.18	1.89	1.24
EIRR (%)	13.6	9.3	15.2	12.1	6.0	13.4	24.5	13.9
Sensitivity (%)								
EIRR in Case-1	10.5	6.7	11.7	9.2	3.1	9.8	19.7	10.1
EIRR in Case-2	8.4	3.3	8.2	6.5	0.5	7.4	15.3	7.1
6.3. Financial Evaluation								
Revenue to Cost Ratio (%)	123.8	124.5	122.6	122.4	110.3	129.8	124.3	122.5
Profit Rate (%)	18.7	19.3	18.3	17.9	9.1	16.4	19.4	17.0
Working Capital to Revenue Ratio (%)	44.4	47.0	43.4	46.3	40.3	40.3	39.4	43.0
Profit to Total Assets Ratio (%)	1.3	1.2	1.3	1.1	0.6	1.2	1.6	1.2

Table of Contents

Glossary

Abbreviations

AfDB	:	African Development Bank
B/C	:	B C ratio or B by C
CFL	:	Cistern Flush Latrine
CTC	:	Communal Toilet Committee
CWP	:	Communal Water Points
CWPC	:	Communal Water Points Committee
DHS	:	Demographic and Health Survey
E.C.	:	Electric Conductivity
EIA	:	Environmental Impact Assessment
EIRR	:	Economic Internal Rate of Return
EPLF	:	Eritrean People Liberation Front
EU	:	European Union
FIRR	:	Financial Internal Rate of Return
FRP	:	Fiberglass Reinforced Pipe
GDP	:	Gross Domestic Product
GOJ	:	Government of Japan
GTZ	:	German Technical Agency
HMSU	:	Hydrometeorological Information Unit
HRD	:	Human Resource Development
IDRC	:	Institute of Development Research of Canada
IEE	:	Initial Environment Examination
IFAD	:	International Fund for Agricultural Development
JICA	:	Japan International Cooperation Agency
MIS	:	Management Information System
MoA	:	Ministry of Agriculture
MoH	:	Ministry of Health
MoLG	:	Ministry of Local Government
MoLWE	:	Ministry of Land, Water and Environment
NGO(s)	:	Non-Governmental Organization
NPV	:	net present value
NUEW	:	National Union of Eritrean Women
NUEY	:	National Union of Eritrean Youth
O&M	:	Operation and Maintenance
PFL	:	Pour Flush Latrine
PHC	:	Primary Health Care
RAD	:	Regional Affairs Department
S/W	:	Scope of Work
UNDP	:	United Nations Development Programme
UNICEF	:	United Nations International Children's Emergency Fund
US$	:	U.S. Dollars
UTM	:	Universal Transversal Mecator

VIP	:	Ventilated Improved Pit Latrine
WD	:	Water Department, MoLWE
WID	:	Women in Development
WLU	:	Water Law Unit
WQPU	:	Water Quality Pollution Unit
WRD	:	Water Resources Department
WRDU	:	Water Resources Development Unit, MoLWE
WRID	:	Water Resources Information Division, MoLWE
WRIU	:	Water Resource Information Unit
WRUMD	:	Water Resource Use Management Division, MoLWE
WSA	:	Water Supply and Sewerage Authority / Water Supply Authority
WSC	:	Water and Sanitation Committee
WSS	:	Water Supply Service
WSSO	:	Water Supply Service Office

Tigrigna Words used in the Report

Adi	:	Village
Kebabi	:	Lowest administrative unit comprising of group of villages
Baito	:	Traditional village assembly
Megabia	:	Elected democratic legislative body at Kebabi level
Ne'us Zoba	:	Sub-Region
Zoba	:	Region

Units and Measures

a	:	Annum
asl	:	Above sea level
av.	:	Average
bgl	:	below ground level
G.d.h	:	German degree of hardness
ha	:	Hectare(s)
hr	:	Hour(s)
in	:	Inch(es)
kg	:	Kilogram(s)
km	:	Kilometer(s)
km^2	:	Square kilometer(s)
kwh	:	kilowatt hours
l	:	Liter(s)
lit	:	Liter(s)
l/c/d	:	Liter(s) per capita per day
m	:	Meter(s)
m^2	:	Square meter(s)
m^3	:	Cubic meter(s)
mg/l	:	Milligram per liter
µS/cm	:	Micro Siemens per centimeter
micro S/cm	:	Micro Siemens per centimeter
min	:	Minute(s)
mm	:	Millimeter(s)
mon	:	month
msl	:	Mean Sea Level
MCM	:	Million cubic meter(s)
mv	:	Milli-volt(s)
Nfa	:	Nakfa
Ohm-m	:	Ohm meter(s)
Ωm	:	Ohm meter(s)
s	:	Second(s)
sec	:	Second(s)
US$	:	US Dollar
yr	:	Year(s)
¥	:	Japanese Yen
°C	:	Degree centigrade
%	:	Percent
"	:	Inch(es)

EXECUTIVE SUMMARY

1. INTRODUCTION

Eritrea gained its independence in 1991, after 30 years of debilitating war. This war has hampered the country's development in all aspects. Since independence, many donor countries/organizations have extended assistance to Eritrea in the field of water supply and sanitation. Japan also has extended its technical assistance, in response to the request of the Eritrean Government.

The Scope of Works for this project was formulated and signed by/between the Preparatory Study Team sent by Japan International Cooperation Agency (JICA) and the Ministry of Mines, Energy and Water Resources (at the time), the Government of Eritrea, in April 1997. In accordance with the Scope of Works, JICA sent the Study Team consisting of twelve members headed by Mr. KUME Takao. The counterpart agency of Eritrea is the Water Resources Department (WRD) under the new Ministry of Land, Water and Environment (MoLWE).

The objectives of the Study are:

1) to evaluate potential of water resources, focusing on groundwater,
2) to formulate a development plan for water supply and sanitation,
3) to conduct a feasibility study for the water supply project, and
4) to pursue technology transfer to counterpart personnel in the course of the Study.

The Study covers the following 7 towns in the Debub Region (please refer to the Guide Map):

Debarwa, Mendefera, Adiquala, Dekemhare, Segeneiti, Adi Keyih, and Senafe.

Through around seven months of field works, since 27 August 1997, Inception Reports I/II, Progress Report, and Interim Report were prepared and submitted to WRD. In the early November 1998, a Draft Final Report was prepared and sent to WRD, through five months of domestic works. And the Report was finalized and submitted to WRD at the beginning of January 1999, in response to the comments by WRD.

2. OVERVIEW OF ERITREA

Eritrea covers an area of 124,320 km^2, and is bordered by the Red Sea to the north and northeast, Sudan to the north and northwest, Ethiopia to the south and southwest and Djibouti on the far south-eastern corner. Despite being a relatively small country, it is divided into three major geographic and climatic regions: the Central Highlands, the Western Lowlands and the Eastern Lowlands running parallel to the Red Sea.

Historically, Eritrea was occupied successively first by the Turks, followed by the Italians and British and finally by the Ethiopians. It emerged as a sovereign state in 1991, after three decades of bitter struggle with the Ethiopians. Following an internationally-supervised national referendum, Eritrea proclaimed its *de jure* independence in May 1993.

In Eritrea, no census has been carried to date. The estimates put the country's population at around 3.5 million, and they are culturally and linguistically diverse, consisting of nine ethnic groups namely: Afar, Bilen, Hedarib, Kunama, Nara, Rashaida, Saho, Tigrigna and Tigre.

The Government of the State of Eritrea is made up of 17 ministries, most of whom are represented at the regions, and six regional administrations. Ministries at the center are responsible for policy matters and for developing guidelines/procedures for program development and implementation, while the Regional (called Zoba) Administration is vested with the responsibility of program or project implementation.

3. THE STUDY AREA: THE DEBUB REGION

3.1 Natural Condition

The Study targets of seven towns are located in the Debub Region, one of six regions in Eritrea with a total area of about 8,350 km^2. The region shares the southern half of the central highlands, characterized by flat or gently undulating plateau surrounded by escarpments and deeply dissected valleys.

Although the area is located in rather low latitudes, the mean annual maximum temperature is around 27°C and the mean annual minimum temperature is as low as about 4°C, because of the high altitude. Average annual precipitation in the region varies from 393 to 696 mm, and the highest rainfall occurs during July and August.

Hydrologically, the Mereb and its tributaries govern the region but all of them are ephemeral. Along these streams, many micro-dams were constructed mainly for agricultural, livestock, and/or artificial recharge purposes, however, surface-water scarcity always exists in the region.

Geological environment of Eritrea consists of Precambrian basement rocks. The basement in Eritrea is divided into several segments and the region is located in part of the eastern segment, the "Nakfa Terrain". The terrain is made up of metavolcanic rocks conformably overlain by a metasedimentary sequence such as schist or phyllites, and the sequence is cut in places by granites. Mesozoic sedimentary rocks, called as Adigrat Sandstone are exposed in the southeastern part of the region, and plateau-forming Tertiary basalts, called as Trap Basalt, are exposed over a wide range in the western part of the area. Alluvial sediments cover areas along the Mereb and its tributaries, especially in the Hazema Plain in the central of the region.

In contrast to the surface water, the groundwater of the region is more abundant. It occurs in all geological formations though, useful quantities and qualities may not be extensive. The main hydrogeologic units are the following;

1) Basement rocks, metamorphic and intrusive rocks with localized low-moderate permeability along fractured and weathered zones,
2) Volcanic rocks with fracture and fissure permeability, and
3) Unconsolidated sediments with various inter-granular permeability.

3.2 Socio-economic Condition

There are 11 sub-regions, called "Neus Zoba", with 212 village administrations at the lowest administrative unit called "Kebabi" under them. These in turn have 884 villages under them. Total population of the Debub Region is around 702,500 with a total of 89,660 in the target 7 towns, as of 1997. The population in all of the towns is rapidly increasing due to migration from the surrounding villages and due to influx of returnees.

