PREFACE

It gives me great pleasure to introduce the District Water Development Study for Meru District.

The Ministry of Water Development has the task of planning for water resources development, both at national and district levels. Districts have been assigned a major role in the development of the country as illustrated by the District Focus Strategy for Rural Development Policy. Consistent with this policy the Ministry of Water Development has put great emphasis on the studies for District Water Development Planning.

Water resources development can only be successfully undertaken if the long-term planning reflects the balance between availability and exploitation of water. Extensive investigations and monitoring are needed to determine the potential of the water resources and the effects of development on long-term basis. Presently, the Districts do not have the research capacity to carry out the necessary studies independently. To overcome this situation, the Ministry of Water Development has established a Water Resources Assessment Section that supports the Districts in carrying out these studies. The Section is being strengthened by the Water Resources Assessment and Planning Project.

The present study provides extensive information on the availability of water resources, the existing supply, the future water demand and the investments involved in developing the water resources in Meru District. Equipped with this information the District will be in a better position to plan its supply facilities. It is only after the District succeeds in explaining to the people the limitations of the natural system and the vulnerability of the environment involving them as much as possible in the planning and construction of their water supplies, that the difficult task of providing water to the people will see a good end.

I express the wish that this important study will be optimally used to achieve this common goal.

(E. K. MWONGERA)
Director of Water Development

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6. Operation and Maintenance Costs
7. Cost Effectiveness Analysis

ABBREVIATIONS

ASAL	=	Arid and Semi-Arid Lands Development Program
CBWDP	=	Central Baringo Water Development Plan
CC	=	County Council
DANIDA	=	Danish International Development Agency
DDC	=	District Development Committee
DDP	=	Meru District Development Plan 1989-1993
DvDC	=	Divisional Development Committee
DWDP	=	District Water Development Plan
DWDS	=	District Water Development Study
EEC	=	European Economic Commission
FINNIDA	=	Finnish International Development Agency
GOK	=	Government of Kenya
GSK	=	Groundwater Survey Kenya
GTZ	=	Deutsche Gesellschaft fur Technische Zusammenarbeit
KFRWSDP	=	Kenya Finland Rural Water Supply Development Project in Western Province
KIDP	=	Kitui Development Program
Ksh	=	Kenya shilling
KWAHO	=	Kenya Water for Health Organization
KWDP	=	Kwale District Community Water Supply and Sanitation Project
L.U.	=	Livestock Unit
LBDA	=	Lake Basin Development Authority
lpcd	=	liters per capita per day
MoA	=	Ministry of Agriculture
MOH	=	Ministry of Health
MoLD	=	Ministry of Livestock Development
MoWD	=	Ministry of Water Development
MPND	=	Ministry of Planning and National Development
msl	=	Meters above mean sea level
NGO	=	Non-Government Organization
NORAD	=	Norwegian Agency for Development
ODA	=	Overseas Development Agency
Shs	=	Kenya shilling
SIDA	=	Swedish International Development Agency
UNDP	=	United Nations Development Project
UNICEF	=	United Nations International Childrens Emergency Fund
USAID	=	United States Agency for International Development
WECO	=	Western College of Arts
WRAP	=	Water Resources Assessment and Planning Project

SUMMARY

The present report is Part 2, of three reports, composing the Meru District Water Development Study. Part 2 presents an inventory of existing water supply in Meru District, the analysis of and recommendation on water supply options and technologies for Meru District, an inventory of costs of the selected technologies, and compares these costs using a cost effectiveness analysis. The objective of the report is to recommend affordable and sustainable water supply options and technologies for Meru District.

The inventory of existing water supply was carried out by collecting data from the files of the MoWD and by field visits, recording the information on survey sheets. The analysis of feasible water supply options was based on this inventory.

The availability of protected water supply for domestic purposes is restricted mainly to the towns, some of the trading centres and institutions, and the rural population where the intake is safe from pollution (e.g. in the forest). The population outside the reach of the protected water supplies receive water from supplies which have an unsafe intake or take water directly from the source, such as springs, wells and rivers.

All protected water supply systems in Meru are piped systems, drawing water from springs and rivers. Most of the supplies are by gravity. Only the MoWD supplies provide treated water. The coverage by the MoWD supplies is 12% of the population. The total coverage by protected water supplies is 30% of the district population. Of the total district population 44% is estimated not to be covered by any supply scheme.

The inventory of the existing supplies covered 186 water supplies, of which 132 are currently operational. The largest number are the self-help supplies (97 operational), which serve 15% of the total district population. Other water supplies are operated (with assistance) by the Diocese of Meru and cover 10% of the district population.

There are 11 public water supplies (MoWD), 5 are in good, 4 are in fair and 2 are in poor condition. Many of the self-help schemes though operational are not completed, about 41. The reliability of the supplies could not be established with accuracy, but it seems that interruptions of supply occur regularly. Since most supplies are gravity systems the major causes for malfunctioning are siltation, pipe bursts due to high pressures and low pressures due to insufficient head.

Financial records are available for MoWD schemes only. Revenue collected for 3 urban schemes excluding Meru averages 81% of revenue billed. Meru water supply has poor revenue collection which is attributed to the reluctance of the Meru Municipal Council to clear their debts.

The cost per m^3 produced is estimated at about 2-4 Shs. and per beneficiary at about 50 Shs. per year. These costs show that cost sharing for water supply does not lay a heavy financial burden on the consumers.

The organisation of the O & M is generally poor, except in some NGO assisted water supplies such as Tuuru and Murugi Mugumango. A major problem in O & M is lack of funds therefore the collection of revenues is a crucial factor in improving the O & M standards. In most supplies O & M costs exceed the revenues collected. Of the rural public supplies revenue collected as percentage of O&M costs averages 30%, while that for urban supplies averages 46% (excl. Meru).

The selection of the feasible water supply technologies was done by considering the different type of water users, the distribution and user related character of the water demand and the type of water sources in the district. Other considerations were the good prospects for community participation, the poorly developed infrastructure and the limited availability of local staff.

In the rural areas supply to centres, institutions and dispersed population should be combined as much as possible. This would allow an efficient operation and maintenance of the supply and also a more easy organisation of the collection and processing of water charges.

For domestic supplies the use of surface water and springs should have priority. These sources allow simple technologies to be applied with which the Meru people have had experience for some time now. Groundwater is an alternative in some areas and may have to be exploited if surface water and springs do not yield enough water. In cases where the water quality from these sources is unacceptable or when treatment is too expensive, groundwater should also be considered.

For the supply of livestock, surface water will also have preference when available, as it is also for irrigation. Only in places where surface water is not available groundwater may be an option (Northern Grazing Area). Industries may also prefer surface water, but if water quality is important then groundwater should be preferred.

WRAP determined the typical properties and components of the water supply technologies selected for Meru District and cost estimates were made for each component. The capital costs include costs of materials, labour, transport and depreciation of construction equipment. Overhead costs, such as depreciation of vehicles, offices and supervision, are not included. Added on are 25% costs for contingencies and preliminaries.

The O & M costs were determined also, as these have to be raised by the community. The operation costs include energy, salaries, chemicals, transport and offices. The maintenance costs include spare parts, tools and costs of repairs.

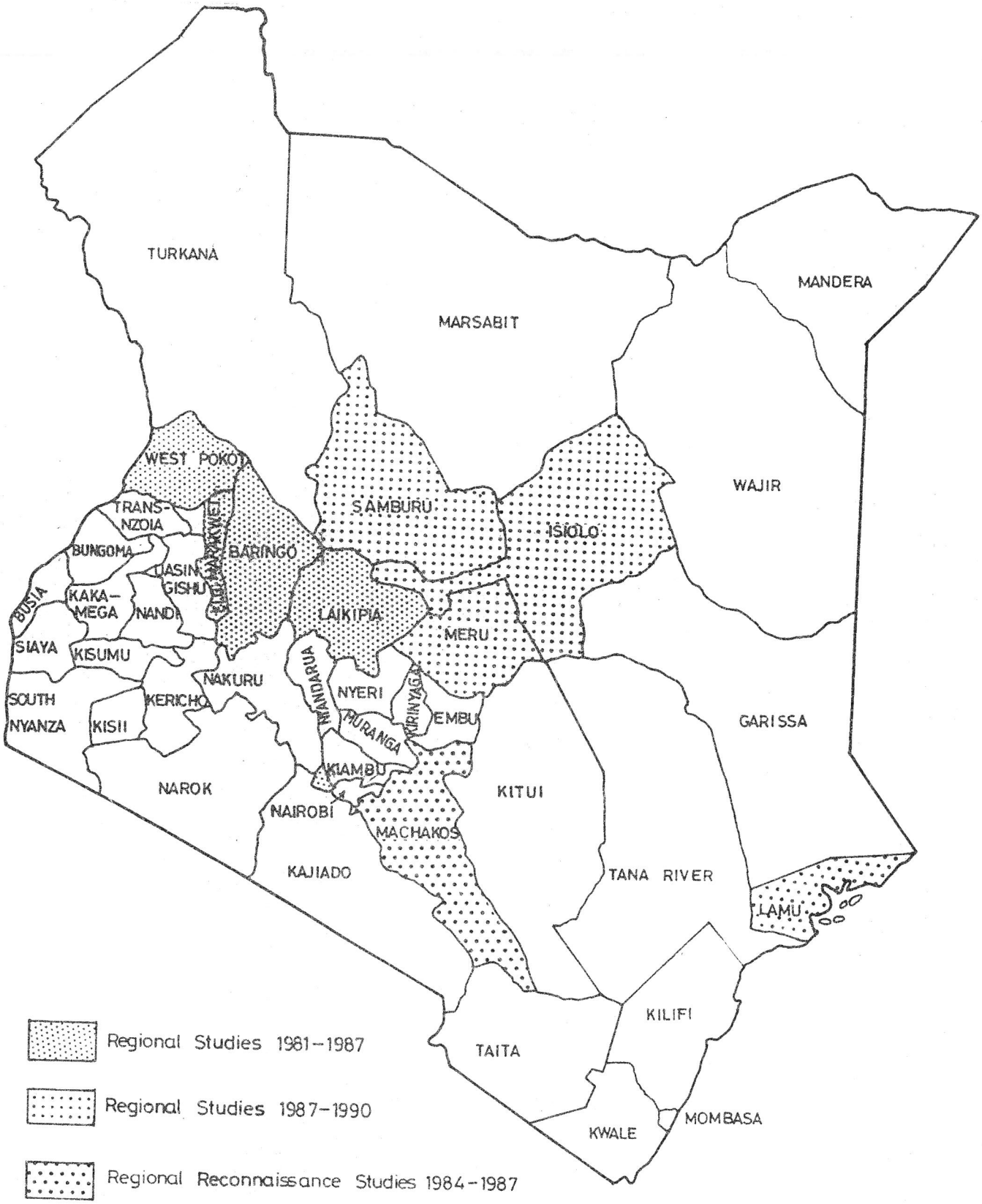
The selected technologies were analyzed using the cost effectiveness approach, which measures the cost per cubic meter capacity of each supply system over its lifetime.

The lowest cost technology applicable in a given circumstance will be the most "cost effective". The analysis was conducted for 22 different types of domestic supply systems, representing supplies to rural areas, rural centres and urban centres. The analysis was carried out over a 20 years period, and the systems were rated according to the 10% discount rate. Conclusions from this analysis must be taken as indicative due to the nature of the used estimates.

The most cost effective systems are generally the spring supplies with or without gravity distribution. However springs are not always feasible, because they are generally constricted to certain areas. Other cost effective systems are dug wells and boreholes with handpumps, followed by shallow boreholes for urban supplies. For rural centres supplies from surface water are more cost effective than from boreholes. The least cost effective system is a water supply from a dam.

The outcome of the comparison of boreholes and dug wells equipped with solar pumps, windmills or motorpumps shows that motor pumps are the most cost effective.

WATER RESOURCES ASSESSMENT & PLANNING PROJECT



Regional Assessment Studies under the WRAP Programme 1981-1990

1. INTRODUCTION

1.1 Purpose and Scope of the Study

The District Water Development Study (DWDS) of Meru District is aimed at providing the basis for the District Water Development Plan (DWDP), which in turn will be the sector input to the District Development Plan (DDP).

The study was undertaken by the Ministry of Water Development in its role of supporting the districts in their task to develop the available water resources in a safe and sustainable way. Two conditions will have to be fulfilled to achieve this goal.

- The development of water resources must be in balance both with the capacity of these resources and with the conditions set by the environment.
- Supply of water to the community must be sustainable, meaning that the proposed schemes be designed in agreement with the technical and financial support capability of the people for whom they will be constructed.

These conditions require a thorough assessment of the situation in the districts and a planning that is in tune with the socio-economic, institutional, and technical developments.

The DWDS can be considered the first stage in the process of formulating a DWDP. The study, based on extensive assessments, describes the water resources development potential in comparison to the projected water demand, discusses the viability of different water supply options in terms of sustainability and safety, and provides estimates of the investment levels involved.

The DWDP based on the study will be more specific in that it also comprises the decisions of the district authorities regarding selection and prioritization of the water development schemes. The plan is to cover a period of 20 years, according to MoWD guidelines, starting from 1993 when operation of the first new schemes will supposedly begin. The DWDP will be an important component of the DDP which includes the entire socio-economical planning of the district in perspective to all the available resources. From the above it may be clear that both plans are closely linked and can only be successfully developed in good co-ordination.

The methodology for planning of water resources development, adopted by the Ministry facilitates full participation of the district authorities, community groups and individuals concerned in all stages of the planning process, which is in line with the District Focus Policy. An outline of the general approach is given in Chapter 2 of this report. A summary of the main aspects of the District Focus Policy related to water development planning is presented in Appendix 1.

In order to provide optimal conditions for district involvement, the DWDS is carried out in three phases. District engineers and institutions concerned with water use and water supply are extensively consulted during the periods of data collection and analysis. The final report includes three volumes, corresponding with the three phases of the study. Each of these volumes is presented and discussed at a DEC-meeting.

The present report on the identification of water supply options and unit costs is Part 2 of the DWDS. The report studies the functioning of the existing water supplies in Meru District in the broad sense (quantity, quality, reliability, cost, cost recovery, operational staff, management), determines the water supply coverage for urban and rural populations, inventories the cost of various water supply technologies, and compares these costs using a cost effectiveness analysis approach. The objective of the report is to recommend affordable water supply options for the variety of situations encountered in Meru District.

1.2 International Co-operation

The District Water Development Study was undertaken under Co-operative Agreement between the Governments of Kenya and The Netherlands.

The studies are carried out by the Water Resources Assessment Section of the Ministry of Water Development, Nairobi, Kenya in co-operation with the TNO Institute of Applied Geoscience, Delft, The Netherlands, within the framework of the **Water Resources Assessment and Planning (WRAP)** project.

Consultancy services were provided by the Netherlands Economic Institute, Rotterdam, The Netherlands and the International Institute for Hydraulic and Environmental Engineering, Delft, The Netherlands.

2. GENERAL APPROACH

The District Water Development Study (DWDS) is a base study for preparation of the District Water Development Plan (DWDP). All components that constitute the DWDP are also covered by the DWDS.

The model introduced by the WRAP project for preparation of a DWDP is shown in figure 2.1. The DWDS follows this model in analysing the various components that finally will lead to the formulation of the DWDP. The study includes three phases focusing on different aspects of the planning, namely:

- the compatibility of available water resources with water demand in the present situation and for projected demand scenarios
- the viability of the technical options for water supply development based on environmental and sustainability criteria
- the investments involved in the district water development and the technical, institutional, social and financial factors determining the sustainability of selected solutions

The results obtained in the subsequent phases of the DWDS are presented in Part 1, Part 2 and Part 3 of the DWDS report. An outline of the Study is given below.

Water Demand Study (Part 1)

The water demand study comprises of analyses and projections of the water consumption by all water users in the District. The baseline data available from various sources are often incomplete and/or inaccurate. Therefore, thorough scrutiny of the data is needed to ensure sufficient reliability of further analysis. The data is processed using a Database Management System that handles both the calculation of the water demand and the projection of the baseline data.

The water demand is calculated using the procedure laid down in the Design Manual of the Ministry of Water Development. The procedure compels to projecting the water demand in 5, 15 and 25 years time. This, in turn, requires analysis of the growth trends of population, livestock, agriculture, industries, tourism, etc.

The method adopted provides for projections following three different scenarios: a high growth scenario based on optimal conditions in economical development, a medium growth scenario corresponding with national and district development expectations and a low growth scenario taking into account the less favourable conditions set by the environment.

It may be clear that the DWDS depends on the input from other sectors, such as livestock and agriculture, to complete the projections in the most realistic way.