It is reported that around 65% of the total population of Eritrea is concentrated in the central highlands. As indicated by the name, the "Christian Highland", most of inhabitants in the central highlands, including the Debub Region, are overwhelmingly Christian, followed by a few Moslems. As an ethnic group, the Tigrigna is the majority, followed by the Saho and Tigre groups.

Most of the inhabitants of this region live in the rural area and derive their livelihood from agriculture. Aside from the civil servants in government institutions, urban people are mostly petty-traders, daily workers and small shop owners. Some towns like Dekemhare and Debarwa are rapidly growing into important industrial zones. The area is also reputed to be rich in minerals and substantial mining exploration activity is taking place.

3.3 Water Supply and Sanitation

For the water sector, the Debub Region has analogy with the whole country. Most of water and sanitation facilities existing in the region date back to the Italian period. They were concentrated in urban areas and designed mainly to serve colonial administrations and export-oriented cash-crop production. Despite the growing population, very little improvements have been done to them during the British and Ethiopian occupations.

Misrule and neglect caused irreparable damage to water and other infrastructure. Presently, access to safe drinking water is very low. UNICEF sources indicate that only 7% in rural areas and 44% in urban areas are estimated to have secure water supply. This, coupled with recurrent drought, caused wells and other water sources to dry up resulting in inconvenience, ill-health and morbidity of the society, especially that of children and the women. Shortage of pipe-borne water forces people to use water directly taken from the rivers, ponds, pools and open dug-wells. This situation gives rise to a high incidence of water-borne or related diseases.

Household access to sanitation facilities is also inadequate. According to UNICEF, it is at less than 1% in rural areas and 48% in urban areas. In the absence of latrines, defecation in the open becomes the norm. However, existing facilities are reportedly clean, odorless and well-maintained.

3.4 Environmental Situation

Eritrea has inherited a degraded natural environment, due to colonization and 30 years of war. During this time, the natural forests have been reduced from an estimated 30% of the total land area to a little more than 2%. This was mainly due to logging for timber, firewood, charcoal and poles, and clearing for agricultural land, uncontrolled grazing, worsening climate and extensive soil erosion.

The vegetation includes Acacia tortilis, Acacia seyal and Acacia abyssinica on rocky and steep sites. Along the rivers, Faidherbia albida, Balanites aegyptiaca and Ziziphusphus spina-christi form the limited woodland forest. Historical records indicate that Eritrea was rich in wildlife. However, the present wildlife condition is little known. According to the Ministry of Agriculture, the main species of wildlife in the region that may be present are leopards, baboons, foxes, jackals, squirrels and monkeys. It was also reported the numbers of variety of birds are yearly increasing.

4. CURRENT SITUATION OF THE TARGET TOWNS

4.1 Location

Southern half of the Central Highland is dissected by the Mereb and forms wide alluvial plan at its central – southern portion. Two highland ridges, from Asmara Highland, extend to south just surrounding the plain. Each one trunk road passes through the ridges bound for Addis Ababa: Route No.1 along the east ridge and No.3 along the west ridge. Among 7 target towns under the Study, 3 towns of Debarwa, Mendefera, and Adiquala are situated along the west route (Route No.3), and the remaining 4 towns: Dekemhare, Segeneiti, Adi Keyih, and Senafe, are located along the east route (Route No.1).

4.2 Current Situations

Current situations of the towns, natural and socio-economic situations, are summarized in Table 4.2.1.

5. STRATEGY ON PLANNING

5.1 Basic Strategy

(1) Target year

In the water resource development project, water supply and sanitation improvement is to be formulated as a phased plan to the year 2015. A preliminary assumption would be that the project would comprise 3 phases, with phase horizons of 2005, 2010, and 2015, respectively. With regard to the first phase (priority project with a target date of around 2005) of the project, facility design and costing would be to the feasibility study level.

(2) Water resources development plan

The water resources development plan would focus primarily on groundwater and underflow. This would include studies on shallow groundwater and deep groundwater.

(3) Water use

Water supply would give priority to domestic water, however, industrial water use would also be considered in the case of towns of Debarwa and Dekemhare.

Table 4.2.1 Current Situation of Seven Towns

Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
1. Natural Condition a. Topography	Hilly zone	Plateau top	Plateau top	Hilly to alluvial p.	Mountain ous	Plateau top	Mountain ous
b. Position N Lat. E Lon.	15°05'34" 38°49'56"	15°05'34" 38°49'56"	15°05'34" 38°49'56"	15°05'34" 38°49'56"	15°05'34" 38°49'56"	15°05'34" 38°49'56"	15°05'34" 38°49'56"
c. Distance from A	33 km	59 km	94 km	39 km	57 km	97 km	120 km
d. Elevation	1,850 m	2.000 m	1,680 m	2,170 m	2,100 m	2,420 m	2,250 m
e. Basement rock	Schists	-	Granite	Granite	Granite	Schists	Phylite
f. Surface cover	Laterite	Basalt	Basalt	Alluvium	Granite	Adigrat S.	Adigrat S.
2. Socio-economy a. Population	4,831	20,371	9,488	21,675	6,146	14,215	12,934
b. House holds	1,224	5,613	2,500	5,820	1,777	3,829	4,094
c. House hold size	3.9	3.6	3.7	3.7	3.5	3.7	3.2
d. Ethnic group (%)							
- Tigrigna	100.0	98.2	100.0	74.0	90.5	64.0	37.5
- Saho	-	1.2	-	13.0	1.3	16.6	24.2
- Tigre	-	-	-	13.0	8.2	-	-
- Others	-	0.6	-	-	-	19.4	38.3
e. Religion (%)							
- Christian	99.0	74.4	79.3	67.0	30.7	61.7	62.5
- Moslem	0.8	23.4	20.7	22.5	10.0	19.7	37.5
- Catholic	0.2	0.9	-	7.9	59.3	1.6	-
- Protestant	-	1.4	-	2.6	-	-	-
3. Water Resources a. Rainfall (mm/a)	659	612	696	524	494	494	528
b. Streams	4-6	3-4	4-6	3-5	3-5	1-2	4-6
c. Micro-dam	14	14	2	10	4	11	5
d. Dug-wells	8	3	10	3	7	2	7
e. Boreholes	5	10	2	23	5	8	7
f. Others	1	-	3	-	-	1	-
4. Water Supply a. Nos of facility							
-House connection	15	650	263	431	105	677	315
- Communal w.p*.	5	5	2	-	6	2	3
- Water tanker	1	1	-	5	-	1	1
b. Consumption (l/c/d)							
- House connection	26	24.1	20.5	25.6	11.7	28.7	10.3
- Communal w.p.	8.6	10.1	14.3	-	8.8	16.5	8.0
- Water tanker	15.6	16.4	-	16.5	-	5.6	16.5
c. Water Tariff (Nfa/m^3)							
- House connection	3.0	1.5-2.0	1.5	2.0	2.0-2.5	3.0-3.5	2.5
- Communal w.p.	7.5	5.0	5.0	-	5.0	5.0	5.0
- Water tanker	10.0	6.25	-	10.0	-	10.0	10.0
- Water vender	16-40	7.0	7.5	-	-	-	-
5. Sanitation a. Public latrine	-	2	2	1	2	2	1
b. Nos. of hospital	1	1	1	1	1	1	1
c.Sewerage facility	No	Exist	Exist	No	No	No	No

*: communal water point

(4) Water supply and sanitation improvement plans

Water supply and sanitation plan would comprise: a) facility plan with appropriate attention to natural and socio-economic condition, b) project cost estimation, c) O&M plan for sustainability of facilities, d) institutional strengthening plan, e) examination of the financial feasibility of the project, and f) project implementation schedule.

(5) Sustainability of the project

Water supply project for rural towns lies with the Water Supply and Sanitation Authority (WSA) of each town with the aim to achieve budgetary independence. Specific recommendations on an operating structure for water supply systems which is sustainable under independent budget will be done.

5.2 Population Projection

For the planning purposes, the seven towns are categorized into two, high growth rate of categoriy-1 and relatively low growth rate of category-2. The population in the target years are to be projected based on the population in 1997, informed by the Ministry of Local Government, and the conditions shown below.

a) Category One: Mendefera, Dekemhare and Debarwa

The growth rate will be:

- at 5% per annum from the year 1998 - 2005, and
- at 4.5% per annum from the year 2006 – 2015.

The number of returnees will be:

- total inflow of 900 from 1997 to 2000,
- total inflow of 1200 from 2001 to 2005,
- total inflow of 1200 from 2006 to 2010, and
- total inflow of 1000 from 2011 to 2015.

b) Category Two: Adiquala, Segeneiti, Adi Keyih and Senafe

The growth rate will be:

- at 4.5% per annum from the year 1998 to 2005, and
- at 3.5% per annum from the year 2006 to 2015.

The number of returnees will be:

- total inflow of 750 from 1997 to 2000,
- total inflow of 1000 from 2001 to 2005,
- total inflow of 1000 from 2006 to 2010, and
- total inflow of 750 from 2011 to 2015.

5.3 Water Demand Projection

(1) Water consumption

From the consideration on the current situation, the target towns are categorized into three classes for future water consumption growth rate. Highly facilitated towns are in category-1, relatively low facilitated towns are in category-3, and category-2 for the medium. Projected water consumption at each town and target years are shown in Table 5.3.1.

(2) Domestic water demand

Service populations of each target year are calculated based on the projected population and water supplied area. And, the domestic water consumption at each target year are estimated as Table 5.3.2.

Table 5.3.2 Domestic Water Consumption (l/c/d)

Name of the Town	In 2005	In 2010	In 2015
Debarwa	18.8	19.9	22.6
Mendefera	23.1	29.4	34.8
Adiquala	20.5	23.6	30.7
Dekemhare	23.1	29.4	34.8
Segeneiti	18.8	19.9	22.6
Adi Keyih	23.1	29.4	34.8
Senafe	20.5	23.6	30.7
Average	21.1	25.0	30.1

(3) Other water consumption

Other water consumption is considered on the bases of field investigation and design criteria of the similar countries.