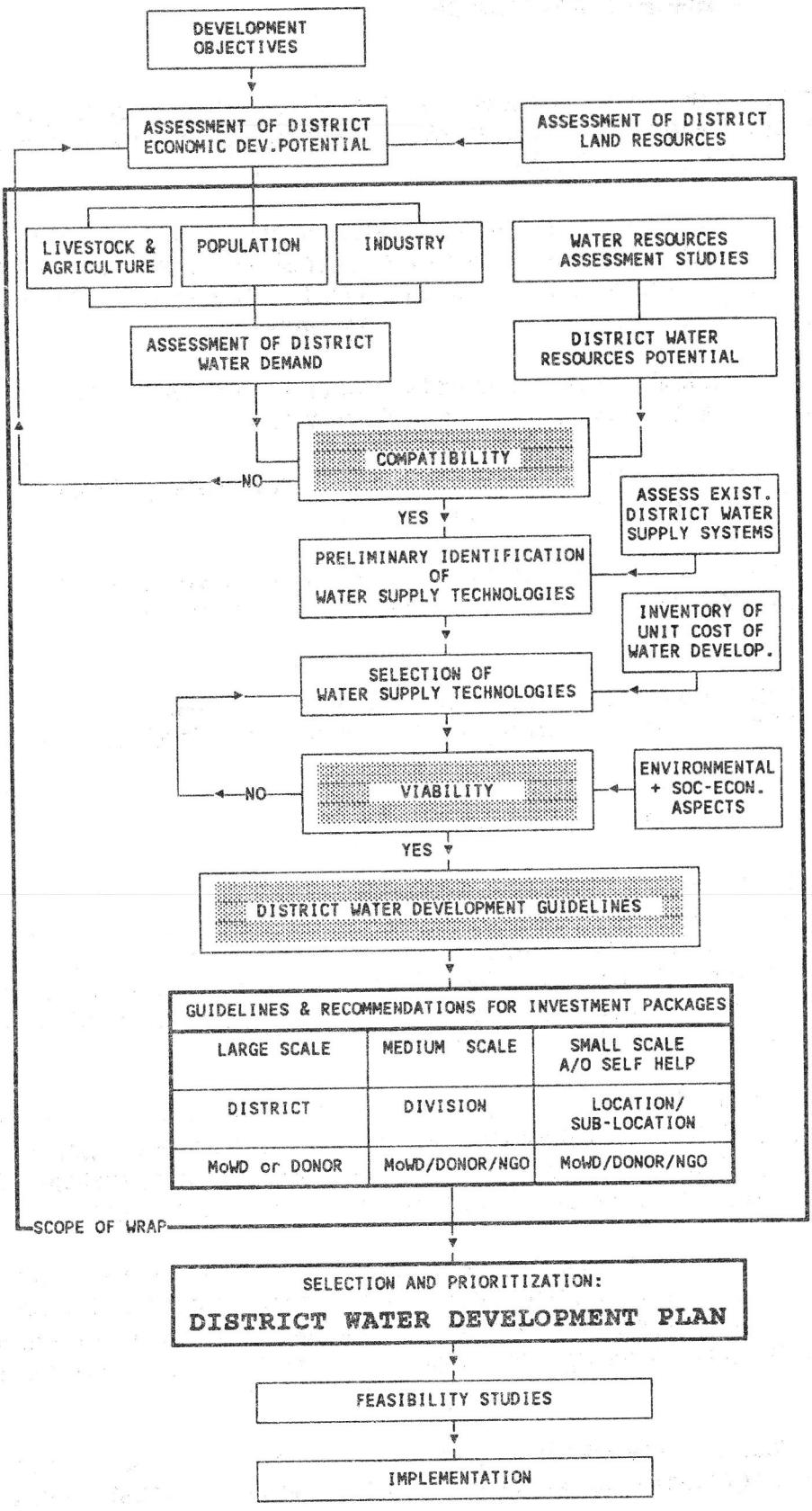


Figure 2.1 Model for Preparation of District Water Development Plan

Water Resources Assessment Study (Part 1)

Water resources assessment studies are an essential component of the DWDS. The assessment studies undertaken within the framework of the WRAP project comprise the following:

- An inventory of available data and studies on the water resources in the District
- A field survey including collection of data on surface water and groundwater, rehabilitation of part of the existing measuring stations and installation of temporary measuring stations. Measurements are made of the quantity and quality of water in rivers, springs, wells and boreholes.
- A geophysical reconnaissance survey using vertical electrical or electromagnetic soundings and profiling, aimed at providing more insight into the hydrogeological conditions. The results of the survey are checked and calibrated by drilling of exploratory boreholes and test pumping.
- An analysis of the geological, geophysical, hydrological and hydrogeological maps and data, both from the inventory and from field investigations.

From all this information and after careful and systematic analysis, water availability maps are prepared which show the water development potential of the area. The water resources assessment investigations are described in a separate report and a summary of the main conclusions on the water development potential is given in Part 1 of the DWDS report.

Comparison of Water Demand and Available Resources (Part 1)

Having estimated the water demand over the next 25 years and the water resources available in the District, a close analysis is made of the water development potential to decide whether the projected water demand can be met. This analysis of water demand versus water resources availability is carried out for each Location.

When comparing the demand with the resources, priorities need to be set whether a District can best support human, livestock, agricultural or industrial development. In this respect both quantity and quality of the water must be considered.

What emerges from this process of comparing the anticipated demand with the resources, is a description of the development potential of the District, based on water availability.

Study of Water Supply Development Options (Part 2)

From the actual and projected water demand and the capacity of existing water supply schemes, the need for further development of the water supplies can be determined.

Limited water resources, contrasting interest or expected negative environmental impact may hamper further development. However, in situations with sufficient water available, often more than one supply option can be considered. A selection of the best alternative must then be based on considerations of financial, technical and environmental viability.

Phase 2 of the DWDS includes:

- Assessment of existing district water supply systems
- Assessment of technical options for water supply improvement
- Inventory of unit costs for water development based on existing supplies
- Preliminary identification of water supply options and cost
- Study of cost-effectiveness of water supply options

The results and conclusions are presented in Part 2 of the DWDS report. Together with Part 1 this forms the basis for the 'District Water Development Guidelines'.

Formulation of Guidelines and Recommendations for Investment Packages (Part 3)

The guidelines and recommendations for the development of the district water resources result in proposals for improvement of the existing water supply situation in the District. The proposed improvements may range from very small local supplies to comprehensive water supply schemes. The investments required to improve the water supply situation have been termed investment packages.

The purpose of the investment packages is to present to the Government of Kenya and interested donors a preliminary estimate of the funds and other inputs needed for water supply development. Each investment package or a combination of them can thus form the core of a water supply project.

Phase 3 of the DWDS includes the following issues:

- Land use, environmental, social, institutional and economic/financial factors to be considered
- Guidelines for assessment of water sector investment proposals
- Examples of investment packages
- Recommendations on required institutional strengthening for implementation of the DWDP
- A framework for a proposal based on the investment packages

The analyses, results, conclusions and recommendations arrived at are presented in Part 3 of the DWDS report. The three parts of DWDS should provide the district authorities with sufficient base information for initiating further development of the water resources in the District.

3. METHODOLOGY

3.1 Introduction

The objective of Part 2 is to recommend affordable and sustainable water supply options for the variety of situations encountered in Meru District. The study distinguishes water supply for urban population in large and small trading centres, water supplies for isolated rural institutions and dispersed rural population, and water supplies for livestock.

WRAP has tried to achieve the best possible accuracy of data, but this could not always be fulfilled satisfactorily, because of insufficient quality or incompleteness of the source data. At this stage of the study WRAP considers the presented data as the best possible estimate.

The quality of the DWDP depends on the data on which the Plan is based. Accurate and realistic planning is only possible if reliable baseline data is available. In this respect the assistance from other ministries, local authorities, projects etc. is not only valuable, but also necessary, because the DWDP cannot be prepared without it. WRAP therefore recommends that much attention is given by all government ministries to the collection and dissemination of up-to-date baseline data.

The descriptions of the supply technologies remain only superficial in the present study, because already sufficient publications exist where detailed information on these can be found. However it would be useful to have a publication accompanying the DWDP which provides descriptions and designs of the technology options. Such a publication may be an update of McPherson et al (1984), which contains a very useful description of the low cost water supply technologies in Kenya. This publication contains also evaluations of implemented projects and gives proposals for new water supply projects.

3.2 Analysis of Water Supply Coverage

The objective of the analysis of the water supply coverage is to establish insight in the geographical distribution of the protected water supply.

The population served by each water supply was estimated on the basis of the areal coverage as indicated on Plate 1, by using the population projections for 1988 obtained from Part 1. For those supplies which are not shown on Plate 1 information on population served was obtained from:

- the MoWD-office in Meru
- field visits to self-help projects
- Plan International for supplies in Igembe and Ntonyiri

The population served could not actually be counted, therefore the calculated coverage can only be considered as approximate.

Water supply can be distinguished in protected and unprotected water supply. Protected water supply means that a safe water quality is ensured to the water user, without contamination reaching the supply point.

The water supply coverage is estimated for each Division for domestic water use. The estimate was made by comparing the number of urban and rural people covered by a protected water supply and those not covered.

3.3 Study of Existing Water Supplies

The objective of the study of existing water supplies is to analyse the condition and effectiveness of the supplies, in order to recommend the appropriate technologies for water supply development in Meru District.

The study of the existing water supplies in the District comprises:

1. A technical description of the water supplies
2. An analysis of the service level and functioning of the water supplies
3. A financial analysis of the water supplies
4. An analysis of the institutional arrangements

The information necessary for the study was collected at the District Water Office and at the water supplies. The main source of information at the District Water Office were the monthly Operational Charts of the MoWD water supplies. The charts consist of four sections.

Section 1: Provides quantities of chemicals used and water quality data
Section 2: Provides the number of pumping hours and fuel consumption
Section 3: Provides the number of connections and total quantities of water produced and water sold.
Section 4: Provides the operational costs, consisting of chemicals, fuel, salaries/wages, overheads, etc.

Examples of the charts are included in Appendix 1. Although the charts are the official record of a water supply, still care must be exercised in using the information. Operators or pump attendants usually fill the charts, but their data may be incomplete or inaccurate, because the usefulness of reliable information is not perceived by them.

Information on each water supply operated by private or other organisations (eg by Diocese of Meru) is available at the District Water Office from the water permit which needs to be issued for each water supply. In Meru District there are more than 1500 water permits, many of which contain inaccurate or incomplete data.
A survey format was designed for the visits to the water supplies, which consists of six sheets on which information can be recorded:

Sheet 1 General Inventory
Sheet 2.1 Inspection Form for Surface Water Sources
Sheet 2.2 Inspection Form for Groundwater Sources
Sheet 2.3 Inspection Form for Distribution System
Sheet 3 Operational Inventory
Sheet 4 Financial Inventory

Examples of the sheets are included in Appendix 1. The inventory sheets are useful and allow easy updating, whenever a supply is visited again. However the information obtained at the site often depends on the knowledge of the people present there, because there is usually not much written information.

Another source of information on the existing supplies is the inventory of infrastructure by the Ministry of Planning and National Development. The section on Water Facilities contains useful basic data.

3.4 Selection of Water Supply Technologies

The objective of the analysis of the supply options is to select the appropriate water supply technologies which suit the conditions prevailing in Meru District.

The analysis of feasible water supply options for Meru District depends on the conclusions which can be drawn from the existing water supply coverage and the functioning of the existing water supplies, taking into consideration that the selected water supply option should give the community the highest service level that it is willing to pay for, will benefit from and has the institutional capacity to sustain.

The main considerations in the selection of water supply technologies are:

- the different water users in the district, which can be distinguished in:
  - urban areas >2000 population
  - rural centres <2000 population
  - rural institutions (schools, health centres, etc.)
  - dispersed rural population mainly living in high and medium potential areas
  - industries
  - tourist lodges
  - livestock
  - wildlife
  - agriculture
- the distribution and user related character of the water demand:
  - urban areas: supply mainly through individual connections
  - rural centres: supply by combination of individual connections and communal water points
  - rural institutions: supply specifically for institution and possibly also for nearby rural population
  - dispersed rural population: supply to market centres and rural homes
  - industries and tourist lodges: large point supply of high required reliability
  - livestock: supply for sedentary and for moving animals
  - wildlife: supply for free moving animals
  - agriculture: supply for irrigation
- the type of water sources in the district
  - many perennial rivers and springs

- high rainfall areas versus low rainfall areas
- poor groundwater potential in Basement areas, resulting in low borehole yields and sometimes unsuitable water quality.
- good groundwater potential in volcanic areas

- the fairly well developed physical infrastructure, resulting in fair to good accessibility and serviceability of water supply systems

- the limited availability of local staff with adequate training in operation and maintenance of water supplies

- the problems related to the effective recovery of investment costs and costs of operation and maintenance.

The present study does not cover all water users as yet:

- industries are expected to be supplied through existing urban water supplies (eg. at Meru) or organize their own supply, therefore no separate industrial water supplies are planned for.

- tourist lodges usually organise their water supply independently, therefore these are not included.

- wildlife uses natural water resources, which are abundant both in Mt. Kenya and Meru National Park

3.5 Cost of Water Supply

The objective of the cost study is:

- to provide estimates of capital costs and operation and maintenance costs for each selected water supply technology
- to enable a cost effectiveness analysis to determine the lowest cost technology
- to provide unit costs of supplies per m^3 produced and per beneficiary for the determination of costs of investment packages.

The cost study on capital costs included:

- The collection of construction costs of complete water supplies or supply components, which can be obtained from contracts, quotations, design reports, project documents, annual project reports, etc.
- The collection of data on design capacities and number of beneficiaries
- The determination of cost per head of population or per m^3 supplied for completed water supply systems

The collected costs were updated to the 1988 price level by using price index figures obtained from the Central Bureau of Statistics.

The costs of O & M were estimated on the basis of information from the Design Manual of the MoWD or from publications. The aspects of O & M are described in paragraph 6.2 for each technology.

The type of water supplies for which costs were obtained are:

1. Domestic water supply (incl. water for livestock kept at the homes):

   a) Conventional surface water supply (intake, treatment, storage, distribution)
   b) Conventional groundwater supply (wells or boreholes, treatment, storage, distribution)
   c) Gravity spring captation systems
   d) Drilled and dug wells with electrical or diesel pumps, hand pumps, windmills and solar pumps
   e) Rainwater harvesting systems: rock catchments, roof catchments
   f) Sub-surface dams and sand dams.

2. Livestock water supply (only for areas where no permanent rivers exist, eg. NGA):

   a) Dams
   b) Pans

The system components for which costs were obtained are:

1. Water treatment plants (type, capacity)
2. Pipelines (for various diameters)
3. Reservoirs (elevated, ground level)
4. Spring captations
5. Drilled and dug wells
6. Hand pumps, windmills, solar pumps

Cost estimates for irrigation systems were not included. It is considered that the planning of irrigation systems must be done primarily from the Ministry of Agriculture and cannot be done by the Ministry of Water Development alone. As the time did not allow to coordinate this issue with the Ministry of Agriculture, the planning of irrigation systems was not included in this study. However Part 3 of the DWDS indicates the water availability for irrigation (chapter 5).

The cost study comprises a cost effectiveness analysis in which the different costs and benefit patterns are compared using the technique of discounting. This refers to the process of transferring future values into present values. The objective of the cost effectiveness analysis is to compare the economics of the different supply technologies to determine the lowest cost technology. Only direct costs are taken into account, which are incurred in establishing, operating and maintaining the water supply. Derived costs, such as costs of land degradation due to a water supply, are not considered. On the benefit side only the water produced is included. Benefits such as improved health of the population are not considered.

4 STUDY OF EXISTING WATER SUPPLY

4.1 Water Supply Coverage

4.1.1 Protected Water Supply Coverage

A protected water supply provides water of a safe quality to the user. Protected water supplies are supplies where the water at the intake is not in danger of being contaminated (e.g with an intake in the forest or a supply from a borehole) or where the water is treated (only MoWD supplies).

The availability of protected water supply for domestic purposes is restricted mainly to the towns, the trading centres, institutions and the dispersed rural population especially in the medium and high potential areas. The population outside the reach of the protected water supplies receive water from supplies which have an unsafe intake or take water directly from the source, such as springs, wells and rivers.

An estimate of the protected water supply coverage can be made on the basis of approximate population numbers served by existing water supplies. Actual counts of population served are not available, but estimates are available from the MoWD and other sources. The total population supplied from protected supplies is estimated at 361,897 or 30% of the total District population.

The MoWD supplies about 12% of the total District population. The total population served by the water supplies included in the WRAP inventory (including supplies with "unsafe" water) is 449,493 or 37.5%. If adding an estimate for the supply coverage of supplies not included in the WRAP inventory then the total coverage by water supplies in the District may be approximated at about 45% of the total population.

The number of people covered by water supplies which are currently proposed or not working, is about 135,000 or 11% of the total population. Therefore 44% of the population is estimated not to be covered in any existing or proposed water supply.

The distribution of the supply coverage between the Divisions is indicated in table 4.1. The Divisions with the poorest coverage are Tharaka, Timau and Tigania. The Divisions with the best coverage are North Imenti and Ntonyiri.

The supply coverage does not indicate the service level of the supply. As described in paragraph 4.2.2, average water production per beneficiary is sometimes low. The supply coverage therefore only indicates the number of beneficiaries using a protected water supply, but it does not indicate the level of supply they receive.

A more accurate estimate of the water supply coverage may be obtained for the District from the household survey carried out for WRAP by the University of Nottingham (Williams and M'Barine, 1990; App. 6, Part 1). This survey covered a "cross-section" of the District rural areas in Nkuene, Mitunguu and Marimanti Locations.

The household survey distinguishes four zones on the basis of the main cash crops grown: coffee/tea zone, coffee zone, coffee/cotton zone and cotton zone (see also table 4.2). The water supply coverage in the surveyed area may be assumed to be a representative sample of the rural areas in the whole district.

Table 4.1 Current Water Supply Coverage

Division Name	Water Supplies with Safe Water (Protected Water Supplies)							Other Supplies	
	MoWD - Supplies		Surface Water		Groundwater		Total No. of Benefic.	Total No. of Suppl.	Total No. of Benefic.
	No. of Suppl.	No. of Benefic.	No. of Suppl.	No. of Benefic.	No. of Suppl.	No. of Benefic.			
Nithi	2	17,714	4	20,700	-	-	38,414	3	4,400
South Imenti	4	44,965	3	4,410	-	-	48,475	30	22,066
Central Imenti	-	-	4	12,600	-	-	12,600	17	26,780
North Imenti	2	36,790	6	18,900	-	-	55,690	13	14,100
Tharaka	-	-	-	-	5	1,000	1,000	4	14,150
Timau	1	2,878	9	3,830	-	-	6,708	1	350
Igembe	1	3,500	12	44,910	20	4,000	52,410	4	4,750
Ntonyiri	-	-	1	80,000	12	3,000	83,000	-	-
Tigania	1	38,600	7	25,000	-	-	63,600	3	1,000
District Total	11	144,447	46	209,450	27	8,000	361,897	75	87,596

Division Name	Total Population (1988)	Water Supplies				Population not Served	
		Safe Water	Other	Not Working/Proposed			
		% of Divisional Population	% of Divisional Population	Total No. of Benefic.	% of Divisional Population	Total Number	% of Divisional Population
Nithi	205,528	18.7	2.1	44,000	21.4	118,714	57.8
South Imenti	149,569	33.1	14.1	20,300	13.6	58,728	39.3
Central Imenti	134,015	9.4	20.0	24,700	18.4	69,935	52.2
North Imenti	153,198	36.4	9.2	8,282	5.4	97,508	63.6
Tharaka	72,618	1.4	19.5	3,200	4.4	54,268	74.7
Timau	33,783	19.9	1.0	2,645	7.8	24,080	71.3
Igembe	130,592	40.1	3.6	25,190	19.3	48,242	36.9
Ntonyiri	116,692	71.1	-	-	-	33,692	28.9
Tigania	203,155	31.3	0.5	4,800	2.4	133,755	65.8
District Total	1,199,150	30.2	7.3	133,117	11.1	616,540	51.4

Note: 1) This estimate may include small water suppplies not covered in the inventory, therefore actual population not served is lower and estimated at 44%.

The water supplies in the first three (coffee) zones are piped surface water supplies, while supplies in the cotton zone are borehole and open furrow supplies. The coverage clearly declines with the decrease in the potential of the zones.

The total area covered by water supply in the district may be obtained from Plate 1. The areas indicated on this map cover about 22% of the residential area of Meru District. Of this 59 supplies are operational, 11 are operational but not completed, 3 are proposed and 1 is not working.