School	5 l/pupil
Hospital, Clinic	100 l/bed
Hotel, Bar, Tea shop, Restaurant	210 l/shop
Church, Mosque	5 l/visitor
Office	5 l/person
Factory	1,000 l/factory
Light industry	5,500 l/ha
Other industry	15,000 l/ha

(4) Physical loss

Physical losses caused by water leakage from pipes, reservoir and taps, illicit connections, etc., are put at 15 %, assuming that the new facilities will be constructed in the target year.

Table 5.3.1 Water Consumption

Name of town	Present water consumption pattern			Expected water demand											
	Mode of supply	Consumption l/c/d	Consumers % of household 1)	Year 2000-2005				Year 2005-2010				Year 2010-2015			
				Consumers (% of hld)		Ave. Consumption (l/c/d)		Consumers (% of hld)		Ave. Consumption (l/c/d)		Consumers (% of hld)		Ave. Consumption (l/c/d)	
				2000	2005	2000	2005	2005	2010	2005	2010	2010	2015	2010	2015
Debarwa	House connection	25	1. 25	15	17	25	28	17	19	28	30	19	22	30	35
	Yard connection	–	–	20	22	20	22	22	24	22	24	24	27	24	27
	Communal water point	8. 56	41. 7	65	61	15	15	61	56	15	15	56	51	15	15
	Water tanker	15. 61	27. 8												
Mendefera	House connection	24. 11	10. 94	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	14. 95	6. 56	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	10. 13	29. 2	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	16. 39	53. 3												
Adiquala	House connection	20. 45	13. 86	20	23	25	29	23	27	29	34	27	31	34	39
	Yard connection	12. 07	6. 14	30	33	20	22	33	37	22	24	37	69	24	27
	Communal water point	14. 31	63. 6	50	44	15	15	44	37	15	15	37	0	15	15
	Water tanker	–	–												
Dekemhare	House connection	25. 59	5. 67	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	15. 67	8. 67	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	–	–	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	16. 51	78. 1												
Segeneiti	House connection	11. 66	3	15	17	25	28	17	19	28	30	19	22	30	35
	Yard connection	5. 94	5	20	22	20	22	22	24	22	24	24	27	24	27
	Communal water point	8. 79	90. 5	65	61	15	15	61	56	15	15	56	51	15	15
	Water tanker	5. 59	–												
Adi Keyih	House connection	28. 73	4. 95	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	12. 64	10. 64	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	16. 45	13. 94	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	–	78. 86												
Senafe	House connection	10. 3	7. 78	20	23	25	29	23	27	29	34	27	31	34	39
	Yard connection	6. 8	6. 62	30	33	20	22	33	37	22	24	37	69	24	27
	Communal water point	8. 04	83. 8	50	44	15	15	44	37	15	15	37	0	15	15
	Water tanker	16. 49	1. 82												

1): The sums aren't necessarily 100% because of multiple answers and neglected other sources.

(5) Maximum daily and peak hour demand

Max. daily water demand = C1 x Average daily water demand
Peak hour water demand = C2 x Max. daily water demand
Coefficient of C1 = 1.2
Coefficient of C2 = 1.5

(6) Water demand projection

Average water demand for each target year is assumed from above mentioned factors and projected water supply service population divided into three phase to cover the whole towns.

5.4 Water Supply System

(1) Water supply system

The project plan for the water supply system employs the same system with the existing one, as a rule. Water sources are to be groundwater due to economic and quality reasons. New water sources and/or the existing water sources involved are connected to the reservoir by pipeline. Water is supplied by pump from water source(s) to a reservoir, and distributed by gravity from the reservoir to water taps.

(2) Water supply area

All of the target towns have a master plan for town planning, demarcating future extension area. Based on the current social conditions and the master plan, taking the topographical feature into the consideration, the administrative town area shall be divided into three zones: developed by the years of 2005, 2010, and 2015, respectively.

(3) Facility plan

Existing water supply facilities are mostly replaced under the project because of obsolete materials or insufficient capacity. However, the existing wells counted as the water sources in the project will be used continuously, and only the well pumps will be replaced to meet the demand. Reservoirs having enough capacity will be used after rehabilitation.

The following major water supply facilities are planned under the project.

- Intake facility: borehole, dug well, well pump,
- Transmission facility: transmission pipeline, booster pump, pump pit,
- Distribution facility: reservoir, distribution pipeline,
- Water service facility: individual connection, communal water point,
- Electricity facility: power supply, generator,
- Others: pump house, valves, flow meter.

5.5 Sanitation Improvement

The first step is to get a clear picture of the current sanitation and health condition of the town with regard to facilities and practices. Following, the collected information is to be analyzed: needs and objectives, the specific targets and the specific target groups are identified. The potential developments are foreseen, and future plans for improved sanitation facilities program are to be formulated for the three consecutive phases. Management and educational plans for effective and sustainable improved sanitation program shall be proposed.

5.6. Financial and Economic Analysis

(1) Water price and revenue

Water price is determined by category of customers and target years, based on:

- Average monthly household income,
- Distribution of household income by category of customers,
- Willingness to pay for water,
- The World Bank recommendation (4% of household income),
- Tariff system by purpose and mode of supply
- Progressive tariff by consuming volume,
- Future growth of household income, and
- Financial sustainability of water supply facilities to be constructed.

Revenue from water charges will be projected from:

- Number of households, by the year and by the category of customers,
- Annual water consumption per household, by the year and by the category of customers,
- Water price, by the year and by the category of customers, and
- Bill collection rate.

Some other revenue sources, such as technical service charge, meter rent, and so on, shall also be considered.

(2) Financial analysis

Basic factors for financial analysis are as follows:

- Project life: 20 years for F/S projects, 30 years for M/P projects
- Discount rate: 10%
- Financing conditions for the initial cost: subsidy
- Cost recovery principle: O&M cost and replacement cost of equipment/facilities to be borne by the beneficiaries
- Durable life of equipment and facilities:
  - (i) Pumps and other electro-mechanical equipment: 15 years
  - (ii) Facilities including boreholes, reservoirs, pipes, communal water points, pumping stations and treatment plants: 50 years
- Corporate income tax: free

Financial analysis will take two forms: projection of financial statements and estimation of financial criteria. Income statement, fund statement and balance sheet will be projected annually. At the same time, major financial indicators such as cost revenue ratio, net profit ratio, the ratio of working capital to revenues, and the ratio of net profits to total assets, will be calculated based on those statements. Using cost benefit streams, financial criteria shall be estimated.

Financial feasibility of the project will be evaluated from the above statements and indicators.

(3) Economic analysis

Based on the estimation of project benefit and economic cost consideration, economic analysis of the Project will be performed for each town. Through the economic analysis, the economic parameters such as NPV, B/C and EIRR will be calculated.

Major benefits accruing from the implementation of the Project are the reduction of water related diseases and general improvement of life-level of the inhabitant on one hand, and the saving of water fetching time on the other. Such benefits can be considered to be reflected into the price of water.

6. DEVELOPMENT PROGRAM

Based on the Strategy on Planning mentioned in the previous chapter, development programs are formulated as a phased plan to the year 2015, with target years of 2005, 2010, and 2015.

6.1 Population and Water Demand Projection

(1) Population projection

The population in the target years are projected in Table 6.1.1.

Table 6.1.1 Summary of Total Population Projected

Year	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
1997	4,831	20,371	9,488	21,675	6,146	14,215	12,934	89,660
2005	9,490	32,450	15,430	34,370	10,680	22,150	20,330	144,900
2010	13,020	41,630	19,320	44,030	13,680	27,310	25,140	184,130
2015	17,230	52,830	23,700	55,880	17,000	33,180	30,610	230,480

(2) Water demand Projection

All of the target towns are consisted of some sub-zones and also some villages. And future town extension area is planned toward any direction or surrounding the old town area. Those areas are classified into three zones to be covered as a service area under the Project by 2005, 2010, and 2015.

Water demands are estimated mainly from the projected population of the service areas, thus classified. The projected water demands of each town and year are shown in the following table.

Table 6.1.2 Water Demand

Target year	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
1. Service population								
2005	7,990	19,750	11,750	26,610	7,270	16,500	15,620	105,490
2010	12,460	33,270	16,490	37,950	11,500	25,500	21,810	158,980
2015	17,230	52,880	23,700	55,880	17,000	33,180	30,610	230,480
2. Service ratio (%)								
2005	84.2	60.9	76.2	77.4	68.1	74.5	76.8	74.0
2010	95.7	79.9	85.4	86.2	84.1	91.7	86.8	87.1
2015	100	100	100	100	100	100	100	100
3. Water demand (m3/day)								
2005	411	1,001	532	1,320	344	849	698	5,155
2010	754	2,283	789	2,452	517	1,424	1,030	9,249
2015	1,318	3,761	1,322	4,962	785	2,095	1,697	15,940

6.2 Water Resources Development

(1) Potential of water resources

An origin of water in a certain basin is basically rainfall. Major part of rainwater is lost by evaporation/transpiration and flowing out through drainage. Only the last remaining part can percolate into a ground recharging groundwater.

a) Rainfall – (effective) Evapotranspiration = Effective rain (mm)
b) Effective rain x catchment area = Total water source (m^3)
c) Total water source – Surface runoff = Groundwater recharge (m^3)

A hundred percent utilization of the yearly recharging is, however, quite difficult under the natural condition. Because, the groundwater recharging by rain fall occurs only in the few months in rainy season, and the groundwater is easily flow down naturally. Any artificial measures, such as an underground dam, is required to achieve the higher utilization rate of the recharging volume of groundwater. The groundwater development potential of each target town is estimated in Table 6.2.1.