The map only shows the major supplies in the District. There are many more supplies as indicated by the large number (more than 1,500) of issued water permits. But these are often very small and are often overlapped by other bigger supplies. The above figures therefore only apply to the water supplies shown on the map.

Table 4.2 Estimated Protected Water Supply Coverage in Rural Areas (1989)

Zone	Percentage Coverage
Coffee/Tea	83%
Coffee	67%
Coffee/Cotton	40%
Cotton	12%

Note: Estimate from household survey area.

4.1.2 Unprotected Water Supply Coverage

The household survey carried out by WRAP in the rural areas of three Locations provides information on the water use from unprotected sources. There is a clear increase in use of unprotected sources going from the wet parts of the sampled area to the dry parts (table 4.2). Especially in the cotton zone most people use open water sources.

The unprotected water sources used are for the whole sample area:

	Wet Season	Dry Season
- river:	60%	70%
- furrow:	14%	9%
- spring:	12%	10%
- well:	5%	4%
- no data:	9%	7%

The distance to the water source is in the wet season more than 1 km for 46% of the households interviewed. In the dry season this percentage is a little higher.

Water is stored at the home by 41% of the households interviewed. This percentage includes households which use water supplied from taps or stand pipes outside their compound. On average 34 litres per household was stored during the night before the interview, which appeared to be 22% of the water carried to the homes.

The average time used for collection of water from sources (unprotected and protected) differs significantly between the three coffee zones and the cotton zone. In the coffee zones times are on average between 13 to 22 minutes, while in the cotton zone time spent is on average 70 minutes.

The quantity of water carried appeared not significantly different between the zones and was on average 15.8 litres per household member.

There is an observed general deterioration in water quality from west to east in the sampled area. Table 4.3 shows the water quality as perceived by the water users.

Table 4.3 Indication of Perceived Water Quality

	Perceived Water Quality		
	Unclean	Bad Taste/Smell	Contains Insects
Coffee/Tea Zone	29 (28.7%)	16 (15.8%)	22 (21.8%)
Coffee Zone	39 (49.4%)	13 (16.5%)	23 (29.1%)
Coffee/Cotton Zone	34 (54.8%)	9 (14.5%)	17 (27.4%)
Cotton Zone	53 (64.6%)	33 (40.2%)	37 (45.1%)
Total	155 (47.8%)	71 (21.9%)	99 (30.6%)

Note: From Household Survey Area

The water-related diseases encountered in this area include malaria, skin and eye infections, bilharzia, worms and diarrhoea. A breakdown of the distribution of the diseases is shown in table 4.4 below.

Both for water quality and for health problems, percentages in the coffee/cotton zone are lower. This probably reflects the beneficial effects of the Mitunguu Irrigation Scheme.

Table 4.4 Water-Related Health Problems

	Water - Related Health Problems				
	% with Malaria	% with skin/eye Infections	% with Worms	% with Diarrhoea	% with Bilharzia
Coffee/Tea Zone	56 (55.4%)	21 (20.8%)	15 (14.9%)	4 (4.0%)	2 (2.0%)
Coffee Zone	55 (69.6%)	18 (22.8%)	29 (36.7%)	12 (15.2%)	2 (2.5%)
Coffee/Cotton Zone	49 (79.0%)	17 (27.4%)	13 (21.0%)	7 (11.3%)	2 (3.2%)
Cotton Zone	73 (89.0%)	37 (45.1%)	33 (40.2%)	20 (24.4%)	3 (3.7%)
Total	233 (71.9%)	93 (28.7%)	90 (27.8%)	43 (13.3%)	9 (2.8%)

Note: From Household Survey Area

The Greater Tharaka Water and Sanitation Project collected water samples from various sources in Tharaka Division. The sampling sources included surface water, shallow aquifers (hand-dug wells, riverbeds, springs, etc), and water from boreholes. All the chemical parameters relevant for drinking water purposes were analyzed on site including bacteriological examinations.

The report on chemical analysis of water from various sources is summarized in Appendix 3a and the bacteriological examination report is summarized in Appendix 3b.

Surface Water: Surface water in Tharaka Division is generally polluted by bacteria/pathogens and probably to some extent by pesticides, fertilizers, and other chemicals. Most of the perennial rivers flow through high potential farming areas and are thus highly polluted. Pollution and turbidity levels are highest during and just after the rains. The water in these rivers is relatively clear with low turbidity during the dry season.

The perennial rivers have a common property in that they contain soft, turbid water with a good amount of dissolved mineral matter and acceptable levels (0.25-1.25 mg/l) of fluoride content as shown in Appendix 3 a. The rivers Mutonga, Kathita, Thanantu and Tana exhibit a high degree of iron content (1.6 - 2.6 Fe mg/l) that exceeds the WHO guideline value of 0.3 mg/l.

All the rivers exhibit a high degree of bacteriological pollution due to the presence of excessive numbers of both faecal and total coliforms (see Appendix 3b). This bacteriological contamination can be attributed mainly to uncontrolled human and animal activities in these rivers. This pollution renders the water from the rivers unsafe for drinking unless treated.

Groundwater: Groundwater in Tharaka Division is mineralized and exhibits fair to good quality characteristics. However, fluoride and total dissolved solids (TDS) concentrations vary significantly. In some localized areas fluoride content in the water exceeds the WHO guideline value of 1.5 mg/l. Such concentrations are considered hazardous to public health in the long-term and therefore pose a major problem to groundwater development in the area.

4.2 Assessment of Existing Water Supply

The water supplies in Meru District can be distinguished as described above in protected water supplies and un-protected water supplies. The protected water supplies are mainly the MoWD water supplies and the supplies which use water from a clear source (intake in the forest, a borehole, etc.). The unprotected water supplies are all other supplies, almost all of which are run by self-help groups. Both type of supplies are presented in this paragraph.

The inventory presented here does not cover all supplies in Meru District, but it includes the major water supplies. A number of small supplies are also included from the detailed inventory carried out in the area of Nkuene and Mitunguu Locations.

The assessment of the existing water supplies includes a technical description, and an analysis of the supplies in terms of the service level, the functioning of the systems, the financial performance and the institutional aspects. Detailed information on each supply is summarised in tables 4.13 and 4.14.

A list of all supplies included in the inventory is presented in Appendix 2, presenting the population served, the area covered had the status of the water supply in November 1990. Descriptions of some of the schemes are enclosed in Appendix 3 (for 22 schemes; all the 11 public water supplies as well as another 11 selected from the private/self help projects).

4.2.1 Technical Description

The protected water supply systems in Meru are mainly piped systems, drawing water from springs and rivers. Most of the schemes are gravity schemes, and only in public (MoWD) water supplies the water is being treated. The developed capacity of all the schemes in the district can not be estimated due to insufficient data. For the public (MoWD) water supplies this has been estimated at 21,400 m³ per day.

Table 4.5 Summary Technical Description of Existing Water Supply

Water Supply Owner	Total No. of Schemes	No. of Schemes		No. of Schemes		Total Developed Capacity (m³/day)	Average Developed Capacity (m³/day)
		Gravity	Pumped	With Treatment	Without Treatment		
Meru W/S	1	1	-	1	-	7,000	7,000
MoWD-Urban	3	2	1	3	-	898	299
MoWD-Rural	7	6	1	6	1	13,511	1,930
Tuuru W/S	1	1	-	-	1	1,700	1,700
Self-Help	40	40	-	-	40	27,937	698
Other	4	4	-	-	4	2,040	510
Total	56	54	2	10	46	53,086	948

4.2.2 Service Level

Drinking water is supplied through communal water points, kiosks, and house connections (metered or un-metered). The number and type of service connections is known for 63 supplies, however, the number of beneficiaries per unit can be only estimated. The large number of inhabitants assumed to be supplied from an individual connection may be understood from the fact that often these connections serve not only one family but rather a group of families.

Table 4.6a Estimated Service Level per Scheme

		Type of Service Connection							
		Communal Water Points				Individual Connections			
		No. of Schemes	Total No. CWP	Total No. Kiosk	No./ Scheme	No. of Schemes	Metered Connection	Non-Metered Connection	Connection / Scheme
Protected	Meru W/S	0	0	0	-	1	2,925	30	2,955
	MoWD-Urban	0	0	0	-	3	807	0	269
	MoWD-Rural	3	51	23	25	7	2,834	3,568	1,019
	Tuuru W/S	1	0	86	86	1	490	0	490
	Self-Help	11	50	0	5	14	1,189	1,328	180
	Other	0	0	0	-	0	0	0	-
	Sub-Total	15	101	109	14	26	8,245	4,926	507
Other	Self-Help	4	43	0	11	27	0	2,643	94
	Other	0	0	0	-	2	0	570	285
	Sub-Total	4	43	0	11	29	0	3,213	108
Water Supplies Total		19	144	109	13	55	8,245	8,139	298

Note: 10 schemes have both communal and individual connections

Table 4.6b Estimated Service Level per Supply Point

Water Supplies with either Communal or Individual Connections									
		Communal Water Points				Individual Connections			
		No. of Schemes	No. of Benefic.	No. of Points	Benefic. /Supply Point	No. of Schemes	No. of Benefic.	No. of Connect.	Benefic. /Connect.
Protected	Meru W/S	0	-	0	-	1	26,790	2,955	9.0
	MoWD Urban	0	-	0	-	3	12,479	807	15.5
	MoWD Rural	0	-	0	-	4	51,478	5,240	9.8
	Tuuru W/S	1	100,000	86	1,163	-	-	-	-
	Self Help	1	3,600	10	360	5	18,610	1,622	11.5
	Other	0	-	0	-	0	-	0	-
	Sub-Total	15	103,600	96	1,079	13	109,357	10,624	10.3
Other	Self Help	2	3,500	14	250	26	11,220	2,243	5.0
	Other	0	-	0	-	2	3,510	570	6.2
	Sub-Total	2	3,500	14	250	28	14,730	2,813	5.2
Water Supplies Total		17	107,100	110	974	41	124,087	13,437	9.2

The majority of the schemes, all public supplies and most of the self-help supplies have individual connections. But metered connections are only found in the protected water supplies.

The unprotected self-help supplies in table 4.6 include many of the small self-help supplies in the area around Nkubu and Mitunguu. The number of connections and the number of beneficiaries per connection in these schemes are much lower, indicating a more dense distribution system, in these small self-help supplies.

Water production is on record for all MoWD schemes and for four self-help schemes. The average water production per beneficiary varies considerably from 20 to 265 lpcd for the MoWD schemes and from 68 to 223 lpcd for the self-help schemes. This wide variation indicates that the available production figures are not accurate.

Table 4.7 Estimated Supply Level (1988)

	Production (m^3/yr)	No. of Beneficiaries	Water Production per Beneficiary (lpcd)		
			Average	Range	
				Minimum	Maximum
Meru W/S	1,728,275	26,790	176	-	-
MoWD-Urban	310,695	12,479	68	48	86
MoWD-Rural	3,838,585	105,178	100	20	265
Tuuru W/S	272,000	100,000	7.5	-	-
Self-Help	2,069,915	37,000	153	68	223
Other	14,804,400	3,510	11,556	3,636	18,580

Notes: 1. Production figure for Tuuru Water Supply applies to water sold.
2. Other supply water for irrigation

The production figures do not indicate the quantity of water supplied to the consumers. This may actually be much less due to losses in the (old) systems which are reported to reach sometimes 60-70%. The small difference in quantities of water produced and water sold in table 4.14 may therefore not represent the actual situation.

The production figure for Tuuru water supply is only 7.5 lpcd. This figure represents the actual quantity supplied to the consumers and indicates the low supply level of this scheme. Currently the distribution capacity is being improved and the supply level should go up in the near future.

The other water supplies in table 4.5 are supplying water for irrigation and therefore water production per benificiary is much higher.

4.2.3 Functioning of the Systems

Of 11 public water supply schemes, 5 are in good working condition, 4 in fair working condition, another 2 are in poor condition, whilst none are under construction or out of order. The four urban systems are in poor to good condition.

Table 4.8 Functioning of the Water Supply Systems

	Water Quality		Working Condition					
	Safe	Unsafe	Good	Fair	Poor	Not Working	Not Completed	Proposed/ Not Start.
MoWD - Urban	4	0	2	1	1	0	0	0
MoWD - Rural	7	0	3	3	1	0	0	0
Self-Help	59	104	48	31	18	4	38	19
Other	6	6	5	6	0	0	0	1
Total	76	110	58	41	20	4	38	20

Note: Working condition of 5 self-help schemes is not known

Of 166 self-help schemes, 102 schemes are operational, but 41 are not completed and 4 are not working. The not completed supplies are sometimes operational e.g if intake and part of the main line are ready. The completion of such projects may take many years.

The reliability of the schemes, expressed in the number of days without water could not be established. But interruptions of supply do occur regularly.

Since most schemes are surface gravity systems the major causes for malfunctioning are siltation, pipe bursts due to high pressures and low pressures due to insufficient head.

There are no reports on the bacteriological quality of water being distributed, except for Tharaka Division (paragraph 4.1.2). The effectiveness of the schemes in terms of providing protected water supply quality can therefore only be assumed. Quality may certainly be doubted for the numerous river schemes (private and selfhelp) that have no treatment at all (see also paragraph 4.1).

4.2.4 Financial Performance

Financial records are available for all the 11 public water supply schemes. This however, is not the case with private and self-help schemes where proper and organised documentation was found only in a minority number of schemes (Table 4.14).

The following analysis therefore must be considered as tentative. The financial records include operation costs, and revenue billed and collected. In a few cases records on the cost at the time of commissioning were available. Costs of operation and maintenance and repairs were not separated where such data were available.

Revenue collected for the 3 urban schemes excluding Meru water supply, averages 81% of revenue billed. Meru water supply on the other hand has a very poor revenue collection turn out with the revenue collected being only about 1% of the billed revenue. The poor revenue collection by the Meru Water Supply is attributed to reluctance by the Meru Municipal Council (water undertakers in the Municipal area) to clear their debts with the MoWD.

Revenue collected in the public rural schemes was 74% of the revenue billed.

Data on operation and maintenance cost were available for only 8 schemes (table 4.9). Cost recovery of O & M is generally insufficient as revenues are less than O & M costs (excluding Kaweru water supply). Tuuru water supply has the best performance of the presented supplies at 66% cost recovery.

Of the public supplies the revenue collected for rural systems averaged 30% while that for urban systems (excluding Meru water supply) averaged 46% of the operation and maintenance cost.

Table 4.9 Cost Recovery in Existing Water Supplies

Water Supply	Annual O & M Cost (Shs)	Annual Revenue		Percentage Revenue Collected to Revenue Billed	Percentage Revenue Collected to O & M Costs
		Billed (Shs)	Collected (Shs)		
Maua	101,280	75,525	26,663	35%	26%
Nkubu	288,000	193,447	151,318	78%	53%
Tigania	228,240	134,073	60,671	45%	27%
Kanyakine	218,595	62,921	60,869	97%	28%
Mitunguu	503,760	170,550	160,187	94%	32%
Tuuru	1,168,000	-	768,069	-	66%
Ng'uru Gakirwe	350,000	-	52,000	-	15%
Kaweru	100,000	-	150,000	-	150%

Table 4.10 Unit Cost of Operation

Water Supply	Operation Costs (Shs)		Annual Operat. Costs (Shs)	Number of Beneficiaries	Production (m^3/yr)
	per m^3 produced	per year and beneficiary			
Maua	1.6	29	101,280	3,500	62,700
Nkubu	2.6	79	288,000	3,665	110,175
Tigania	0.2	6	228,240	38,600	945,345
Kanyakine	2.6	52	218,595	4,200	85,462
Mitunguu	2.6	99	503,760	5,100	193,919
Tuuru	4.3	12	1,168,000	100,000	272,000
Ng'uru Gakirwe	0.2	212	350,000	1,650	2,190,000
Kaweru	0.2	15	100,000	6,500	528,520

Note: Production for Tuuru Water Supply is water sold

The operation costs per benificiary and per m^3 produced vary greatly, probably due to the poor accuracy and incompleteness of the data. The cost per m^3 produced is around 2 - 4 Shs if excluding the low extremes. The cost per benificiary is around 50 Shs per year, although bigger deviations occur from the average.

The costs per beneficiary indicate that cost sharing for water supply does not have to lay a heavy financial burden on the consumers. Even when considering that maintenance costs are not much included here.

4.2.5 Institutional Aspects

Of the 186 water supplies included in the inventory, 132 are currently operational. Together these supply 37% of the population. The largest number are the self help supplies which serve 15% of the population. All supplies use surface water or springs, groundwater supplies are not significant.

The estimate of the benificiaries served from supplies not in the inventory is 90,124, which means that currently about 55% of the District population does not receive any water supply.

Table 4.11 Agencies Operating the Existing Water Supplies

Owner/Operator	Total No. of Schemes	Operating Schemes Only		
		No. of Schemes	Beneficiaries	
			Number	% of total
MoWD {- Urban	4	4	39,269	3
{- Rural	7	7	105,178	9
Diocese of Meru	7	6	120,850	10
GOK/MoA/MoE	3	2	2,610	-
Self Help/Plan	21	14	32,440	3
Self Help	142	97	139,966	12
Other	2	2	1,180	-
Sub-Total	186	132	441,493	37
Groundwater Supplies			8,000	1
Supplies not in inventory			90,124	8
Population not served			659,533	55
Total			1,199,150	100

The MoWD operates 11 supplies, but is also involved in many self-help projects, through technical assistance in design or construction.

The 11 schemes operated by MoWD employ a total of about 130 personnel on site. Which means 1 staff member on every 1,033 beneficiaries. Supervision and supplies are provided by MoWD divisional and district staff.

Information on staff is available on three self help supplies, but only one of these is operated in a similar way as the public supplies: Murugi Mugumango. Tuuru water supply employs a small number of staff, because O & M is assisted by the missions in the supply area. Ng'uru Gakirwe has a large irrigation component and therefore has many more staff than the others. On average the three self help supplies have 1 staff member on every 3,000 beneficiaries.

Table 4.12 Staffing of Water Supplies (1989)

	Type of Scheme	Number of Beneficiaries	Number of Site Staff	Number of Site Staff	
				per scheme	per 1000 Beneficiaries
MoWD	- Meru	26,790	16	16	0.6
	-Nkubu, Chuka, Maua	12,479+	25 +	8.3	2.0
	Urban Schemes	39,269	41	10.25	1.0
MoWD	Rural Schemes	95,058	89	12.7	0.9
MoWD	**All Schemes**	134,327	130	11.8	1.0
Self Help :	Murugi Mugumango	14,700	18	18	1.2
	Ng'uru Gakirwe	1,650	6	6	3.6
	Tuuru	100,000	(15)	(15)	0.15
Self Help:	**Summary**	116,350	39	13	0.33

Note: Meru water supply staff includes 22 for Municipal Council and 12 for MoWD

The staffing figures indicate that the rural supplies need 1 staff member to every 800 - 1,100 beneficiaries. This conforms to the staffing requirements as laid down in the MoWD Design Manual and is also confirmed by experience in the Murugi Mugumango water supply.