Table 6.2.1 Groundwater Development Potential

Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
1. Rainfall (mm/a)	658.5	611.5	695.5	523.6	494.3	493.7	528.1
Effective rainfall	179.9	172.4	254.3	139.9	96.6	64.2	102.4
Recharging	72.0	69.0	101.7	56.0	38.6	25.7	40.9
2.Area of Groundwater basin							
Main basin	Debarwa	Mendefera	Gefih R.	A. Golol	A. Howya	A.Wegera	R. Ribis
Area (km^2)	195	165	210	47.6	11.5	16.9	27.4
Sub-basin	-	-	Semomo	-	Mirakat	Adi Keyih	E. Abune
Area (km^2)			12.6		5.8	16.1	53.8
Third basin	-	-	-	-	-	Tekonda	-
Area (km^2)						35.0	
3. Yearly recharge							
Main basin (MCM)	14.0	11.4	>20.0	2.67	0.44	0.43	1.12
Sub-basin	-	-	0.21	-	0.22	0.41	2.20
Third basin	-	-	-	-	-	0.90	-
4. Development Potential (m^3/day)							
Main basin	>10,000	2,600	>16,000	5,000	720	590	1,010
Sub-basin	-	-	580	-	200	560	1,650
Third basin	-	-	-	-	-	990	-
5. Water demand (m^3/day)	1,318	3,761	1,322	4,962	785	2,095	1,697

(2) Water resources development plan

Depending upon the groundwater development potentials and the water demand, the water resources development plans for target towns and years are worked out as shown in the following table (Tab. 6.2.2) and Figure 6.2.1 to 6.2.7. (Appendix) As shown in the table and figures, groundwater potential in Mendefera is not enough to meet the water demand in 2015, and the surface water development at the main Mereb shall be required. Then, to meet the 2015 water demand for Dekemhare, another water source development such as an underground dam will be needed.

Table 6.2.2 Water Resources Development Plan

Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
1. Existing water Resources (yield, m^3/day)	BH-12 (207)	BH-4, BH-5 (546.9)	Dug-wells (302)	BH-14,19 and others (553)	DW-1 (276)	DW-2 & BH-7 (415)	BH-9,10 (622)
2. Plan for 2005 (yield, m^3/day)	DEB-1 (411)	BH-4, 5 MEN-2, & nMEN-1,2 (1001)	Dug-wells & Intake facility (532)	BH-14,& DEK-1, 2 (1,320)	SEG-2 (344)	DW-2, BH-7, & ADI-2 (968)	Above and, BH-14 (726)
3. for 2010 (yield, m^3/day)	DEB-1 (754)	Above and, nMEN-3 to nMEN7 (2,283)	Above and, nADQ-1 (789)	Above and, BH-19, nDEK-1, and 2 (2,452)	SEG-2 (517)	Above and, BH-4, 5, ADI-1, nADI-1 (1,486)	Above and, nSEN-2, nSEN-3 (1,141)
4. for 2015 (yield, m^3/day)	DEB-1 & BH-12 (1,318)	Above and, Surface water source (3,761)	Above and, nADQ-2 (1,322)	Under-ground dam (4,962)	SEG-2 & DW-1 (785)	Above and, nADI-2,3 (2,095)	Above and, SEN-1, & nSEN-1,4 (1,697)

6.3 Water Supply and Sanitary Facility Plan

(1) Water supply facility plan

Water supply facilities of this project consist of intake facilities (borehole and well pump), transmission facilities (transmission pipeline, pump pit and booster pump), distribution facilities (reservoir and distribution pipeline), service facilities (individual connections and communal water points) and others (power supply and control house). These facilities are planned and summarized in Tables 6.3.1. to 6.3.3.

(2) Sanitary facility plan

a) School and public latrines

School latrine

The type of toilet designed is one unit with two compartments, for girls and for boys in the opposite direction. Each compartment has five latrines. The latrine is water carriage type, but pour flush latrine with tap provided at lower level on the side of the Turkish WC, in order to avoid water wastage and breakage of flushing system. The tap water shall also be used for anal cleansing purpose, but for those who prefer to use paper basket shall be provided. In order to develop hand washing practice after using the toilets, hand wash troughs are provided for both girls and boys section.

Public latrine

From the public health point of view, public areas such as market places, bus terminals, stadium etc., are proposed to be provided with public toilets. The type of public toilet recommended is the same as that of school toilets.

Table 6.3.4 School and Public Latrine

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
School latrine								
2005	2	5	3	6	3	3	3	25
2010	1	1	1	1	1	1	1	7
2015	1	1	1	1	1	1	1	7
Public latrine								
2005	3	5	3	5	3	5	3	27
2010	1	1	1	1	1	1	1	7
2015	1	1	1	1	1	1	1	7

b) Public sanitation facility

The study target towns, at present, are lacking most of public sanitation facilities. Provision of all of necessary public facilities at the first phase of the project may not be economically feasible. However, improvement of public facilities such as wastewater and storm water drainage, refuse disposal, etc., are quite substantial and some recommendations are presented in chapter 6.7 Sustainable Sanitation Improvement.

c) Private sanitation facility

The latrines recommended are in line with the type of water supply facilities provision. The coverage anticipated is proportional to the water supply facilities coverage. Basically three types of toilet for three modes of water services are recommended as tabulated below, but communal latrines are not recommended for the reason of difficulty in its management. It is rather recommended shared latrines for up to four families.

House connection users:	Cistern flush latrine (CFL)
Yard connection users:	Pour flush latrine (PFL)
Communal water point users:	Ventilated improved pit latrine (VIP)

Table 6.3.1 Water Supply Facilities (2005)

Facility	Description	Unit	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
Intake Facility	New well	sets		2	1		1			4
	Existing well	sets		2		1		2	3	8
	Observation well	sets	1	1		2		1		5
	Dam	sets								
	(Sub-total)	sets	1	5	1	3	1	3	3	17
Well Pump Facility	Submersible pump		DEB-1, 0.288m3/min 73.3m, 1set	BH-5, 0.096m3/min 81.0m, 1set	All In., 0.372m3/min 118.9m, 1set	DEK-1, 0.198m3/min 28.1m, 1set	SEG-2, 0.240m3/min 135.3m, 1set	DW-2, 0.096m3/min 101.0m, 1set	BH-14, 0.072m3/min 71.2m, 1set	
				MEN-1, 0.120m3/min 87.7m, 1set		DEK-2, 0.336m3/min 39.5m, 1set		BH-7, 0.192m3/min 13.1m, 1set	BH-10, 0.144m3/min 64.3m, 1set	
				nMEN-2, 0.120m3/min 68.4m, 1set		BH-14, 0.384m3/min 56.1m, 1set		ADI-2, 0.300m3/min 102.6m, 1set	BH-9, 0.288m3/min 63.1m, 1set	
				nMEN-1, 0.120m3/min 18.2m, 1set						
				BH-4, 0.288m3/min 75.8m, 1set						
	(Sub-total)	sets	1	5	1	3	1	3	3	17
Transmission Pipeline	DCIP 200mm	m				6,191.0				6,191.0
	ditto 150mm	m								0.0
	ditto 125mm	m		1,779.0						1,779.0
	ditto 100mm	m	690.0	624.0	2,851.0	948.0	4,168.0	3,771.0	1,164.0	14,216.0
	ditto 80mm	m		4,577.0		628.0	1,085.0	1,772.0		8,062.0
	ditto 60mm	m		2,667.0				343.0	962.0	3,972.0
	(Sub-total)	m	690.0	9,647.0	2,851.0	7,767.0	5,253.0	5,886.0	2,126.0	34,220.0
Booster Pump Facility	Centrifugal pump			BP.1, 0.240m3/min 99.8m, 1set	BP.1, 0.372m3/min 16.0m, 1set	BP.1, 0.918m3/min 100.8m, 1set	BP.1, 0.240m3/min 96.0m, 1set	BP.2, 0.288m3/min 48.2m, 1set		
				BP.2, 0.240m3/min 101.1m, 1set		BP.1', 0.218m3/min 15.0m, 1set		BP.1, 0.300m3/min 112.1m, 1set		
	(Sub-total)	sets		2	1	2	1	2		8
Pump Pit	Made of RC			15m3, 2 sets		30m3, 1 set	15m3	15m3, 2 sets		
	(Sub-total)	sets		2		1	1	2		6
Reservoir	Made of RC		140m3	340m3	180m3	440m3	140m3	290m3, h=5.5m		
	Made of F R P				35m3, h=13m	15m3, h=12m				
	Existing								1	
	(Sub-total)	sets	1	1	2	2	1	1	1	9
Distribution Pipeline	P V C 300mm	m				133.0				133.0
	ditto 250mm	m		980.0		205.0		643.0		1,828.0
	ditto 200mm	m		832.0		940.0		216.0	318.0	2,306.0
	ditto 150mm	m	365.0	1,970.0	15.0	1,486.0	531.0	1,081.0	254.0	5,702.0
	ditto 125mm	m		454.0	212.0	2,599.0	232.0	844.0	1,270.0	5,611.0
	ditto 100mm	m	1,513.0	1,114.0	1,326.0	1,275.0	954.0	776.0	774.0	7,732.0
	ditto 75mm	m	18,780.0	22,716.0	12,744.0	37,136.0	9,365.0	15,833.0	14,523.0	131,097.0
	ditto 50mm	m								
	(Sub-total)	m	20,658.0	28,066.0	14,297.0	43,774.0	11,082.0	19,393.0	17,139.0	154,409.0
Control House		sets	1	7	2	5	2	5	3	25
Communal Water Point		sets	12	13	8	20	10	9	8	80
Individual Connection		sets	409	2,593	935	2,676	525	1,730	1,480	10,348
Temporary Road	Width 3.0m	m	700	5,500	300	200	3,000	3,000	500	13,200

Table 6.3.2 Water Supply Facilities (2010)