The urban public supplies at Chuka, Nkubu and Maua seem currently to be overstaffed, but this may also be due to the relatively small number of beneficiaries.

Table 4.13 Existing Water Supplies in Meru District: Technical Data

Nr.	NAME OF SUPPLY	SUB-LOCATION OR LOCATION	SOURCE	OWNER/ ASSIST. AGENCY	YEAR COMM	PUMP PLANT	DISTRIB. CAPACITY (M3/DAY)	STORAGE (M3)	PIPES (KM)	QUAL. SOURCE	TREAT-MENT	1988 POPUL. SERVED	METER CONNC.	NON-METERED CONNC.	KIOSKS	CWP	AREA (KM2)	CATTLE TROUGH /DIP	WORK COND.
	MoWD/Urban Supplies																		
3.1	Maua	Maua	River	MoWD	1957	Gr	169	45	4	OP	Full	3,500	242	0	0	0	3	1	3
4.1	Meru	Ntima	River	MoWD-MC	1970	Gr	7,000	1600	-	OP	F,Cl	26,790	2,925	30	0	0	25	-	1
6.1	Nkubu	Nkuene	River	MoWD	1972	EP	314	125	10	OP	Full	3,665	215	0	0	0	2	0	2
7.1	Chuka	Karingani	River	MoWD	1977	Gr	415	700	-	OK	Cl	5,314	350	0	0	0	4	-	1
	MoWD/Rural Supplies																		
1.1	Timau	Kirimara	SP	MoWD	1978	Gr	130	500	41.5	OK	0	2,878	311	4	0	0	9	0	2
2.1	Tigania	Tigania Div.	SP	MoWD/SIDA	1977	Gr	2,004	324	51	OK	Cl	38,600	329	135	0	42	60	2	1
4.2	Nkabune	Nyaki	River	MoWD/SIDA	1978	Gr	293	100	8	OP	Full	10,000	304	0	20	0	10	2	1
6.2	Mwimbi	Igoji	River	MoWD	1978	Gr	4,290	325	(65)	OK	Cl	32,000	327	1,189	0	-	60	-	2
6.3	Kanyakine	Kanyakine	River	MoWD	1974	Gr/DP	270	260	32	OP	Full	4,200	437	0	0	0	15	0	3
6.4	Mitunguu	Mitunguu/ S. Tharaka	River	MoWD/SIDA	1976	Gr	624	250	18	OP	Full	5,100	394	0	3	9	45	2	1
7.2	Karingani	Karingani	River	MoWD	1970	Gr	5,900	-	-	OK	Cl	12,400	732	2,240	-	-	23	-	2
	Other Supplies																		
2.8	Kamberia	Akithii/Mituntu	SP	Miss/SH	1987	Gr	1,090	100	19.0	OK	0	12,100	-	-	-	15	60	3	1
2.9	Mbaranga	Muthara	River	Miss	1982	Gr	190	50	7.0	OK	0	3,600	0	0	0	10	5	3	1
2.10	Lailuba	Athwana	River	Miss	1983	Gr	240	10	7.0	OP	0	1,000	0	0	0	9	3	1	1
2.11	Mikinduri Girls	Mikinduri	River	Miss	1987	Gr	-	90	4.6	(OK)	0	750	0	20	0	4	2	0	1
2.12	Lanyiro	Muthara	River	Meth	-	Gr	-	14	8	OK	0	1,150	0	0	0	-	5	-	1
2.14	Tigania M. Hosp.	Muthara/Akithii	SP	Miss/SH	1967	Gr	520	60	9	OK	0	2,500	20	3	0	12	4	0	1
3.2	Tuuru	Ithima/Mutuati	SP	Miss/SH	1969	Gr	1,700	4,000	190	OK	0	100,000	490	0	86	-	550	5	2
6.	Mitunguu Irriga.	Mitunguu	River	MoA/GTZ	1985	Gr	34,560	64.4	81.0	OP	0	1,860	0	310	0	0	-	1	1
6.	Muguru Coffee Fact.	Ngonyi	River	FCU	1982	Gr	-	23	1.26	OP	0	30	0	4	0	0	-	0	1
7.14	Kathwana Pre.site	Kanjuki	River	GOK	-	Gr	150	-	-	OP	0	1,000	-	-	-	-	5	-	6
8.1	Ng'uru Gakirwe	S. Tharaka	River	Miss/SH	1989	Gr	6,000	25	29.5	OP	0	1,650	0	260	0	0	20	0	1
	Self Help Supplies																		
1.3	Mukuria	Ontulili	River	SH	UC	Gr	380	135	-	OK	0	400	-	-	-	-	5	-	1
1.4	Katheri Ontulili	Ontulili	River	SH	UC	Gr	270	-	-	OK	-	450	-	-	-	-	6	-	5
1.8	Muguna Timau	Kithithina	River	SH/RDF	UC	Gr	-	-	-	OK	(0)	300	-	-	-	-	6	-	4
1.9	Kiguru	Ngushishi	River	SH/MoWD	UC	Gr	36	135	-	OP	-	200	-	-	-	-	3	-	1
1.13	Muthatene	Buuri	SP	SH	-	Gr	-	150	-	OK	0	140	-	-	-	-	3	-	3
1.14	Marania Ntirimiti	Buuri	River	SH	-	Gr	1,500	-	-	(OK)	0	600	-	-	-	-	25	-	5
1.15	Ndurumuru	Buuri	SP	SH	UC	Gr	864	-	-	OK	-	200	-	-	-	-	5	-	5
2.4	K.K. Mwethe	Mikinduri	River	SH/RDF	1983	Gr	1,500	135	3	OK	0	4,200	-	-	-	-	8	-	2

BH = Borehole
SP = Spring
EP = Electrical Pump
DP = Diesel Pump
S = Solar Pump
HD = Hydram
Gr = Gravity
WM = Windmill
MC = Municipal Council
Plan = Plan International

Miss = Diocese of Meru
SH = Self Help
MoLD = Min. of Livestock Dev.
MoA = Min. of Agriculture
MoWD = Min. of Water Development
FCU = Farmers' Co-operative Union
EEC = European Economic Community
GOK = Government of Kenya
GTZ = German Technical Aid
Meth = Methodist Church
CHF = Canadian Hunger Foundation

CWP = Communual Water Points
OP = Organic Pollution
OK = Good Water Quality
NOK = Not Good Quality
Cl = Chlorination
F = Filtration
IP = Industrial Pollution
UC = Uncommissioned

- = No data available
0 = nil
( ) = Data not accurate

WORKING CONDITION

1 = Good
2 = Fair
3 = Poor
4 = Not Working
5 = Not Completed
6 = Not Started / Proposed

Table 4.13 (Cont.) Existing Water Supplies in Meru District: Technical Data

Nr.	NAME OF SUPPLY	SUB-LOCATION OR LOCATION	SOURCE	OWNER/ ASSIST. AGENCY	YEAR COMM	PUMP PLANT	DISTRIB. CAPACITY (M3/DAY)	STORAGE (M3)	PIPES (KM)	QUAL. SOURCE	TREAT-MENT	1988 POPUL. SERVED	METER CONNC.	NON-METERED CONNC.	KIOSKS	CWP	AREA (KM2)	CATTLE TROUGH /DIP	WORK COND.
3.3	Kaweru	Njoune, Kanjoo Athiru Ruujine	SP	SH/PLAN	1986	Gr	1,470	415	31	OP	0	6,500	0	(400)	0	28	50	29	1
3.8	Akachiu	Amungenti	SP	SH/PLAN	1986	Gr	500	150	(30)	OK	0	2,200	0	(100)	0	11	10	1	1
3.9	Amwamba	Auki	River	SH/PLAN	1987	Gr	199	125	20	OK	0	6,800	0	196	-	5	8	1	1
3.10	Athi	Kirindine	SP	SH/PLAN	1987	Gr	271	95	14.7	OK	0	1,600	0	60	0	8	10	1	2
3.11	Mukine	Kiegoi/Amwathi	River	SH/PLAN	1988	Gr	220	75	9	OP/IP	0	700	0	(200)	0	0	2	0	1
3.12	Kanjara/ Muthathene	Kiegoi	River	SH/PLAN	1989	Gr	108	75	6	OK	0	400	0	(70)	0	0	2	0	1
3.13	Ntingirai	Kiegoi	River	SH/PLAN	1990	Gr	450	130	18.5	OK	0	2,500	0	200	0	0	7	1	1
3.14	Gitwe	Burieruri	SP	SH/PLAN	1987	Gr	260	50	3.6	OK	0	3,000	0	30	0	4	4	1	1
3.15	Murimi	Antubetwe Njoune	SP	SH/PLAN	1989	Gr	294	50	8	OP	0	2,500	0	0	0	5	5	6	1
3.16	Gitura 4K Club	Amwathi	SP	SH/PLAN	1987	Gr	130	100	1.0	OK	0	2,200	0	1	0	1	-	1	1
3.17	Ngongone	Athiru Gaiti	SP	SH/PLAN	1990	Gr	260	25	4.8	OK	0	900	0	3	0	3	5	0	1
3.18	Bwathu	Athiru Gaiti	SP	SH/PLAN	1990	Gr	354	0	5	OK	0	950	0	0	0	0	5	0	1
3.19	Nthambiro	Kanjoo	SP	SH/PLAN	1988	Gr	260	0	5	OK	0	-	0	0	0	5	-	3	3
3.20	Rwaene	Amwathi	SP	SH/PLAN	1989	Gr	-	75	4.65	OK	0	-	0	(80)	0	0	-	1	1
3.21	MathaWe	Auki	SP	SH/PLAN	1990	Gr	432	20	5	OK	0	2,190	0	0	0	0	2	1	1
3.22	Muhorone	Kiegoi	SP	SH/PLAN	UC	Gr	-	-	-	OK	0	1,890	-	-	-	-	2	-	6
3.23	K.K. Karui	Kiegoi	SP	SH/PLAN	UC	Gr	-	-	-	OK	-	710	-	-	-	-	-	-	5
3.24	Kimuthi	Kangeta	SP	SH/PLAN	UC	-	-	-	-	OK	-	-	-	-	-	-	-	-	5
4.4	Naari Kirua	Kirua	River	SH/MoWD	UC	Gr	-	-	-	OK	0	9,200	-	-	-	-	44	-	2,5
4.11	Ndekero	Nyaki	SP	SH/CARE	UC	Gr	-	-	-	OK	0	300	-	-	-	-	1	-	1
4.14	Mbuta	Mwanganthia	River	SH	-	Gr	-	-	-	OP	0	1,000	-	-	-	-	2	-	2
4.16	Nyonta	Nyaki	River	SH	-	Gr	-	-	-	OP	0	2,500	-	-	-	-	8	-	2
4.19	Muguna `B'	Nyaki	River	SH	UC	Gr	-	-	-	OK	0	2,500		-	-	-	6	-	2,5
4.	Karai Kanani	Nyaki	River	SH	-	Gr	-	-	-	-	0	282	-	-	-	-	-	-	2
5.1	Katheri Nthimbiri	Abothuguchi	River	SH	1982	Gr	270	500	-	OK	0	5,800	-	-	-	-	5	-	3,5
5.3	Kibaranyeki	Abothuguchi	SP	SH	UC	Gr	1,200	130	-	OK	0	1,800	-	-	-	-	5	-	3
5.4	Magundu	Ntima	River	SH	-	Gr	-	-	-	OP	0	2,000	-	-	-	-	2	-	3
5.5	Ntumburi	Ntumburi	SP	SH/EEC	1987	Gr	743	225	55	OK	0	5,000	0	0	0	50	40	3	1
5.12	Kariene Baragu	Gatimbi	River	SH	-	Gr	-	-	-	OP	0	1,000	-	-	-	-	2	-	2
5.14	Gaitu Gaguma	Mwanganthia	River	SH	UC	Gr	1,000	135	-	OP	0	6,000	-	-	-	-	3	-	3
5.15	Ciontare	Mwanganthia	River	SH	-	Gr	1,000	-	-	OP	0	1,450	-	-	-	-	4	-	2
5.18	Mujwa Mututa	Mwanganthia	River	SH	-	Gr	2,000	-	-	OP	0	3,200	-	-	-	-	9	-	3
5.19	C.Abothuguchi	Gatimbi	River	SH	1985	Gr	1,620	300	-	OP	0	7,500	-	-	-	-	16	-	2
5.20	Kanja Women Group	Mwanganthia	River	SH/RDF	UC	Gr	-	-	-	OP	0	2,000	-	-	-	-	7	-	5
5.22	Njuthine	Mwangathia	River	SH	UC	Gr	-	-	-	OP	0	230	-	-	-	-	2	-	5
5.31	Kirie	Ngonyi	River	SH	1987	Gr	226	0	34.7	OP	0	-	0	0	0	0	-	0	2
6.5	Taita/Muguru	Nkuene	River	SH	1974	Gr	90	0	16	OP	0	(910)	0	160	0	0	4	0	2
6.6	Kithinu/Mari	Kothine	River	SH	1979	Gr	430	318	19	OP	0	3,180	0	536	0	0	4	1	2
6.7	Lower Kithangani	Kanyekine	River	SH	-	Gr	1,216	135	-	OP	-	6,000	-	-	-	-	24	-	3
6.10	Mwirangara I	Nkuene	SP	SH	1976	Gr	-	96	56	OP	0	1,000	0	500	-	-	2	1	2
6.13	Maigene	Igoki	River	SH	1976	Gr	113	136	10.8	OP	0	1,500	0	80	0	0	2	0	2
6.14	Igandene	U. Kiungone	SP	SH	-	Gr	-	-	-	OK	0	200	-	-	-	-	1	-	6
6.15	Kirugakwi	Uruku	River	SH	U.C	Gr	-	-	-	OP	0	720	0	-	0	0	1	1	5

Table 4.13 (Cont.) Existing Water Supplies in Meru District: Technical Data

Nr.	NAME OF SUPPLY	SUB-LOCATION OR LOCATION	SOURCE	OWNER/ ASSIST. AGENCY	YEAR COMM	PUMP PLANT	DISTRIB. CAPACITY (M3/DAY)	STORAGE (M3)	PIPES (KM)	QUAL. SOURCE	TREAT-MENT	1988 POPUL. SERVED	METER CONNC.	NON-METERED CONNC.	KIOSKS	CWP	AREA (KM2)	CATTLE TROUGH /DIP	WORK COND.
6.	Igoji	Igoji	River	SH	1985	Gr	1,210	-	-	-	-	6,000	-	-	-	-	-	-	-
6.	Munyaka Gitiri	Ngonyi	River	SH	1976	Gr	-	0	7.29	OP	0	(208)	0	26	0	0	-	0	1
6.	Konjunguru	Kigane	River	SH	1988	Gr	-	0	14	OP	0	1,000	0	-	-	-	-	1	1
6.	Cypriano Kimathi	Kathera	River	SH	1971	Gr	1.75	0	0.060	OP	0	15	0	1	0	0	-	1	1
6.	Gatuirura	Kathera	SP	SH	1978	Gr	-	-	1.4	OP	0	30	0	5	0	0	-	0	2
6.	Kathiano	Kathera	River	SH	1977	Gr	-	0	3.1	OP	0	250	0	31	0	0	-	0	1
6.	Mirugi/Gakuri /Nugu	Kigane	River	SH	1977	Gr	-	23	6.0	OP	0	540	0	67	0	0	-	0	1
6.	Kiruma	Kathera	River	SH	1977	Gr	-	0	3.5	OP	0	210	0	35	0	0	-	0	1
6.	Kirima	Uruku	River	SH	1977	Gr	-	0	7.2	OP	0	280	0	40	0	0	-	0	1
6.	Kanyoo	Kathera	River	SH	1984	Gr	-	0	4.4	OP	0	100	0	14	0	0	-	0	2
6.	Uruku U/Thingithu	Uruku	River	SH	1980	Gr	216	0	32	OK	0	510	0	84	0	0	-	0	1
6.	Kathima	Uruku	River	SH	1979	Gr	-	0	2.4	OP	0	65	0	13	0	0	-	0	3
6.	Marimba Ngweti	Uruku	River	SH	1987	Gr	-	0	14	OP	0	350	0	50	0	0	-	0	1
6.	Karindwa	Kathera	River	SH	1979	Gr	-	0	9.35	OP	0	260	0	26	0	0	-	0	2
6.	Nguru	Kigane	River	SH	1979	Gr	-	0	5.3	OP	0	260	0	26	0	0	-	0	1
6.	Muroe	Uruku	River	SH	1979	Gr	-	0	5	OP	0	400	0	42	0	0	-	0	3
6.	Nkui	Kirendene	River	SH	1975	Gr	-	0	13.0	OP	0	300	0	43	0	0	-	0	2
6.	Mamuru	Kirendene	River	SH	1967	Gr	-	0	8.0	OP	0	1,000	0	150	0	0	-	0	2
6.	Kithunguri/Mutheri	Ngonyi	River	SH	1974	Gr	-	0	8.85	IP	0	300	0	61	0	0	-	0	2
6.	Kithinu Green	Ngonyi	River	SH	U.C	Gr	-	0	-	OP	-	1,800	-	-	-	-	-	0	5
6.	Kinoru	Ngonyi	River	SH	1974	Gr	-	0	10.57	OP	0	500	0	70	0	0	-	0	1
6.	Kathiari	Ngonyi	River	SH	1976	Gr	-	0	1.1	OP	0	27	0	3	0	0	-	0	3
6.	Thingithu/ Kithunguri/Nkumari	Ngonyi	River	SH	UC	Gr	-	315	(20)	OP	0	2,000	0	0	0	0	-	0	5
6.	Ekumbo/Rwitu /Ndamene	Ngonyi	River	SH	1977	Gr	-	0	8.4	OP	0	525	0	35	0	0	-	1	2
6.	Kaurone	Kirendene	River	SH	1987	Gr	-	0	4.98	OP	0	200	0	25	0	0	-	0	1
6.	Ntitune Spring	Kirendene	SP	SH	UC	Gr	-	0	22.4	OK	0	500	0	81	0	0	-	0	5
6.	Pius M'Arunga	Ngonyi	BH	SH	1957	MP	-	0	0	OK	0	46	0	0	0	1	-	0	1
7.3	Murugi Mugumango	Chogoria/Kiera	River	SH/CHF	1983	Gr	1,690	-	(92)	OK	0	14,700	1,187	0	-	-	35	-	1
7.4	Gantaraki	Muthambi/Chog.	River	SH	-	Gr	(2,245)	135	-	OK	0	5,000	-	-	-	-	12	-	1
7.5	Mutindwa E.West	Chogoria	River	SH	-	Gr	-	-	-	OK	0	400	-	-	-	-	1	-	1
7.7	Magumoni	Magumoni	River	SH/MoWD /EEC	1987	Gr	2,333	500	-	OK	0	19,000	-	-	-	-	45	-	5
7.13	Gatua/Karimba /Muguna	Muthambi/ Karingani	River	SH/GOK	-	Gr	(564)	-	-	OK	0	13,700	-	-	-	-	35	-	5
7.	Mara-Kiangua Ker.	Kiera	River	SH	1987	Gr	-	-	-	OP	0	-	-	-	-	-	-	-	2
8.2	Kathita Gatunga	N. Tharaka	River	SH/Miss	-	Gr	11	-	-	OP	-	(3,000)	0	0	-	-	20	-	5
8.4	Gachiongo	N. Tharaka	River	SH	-	Gr	-	-	-	(NOK)	-	(3,000)	-	-	-	-	-	-	2
8.7	Mitunguu/Tunyai Furrow	Tunyai	River	SH	1928	Gr	-	0	(29) (furrow)	OP	0	6,500	0	0	0	0	(20)	0	3
8.9	Nkondi Solar	Nkondi	BH	SH/MoWD	1991	S	50	45	-	OK	0	2,000	-	-	-	-	-	-	5