Facility	Description	Unit	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
Intake Facility	New well	sets		5	1	2		1	2	11
	Existing well	sets				1		2		3
	Observation well	sets						1		1
	Dam	sets								
	(Sub-total)	sets	0	5	1	3	0	4	2	15
Well Pump Facility	Submersible pump		DEB-1, 0.522m3/min 82.8m, 1set	nMEN-7, 0.180m3/min 90.0m, 1set	nADQ-1, 0.192m3/min 24.0m, 1set	nDEK-2, 0.264m3/min 120.9m, 1set	SEG-2, 0.360m3/min 78.9m, 1set	ADI-1, 0.060m3/min 37.5m, 1set	nSEN-3, 0.144m3/min 109.8m, 1set	
				nMEN-6, 0.180m3/min 65.6m, 1set		nDEK-1, 0.264m3/min 85.2m, 1set		BH-5, 0.060m3/min 18.6m, 1set	nSEN-4, 0.144m3/min 60.5m, 1set	
				nMEN-5, 0.180m3/min 45.2m, 1set		BH-19, 0.288m3/min 129.3m, 1set		DW-2, 0.096m3/min 113.5m, 1set		
				nMEN-4, 0.180m3/min 30.7m, 1set		DEK-2, 0.336m3/min 44.6m, 1set		BH-4, 0.096m3/min 108.7m, 1set		
				nMEN-3, 0.180m3/min 32.8m, 1set		BH-14, 0.384m3/min 61.1m, 1set		nADI-1, 0.114m3/min 95.1m, 1set		
								ADI-2, 0.384m3/min 111.7m, 1set		
	(Sub-total)	sets	1	5	1	5	1	6	2	21
Transmission Pipeline	DCIP 200mm	m								2,900.0
	ditto 150mm	m		2,900.0				800.0	2,900.0	14,600.0
	ditto 125mm	m		3,800.0	5,000.0	2,100.0			3,200.0	8,300.0
	ditto 100mm	m		1,600.0		3,500.0		4,900.0		11,300.0
	ditto 80mm	m		3,800.0	100.0	2,500.0		3,960.0	2,700.0	8,160.0
	ditto 60mm						1,500.0			
	(Sub-total)	m	0.0	12,100.0	5,100.0	8,100.0	1,500.0	9,660.0	8,800.0	45,260.0
Booster Pump Facility	Centrifugal pump			BP.3, 0.720m3/min 95.8m, 1set	BP.2, 0.192m3/min 101.6m, 4sets	BP.1, 1.446m3/min 111.1m, 1set	BP'.1, 0.360m3/min 78.9m, 1set	BP.3, 0.120m3/min 83.4m, 2sets	BP.1, 0.288m3/min 92.1m, 1set	
				BP.4, 0.900m3/min 77.0m, 2sets		BP.1', 0.287m3/min 15.0m, 1set	BP.1, 0.264m3/min 99.3m, 1set	BP.4', 0.144m3/min 95.1m, 1set		
							BP.2, 0.096m3/min 98.7m, 1set	BP.4, 0.144m3/min 105.5m, 1set		
								BP.1, 0.384m3/min 115.0m, 1set		
								BP.2, 0.384m3/min 52.6m, 1set		
	(Sub-total)	sets		3	4	2	3	6	1	19
Pump Pit	Made of RC			25m3	20m3, 4sets	15m3	15m3, 2sets	15m3, 4sets	15m3	
				30m3, 2sets						
	(Sub-total)	sets		3	4	1	2	4	1	15
Reservoir	Made of RC		120m3	430m3	40m3	380m3		190m3, h=5.5m		
	Made of F R P				50m3, h=13m		50m3, h=12.5		0	
	Existing								0	7
	(Sub-total)	sets	1	1	2	1	1	1		0.0
Distribution Pipeline	P V C 200mm	m								0.0
	ditto 150mm	m						159.0		879.0
	ditto 125mm	m		210.0		510.0		668.0	316.0	3,034.0
	ditto 100mm	m		1,484.0		566.0		653.0	644.0	6,334.0
	ditto 75mm	m	174.0	2,228.0	602.0	1,921.0	112.0	11,331.0	7,685.0	96,270.0
	ditto 50mm	m	14,878.0	31,887.0	4,531.0	13,696.0	12,262.0			
								12,811.0	8,645.0	106,517.0
	(Sub-total)	m	15,052.0	35,809.0	5,133.0	16,693.0	12,374.0	8	3	28
Control House		sets	0	8	5	3	1	7	3	48
Communal Water Point		sets	6	13	5	9	5	771	668	4,973
Individual Connection		sets	218	1,307	439	1,343	227	6,500	3,000	22,500
Temporary Road	Width 3.0m	m		8,000	5,000					

Table 6.3.3 Water Supply Facilities (2015)

Facility	Description	Unit	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
Intake Facility	New well	sets	1		1	1			2	5
	Existing well	sets	1				1	2		4
	Observation well	sets							1	1
	Dam	sets		1						
	(Sub-total)	sets	2	1	1	1	1	2	3	10
Well Pump Facility	Submersible pump		DEB-1, 0.258m3/min 79.9m, 1set		nADQ-2, 0.360m3/min 62.5m, 1set	DAM, 1.746m3/min 120.6m, 1set	SEG-2, 0.432m3/min 87.7m, 1set	nADI-3, 0.192m3/min 39.2m, 1set	SEN-1, 0.060m3/min 17.9m, 1set	
			BH-12, 0.138m3/min 75.7m, 1set				DW-1, 0.114m3/min 70.6m, 1set	nADI-2, 0.246m3/min 77.1m, 1set	nSEN-3, 0.144m3/min 117.1m, 1set	
									nSEN-2, 0.144m3/min 125.3m, 1set	
									nSEN-1, 0.144m3/min 90.9m, 1set	
									nSEN-4, 0.192m3/min 79.0m, 1set	
	(Sub-total)	sets	2		1	1	2	2	5	13
Transmission Pipeline	DCIP 200mm	m				11,200				11,200.0
	ditto 150mm	m		43,000.0						43,000.0
	ditto 125mm	m								0.0
	ditto 100mm	m			1,900.0			2,700.0		4,600.0
	ditto 80mm	m	690.0					2,300.0	900.0	3,890.0
	ditto 60mm		480.0				400.0		5,200.0	6,080.0
	(Sub-total)	m	1,170.0	43,000.0	1,900.0	11,200.0	400.0	5,000.0	6,100.0	68,770.0
Booster Pump Facility	Centrifugal pump			BP.5, 1.026m3/min 110.9m, 5sets	BP.2, 0.552m3/min 109.8m, 4sets	BP.2, 1.746m3/min 120.6m, 1set	BP.1, 0.432m3/min 87.7m, 1set	BP.5, 0.438m3/min 123.0m, 1set	BP.1, 0.480m3/min 102.6m, 1set	
						BP.1', 0.310m3/min 15.0m, 1set	BP.1, 0.276m3/min 100.9m, 1set	BP.6, 0.582m3/min 107.7m, 1set	BP.2, 0.204m3/min 70.0m, 1set	
							BP.2, 0.156m3/min 122.1m, 1set			
	(Sub-total)	sets		5	4	2	3	2	2	18
Pump Pit	Made of RC			35m3, 5sets		55m3		15m3	15m3	
								20m3		
	(Sub-total)	sets		5		1	0	2	1	9
Reservoir	Made of RC		180m3	240m3	70m3	720m3		220m3, h=5.5m	110m3	
				180m3	30m3	50m3, 2 sets				
				50m3		30m3				
				40m3						
	Made of FRP				90m3, h=13m		80m3, h=12.5m			
	Existing									
	(Sub-total)	sets	1	4	3	4	1	1	1	15
Distribution Pipeline	PVC 300mm	m								
	ditto 250mm	m								0.0
	ditto 200mm	m				71.0				71.0
	ditto 150mm	m		883.0		2,336.0		310.0		3,529.0
	ditto 125mm	m		513.0		2,695.0		152.0	120.0	3,480.0
	ditto 100mm	m	2,242.0	1,877.0		3,489.0	44.0	1,049.0	0.0	8,701.0
	ditto 75mm	m	2,195.0	3,329.0	1,623.0	5,379.0	2,201.0	1,979.0	1,606.0	18,312.0
	ditto 50mm	m	18,911.0	31,140.0	1,567.0	33,922.0	15,527.0	6,575.0	594.0	108,236.0
	(Sub-total)	m	23,348.0	37,742.0	3,190.0	47,892.0	17,772.0	10,065.0	2,320.0	142,329.0
Control House		sets	1	5	1	2	1	4	4	18
Communal Water Point		sets	6	19	7	22	10	5	4	73
Individual Connection		sets	334	1,777	561	1,832	330	984	811	6,629
Temporary Road	Width 3.0m	m	500	3,500	2,000		400	7,000	4,000	17,400

6.4 Institutional Strengthening Plan

Major discussions on the institutional strengthening plans, mainly for national level, are summarized below.

(1) The Ministry of Land, Water and Environment (MoLWE)

The MoLWE has three Departments, one each for water, land and environment. The former Water Resource Department (WRD) has been reorganized within the new MoLWE, presently called as Water Department (WD) having two divisions under it. The WD will require additional manpower if it is to dispense its mandate properly. Then, training in several grades and terms will be needed in order to enhance the level of skills of the experts.

(2) The Ministry of Local Government (MoLG)

The primary mandate of the MoLG is to act as the main coordinating and facilitating body for the regions in their dealings and relationships with the ministries at central level. The Regional Affairs Department (RAD) is one of the five departments under it. When a major water project to be implemented arises, the RAD establishes a project management unit (PMU), which would assume direct responsibility for the implementation of the project. For this Project also a PMU will be established under RAD. It is proposed that the Head of the PMU be an engineer with extensive technical knowledge and experience in water facility construction and first hand knowledge of international cooperation.

(3) Ministry of Health (MoH)

Environmental Health and Sanitation Unit (EHSU) is one of the five units under the Primary Health Care Division (PHC), Health Service Department (HSD). It is responsible for developing and revising legislation, policies, standards and guidelines concerning environmental health and sanitation. Additionally it is involved in training of personnel, research and evaluation and rendering technical advice to regions. The EHSU will be strengthened both at the national and regional levels, by training 6 sanitation specialists for first degree and 30 assistant sanitarians for diploma to be stationed at the regions and sub-regions.