Table 4.14 Existing Water Supplies in Meru District: Operational Data

Nr.	Name of Supply	Location	Maintenance Agency	Utilization			Average Walking Distance (Km)	Rates F/M	Water Produced (M3/Y)	Water Sold (M3/Y)	Revenue Billed (Year)	Revenue Collected (Year)	Operation & Maintenance (Kshs/Year)	Source of Information
				Households	Livestock (LU)	Irrigation								
	MoWD/Urban Supplies													
3.1	Maua	Maua	MoWD	350	583	-	-	M	62,700	56,422	75,525	26,663	101,280	3
4.1	Meru	Ntima	MoWD-MC	2,679	4,981	-	-	M	1,703,750	1,703,750	1,718,736	11,711	-	3
6.1	Nkubu	Nkuene	MoWD	366	611	-	-	M	110,175	100,471	193,447	151,318	288,000	3
7.1	Chuka	Karingani	MoWD	531	-	-	-	M	135,050	130,915	218,782	219,111	-	1
	MoWD/Rural Supplies													
1.1	Timau	Kirimara	MoWD	287	480	-	-	M	44,139	41,106	100,247	67,343	-	3
2.1	Tigania	Tigania Div.	MoWD	3,860	-	-	-	M	945,345	818,863	134,073	60,677	228,240	2
4.2	Nkabune	Nyaki	MoWD	1,000	(1,000)	-	-	M	71,199	61,680	71,036	78,901	-	3
6.2	Mwimbi	Igoji	MoWD	3,200	(4,981)	-	-	M	1,785,070	1,263,879	366,283	288,032	-	1
6.3	Kanyakine	Kanyakine	MoWD	420	(700)	-	-	M	85,462	48,421	62,921	60,869	218,595	3
6.4	Mitunguu	Mitunguu/S. Th	MoWD	510	1,247	-	-	M	193,919	121,647	170,550	160,187	503,760	3
7.2	Karingani	Karingani	MoWD	1,240	(4,000)	-	-	M	1,173,840	1,105,779	407,961	252,188	-	1
	Other Supplies													
3.2	Tuuru	Ithima/Mutuati	SH/Miss	10,000	-	-	-	F	-	272,000	-	768,069	1,168,000	3
6.	Mitunguu Irrigation	Mitunguu	MoA	186	830	Large	-	F	12,614,400	0	(150,000)	110,000	36,600	3
6.	Muguru Coffee Fact.	Mitunguu	FCU	3	6	-	-	F	-	0	0	0	0	3
7.14	Kathwana P. Site	Kanjuki	MoWD/SH	100	-	-	-	F	-	-	-	-	-	2
8.1	Ng'uru Gakirwe	South Tharaka	Miss	165	350	Large	-	F	-	2,190,000	-	52,000	350,000	3
	Self Help Supplies													
1.3	Mukuria	Ontulili	SH	40	500	-	-	F	-	-	-	-	-	3
1.4	Katheri Ontulili	Ontulili	SH	45	583	-	-	F	-	-	-	-	-	3
1.8	Muguna Timau	Kirimara	SH	30	417	-	-	F	-	-	-	-	-	3
1.9	Kiguru	Kirimara	SH	20	100	-	-	F	-	-	-	-	-	3
1.13	Muthatene	Kisima	SH	14	300	-	-	F	-	-	-	-	-	3
1.14	Marania Ntirimiti	Kisima	SH	60	833	-	-	F	-	-	-	-	-	3
1.15	Ndurumuru	Kisima	SH	20	300	-	-	F	-	-	-	-	-	3
2.4	K.K. Mwethe	Mikinduri	SH	420	5,000	-	-	F	-	-	-	-	-	3

MoWD = Ministry of Water Development
SH = Self Help
MC = Municipal Council
MoA = Ministry of Agriculture
Miss = Diocese of Meru
MoLD = Ministry of Livestock Development
FCU = Farmers' Co-operative Union

\- = No data available
( ) = Data not accurate
F = Fixed Rates
M = Metered

Source of Information:

1. Data from Operational Chart or from monthly O & M Report.
2. Data from Inventory Ministry of Planning & National Dev.
3. Data Collected from Fieldvisit
4. Data Collected from PLAN International

Table 4.14 (Cont.) Existing Water Supplies in Meru District: Operational Data

Nr.	Name of Supply	Location	Main-tenance Agency	Utilization			Average Walking Distance (Km)	Rates F/M	Water Produced (M3/Y)	Water Sold (M3/Y)	Revenue Billed (Year)	Revenue Collected (Year)	Operation & Maintenance (Kshs/Year)	Source of Inform-ation
				Households	Livestock (LU)	Irrigation								
3.3	Kaweru	Maua & Athiru Ruujine	SH	650	(12,000)	-	-	F	528,520	-	-	123,000-150,000	90-100,000	1,4
3.8	Akachiu	Akachiu	SH	220	(3,000)	-	-	F					-	
3.9	Amwamba	Akachiu	SH	680	620	-	-	F		-	-	3,000	-	4
3.10	Athi	Akachiu	SH	160	300	-	-	F		-	-	5,880	6,000	4
3.11	Mukine	Maua/Kiegoi	SH	70	(6,000)	-	-	F		-	-	2,000	-	4
3.12	Kanjara Muthathene	Kiegoi	SH	40	270	-	-	F		-	-	-	-	4
3.13	Ndingirai	Kiegoi	SH	250	1,350	-	-	F		-	-	21,120	0	4
3.14	Gitwe	Njia	SH	300	50	-	-	F		-	-	-	-	4
3.15	Murimi	Maua	SH	250	220	-	-	F		-	-	-	-	4
3.16	Gitura 4K Club	Akachiu	SH	220	270	-	-	F		-	-	-	-	4
3.17	Ngongone	Akachiu	SH	90	182	-	-	F		-	-	-	-	4
3.18	Bwathu	Akachiu	SH	95	750	-	-	F		-	-	-	0	4
3.19	Nthambiro	Maua	SH	-	-	-	-	F		-	-	-	0	4
3.20	Rwaene	Maua	SH	-	-	-	-	F		-	-	-	-	4
3.21	Mathawe	Akachiu	SH	219	660	-	-	F		-	-	-	-	4
3.22	Muhorone	Kiegoi/Akachiu	SH	189	570	-	-	F		-	-	-	-	4
4.4	Naari-Kirua	Kirua	SH	920	(3,330)	-	-	F	-	-	-	-	-	2
4.11	Ndekero	Nyaki	SH	30	67	-	-	F	-	-	-	-	-	2
4.14	Mbuta	Mwanganthia	SH	100	458	-	-	F	-	-	-	-	-	2
4.16	Nyonta	Nyaki	SH	250	670	-	-	F	(98,550)	-	-	-	-	2
4.19	Muguna 'B'	Nyaki	SH	250	2,670	-	-	F	-	-	-	-	-	2
4.	Karai Kanani	Nyaki	SH	28	47	-	-	F	-	-	-	-	-	2
5.1	Katheri Nthimbiri	Abothuguchi	SH	580	2,900	Small	-	F	-	-	-	-	-	2
5.3	Kibaranyeki	Abothuguchi	SH	180	167	-	-	F	-	-	-	-	-	2
5.4	Magundu	Ntima	SH	200	-	-	-	F	-	-	-	-	-	2
5.5	Ntumburi	Kibirichia	SH/MoWD	500	5,330	-	-	F	-	0	0	-	48,000	3
5.12	Kariene Baragu	Gatimbi	SH	100	667	-	-	F	-	-	-	-	-	2
5.14	Gaitu Gaguna	Mwanganthia	SH	600	11,670	-	-	F	-	-	-	-	-	2
5.15	Ciontare	Mwanganthia	SH	145	833	-	-	F	-	-	-	-	-	2
5.18	Mujwa Mututa	Mwanganthia	SH	320	1,083	-	-	F	-	-	-	-	-	2
5.19	Central Abothuguchi	Gatimbi	SH	750	2,667	-	-	F	591,300	-	-	-	-	2
5.20	Kanja Women Group	Mwanganthia	SH	200	450	-	-	F	-	-	-	-	-	2
5.22	Njuthine	Mwangathia	SH	230	(670)	-	-	F	-	-	-	-	-	2
5.31	Kirie	Mitunguu	SH	-	1,730	-	-	F	-	0	0	0	-	3
6.5	Taita/Muguru	Nkuene	SH	91	(700)	-	-	F	-	0	0	0	-	3
6.6	Kithinu/Mari	Igoki	SH	318	2,475	-	-	F	-	0	0	-	4,300	3
6.7	Lower Kithangari	Kanyekine	SH	600	1,000	-	-	F	-	-	-	-	-	2
6.10	Mwirangara I	Nkuene	SH	100	1,750	-	-	F	-	0	0	0	-	3
6.13	Maigene	Nkuene/Igoki	SH	150	400	-	-	F	-	0	0	-	2,400	3
6.14	Igandene	Abogeta	SH	20	(2,525)	-	-	F/M	-	-	-	-	-	2
6.15	Kirugakwi	Nkuene	SH	72	280	-	-	F	-	0	0	0	-	3

Table 4.14 (Cont.) Existing Water Supplies in Meru District: Operational Data

Nr.	Name of Supply	Location	Main-tenance Agency	Utilization			Average Walking Distance (Km)	Rates F/M	Water Produced (M3/Y)	Water Sold (M3/Y)	Revenue Billed (Year)	Revenue Collected (Year)	Operation & Maintenance (Kshs/Year)	Source of Inform-ation
				Households	Livestock (LU)	Irrigation								
6.	Igoji	Igoji	SH	600	-	-	-	M	-	-	-	-	-	2
6.	Munyaka Gitiri	Mitunguu	SH	20	78	-	-	F	-	0	0	0	0	3
6.	Konjuguru	Nkuene	SH	100	750	-	-	F	-	0	0	0	-	3
6.	Cypriano Kimathi	Nkuene	SH	1	17	-	-	F	-	0	0	0	9,600	3
6.	Gatuirura	Nkuene	SH	3	15	-	-	F	-	0	0	0	-	3
6.	Kathiano	Nkuene	SH	25	115	-	-	F	-	0	0	0	-	3
6.	Mirugi/Gakuri/Nugu	Nkuene	SH	54	158	-	-	F	-	0	0	0	-	3
6.	Kiruma	Nkuene	SH	21	93	-	-	F	-	0	0	0	-	3
6.	Kirima	Nkuene	SH	28	120	-	-	F	-	0	0	0	-	3
6.	Kanyoo	Nkuene	SH	10	80	-	-	F	-	0	0	0	-	3
6.	Uruku U/Thingithu	Nkuene	SH	51	310	-	-	F	-	0	0	0	-	3
6.	Kathima	Nkuene	SH	6	34	-	-	F	-	0	0	0	-	3
6.	Marimba Ngweti	Nkuene	SH	35	200	-	-	F	-	0	0	0	-	3
6.	Karindwa	Nkuene	SH	26	110	-	-	F	-	0	0	0	-	3
6.	Nguru	Nkuene	SH	26	80	-	-	F	-	0	0	0	-	3
6.	Muroe	Nkuene	SH	40	105	-	-	F	-	0	0	0	-	3
6.	Nkui	Mitunguu	SH	30	720	-	-	F	-	0	0	0	-	3
6.	Mamuru	Mitunguu	SH	100	1,250	-	-	F	-	0	0	0	0	3
6.	Kithunguri Mutheri	Mitunguu	SH	30	140	-	-	F	-	0	0	0	0	3
6.	Kithinu Green	Mitunguu	SH	180	916	-	-	F	-	0	0	0	0	3
6.	Kinoru	Mitunguu	SH	50	290	-	-	F	-	0	0	0	0	3
6.	Kathiari	Mitunguu	SH	3	7	-	-	F	-	0	0	0	0	3
6.	Thingithu/Kithung. Nkumari	Mitunguu	SH	200	520	-	-	F	-	0	0	0	0	3
6.	Ekumbo/Rwitu/Ndam.	Mitunguu	SH	52	207	-	-	F	-	0	0	0	0	3
6.	Kaurone	Mitunguu	SH	20	103	-	-	F	-	0	0	0	0	3
6.	Ntitune Spring	Mitunguu	SH	50	322	-	-	F	0	0	0	0	0	3
6.	Pius M'Arunga	Mitunguu	SH	5	11	-	-	F	-	0	0	0	4,020	3
7.3	Murugi Mugumango	Chogoria/Kiera	SH	1,470	4,670	Small	-	F	-	-	-	420,000	-	2
7.4	Gantaraki	Muthambi/Chog.	SH	500	667	-	-	F	-	-	-	-	-	2
7.5	Mutindwa East/West	Chogoria	SH	40	10,830	-	-	F	-	-	-	-	-	2
7.7	Magumoni	Magumoni	SH	1,900	5,689	-	-	F	851,545	-	-	-	-	2
7.1	Gatua/Muguna/Karimba	Muthambi	SH	1,370	-	-	-	F	-	-	-	-	-	2
7.	Mara-Kiangua Keria	Kiera	SH	-	-	-	-	F	-	-	-	-	-	2
8.2	Kathita Gatunga	N. Tharaka	SH	300	116	-	-	F	-	-	-	-	-	3
8.4	Gachiongo	N. Tharaka	SH	300	500	-	-	F	-	-	-	-	-	3
8.7	Mitunguu/Tunyai/ Muthangacwe Furrow	Mitunguu/ Tharaka	SH	650	9,006	Small	-	N/A	-	0	0	0	0	3

5 WATER SUPPLY DEVELOPMENT TECHNOLOGIES

5.1 Need for Improved Water Supply

The current water supply coverage by supplies using surfacewater and groundwater is about 45% of the total District population. This means that more than half of the population do not receive water from water supplies.

Of the population covered by water supplies 30% receive safe water, while 15% receive un-safe and un-treated water. To improve this situation it will be necessary to rehabilitate existing supplies by relocating intakes, replacing leaking pipes, protecting storage reservoirs and including some form of treatment, like filtration, chlorination or other.

The service level of the existing supplies is reasonable, mainly because almost all supplies use gravity distribution. However in many supplies pressures are low in at least part of the distribution system due to overutilization of the facility. Such supplies need rehabilitation because the current demand exceeds the demand, for which the system was designed.

The operation and maintenance of the supplies is done either by the Ministry of Water Development or by self help groups or by NGO's, like the Diocese of Meru. The execution of the O & M is often below standard, as may be learned from the large quantities of water not accounted for (upto 60-70%), as reported for some supplies.

The organisation of the O & M is generally poor, except in some NGO assisted water supplies such as Tuuru and Murugi Mugumango. A major problem in O & M is lack of funds therefore the collection of revenues is a crucial factor in improving the O & M standards. In most supplies O & M costs exceed the revenues collected (this is discussed in Part 3 of this study).

In part of the District (especially in North, Central and South Imenti) people have organised water supplies through small self help groups. These water supplies are inefficient compared with large schemes, if improvement of the quantity and quality of the water supplied is to be achieved. The Murugi Mugumango water supply shows that the combination of self help groups and an improved organisation structure will improve the service level. However, as at Murugi Mugumango this may not be achieved, without assistance from outside through e.g an NGO.

The DWDS in preparation for the DWDP will concentrate on proposals for improvement of domestic supplies. This includes water supply to the population and their livestock (if kept at the homestead), to institutions, to administrative offices and to commercial buildings. Water supply for irrigation is not included except for watering of kitchen gardens which is supposed to be covered by the applied unit consumption rates (Part 1).

Proposals for separate irrigation schemes or for separate livestock supplies will not be included. At this stage of the study there is not enough information to include such supplies and also there is not enough time for co-ordination with the relevant sectors.

5.2 Meru Context

5.2.1 Settlements

Four types of settlements may be distinguished in Meru, namely towns, rural and market centres, rural farms and "independent" settlements. Approximately only 3.5% of the population lives in the five main urban areas and an unknown, but probably also small percentage in the rural/market centres.

The four types of settlements have distinct water supply characteristics. These characteristics are described below:

- Small and medium size urban areas such as Meru, Nkubu, Chogoria, Maua and Chuka (population >2,000), which serve as major market centres and as service centres. Dominated by Meru town, the only Urban Council in the District, these towns support a wide range of economic activity with extensive government services, small scale industries, retailing of consumer goods and agricultural inputs. They are also transport nodes, with bus stops and matatu termini. The urban area is fairly defined, and little semi-permanent settlement is found around the town areas. Town infrastructure is better than elsewhere in the district, and includes sealed roads, water supply, electricity and, in the case of Meru town, waste water treatment. This infrastructure is usually in poor condition.

- Rural and market centres such as Igoji, Kanyakine and Mitunguu (population <2,000), in which the permanent, formal sector structures are ranged along one or two main streets (shops selling basic consumer goods, retailing of basic agricultural inputs, a coffee shop, a dispensary, etc.). Most have a water supply. Roads are not sealed and are in appalling condition. These centres serve a surrounding area of very low density farm houses.

- Farm houses in rural areas are usually positioned on individual plots. In the high potential areas the farms are small, ranging from 1 acre to 10 hectares, with the area becoming larger as the potential of the district declines (the average farm size in the household survey was 3.3 hectares). Increasingly the structures on these farms are being built of more permanent materials, with galvanised iron roofs and plastered, sometimes masonry, walls. Piped water supplies are common, especially in the high potential districts, where up to 80% of households use taps (mainly individual standpipes outside the house). Also in high potential areas, small scale irrigation of crops is practised on an increasing scale. In the drier areas, large scale irrigation schemes comprising of many small holders grow cash crops such as tobacco, cotton and Asian vegetables. Additional detail on these settlements and their water usage can be found in the Household Survey Report contained in Appendix 6 in Part 1.

- "Independent" facilities such as tourist lodges, missions, schools and health centres, and agro-processing industries (for example coffee factories) are scattered through the district. Most (schools sometimes being the exception) are well built and service modern structures, although road connections to urban centres are sometimes of poor quality.

The district is reasonably prosperous, but heavily populated. Thus the district household income is only in the upper range of the middle income districts according

to the 1981/82 Rural Household Budget Survey. Meru had a household monthly income of Shs 999 against Kajiado/Narok with Shs 1,674 and Siaya with Shs 379 (highest and lowest).

5.2.2 Infrastructure

Given the income of the district and the extensive cash economy, infrastructure in the district is poor.

Water supplies are perhaps the most advanced form of infrastructure, assisted by the ready availability of surface water in the District. But this resource is also extensively utilised, and the schemes often function at low levels of efficiency.

Two good sealed roads provide transport links to other districts and to Nairobi. But arterial feeders to these roads are in poor, sometimes atrocious condition, a product of poor roadbuilding soils and heavy traffic (the consequence of higher cash incomes). These roads do not provide adequate access to markets for a large proportion of the district cash crops, particularly coffee and tea.

Waste water treatment is an increasingly important component of infrastructure. The main areas of concern are urban waste water and coffee factory waste. Meru town has the only waste water treatment system, and this is not functioning adequately. Coffee factories are required to recycle their waste water, and to hold the un-recyclable high concentration wastes in holding ponds. Owing to lack of monitoring resources, it is not possible to assess the performance of these systems, but reported incidents of pollution have occurred. As cash crops spread through the district pollution will become a more pressing problem in rural areas.

Electricity is supplied to towns but most rural settlements are not yet connected.

5.2.3 Organisation and Attitude

Although relatively homogenous and integrated into the formal economy, the people of Meru retain strong links to their clans. There is a strong tradition of self-help activity, especially in the water sector. The household survey shows that people are willing to make, and have made, significant contributions to self help schemes, especially in high potential areas. The average amounts contributed for coffee/tea, coffee, coffee/cotton and cotton zones were Shs 4,023, 2,329, 1,974 and 517 respectively.

However, inter-clan competition has been, and continues to be, a significant issue for the district. The structure of government has been flexible enough to organise itself parallel to the clan structure, with selection of chief and sub-chiefs mostly reflecting the preferences of the clan and its elders. This being said, there remains a wide diversity of groupings within the district.

This has two implications for the development of water resources. The first implication is for design of water supplies. Within these groupings there are social groups which have differing cultural requirements and income levels which will effect their effective demand for the various technical options. These different groups can afford different amounts for their water and have different priorities with respect to availability/quality /use. The result is that they will often demand different things from water supplies.

The second implication is for the organisation structure of water supply projects. The co-operation possible within a clan is not always easy to achieve across clan lines. With water supply projects becoming larger, and encompassing more groups, this issue becomes more acute. It has been met and overcome in the Tuuru scheme with intensive efforts on the part of the Diocese of Meru required. In the Murugi-Mugumango scheme, the issue was addressed at the beginning, with donor approval conditional on the establishment of the basis for a professional management structure, independent (as far as possible) of clan loyalties.

5.3 Considerations for Technology Choice

The definition of technical options for the extension and improvement of water supply coverage should be placed within the context of the Meru situation, as described in the previous paragraphs.

For increased coverage of protected drinking water supply it is felt that a first distinction should be made where it concerns urban areas (>2000 population), rural village type settlements (<2000 population, e.g. trading centres), rural institutions, and dispersed rural population:

Major considerations in developing water supply are the following:

1. Good prospects for community participation, as shown by the great number of self help groups, which enhances the possibility for effective cost recovery;

2. Limited availability of local staff with adequate training in operation and maintenance of water supplies;

3. Poorly maintained road infrastructure and limited availability of electricity in the rural areas

4. Equal distribution of the (abundant) water resources over the district;

5. Protection of water quality in surface water streams for downstream users.

Table 5.1 Considerations for Technology Choice

Type of Supply Area	Characteristic Associated with Choice of Technology			
	Approximate Population per Supply Unit (1988)	Accessibility	Local Maintenance Capacity	Cost Recovery Potential
Meru Town & Surround.	70,000	good	good	good
Other Urban Areas	5,000	good	good	good
Rural Centres	1,000	fair	fair	good
Rural Institutions	500	fair	fair	good
Dispersed population	<100	fair to poor	fair to poor	fair

Note: The supply to rural centres, institutions and population should be combined where feasible.

The above considerations can be interpreted for the various supply areas as shown in table 5.1. In view of the above characteristics the technologies to be selected should, certainly outside the urban centres be confined to low cost technologies with minimum maintenance requirements.

In the rural areas supply to centres, institutions and dispersed population should be combined as much as possible. This would allow an efficient operation and maintenance of the supply and also a more easy organisation of the collection and processing of water charges.

5.4 Technology Choice

The sources to be considered for water supply development in Meru District as recommended in Part 1 are surfacewater, springs and groundwater:

- surface water from rivers is available in abundant quantities in many areas and it is already used in many supplies;
- springs are concentrated along the Mount Kenya and Nyambene Range and many are already used in (small) water supplies;
- groundwater is an important water resource in only some of the (drier) Divisions.

The procedure to determine the availability of the water resources for the different water users is described in Part 1. It is based on the following assumptions:

1. Surfacewater availability is determined from the analysis of runoff and rainfall and the only quantity of surfacewater not available for use in Meru District is the minimum discharge which is required into the Tana and Ewaso Nyiro rivers;

2. Springs should be used completely and preferably for domestic water supplies;

3. Groundwater availability is based on data from existing boreholes and wells; groundwater should be used in areas where the demand cannot be supplied from other water sources, due to insufficient quantity or quality, or where groundwater is better feasible than surfacewater.

Table 5.2 Water Resources Availability and Water Use in 2013 - Scenario 2 (m^3/day)

Division	Water Resources Available				Total Water Use			
	Surface Water	Springs	Ground Water	Total	Domestic Livestock	Irrigation Industries	Baseflow	Total
C. IMENTI	136,076	52,253	4,705	193,035	24,870	143,750	24,415	193,035
IGEMBE	23,833	69,984	9,882	103,699	21,073	73,700	8,867	103,640
N. IMENTI	100,510	15,501	6,162	122,173	34,534	77,050	10,178	121,762
NITHI	497,003	40,871	0	537,874	46,794	406,700	83,901	537,395
NTONYIRI	20,500	86	23,693	44,279	16,782	16,750	0	33,532
S. IMENTI	244,074	81,173	1,014	326,261	32,286	252,000	41,975	326,261
THARAKA	337,933		2,005	339,938	8,714	331,200	0	339,914
TIGANIA	133,341	78,835	9,934	222,110	33,739	162,400	25,788	221,927
TIMAU	65,069	11,403	2,088	78,560	7,090	59,700	11,814	78,604
MERU DISTR.	1,558,339	50,106	59,484	1,967,928	225,882	1,523,250	206,937	1,956,069

The proposed allocation of the water resources was determined according the following priorities (see chapter 7, Part 1):

1. Domestic water supplies (including livestock at the homesteads);

2. Reservation of surfacewater baseflow for environmental purposes and to retain a minimum inflow into the Tana and Ewaso Nyiro rivers;

3. Livestock water supply in ASAL areas;

4. Irrigation water supply in ASAL areas;

5. Industrial water supply (mainly coffee factories and agro-industries)

6. Other uses, e.g. irrigation in high potential areas, non agro-industries, etc.

The water quantities presented here are only summaries. The detailed comparison of water resources and water demand is included in Part 1.

The analysis of the required supply capacity in relation to the existing supply capacity is presented in Part 3, together with the cost estimates of the water development. These cost estimates are based on the technology choice as described in this chapter.

The technical options recommended for the provision of water supply based on the above considerations are shown in tables 5.3 and 5.4 for the various supply categories.

For rural areas, provided suitable precautions are taken to avoid source contamination, one source could provide for domestic supply through a communal water point and for livestock watering through troughs. Joint source development may be very cost-effective.

Summarizing the above, the technologies to be considered for the various types of users would be as shown in table 5.4.

Based on the above considerations and using this list of recommended technologies it was concluded that for domestic supplies the use of surface water and springs should have priority. These sources allow simple technologies to be applied with which the Meru people have had experience for some time now. Groundwater is an alternative in some areas and may have to be exploited if surface water and springs do not yield enough water. In cases where the water quality from these sources is unacceptable or when treatment is too expensive groundwater should also be considered.

For the supply of livestock surface water will also have preference when available, as it is also for irrigation. Only in places where surface water is not available groundwater may be an option (Northern Grazing Area). Industries may also prefer surface water, but if water quality is important then groundwater should be preferred.

Table 5.3 Suitability of Technologies for Domestic Water Supply

Domestic Water Supply Development Options				Suitability 1) for Supply Category 2)						
Source Development		Water Supply Development								
Source	Technology	Water Distribution	Technology	1	2	3	4	5	6	7
Surface water	Direct intake	Multiple Outlet	Gravity supply + treatment + storage + distribution	++	++	++	++	-	-	++
			Gravity supply + storage + distribution system	-	-	-	+	++	++	+
Spring	Spring Captation	Single outlet	Storage	-	+	+	++	+	-	-
		Multiple outlet	Storage + Distribution System	+	++	++	++	+	-	+
Ground-water	Drilled/Dug Well	Single outlet 3)	Hand pump	-	-	+	+	+	-	-
			Windmill + Storage	-	-	+	-	++	-	-
			Diesel pump + Storage	-	-	+	-	+	-	+
			Electrical pump + Storage	-	-	++	-	+	-	++
		Multiple outlet	Windmill + Storage + Distribution System	-	-	+	-	+	-	-
			Motor pump + Storage + Distribution System	++	++	+	-	-	-	-
Rain water	Roof Catch-ments	Single outlet	Gutters + Storage	+	++	++	++	-	-	-
	Rock Catch-ments	Single outlet	Storage	-	+	+	+	+	-	-
		Multiple outlet	Storage + gravity distrib.	-	-	+	+	+	-	-
Sub-surface dam	Sub-surface dam + dug well	Single outlet	Hand pump	-	-	+	+	-	-	-
			Windmill + Storage	-	-	+	-	+	-	-
Dam or Pan	Earth dam or Pan	Single outlet	Trough	-	-	-	-	+	-	-

Note: 1) Suitability: (-) not suitable, (+) suitable, (++) very suitable

2) Supply category:
1. Urban Centre
2. Rural Centre
3. Rural institution
4. Dispersed Rural Population
5. Livestock in ASAL area
6. Irrigation in ASAL area
7. Industry

3) Single outlet may be a communal water point/kiosk, or a single line with some CWP's or kiosks

Table 5.4 Recommended Technologies for Various Types of Users

Supply Area	Source Development	Water Supply Development 1)	Feasi-bility
Urban Areas	Surface Water Intake Drilled wells Spring protection Roof Catchment	Treatment + storage + distribution Motorpump + storage + distribution Storage + distribution Gutters + storage (individual)	++ ++ + +
Rural Centres	Surface Water Intake Drilled Well Spring Protection Roof Catchment Rock Catchment	Treatment + storage + distribution Motorpump + storage + distribution Storage + distribution Gutters, storage (individual) Storage	++ ++ ++ ++ +
Rural Institution	Surface Water Intake Spring protection Roof Catchment Dug/Drilled wells Dug/Drilled well Dug/Drilled well Sub-surface Dam Rock Catchment	Treatment + storage + distribution Storage Gutters, storage (individual) Hand pumps (small units) Windmill + storage (large unit) Motorpump + storage (large unit) Dug Well + Handpump or Windmill Storage	++ ++ ++ + + +/++ + +
Dispersed Rural Population	Surface Water Intake Spring protection Roof Catchment Rock Catchment Dug/Drilled Well Sub-surface Dam	Treatment + storage + distribution Storage + distribution Gutters, storage (individual) Storage Hand pump Dug Well + Hand pump	++ ++ ++ + + +
Livestock in ASAL Areas 2)	Surface Water Intake Dug/Drilled well Dug/Drilled wells Dug/Drilled well Spring protection Dam construction Rock Catchment	Storage + distribution Windmill, storage, trough Hand pumps Motorpump + storage Storage + distribution Fencing, trough Storage	++ ++ + + + + +
Irrigation in ASAL Areas	Surface Water Intake	Storage + distribution	++
Industry	Surface Water Intake Dug/Drilled well Spring protection	Treatment + Storage + distribution Motorpump + storage Storage + distribution	++ ++ +

1) Development shown in decreasing order of suitability for each type of supply area
2) Supply may be used also in combination with supply to rural population, provided measures are taken to ensure adequate water quality.

6. COST OF WATER SUPPLY

The objective of the cost study is to provide estimates of capital (construction) costs and operation and maintenance costs for each water supply technology which is feasible in Meru District. Both costs are used for a cost effectiveness analysis and for the determination of unit costs per m^3 produced and per benificiary.

Information on costs was obtained from the Ministry of Water Development, from NGO's working inside the MoWD (Norad, SIDA), from other water projects (LBDA, KEFINCO, etc.) and from various publications. The costs were analyzed and were adapted to enable comparison. If necessary, costs were converted to 1988 - price levels.

6.1 Description and Cost Estimates of Water Supply Technologies

The description of the technologies is included as background information to the cost estimates. The description is fairly general and designs are not given. More detailed descriptions can be found in other publications, e.g. in McPherson et al. (1984).

The estimates of construction costs given here were considered to contain the following items:

- costs of materials
- costs of skilled and unskilled labour
- costs of transport
- costs of depreciation of construction equipment

At this stage of planning, cost estimates need only be indicative, as the objective is only to provide a rough estimate of the cost of water development. Cost estimates on complete supplies or components of complete supplies were collected from many different sources. The sources of information are summarized in Appendix 4 in tables, which include:

- the total project cost or the cost of one water supply component
- population served
- costs per capita

It is often difficult to compare directly the costs from different sources for a similar water supply or water supply component, because these costs are usually not compatible. This is due to several factors, most important:

- differences in designs: apart from differences in the structural designs, also different makes of handpumps, motorpumps, etc. are being used. Sometimes materials are imported by the project (duty free).
- level of community participation: the local community is normally involved in the construction, but their required contribution, in terms of materials, labour or transport may differ. The costs of this contribution is usually not specified.
- allocation method of labour costs: labour provided by the community is sometimes paid for, but often provided free of charge. The free labour however should also be included as costs, because it must be treated as if it is a financial contribution by the community.

Table 6.1 Development Costs of Domestic Water Supply

Supply Area	Source Development	Water Supply Development	Initial Capital Cost (Shs) 1)			Annual O&M Cost (Shs)	Capital Cost/ Capita (Shs)	Annual Cost/ Capita (Shs)	Capital Cost/ m^3/day (Shs)	Annual Cost/ m^3/day (Shs)
			Source Develop.	Supply Develop.	Total Cost					
Urban Area 5,000 pop. (200 m^3/day)	Boreholes (2, 40 m)	Electr. subm. pump, storage, chlorination, distribution	625,000	4,112,500	4,737,500	524,375	940	105	23,700	2,600
	Boreholes (2, 100 m)	Electr. subm. pump, storage, chlorination, distribution	1,125,000	4,112,500	5,237,500	633,375	1,048	127	26,200	3,170
	Spring protection	Storage, chlorination, gravity distribution	500,000	4,487,500	4,987,500	304,750	998	60	24,950	1,525
	Surface Water Intake (weir)	Transmission, treatment, storage, distribution	250,000	5,687,500	5,937,500	723,375	1,188	145	29,700	3,600
	Surface Water Intake (Dam)	Transmission, treatment, storage, pump, distribution	6,250,000	5,937,500	12,187,500	941,875	2,438	188	60,950	4,700
Rural Centre 1000 pop. (40 m^3/day)	Boreholes (2, 40 m)	Windmill, storage, 6 cwp.	837,500	1,312,500	2,150,000	34,750	2,150	35	53,750	870
	Boreholes (2, 40 m)	Solar pump, storage, 6 cwp.	1,000,000	1,312,500	2,312,500	49,525	2,312	50	57,800	1,240
	Boreholes (2, 40 m)	Electr. subm. pump, storage, 6 cwp.	375,000	1,312,500	1,687,500	106,875	1,690	107	42,200	2,670
	Spring protection	Grav. supply, storage, 6 cwp	125,000	800,000	925,000	54,500	925	55	23,125	1,360
	Surface Water Intake (weir)	Gravity supply, storage, filtr. & chlor., 6 cwp.	125,000	1,300,000	1,425,000	67,250	1,425	67	35,625	1,680
	Surface Water Intake (intake chamber)	Hydram, storage, filtr. & chlor., 6 cwp.	212,500	1,300,000	1,512,500	84,125	1,512	84	37,800	2,100
Rural Institution or Rural Area 200 pop. (10 m^3/day)	Dug Well (10 m)	Handpump	37,500	75,000	112,500	500	565	2.5	11,250	50
	Borehole (40 m)	Handpump	125,000	62,500	187,500	1,875	940	9.4	18,750	188
	Spring protection	Storage, one outlet	37,500	-	37,500	500	188	2.5	3,750	50
	Surface Water Intake (intake chamber)	Gravity supply, storage, 1 cwp	62,500	268,750	331,250	15,313	1,660	77	33,125	1,530
	Roof Catchment	Gutters, storage	-	200,000	200,000	2,000	1,000	10	20,000	200
	Rock Catchment 2)	Storage	50,000	100,000	150,000	1,500	750	7.5	15,000	150

Price level: 1988

Notes: 1) For detailed estimates of capital costs, see Appendix 5.
2) Indicative cost estimate, because this depends very much on local conditions.

- allocation method of overhead costs: overhead costs differ greatly from project to project, but are often also allocated differently to the construction costs. The costs of expatriate assistance or of materials bought with overseas funds is sometimes not included in the overhead costs.

The DWDS has tried to use appropriate designs by determining the typical properties and components of the water supply technologies specific for Meru District, and to obtain separate cost estimates for these components.

The construction costs of each component were analysed and finally cost estimates were determined of the complete water supply options, which are applicable to the conditions in Meru District (Appendix 5). The costs are summarized in table 6.1.