(4) Water Supply and Sanitation Authority of Eritrea (WSA)

A WSA should be established as an autonomous body taking charge of the management of all water and sewerage/sanitation facilities in the country. It is proposed that the national level WSA should be overseen by a Board whose members should be from the main focal ministries and other interest group in the country. The Board will report to the Minister of the MoLWE. It is important to have two main departments under it: one for urban and another for rural and it is proposed that these two main departments ought to have separate divisions for water supply and for sanitation. Under these two divisions, there will be six units one for each six regions of the country.

It is proposed that each town's WSA management become an autonomous unit with its separate cost center, possibly retaining its own income for maintenance and repair works. In order to minimize costs,

local WSA should operate with minimum staff. The number of staff in local WSA will be determined as per the requirement of the facilities and number of beneficiaries.

6.5 Project Cost

(1) Project Cost for water supply

Project cost consists of the following main facilities and items:

a) Construction cost
- Intake facilities (borehole, well pump, etc.)
- Transmission facilities (booster pump, pump pit, transmission pipeline, etc.)
- Distribution facilities (reservoir, distribution pipeline, etc.),
- Service facilities (individual connection, communal water point, etc.)
- Electric facilities (control house, power supply, etc.), and
- Others (temporary road etc.)

b) Engineering fee,
c) Administration cost
d) Physical contingencies, and
e) Price contingencies

Project costs for local currency component consists of earth works, concrete works, pipe laying works, installation of mechanical and electrical facilities, temporary works, etc., while for foreign currency component consists of materials and equipment, such as pipes and its fittings, valves, pumps, control panels, etc..

In respect of the construction cost, the percentages for engineering fee and administration cost are assumed as 10% and 2% of construction cost, respectively. Physical contingencies are assumed at 10% of the sum of the construction cost, engineering fee and administration cost.

Project costs of each target year are estimated in Tables 6.5.1 to 6.5.3.

Table 6.5.1 Project Cost in 2005

(Thousand Nakfa)

Description	Local C.	Foreign C.	Total	Remarks
1. Project cost				
Debarwa	4,270	2,987	7,257	
Mendefera	11,066	12,860	23,926	
Adiquala	4,336	5,606	9,942	
Dekemhare	11,275	14,986	26,261	
Segeneiti	5,129	6,100	11,229	
Adi Keyih	7,736	8,318	16,054	
Senafe	4,049	4,314	8,363	
Sub total	47,861	55,171	103,032	
2. Price escalation	7,348	8,460	15,808	
Total	55,209 (7,887)	63,631 (9,090)	118,840 (16,977)	(Thousand USD)

Table 6.5.2 Project Cost in 2010

(Thousand Nakfa)

Description	Local C.	Foreign C.	Total	Remarks
1. Project cost				
Debarwa	2,647	1,752	4,399	
Mendefera	14,024	16,924	30,948	
Adiquala	5,706	8,201	13,907	
Dekemhare	5,995	10,437	16,432	
Segeneiti	2,673	4,207	6,880	
Adi Keyih	18,174	19,003	37,177	
Senafe	5,229	8,279	13,508	
Sub total	54,448	68,803	123,251	
2. Price escalation	25,492	32,173	57,665	
Total	79,940 (11,420)	100,976 (14,425)	180,916 (25,845)	(Thousand USD)

Table 6.5.3 Project cost in 2015

(Thousand Nakfa)

Description	Local C.	Foreign C.	Total	Remarks
1. Project cost				
Debarwa	4,702	4,186	8,888	
Mendefera	23,166	45,689	68,855	
Adiquala	2,611	5,882	8,493	
Dekemhare	14,079	20,784	34,863	
Segeneiti	3,373	5,024	8,397	
Adi Keyih	7,031	6,925	13,956	
Senafe	4,596	5,977	10,573	
Sub total	59,558	94,467	154,025	
2. Price escalation	55,508	87,571	143,079	
Total	115,066 (16,438)	182,038 (26,005)	297,104 (42,443)	(Thousand USD)

(2) Project cost for sanitation

Project cost for sanitation is estimated as follows:

Table 6.5.4 Project Cost for Sanitation

Thousand Nakfa (Thousand USD)

Target year	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
2005	420	840	504	924	504	672	504	4,368 (624)
2010	225	225	225	225	225	225	225	1,575 (225)
2015	301	301	301	301	301	301	301	2,107 (301)

6.6 Sustainability of Water Supply Facility

(1) Capacity building for WSA

The draft Water and Sanitation Law envisages the establishment of WSA whose mandate will be to the manage water and sanitation facilities and thus ensure the provision of water supply and sanitation services to both urban and rural areas of the country. Smooth and successful implementation of water supply project, as well as O&M of the facilities constructed, will depend upon the capability of each local WSA.

For a quick establishment, the current WSS shall be transferred to the new WSA. The primary objective of the local WSA is to supply clean and safe water in a sufficient, sustainable and efficient manner. To fulfill it, the local WSA has to fully become technically, financially and legally competent. Organizationally, each local WSA shall ultimately be composed of 4 divisions and 15 sections, under a Manager, Customer Services, and Internal Audit. Divisions are Administrative Service, Financial Service, Technical Service, and Sanitary Service.

The Manager is responsible for the stable and successful management of the local WSA and represents the local WSA in the dealings with committees, the town municipality and National WSA. Customer Service functions as a window or opening for communications with the consumers in general. Internal Audit is essential for a strict observance of rules and regulations in financial management.

(2) Operation and Maintenance cost (O&M cost)

As mentioned above, all water supply facilities are to be operated and maintained under the full responsibility of WSA.

Total O&M cost in each target year is estimated in the following table:

Table 6.6.1 Annual O&M Cost

(Thousand Nakfa)

Name of Town	In 2005	In 2010	In 2015	Remarks
Debarwa	301	558	924	
Mendefera	848	2,152	4,393	
Adiquala	434	870	1,554	
Dekemhare	938	1,516	3,047	
Segeneiti	407	662	952	
Adi Keyih	747	1,386	2,090	
Senafe	471	837	1,356	
Total	4146 (592)	7,981 (1,140)	14,316 (2,045)	(Thousand USD)

(3) People's participation

People's active participation and self-reliance constitute the main pillars of the Government's development policy. Although the O&M of water supply system such as an operation of pump, repairing and replacement of facility/equipment, collection of the water bill, and so on, are conducted by WSA, a participation of the inhabitant and/or community to the management of the system such as a

cleaning of the facility, ordering the water fetching, proposing the improvement plan, request on new water supply or sanitary facilities, etc., is quite important. Participation is multi-faceted and may involve almost all stages of the project cycle. Based on the implications drawn from the development principles, the following recommendations are made to enhance people's participation.

a) Continuous sensitization and awareness creation program will need to be an in-built feature of the program.
b) The Goverment shall continue to involve beneficiary communities, and recommend on the broad strategy which the Government could follow in ensuring people's participation in the management and administration of water and sanitation facilities.
c) Introduce and develop a viable management system for water and sanitation facilities that will be operated and maintained by WSA.
d) Education and training need to be an in-built system of any program that seeks the active involvement of communities.

(4) Community based management

For all target towns, community based management would involve the following principles:

a) Communities must manage the improved, as well as unimproved or existing, water points and sanitation facilities, with all that such ownership entails.
b) Hardware and software components of the water supply and sanitation facilities shall be given equal attention.
c) Linking hygiene and sanitation interventions with water supply infrastructures is neressary.
d) There exist various interest groups in each town, such as those pertaining to age, sex, income, occupation, values and attitudes. It is important, therefore, not to rely solely on community elders but rather to bring various groups, notably women and young men into the process.

6.7 Sustainable Sanitation Improvement

(1) Sanitation management plan

At present, the managing body for all public facilities is the town administration. The town administration has many duties and responsibilities, not only too much to manage but also ineffective. Therefore, introduction of autonomous management systems is highly recommended. The town administrator remains as the overall inspector of the facilities. And the management responsibility of public facilities shall be given either to an individual, on contractual or rental basis, or a community committee for sanitary facilities which shall be formed to operate and manage the systems.

The public latrines proposed incur minimum cost which is limited to monthly expenses of water, detergent and cleaning material and once in two to three years of de-sludging. For the school latrines, cleaning and keeping the latrines in good condition shall be the students responsibility.

The solid waste management, at present, is under the responsibility of town administrations with a great deal of cooperation of the people. For more effectiveness, it is highly recommended to develop a plan which introduce a waste handling norm which involves the participation of all groups of the society in a day to day life.

(2) Educational program development

The educational program developed should be able to address different groups of beneficiaries by age, sex, education, cultural and religious background. A Hygiene Education Manual was provided under the Study, however, such educational program once developed does not mean the end of it. Every time, the program shall be updated to fit to whom it is addressed. Choosing appropriate teaching mechanism to fit the addressed target group such as radio, posters, TV, video, or face to face communication, is very important.

School children can be given the education in the schools, and youth association. The most effective way of teaching children in sanitation and hygiene is to practically make them get used to clean latrine usage, develop hand washing habit after using latrine and cleaning latrine. Church and Mosque are places where elderly people have trust. These institutions if possibly be used to reach elderly people in hygiene/sanitation educational programs effective outcome can be envisaged. Because of the business, an independent hygiene/sanitation program schedule for housewives may not be effective and realistic. An effective and easy way of addressing women might be through the existing radio educational programs which is broadcast during working hour or through existing institution such as the Eritrean Women Association, community administration, church or mosque.

The educational posters are one of the basic means for the sanitation improvement of the town. The intended messages to be conveyed in the posters are: explanation on risk of pathogens on health, keeping food and water safe from contamination, responsibility of the society on protecting the environment and surface waters from pollution, developing habit of hand washing and latrine usage, demonstration of low cost/safe household latrine, and so on.

6.8 Financial Plan

(1) Willingness to pay

Households were classified into three groups according to their monthly income level; namely, below 600 Nfa as the low, 600 to 999 Nfa as the middle, and 1,000 Nfa or more as the high income group. The socio-economic survey reported the average willingness to pay of each income group as shown in Table 6.8.1.