The capital costs do not include overhead costs, such as depreciation of vehicles, costs of office staff or expatriate staff. The costs include costs of preliminaries (15%) and of contingencies (10%), which is according to the MoWD Design Manual for the preliminary design stage. For easiness both percentages were combined to 25% contingencies.

The typical properties and components of the water supply options for Meru District are described in the next paragraphs by separating source development and water supply development. The description of the source development also includes a summary of the average properties of the water sources in Meru District (see also chapter 6 of Part 1).

6.1.1 Source Development

Surface Water Intake: The intake on a perennial river may consist of a weir or a dam. The site should be at a level that allows the water to be gravitated to the supply area, and be preferably upstream of pollution sources or farming areas.

In Meru District many weirs or simply intake chambers have been constructed to divert surface water into a furrow or a pipe. The weirs are made of concrete and often require much attention, because of debris blocking the inlet. Proper design of the inlet structures is therefore very important.

Dams, which create storage at the inlet site, have not been constructed, because the continuous flow in the rivers is sufficient. The feasibility of dams has not been studied by WRAP, because the projected water demand does not require large size intake structures.

Surface water intakes are feasible at many sites in Meru District. The cost estimate for an average weir including diversion box and all fittings adopted for the Meru District Water Development is 200,000 Shs (Appendix 5).

Springs: Spring sources may be tapped with drains placed in a gravel pack and discharging into a storage chamber (spring box). The supply may consist of a single outlet and a drainage channel (design KEFINCO) or of a pipeline with communal water supply points, storage tanks and cattle troughs. This has proved to be a workable supply system in many parts of Kenya, although difficulties are experienced with maintenance of pipeline and water points. Proper protection of the catchment area is very important and surface water should be diverted away from the intake.

Artesian springs are preferred more than gravity springs due to less fluctuation in water quantity and better bacteriological quality, but most springs in Meru District are gravity springs. WRAP carried out a spring inventory, which covered more than 550 springs mainly in the Mount Kenya and Nyambene area. Spring discharges range from very small to more than 100 m^3/day.

Cost estimates on spring supplies with a single outlet were available from SIDA (Kwale Project) and FINNIDA (KEFINCO). The construction cost is about 25,000 Shs.

In Meru springs are often at some distance from the village, therefore it may be necessary to convey the water to the people. This would also be necessary if the spring is inside the forest. Therefore also options were costed including a pipeline and storage (Appendix 5).

Dug Wells: Shallow wells (or hand drilled tube wells) are feasible in areas, where sedimentary deposits exist near surface water channels. They can also be considered as means of water quality improvement as for example as off-takes in pans and dams. Shallow well siting for natural aquifers should be undertaken by specialists. Inner lining of wells may be done with rings of brick, stone or concrete rings precast or cast in situ, etc. The wells must be protected from pollution by a well cover. Abstraction of water may be done by a windmill, a hand pump or by other means.

Cost estimates of dug wells fitted with hand pumps were available from LBDA, SIDA and FINNIDA. The construction cost is about 60,000-80,000 Shs, which means a unit cost of about 300-400 Shs/capita. The unit cost determined for Meru District is 565 Shs/capita (Appendix 5). These costs do not include survey costs to determine the location of the well, which may give additional costs of about 10,000 Shs.

Drilled Wells: Drilled deep wells or boreholes are feasible at many locations in Meru District. The abstraction method depends on the demand, but can be either by motor pump, windmill or hand pump. Well siting should be undertaken by specialists, if possible using geophysical techniques. Typical properties of boreholes in Meru District are summarized in table 6.2.

Table 6.2 Average Properties of Boreholes in Meru District

	Basement Area	Mt. Kenya North Side	Mt. Kenya East Side	Kibirichia/ Kirua	Lower Slopes Nyambene	Ntonyiri Area	Nyambene Igembe	
Drilled Depth	20-40	50-150	40-70	>200	30-100	30-200	10-60	m
Length of Filters	10	20	30	?	10- 20	?	10-20	m
Borehole Yield	2-4	5-10	5-10	20	10- 40	3-6	0-10	m^3/hr
Rest Level	15-25	20-100	20-60	> 200	20- 80	deep	10-40	m
Success Rate	30%	90%	90%	90%	90%	20%	70	m

The unit cost of borehole drilling, casing, development, testing, etc. (no pump) depends on the local conditions and number of boreholes to be drilled. Appendix 4 contains some cost estimates. For the DWDS a unit cost of 2,500 Shs/m is applied.

Cost estimates of boreholes fitted with hand pumps were available from LBDA, SIDA, FINNIDA and PENCOL. The costs vary considerably, mainly due to the depth of drilling. The construction cost adopted for Meru District was based on boreholes with

a depth of 40 m and of 100 m (Appendix 5). The cost estimate does not include survey costs to determine the location of the borehole, which may give an additional cost of about 10,000-25,000 Shs or more.

Sub-Surface Dams And Sand Dams: In seasonal flow rivers, water extraction in the dry season may be improved by building a structure across the river bed under the surface to retain the sub-surface flow. Water is generally withdrawn through infiltration drains and large diameter wells up-stream of the sub-surface dam. Suitable sites often coincide with a natural barrier in a river such as a rock outcrop or impervious material in the river bed. This type of sub-surface dam has proved successful in many parts of Kenya. This method may be useful especially in areas where groundwater outside the river sediments is saline or has a high fluoride concentration.

Sand dams are useful in semi-arid areas where flood water carries a high silt load and evaporation is high. The dam should be built in stages to ensure the deposition of sand and gravel. However, often this construction in stages is ignored.

The potential for sub-surface dams or sand dams was not investigated by WRAP. But some sand dams were constructed by EMI-ASAL in Tharaka Division.

Cost estimates obtained from other studies (PENCOL, GSK) indicate a unit cost of 1500 Shs/capita. It is not clear whether costs of dug wells are included. More study of this technology is needed, to determine the feasibility in Meru District and the associated construction costs.

Rock and Roof Catchments: Rock catchments are simple in nature. Siting should take into account community access and geological structure. The best sites are found on lower reaches of bare rock inselbergs which minimise runoff loss to soil, vegetation and fractures. Storage may be provided behind dams, because generally a large storage is required (see table 6.3). The required catchment area depends on rainfall quantity and variability, but often the available area is limited due to the local conditions.

Roof Catchments for schools and other institutions where extensive roof corrugation exists, and which include guttering and ground storage tanks, may offset the water supply problem considerably. The length of dry periods must be considered in the design of the tank. First water from each shower should be prevented from entering the storage to reduce pollution by dust, leaves and bird droppings on the roof.

Table 6.3 Required Area and Storage of Rainwater Catchments

Continuous Demand (m^3/day)	Storage Tank (m^3)	250 mm rainfall		600 mm rainfall	
		Roof Area (m^2)	Rock Area (m^2)	Roof Area (m^2)	Rock Area (m^2)
1	120	2,250	3,600	940	1,500
5	600	11,250	18,000	4,690	7,500
10	1,200	22,500	36,000	9,375	15,000
20	2,400	45,000	72,000	18,750	30,000

Notes: 1) Storage capacity = 0.03 x Demand x (T + 2)
T = longest dry spell = 2 months
2) Surface Area = (450 x Demand) / coef x 90% - rain
coef = 0.8 for roof catchments and
0.5 for rock catchments

The required surface area and storage for rainwater harvesting can be estimated roughly with formulas provided in the MoWD Design manual. The 90% - probability annual rainfall is used, which varies considerably in Meru District from the high areas to the low areas.

The required sizes of storage and area indicate that in many cases rainwater can only be used as an additional drinking water source (Eg. a school with 400 m^2 roof area could supply 175 people every day with only 1-2 litre drinking water). With rock catchments the required storage capacity can only be obtained behind small dams (this solution is used frequently in Kitui District).

It was not possible to obtain good cost estimates on rock catchments. Costs of these depend very much on the local conditions. The feasibility of rock catchments is insufficiently known in Meru District. Therefore more study is needed of this technology.

Cost estimates of roof catchments are included in Appendix 4. The cost is about 1000 or more Shs/capita. It is clear that both roof and rock catchments have little potential to supply the full water demand for domestic use. More study is needed of these technologies.

Pans and Dams: Meru District has abundant surface water sources therefore the construction of pans or small dams is not very much needed. For completeness however a description is given here.

Small reservoirs (<10,000 m^3) can usually be constructed with small earth-moving equipment. They are relatively cheap and not difficult to operate and maintain. Site selection must be done by qualified personnel. Earth dams need proper catchments (conservation measures are often needed as a pre-condition). Siltation is almost inevitable if no measures are taken. Evaporation in the reservoirs is usually high. Spillways must be properly designed to prevent erosion and overtopping of the dam. The site must be properly selected to have maximum storage and should not have leakages. Care should be taken to prevent mosquito and snail breeding.

Fencing of the reservoir and dam site is necessary to prevent pollution and erosion by livestock. For domestic consumption, a shallow well at the foot of the dam where some seepage occurs, may be constructed which will draw reasonably clean water. Alternatively an off-take structure may be constructed in the lower part of the reservoir connected to a filter structure with a hand pump.

Cost estimates of dams and pans constructed in Meru District were not available. Only a few cost estimates from other Districts were available, which however vary considerably, because Baringo-estimates are based on contractor prices, while Kitui-estimates are based on a large community contribution in labour.

A rough estimate was made of total costs based on rates obtained from dam construction in Samburu District (DCU5). The unit cost per m^3 works out at 50 Shs/m^3.

- Small dams/pans (5000 m^3): 250,000 Shs
- Medium earth dams (25,000 m^3): 1,250,000 Shs

6.1.2 Supply Development

Hand pumps: These are easy to install and are not expensive. Hand pumps require regular, sometimes skilled maintenance, which if well organised, improves considerably the reliability of operation. Hand pumps can pump water from a maximum depth of 60 m, but generally the water level should be less to assure a reasonable yield and to reduce the wear and tear of the pump. The yield of the well or borehole should be between 0.5 and 2.0 m^3/hr (or more). An average person can draw the following quantities from a well:

Dynamic water level (m)	5	10	20	30	40	50
Yield (m^3/hr)	3.5	2.0	1.0	0.8	0.65	0.5

Source: (IHE, 1988)

The most common types of hand pumps installed in Kenya are:

Shallow depth	- NIRA (Kefinco), SWN (LBDA)
Medium depth	- Afridev (Kefinco, Kwale), SWN (LBDA)
Large depth	- India Mk II (Kefinco)

The Afridev and India Mk II are manufactured locally (e.g by WECO in Kakamega for Kefinco). The Afridev pump costs 14,000 Shs ex works at Nairobi. The SWN pump used by LBDA costs, including installation 14,000 - 32,000 Shs, depending on the depth of the water (Appendix 4).

Windmills (Pumps): Wind is free, therefore windmills are relatively cheap in operation. But windmills are expensive to install. They may be combined with a hand pump so that water can be pumped by hand if there is no wind. Or a diesel engine may be used as standby. If only wind power is used, a three day storage of water is required as minimum.

The most common and successful Kijito windmill is produced with four different rotor sizes (3.7, 4.9, 6.0 and 7.5 m diameter). Standard height is 9 m, but an extension to 12 m is possible. The costs are summarised in Appendix 4.

IT-Power (1989) has made a cost comparison between wind pumps and stand-alone diesel pumps. Three curves were derived for monthly wind speeds of 2.5, 3.0 and 3.5 m/s. Combinations of volume and head below the curves are those for which wind pumps provide cheaper water on a life cycle costing basis.

Hydraulic Rams: A hydraulic ram uses a large volume of water to pump a small proportion of that volume. Rams require careful adjustment. Ram pumps are relatively expensive, but easy to maintain. The application of ram pumps is limited to locations with ample flowing water. In Meru such sites are found along the many streams crossing the district.

Solar Pumps: Solar pumps are suitable in areas where sunshine is abundant. They may pump as much as 6 l/s. Sophisticated technology is required and they are not easy to repair. The cost of a complete solar pump unit is about 325,000 Shs (ex. works). Not many solar units have been installed as yet but some donors currently include solar units in their projects, therefore it will be interesting to monitor the performance of these units.

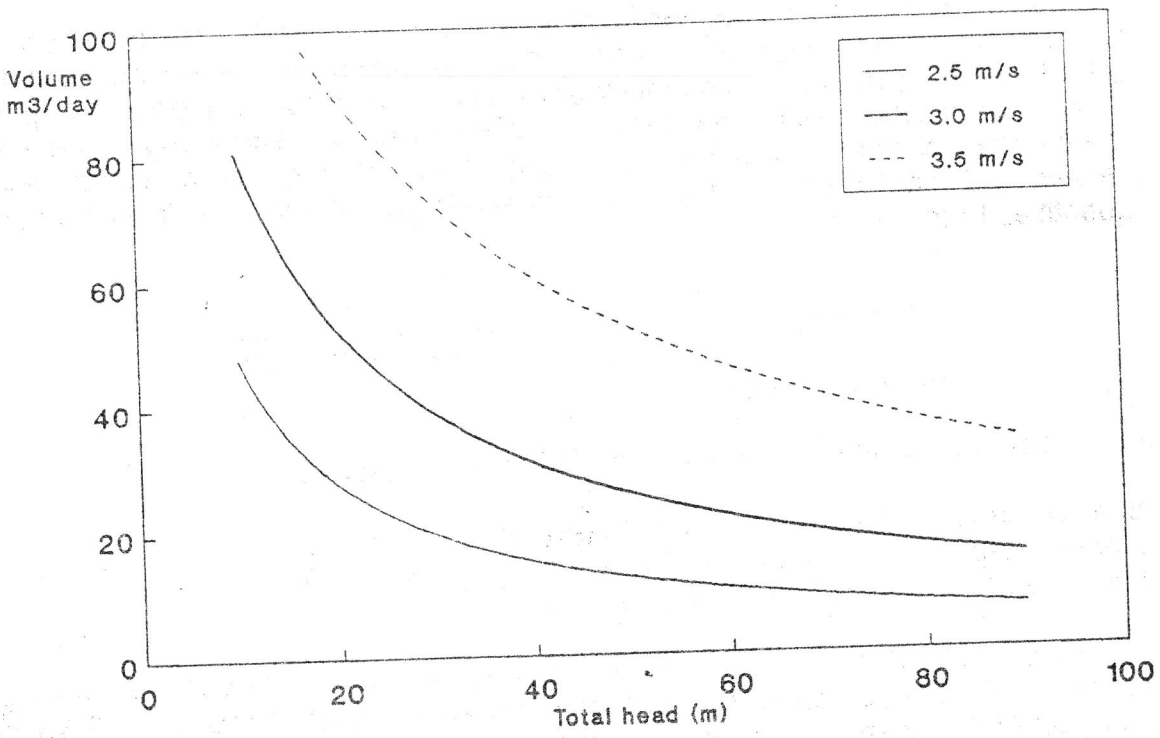


Fig. 6.1 The Economics of Wind Pumps Versus Diesel Pumps for Village and Livestock Water Supplies in Kenya (from: IT-Power, 1989)

Diesel and Electric Pumps: Diesel pumps in remote areas often lack fuel, spare parts and personnel to maintain. Electric motors need less maintenance and are more reliable and are preferred where a reliable supply of electricity is available.

The selected water supply options all deliver water by gravity to the consumers. It is assumed that motor pumps are included only to pump water from the source to the full treatment plant. The pump capacity to the treatment plant is based on 24 hours pumping. Borehole pumps are also designed to operate 24-hours.

The total cost of a diesel generator and borehole pump is estimated at 150,000 to 200,000 Shs. The cost of a pump plant in a surface water scheme between intake and supply area depends on the discharge and head but preliminary may be estimated at 500,000 Shs for 200 m^3/day supply.

Storage: Sufficient storage is required at a water supply to cover periods of peak demand or to supply water if the supply is temporarily out of order (emergency storage). The MoWD Design Manual states that emergency storage is not required in rural areas, including rural centres, except for supplies from windmills (3 days storage) or from a single borehole (1 day storage). This study however applies 1 day storage also for supplies from a spring or from surface water, including urban supplies (5000 people). The required storage for rainwater harvesting systems is already described in the previous paragraph.

The costs of storage was based on masonry/concrete tanks and was estimated at Shs 3,000 per m^3.

Treatment: Water schemes supplying domestic water always require some kind of treatment, to ensure a safe water quality. Supplies using as source springs or surface water either include treatment by filtration or chlorination only or include full treatment. Supplies using groundwater as source usually need treatment by chlorination only.

The cost of treatment works for urban supplies was estimated at 200 Shs per m^3/day for chlorination only and at 5000 Shs per m^3 for full treatment. A full treatment plant comprises chemical feeders, flocculation and sedimentation tanks, sand filters, pumps and storage for backwashing of filters.

Treatment is important in Meru District because of the intensive use of the surface-water, which is discharged back in the river without control. E.g coffee factories or urban areas discharge waste water into the rivers.

Distribution System: A piped distribution system may be included for supplies to rural areas, rural centres or urban centres. The number of connections for a typical water supply were determined at:

	Rural Centre (40 m^3/day)	Urban Area (200 m^3/day)	Urban Area (600 m^3/day)
Individual Connections	-	400	1,200
Communal Water Points	6	10	30

It is difficult to establish a unit cost for distribution systems, because it is not possible to generalizediameters and lengths of pipes. Comparison of various distribution systems installed with assistance from SIDA or Norad yielded a rough estimate which will be applied in this District Water Development Study:

- distribution system for 500 people : 400 Shs per capita
- distribution system for 5000 people : 200 Shs per capita

Costs of supply points were adopted from SIDA:

Communal water points : 15,000 Shs each
Cattle Troughs : 25,000 Shs each

The cost of an individual connection was generally estimated at 2000 Shs per connection.

6.2 Cost of Operation and Maintenance of Water Supplies

The success of a water supply depends on various factors, of which the organisation of the operation and maintenance (O & M) is one of the most important. When planning for water supply development it is crucial that the O & M is taken into account. Implementation of water supplies should not be started, unless satisfactory conditions are created for the O & M.

The policy of the government is that O & M of water supply facilities is undertaken primarily through joint efforts between the government and the beneficiaries, which requires that communities contribute significantly towards the (construction and) maintenance of facilities. It is therefore important that the communities participate in the decision making at the earliest stage possible.

Government policy is also that cost recovery is an essential element in the water supply programmes. In urban areas water prices should cover both maintenance and capital costs. In rural areas water rates should cover at least the direct O & M costs of the water supply.