Table 6.8.1 Willingness to Pay

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Average
Low income group (%)	47.2	41.8	49.1	28.5	58.2	44.7	55.3	46.4
Willingness (Nfa/m^3)	9.6	9.0	10.3	9.0	8.6	9.7	8.4	9.2
% of income	3.1	2.4	2.8	2.2	2.7	2.0	2.1	2.5
Middle income g.(%)	38.9	36.6	29.1	41.0	32.9	39.1	25.9	34.8
Willingness (Nfa/m^3)	12.1	11.8	15.7	12.0	14.9	10.9	11.1	12.6
% of income	1.7	1.5	2.0	1.6	2.2	1.3	1.4	1.7
High income g.(%)	13.9	21.6	21.8	30.5	8.9	16.2	18.8	18.8
Willingness (Nfa/m^3)	16.9	16.8	25.0	21.7	15.8	15.9	11.6	17.7
% of income	0.9	1.1	1.6	1.4	1.3	0.8	0.7	1.1
Average								
Willingness (Nfa/m^3)	11.6	11.7	15.1	14.1	11.3	11.2	9.7	11.3
% of income	1.7	1.5	2.0	1.5	2.2	1.3	1.3	1.4
Average Monthly Income (Nfa)	676	774	739	917	518	877	743	791

The figure shows that the riches people are willing to pay high tariff, but the share of it in their income is less than the poor. It results, in fact, the riches have less willing to pay for water in terms of the percentage of their income.

(2) Water tariff analysis

To fulfill the financial objective of sustainable management for each local WSA, as well as the social objective of justice, water price is proposed to be at the highest for the house connection users, at a medium level for the yard connection users and the lowest for the communal water point users. In the same context, the payment for water in terms of percentage of income, will also be higher for the house/yard connection users than for the communal water point users. In all cases, the percentage of water payment to income will not exceed 4% as recommended by the World Bank.

After a series mathematical model simulations to attain financial viability and stability for the local WSA, and at the same time to fulfill social fairness and justice, the proposal for water prices in the target years are figured out as shown in Table 6.8.2.

Table 6.8.2 Proposed Water Tariff

(Nfa/m^3)

Item	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Average
House Connection								
2005	7.5	9.0	7.5	7.0	10.0	8.0	7.0	8.0
2010	6.5	12.0	10.0	6.0	11.0	10.0	9.5	9.3
2015	6.5	12.0	10.0	6.0	11.0	10.0	9.5	9.3
Yard Connection								
2005	4.0	6.0	5.0	5.0	8.0	6.0	4.0	5.4
2010	4.0	9.0	7.0	4.0	9.0	7.0	6.0	6.6
2015	4.0	9.0	7.0	4.0	9.0	7.0	6.0	6.6
Communal Water Point								
2005	2.0	2.0	2.0	2.0	4.0	2.0	2.0	2.3
2010	2.0	-	2.0	-	4.0	-	2.0	2.5
2015	2.0	-	-	-	4.0	-	-	3.0

(3) Revenue estimation

The revenue sources of the local WSA are water charge, technical service charge, meter rent and miscellaneous revenues.

Water charge is the main source of revenue. It is collected from the house connection, yard connection and communal water point users. Water charge has been calculated from the number of households, family size, consumed volume and water price by the mode of water supply in each year. In converting the amount of water charge into the revenue, bill collection efficiency was assumed to be 98% based on the current situation.

When the local WSA installs an individual connection for a customer, the local WSA collects the technical service charge in addition to the material cost. It is calculated at 378 Nfa on average. The third source of revenue, the rental fee of the meter is assumed to be 1 Nfa per month per individual connection. In addition there are miscellaneous revenues, namely the sale of materials, fines, etc., however, they shall not be taken into account because they are of irregular and unpredictable.

The revenue deriving from the above-mentioned sources must be sufficient and stable enough to sustain the management of the local WSA in the years to come.

(4) Projection of financial statement

In preparing the projected financial statements, the following were assumed:

a) Initial cost will be totally subsidized by the government.
b) The people of the town will bear the O&M and the replacement costs of all facilities as a water charge.
c) No tax will be imposed on the profit from water supply operations.
d) Project life will be 30 years since the start of the first phase implementation.

The ratios in the financial statements such as Revenue to Cost Ratio, Profit Rate, etc., are shown later in Table 6.9.2. These figures show that each local WSA will be financially successful and stable management.

6.9 Project Evaluation

(1) Economic evaluation

a) Benefits of water

After its implementation of the Project, women and young children will be relieved from the daily repetition of water fetching drudgery, drastically reduce water-related diseases, and improve the people's sanitary and living standard totally.

These economic benefits can be reflected in the prices of water. Currently, the prices of water is fixed, ranging from 1.5 to 10 Nfa/m^3 depending on the service modes. Such water prices only partially represents the economic benefits of water, but not fully due to institutional consideration. It is regarded that the economic benefits of water is fully reflected in the prices of the water bought from water vendors. In Debarwa, water prices from water vendors range 16 to 40 Nfa/m^3. Thus, the economic benefits of piped water is assumed at 20 Nfa/m^3.

b) Projection of water consumption and population without project

The unit consumption rate of piped water in the seven towns is calculated at 10.3 l/c/d on an average. In the case of "without" project, it is assumed that this law water consumption rate will continue throughout the project life period.

If the Project is not implemented, it is expected that the population of the town will not grow as fast as envisaged in this study due to constraints in water supply. In the case of "without" project, it is assumed that the growth rate of population will decrease to a half of the rate foreseen against the case of "with" project.

c) Other conditions/assumptions

The following conditions/assumptions were estimated in addition to the above ones.

i) Project life: 30 years from the start of the first phase works
ii) Opportunity cost of capital: 10%, an average value perceived appropriate by the World Bank
iii) Standard conversion factor: 0.9, to be applied to local components of initial cost

d) Economic analysis

Cost benefit streams were prepared based on all the above-mentioned conditions and assumptions, which are summarized in Table 6.9.1, together with the results of sensitivity analysis. As shown in this table, the EIRR of the Project of some towns are below 10% or the assumed opportunity cost of capital (OCC), however, it may be tolerable considering the social nature of the Project. More than half of the towns show the soundness of the Project.

e) Sensitivity analysis

Sensitivity analysis was performed to see how EIRR would change if the cost overrun of 20% occurred (Case-1) or if the cost overrun of 20% and the 10% decrease of the benefits simultaneously happened (Case-2). The result are shown in the following table.

Table 6.9.1 Economic Analysis

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Average
NPV (Thousand Nfa)	7,111	-18,825	578	26,597	-3,939	2,821	8,457	3,257
B/C	1.46	0.75	1.03	1.48	0.79	1.08	1.39	1.14
EIRR (%)	15.2	6.2	10.4	15.0	6.7	11.3	16.1	11.6
Sensitivity (%)								
EIRR in Case-1	12.6	3.8	7.6	12.6	4.2	8.4	12.6	8.8
EIRR in Case-2	11.0	1.9	5.4	10.9	2.4	6.6	10.0	6.9

EIRR of most towns have gone down below 10%, some are far below the OCC. However, they stay above the discount rate of zero even under the such unfavorable situation.

(2) Financial evaluation

The financial internal rate of return (FIRR) cannot be calculated due to the peculiar state of cost benefit streams, characterized by the absence of initial cost in the cost stream. Therefore, financial evaluation was done only for the projected financial statements, which are summarized below.

Table 6.9.2 Financial Statements

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Average
Revenue to Cost Ratio (%)	120.2	125.5	121.4	122.9	110.7	122.0	123.9	120.9
Profit Rate (%)	13.8	17.1	16.0	15.2	8.2	16.4	17.6	14.9
Working Capital to Revenue Ratio	40.0 (%)	46.3 (%)	41.5 (%)	44.2 (%)	39.7 (%)	42.7 (%)	43.1 (%)	42.5 (%)
Profit to Total Assets Ratio (%)	1.1	1.2	1.2	1.1	0.6	1.2	1.3	1.1

The table shows that the local WSA have a reasonable extent of profit to provide for unpredictable financial turbulence, a large reserve oft working capital to prepare for replacement of facilities and a nominal profit to the assets invested in the years to come.

(3) Organizational evaluation

The evaluation of the organizational measures can be summarized as follows:

a) Planning and execution of water supply and sanitation projects in the country and in the town will be streamlined and properly effected, and appropriate capacity building measures will be taken.
b) A viable training component will be developed in order to meet the skilled manpower requirements at the country, Debub Region and town levels.
c) Project execution will be effected by the PMU which will be established in the MoLG.
d) Local WSA will be established in each town and assistance rendered to strengthen it institutionally and to the training of skilled personnel.
e) Sanitation and environmental health will institutionally occupy its proper position in the local WSA to fulfill the urgent needs for its sanitary improvement.
f) The community in the town will assume prime position in the planning, implementation and management of water and sanitation facilities in their locality.

(4) Technological evaluation

The proposed water supply system is composed of relatively simple facilities, those of which are not quite different from the existing ones. Main materials for the project, such as PVC pipe, submersible pump, ductile cast iron pipe, etc., are recently common in Eritrea. Although a new material made of fiberglass reinforced plastic (FRP) is to be introduced for elevated tank, the light material could facilitate the construction work very smoothly. The material is also expected to have a long life span comparing with other conventional materials, thus the long run cost could be reduced for the reservoir.

The construction works are carried out by manual labor at present. However, use of construction machinery shall be considered to minimize the construction period. The construction works by machinery will be useful and common in future.

(5) Social and WID evaluation

In evaluating the social and WID aspects, the following items shall be considered:

a) The improvement in piped water supply in the town will result in the significant reduction of time and energy spent in the collection of water, particularly for women, girls and boys.

b) This should improve the quality of life for these social groups, making the town a more pleasant place to live.

c) By the provision of toilets, there will be not only more hygienic environments, but will also allow the women and girls the privacy which they have been not allowed to have.

d) The project will allow the participation of the community in making decisions regarding the location of public water and sanitation facilities, thus enhancing their sense of empowerment.

(6) Environmental impact assessment

The project focuses the development of groundwater for drinking in the seven urban towns. The scale of the project is not large, and there is no major construction involved. Boreholes shall be drilled at some locations but dynamic water levels are kept within the normal yearly fluctuation. Thus, no major negative impact on the environment is expected in terms of social, natural environment including pollution. Therefore, attention should be given on the amount of water that is planned to withdraw from the source and dynamic water levels whether they stay within the design level. For this purpose, monitoring of water level is recommended. On the other hand, supply of safe water will improve the living condition and formulation of sanitary education plan will upgrade the existing health and hygienic conditions of the rural people.

Environmental screening and scooping for IEE in JICA format have been performed for this sub-regional town. Based on the result of the IEE, EIA is not necessary for this project.

6.10 Project Implementation Plan

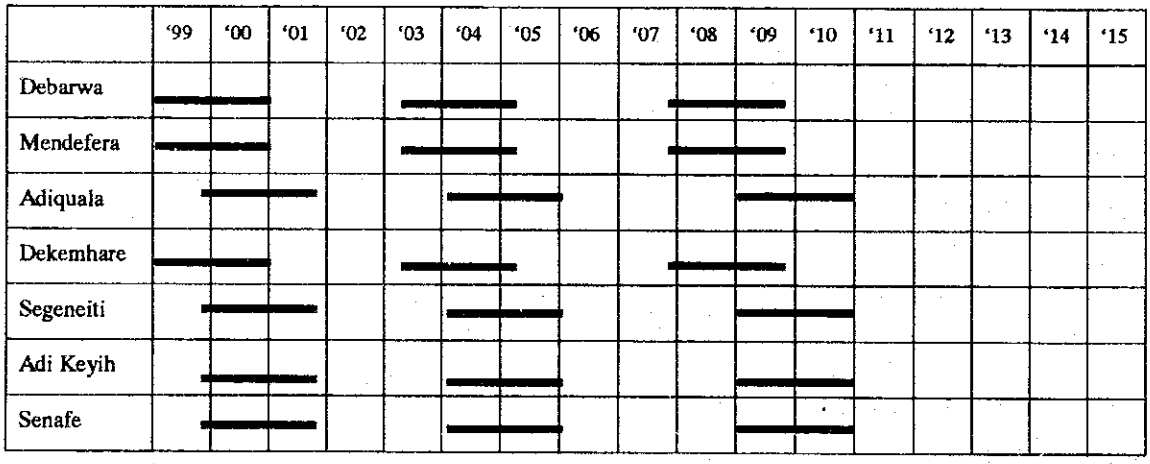
Major works of this project will be borehole drilling work, pipe laying work, civil works, mechanical and electrical works, etc.

The implementation schedule is divided into three phases to meet the target year and into two stages; namely, a) preparation of budget including the foreign currency portion and of detail design together with tender documents, and b) construction of the project.

Seven towns are also divided into two groups. Group 1 consists of three towns of Debarwa, Mendefera and Dekemhare which locate near the capital of Asmara, have a rapid population growth rate and are expected to be main industrial zone. Group 2 include the remaining four towns.

The implementation schedule of the Project is proposed as follows:

Figure 6.10.1 Implementation Schedule



7. PROJECT FEASIBILITY STUDY

Project feasibility was studied for the priority projects targeting the year of 2005, among the total development programs examined in the previous chapter.

7.1 Groundwater Development Plan

The projected water demand in 2005 ranges from around 340 to 850 m^3/day in most of the cases and 1,320 m^3/day at the maximum in Dekemhara. The borehole(s) drilled under the Study, or together with the existing wells, can cover the water demand by the year 2005, except for Mendefera and Adiquala. In the case of Mendefera, drilling of two new boreholes is required. Adiquala has no borehole drilled under the Study, and a new intake facility to collect the seepage water from Semomo Dam is proposed. Groundwater development plans for every target town are summarized as Table 7.1.1.

Table 7.1.1 Groundwater Development Plan (2005)

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe
Water Demand (m^3/day)	411	1,001	532	1,320	344	849	698
Test Wells (m^3/day)	DEB-1 (778)	MEN-1 (173)	-	DEK-1 DEK-2 (769)	SEG-2 *1 (622)	ADI-2 (553)	-
Existing Wells (m^3/day)	-	BH-4 BH-5 (547)	DW-1 DW-2 DW-14 DW-15 (302)	BH-14 (551)	-	DW-2 BH-7 (296)	BH-9 BH-10 BH-14 (698)
Proposed Wells to be drilled (m^3/day)	-	nMEN-1 nMEN-2 (281)	-	-	SEG-2' *2 (344)	-	-
Others (m^3/day)	-	-	Intake *3 (230)	-	-	-	-

*1: Required to re-drill because of high way expanding plan.

*2: Re-drill of SEG-2, around 30m downstream of the original SEG-2.

*3: New intake facility to collect the seepage water of Semomo dam.

7.2 Facility Design

Facilities required for the Project are boreholes, well pumps, transmission/distribution pipelines, reservoir, booster pumps, pumping pits, control houses, service facilities, public latrines, etc. Total facility plan for the target year 2005 is summarized in Table 7.2.1 and 7.2.2.

Table 7.2.2 School and Public Latrine

	Debarwa	Mendefera	Adiquala	Dekemhare	Segeneiti	Adi Keyih	Senafe	Total
School latrine	2	5	3	6	3	3	3	25
Public latrine	3	5	3	5	3	5	3	27

Table 7.2.1 Water Supply Facilities (2005)

Facility	Description	Unit	Debarwa	Mendefera	Adiquala	Dekembare	Segeneiti	Adi Keyih	Senafe	Total
Intake Facility	New well	sets		2	1		1			4
	Existing well	sets		2		1		2	3	8
	Observation well	sets	1	1		2		1		5
	Dam	sets								
	(Sub-total)	sets	1	5	1	3	1	3	3	17
Well Pump Facility	Submersible pump		DEB-1, 0.288m3/min 73.3m, 1set	BH-5, 0.096m3/min 81.0m, 1set	All In., 0.372m3/min 118.9m, 1set	DEK-1, 0.198m3/min 28.1m, 1set	SEG-2, 0.240m3/min 135.3m, 1set	DW-2, 0.096m3/min 101.0m, 1set	BH-14, 0.072m3/min 71.2m, 1set	
				MEN-1, 0.120m3/min 87.7m, 1set		DEK-2, 0.336m3/min 39.5m, 1set		BH-7, 0.192m3/min 13.1m, 1set	BH-10, 0.144m3/min 64.3m, 1set	
				nMEN-2, 0.120m3/min 68.4m, 1set		BH-14, 0.384m3/min 56.1m, 1set		ADI-2, 0.300m3/min 102.6m, 1set	BH-9, 0.288m3/min 63.1m, 1set	
				nMEN-1, 0.120m3/min 18.2m, 1set						
				BH-4, 0.288m3/min 75.8m, 1set						
	(Sub-total)	sets	1	5	1	3	1	3	3	17
Transmission Pipeline	DCIP 200mm	m				6,191.0				6,191.0
	ditto 150mm	m								0.0
	ditto 125mm	m		1,779.0						1,779.0
	ditto 100mm	m	690.0	624.0	2,851.0	948.0	4,168.0	3,771.0	1,164.0	14,216.0
	ditto 80mm	m		4,577.0		628.0	1,085.0	1,772.0		8,062.0
	ditto 60mm	m		2,667.0				343.0	962.0	3,972.0
	(Sub-total)	m	690.0	9,647.0	2,851.0	7,767.0	5,253.0	5,886.0	2,126.0	34,220.0
Booster Pump Facility	Centrifugal pump			BP.1, 0.240m3/min 99.8m, 1set	BP.1, 0.372m3/min 16.0m, 1set	BP.1, 0.918m3/min 100.8m, 1set	BP.1, 0.240m3/min 96.0m, 1set	BP.2, 0.288m3/min 48.2m, 1set		
				BP.2, 0.240m3/min 101.1m, 1set		BP.1', 0.218m3/min 15.0m, 1set		BP.1, 0.300m3/min 112.1m, 1set		
	(Sub-total)	sets		2	1	2	1	2		8
Pump Pit	Made of RC			15m3, 2 sets		30m3, 1 set	15m3	15m3, 2 sets		
	(Sub-total)	sets		2		1	1	2		6
Reservoir	Made of RC		140m3	340m3	180m3	440m3	140m3	290m3, h=5.5m		
	Made of F R P				35m3, h=13m	15m3, h=12m				
	Existing								1	
	(Sub-total)	sets	1	1	2	2	1	1	1	9
Distribution Pipeline	P V C 300mm	m								
	ditto 250mm	m				133.0				133.0
	ditto 200mm	m		980.0		205.0		643.0		1,828.0
	ditto 150mm	m		832.0		940.0		216.0	318.0	2,306.0
	ditto 125mm	m	365.0	1,970.0	15.0	1,486.0	531.0	1,081.0	254.0	5,702.0
	ditto 100mm	m		454.0	212.0	2,599.0	232.0	844.0	1,270.0	5,611.0
	ditto 75mm	m	1,513.0	1,114.0	1,326.0	1,275.0	954.0	776.0	774.0	7,732.0
	ditto 50mm	m	18,780.0	22,716.0	12,744.0	37,136.0	9,365.0	15,833.0	14,523.0	131,097.0
	(Sub-total)	m	20,658.0	28,066.0	14,297.0	43,774.0	11,082.0	19,393.0	17,139.0	154,409.0
Control House		sets	1	7	2	5	2	5	3	25
Communal Water Point		sets	12	13	8	20	10	9	8	80
Individual Connection		sets	409	2,593	935	2,676	525	1,730	1,480	10,348
Temporary Road	Width 3.0m	m	700	5,500	300	200	3,000	3,000	500	13,200