The involvement of the community in the O & M of the water supplies is actively promoted in several programmes around Kenya (e.g in LBDA, Western and Kwale). The approach may differ slightly between these programmes, but generally communities are expected to participate in all phases, in the planning, construction, operation and maintenance of the supplies. Usually the communities form water committees, which are responsible for the water supply. Part 3 elaborates further on the aspect of community participation.

The O & M costs of the various selected technologies, described in the previous chapter, were estimated using information from the above mentioned programmes and from publications. O & M costs were found for only some of the supply technologies. The costs are expressed in Shs/m^3 produced (Appendix 6). The annual maintenance costs may also be estimated as a percentage of the construction (installation) cost as presented in the MoWD Design Manual (Appendix 6).

The available examples of O & M costs can not always be compared directly, because the organisation of the O & M may differ. WRAP has adopted as much as possible O & M costs, as they have to be raised by the community, without a contribution from projects or such. The O & M costs may include:

Operation:
- fuel or electricity
- salaries of operators, attendants etc.
- chemicals
- transport and offices

Maintenance:
- spare parts
- tools
- costs of repair

The true cost of spare parts are not always available, because sometimes parts have to be imported and are provided by the projects free of charge or against the duty free price. Costs of replacement due to expiry of the lifetime of materials are not included in the O & M costs. These are dealt with separately in the costing of the water supplies in Part 3. However the lifetime is indicated of the technologies described below.

Surface Water Intakes: The main attention given to intakes is to ensure that the diversion inlet is kept free from debris. Usually intakes located in the forest have little problems. But if human activities take place upstream of the intake, then much time may have to be devoted to the proper functioning of the intake.

Operation: - cost of attendant unless intake site is trouble free
Maintenance: - 1% of capital costs
Lifetime: - 40 years

Springs: The operation of a spring supply is usually easy, because it does not involve valves. It is important that a good design is used, which ensures as little as possible disturbance of the spring flow. Contamination of the spring can be prevented by protecting the area immediately above and around the spring and by keeping the collection point at a distance. The spring can also be connected to a (gravity) piped system in which case the operation becomes similar to other piped systems.

Operation: - no costs (unless a spring attendant is needed)
Maintenance: - very low, estimate 2% of capital cost
Lifetime: - 30 years

Dug Wells: The operation of a dug well depends on the installed type of pump, which are described below. Open dug wells without a cover are not considered in this study. The maintenance of dug wells which are covered is rarely required.

Operation: - no costs
Maintenance: - no costs
Lifetime: - 20 years or more

Boreholes: Generally little maintenance is needed for boreholes, if the borehole is properly designed. But the operation can be troublesome if a wrong borehole screen is installed, which causes sediments to enter. Separate operation costs are not included, as these depend on the type of pump.

Operation: - no costs
Maintenance: - 1% of capital cost
Lifetime: - 20 years

Handpumps: Many publications are available on the operation and maintenance of handpumps and therefore the description here can be short. Improvements to handpumps are made continuously and some types are now manufactured in Kenya. However some parts need to be imported, because the quality of locally available material is not sufficient (PVC pipes for rising main, pump cylinder, bearings).

The handpumps can be distinguished in VLOM (Village Level Operation and Maintenance) and not VLOM. In case communities are expected to be responsible for the O & M of handpumps, then it is necessary to install handpumps of the VLOM type. VLOM handpumps in Kenya are the NIRA 85 and Afridev both in use by KEFINCO and the latter also in Kwale. Not VLOM handpumps are the India Mark II and the SWN, which are used by respectively KEFINCO and LBDA. The costs of maintenance are indicated at 200 Shs/year by LBDA and Kwale. KEFINCO estimates the costs at 500-1000 Shs/year, which also includes the cost of repairman. Usually maintenance becomes more expensive, if the watertable is deeper.

Operation: - no costs (unless a pump attendant is paid)
Maintenance: - 500 Shs/year for handpump on a dug well
1,000 Shs/year for handpump on a borehole
Lifetime: - 6 years or more

Windmills: The O & M of windmills is easy and very little maintenance is required. Normally only some greasing is needed. An attendant is usually required and the operation costs therefore have to include his salary.

Operation: - 12,000 Shs/year (salary of attendant)
Maintenance: - 1,000 - 1,500 Shs/year
Lifetime: - 20 years

Solar Pumps: The solar pumps have only recently been introduced and not many units have been installed as yet. O & M is easy and very little maintenance is needed. The major problem may be the breakage of the panels by vandalism or wind gusts, although it appears that panels currently on the market do not break easily. Maintenance costs therefore may comprise mainly replacement of broken panels, which cost about 10,000 Shs each.

Operation: - none (unless an attendant is required)
Maintenance: - 5,000 Shs/year
Lifetime - panels:- 20 years
- pump:- 5 years (15,000 hours)

Motor Pumps: The O & M of motor pumps depends on the type. Electrical pumps usually require little maintenance. Diesel engines either driving pumps directly or through a generator, require regular maintenance. This has to be done by a mechanic, who is usually in the staff which runs the pump plant. Operation costs of motor pumps also include energy costs.

Operation: - costs include salaries + energy (electricity or fuel)
Maintenance: - Regular service of engines is needed. The MoWD estimate is 5% of the capital costs of pumps and generators.
Lifetime: - 10 years for pumps and generators

Distribution Systems: The O & M depends on the size of the system and the pressures in the pipes. Simple gravity supplied distribution systems are easy to maintain. But a proper design including gate valves, wash-outs, air-valves, etc. is needed, to ensure easy operation of the system. Storage is usually included in the system to ensure supply during peak hours.

Operation: - cost of attendant
Maintenance: - 1% of capital cost
Lifetime: - 30 years

The operation of larger distribution systems which supply urban centres normally involve a number of staff, which require an office, transport etc. The costs of O & M is estimated according the rates used by the MoWD.

Operation: - depends on number of staff
Maintenance: - 2% of capital costs (1% for piping only)
Lifetime: - 30 years

Pans and Dams: The maintenance of pans and dams is often neglected, although regular attention may improve the lifetime of the facility. A major problem is the generally high rate of erosion in the semi-arid areas, which causes a reduction in storage capacity of the reservoirs. Only measures in the catchment areas can remedy this. Scooping of the pans and dams may maintain a sufficient water storage. But if this is not done on a regular bases, than often large desalting operations are needed. These may prove just as expensive as building a new pan or dam.
Larger dams usually have an attendant, who may also be able to repair the fencing or to maintain the vegetation on and around the embankment(s). An attendant will also be required, to operate an off-take for domestic use.

Operation: - 12,000 Shs/year (salary of attendant)
Maintenance: - 5% of capital cost
Lifetime: - varies from site to site, but may be only a few years in areas with high erosion.

Sub-surface Dams and Sand Dams: The maintenance may be very little if a proper design is used. The water is usually abstracted through dug wells or a piped off-take and the O & M of these do not differ from similar supplies.

Operation: - none (unless an attendant is required)
Maintenance: - 1% of capital cost
Lifetime: - 20 years or more

Rock Catchments: The maintenance may be very little if a proper design is used.

Operation: - none (unless an attendant is required)
Maintenance: - 1% of capital cost
Lifetime: - 20 years

Roof Catchments: The O & M is done on a private basis, because the supply is either for a family or an institution. The maintenance should be very little, unless poor materials are used for gutters or storage.

Operation: - none
Maintenance: - 1% of capital cost
Lifetime: - 20 years (corrugated tanks 10 years)

6.3 Cost Effectiveness Analysis

6.3.1 Introduction

A complete economic analysis of a water supply system would take into account the costs of the system over the life of the project and compare them to the benefits of the system. In practice, while costs are relatively straightforward to establish, the full benefits of water supplies are difficult to estimate. This is particularly the case in rural supplies where time savings, health and induced economic activity will be important. A methodology for assessment of some of these benefits is set out in Paragraph 4.2 of Part 3, but it is not possible to undertake this assessment for the various systems in general as the value of these benefits (and costs) is project specific. The approach adopted in this section considers only the cost and the output of the systems.

This approach is known as cost effectiveness analysis. It measures the cost per cubic meter capacity of each system over its lifetime. The lowest cost technology applicable in a given circumstance will be the most "cost effective". Table 6.1 sets out the costing of the various types of supplies considered in the previous sections of this report. The present cost per cubic meter capacity is found using a technique known as discounting, where future expenditures are expressed in present values.

The methodology followed in discounting costs and benefits involved the following steps:

1. Estimate of the costs incurred in the system, e.g.:
   - capital costs: buildings, drilling equipment, vehicles, engines, pumps;
   - recurrent costs: staff salaries, allowances, operation & maintenance, spare parts, fuel and lubricants.
2. Estimate of the yields of water in m^3, similarly as in step 1 above, year by year.

3. Discounting of all costs figures to arrive at their present values by using different discount rates.
4. Calculation of the cost effectiveness per m^3 capacity of water supply at present value by totalling the discounted costs divided by the annual yield of the system.

The discounting was done using three different rates 5%, 10% and 15%. This range of percentages was used to indicate that the ranking of the technologies may differ according to the selected discount percentage.

Table 6.4 Results of Cost Effectiveness Analysis

Ranking Number	Technology	Total Yield (m^3)	Total Capital Costs (Shs)	Total O&M Costs (Shs)	Total Cost/m^3 (Shs) 5% disc.	10% disc.	15% disc.
Urban Area							
5	Spring, Gravity Distribution, 200 m3 St.	1,533,000	4,987,500	6,399,750	124.5	108.0	98.6
6	Spring, Gravity Distribution, 100 m3 St.	766,500	2,562,500	3,354,750	129.1	111.8	102.0
7	2 Boreholes, Motorpump, Distribution	4,599,000	12,662,500	29,812,125	143.7	117.4	102.5
8	2 Boreholes, Motorpump, Distribution	1,533,000	5,037,500	11,011,875	163.6	134.2	117.5
10	2 Boreholes, Motorpump, Distribution	766,500	2,643,750	5,516,438	167.5	138.3	121.7
13	2 Boreholes (100m), Motorpump, Distrib.	1,533,000	5,637,500	13,300,875	191.2	155.6	135.4
15	Surface Water, Weir, Distribution	1,533,000	5,937,500	15,190,875	214.7	175.6	153.3
16	2 Boreholes, Solar pump, Distribution	630,000	3,812,500	3,625,125	201.2	176.9	163.2
20	Surface Water, Weir, Pump, Distribution	1,533,000	7,562,500	18,598,125	260.0	209.0	180.1
22	Surface Water, Dam, Pump, Distribution	1,533,000	13,187,500	19,779,500	347.4	293.4	262.7
Rural Centre							
4	Spring, 40 m3 Storage	306,600	925,000	1,144,500	113.6	98.9	90.5
11	Surface Water, Chamber, Gravity Distr.	306,600	1,387,500	1,404,375	156.7	138.6	128.3
12	Surface Water, Weir, Gravity Distr.	306,600	1,425,000	1,412,250	159.6	141.4	131.0
14	Surface Water, Chamber, Hydram, Distr.	306,600	1,612,500	1,766,625	184.5	160.1	146.3
17	2 Boreholes, Motorpump, Limited Distr.	306,600	1,787,500	2,244,375	217.4	186.9	169.6
19	2 Boreholes with Windmill	252,000	2,150,000	729,750	218.2	206.7	200.2
21	2 Boreholes, Solar pump, Limited Distr.	252,000	2,432,500	1,040,025	253.2	234.6	224.2
Rural Area							
1	Spring	76,650	37,500	10,500	12.1	11.6	11.3
2	Dug Well with Handpump	76,650	187,500	10,500	44.4	39.4	36.6
3	Borehole with Handpump	76,650	262,500	39,375	70.1	63.5	59.9
9	Surface Water, Chamber, Gravity Supply	76,650	431,250	321,563	160.4	137.2	124.6
18	Dug Well with Windmill	126,000	1,012,500	358,313	207.0	195.8	189.4

Note (1) - Total Cost/m^3 is the total discounted cost per cubic meter capacity per year
(2) - Roof and rock catchments and sub-surface dams were not included in the analysis, because more detailed study is needed on their feasibility and because available cost estimates are not sufficiently accurate.
(3) - Total Capital Costs include investment + replacement costs.

6.3.2 Results of Analysis

The water supplies dealt with here will mainly supply water for domestic use. Table 6.1 on page 40 presents an overview of the cost of water supply development for the different supply areas: urban area (5,000 population), rural centre (1,000 population), rural institution (200 population) and rural area (200 population).

Indicated in table 6.1 are estimates of the initial capital (investment) costs, the annual 0 & M costs and the costs per capita and per m^3/day capacity.

The cost effectiveness exercise was conducted for 22 different types of domestic supply systems, representing supplies to rural areas, rural centres and urban areas (Appendix 7). The analysis was carried out over a 20 year period, and the systems were ranked according to the 10% discount rate (Table 6.4).

It should be noted that this analysis was carried out in order to obtain a ranking of systems according to cost effectiveness criteria. It does NOT produce an average cost of water over the lifetime of the project. These costs are discussed in paragraph 6.4.2.

6.3.3 Conclusions

The total costs in Shs/m^3 calculated for a period of operation of 20-years were used to compare technologies with different supply capacities. Due to the nature of the estimates used the following conclusions must be taken as indicative.

The ranking of the systems may differ depending on the discount rate. Systems with low O & M costs will benefit in the comparison if the discount rate is low, while systems with high O & M costs will benefit in the comparison from a high discount rate.

The most cost effective systems are generally the spring supplies with or without gravity distribution. However springs are not always feasible, because they occur only in part of the district. Other cost effective systems are dug wells and boreholes with handpumps, followed by boreholes (40 m deep) for urban supplies. For rural centres supplies from surface water are more cost effective than from boreholes, mainly due to lower capital costs.

The outcome of the comparison of boreholes equipped with solar pumps, windmills or motorpumps shows that motor pumps are the most cost effective. Systems with a solar pump or a windmill have relatively low O & M costs, but the total yield is also lower, because it was assumed that these systems supply water only during 300 days per year.

The least cost effective system is a water supply from a dam. The supply from a dam usually has high capital and O & M costs and will only be cost effective in case of a high annual yield.

6.4 Unit Cost Analysis

In addition to examining costs from the cost effectiveness viewpoint, additional insight into costs may be had by examining unit costs per capita and per m^3 produced for each water supply technology. The unit costs will be used to calculate the total cost of the water supply development in each sub-location of Meru District. This will be included in the so called investment packages, which are described in Part 3 of this study.

6.4.1 Unit Cost per Beneficiary

The water supplies dealt with here mainly supply water for domestic use. Therefore only population is considered as beneficiaries. The cost per beneficiary is estimated per head of population. The costs are based on the initial capital costs and are presented in table 6.1.

The supply to urban areas has been costed for three options: boreholes, springs or surface water intakes. The capital costs per capita of the three do not differ much at around 1,000 Shs, but the surface water option is the most expensive especially if using a dam as intake.

The supply to rural centres (1000 population) is relatively expensive due to the cost of distribution. Per capita costs for supply from surface water are 1,500 Shs. Generally the cheapest option is water supply from springs, but this option is of course feasible only if a spring can be used. The second cheapest option is an intake weir with gravity supply, which is 1,425 Shs/capita. Boreholes are more expensive, at 1,700 - 2,300 Shs per capita.

The supply of the rural population or institutions is relatively cheap, because of the simple technologies used for these small supplies. Costs per capita range from 200 Shs for the spring supply to 600 - 950 Shs for handpump supplies. Roof catchments are roughly estimated at 1,000 Shs. per capita.

6.4.2 Unit Cost per m^3

The average cost of each m^3 of water supplied during a 20-year period of operation may be calculated using the same discounting technique as described in paragraph 6.3.1. The only difference in calculation is that the annual yield is also discounted. This has been done for the systems of table 6.1 and the results are described here.

The unit cost gives an indication of the financial contribution which may be required from the rural population. The least expensive options for supply of rural population show a cost price of about 2-8 Shs/m^3 or 4-16 cts/debe (20 litres). The annual O & M cost is 2.5-10 Shs/capita.

In the rural centres and urban areas the cost price of water is generally higher at about 10 Shs/m^3 or more, depending on the technology. Only the supply from springs is less than 10 Shs/m^3.

The unit costs in Shs/m^3 should only be used indicatively, because the absolute values are considered to be insufficiently accurate. This is due to the accuracy of the estimates used and the applied limitations in costs and yields (no other benefits are included). The following conclusions can be made (the indicated unit costs refer to a discount rate of 10%):

Surface Water Intakes: The use of surface water from streams is usually attractive in case a gravity supply is possible: unit costs are about 15 - 20 Shs/m^3. But it is expensive when pumping is needed: more than 20 Shs/m^3. The O & M of surface water supplies includes treatment, which is not needed (except chlorination) for groundwater or spring supplies.

Springs: This technology generally has the lowest capital costs and unit costs: 1-2 Shs/m^3 for rural supplies, 10-12 Shs/m^3 for supplies in rural centres or urban areas.

Boreholes: Various methods to abstract the water from a borehole were analyzed. Generally boreholes are less expensive for big supplies than for small supplies. Fitted with a handpump the unit costs are about 7 Shs/m^3, depending on the daily yield. Fitted with a windmill the unit costs are about 22 Shs/m^3. Fitted with an electrical submersible pump the unit costs are 14-16 Shs/m^3 for urban supplies and about 20 Shs/m^3 for supplies to rural centres. Comparison of solar pumps, windmills and electrical pumps shows that the latter is cheaper. Supplies with solar pumps cost about 25 Shs/m^3.

Roof or Rock Catchments: The unit costs of these options were not analyzed, because this type of supply is not expected to be able to cover the water demand all year around.

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APPENDIX 1

WRAP - INVENTORY SHEETS FOR EXISTING WATER SUPPLIES

OPERATIONAL CHARTS OF MOWD WATER SUPPLIES

APPENDIX 1

WRAP - INVENTORY SHEETS FOR EXISTING WATER SUPPLIES

Sheet 1	General Inventory
Sheet 2.1	Water Supply Inspection Form for Surface Water Source
Sheet 2.2	Water Supply Inspection Form for Groundwater Sources
Sheet 2.3	Water Supply Inspection Form for Distribution System
Sheet 3	Operational Inventory
Sheet 4	Financial Inventory

OPERATIONAL CHARTS OF MOWD WATER SUPPLIES

Section 1:	Provides Quantities of Chemicals used and Water Quality Data
Section 2:	Provides the Number of Pumping Hours and Fuel Consumption
Section 3:	Provides the Number of Connections and Total Quantities of Water Produced and Water Sold.
Section 4:	Provides the Operational Costs, Consisting of Chemicals, Fuel, Salaries/Wages, Overheads, etc.

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT

-Survey of Existing Water Supplies-

GENERAL INVENTORY **SHEET 1**

Date of Field Check:

Name of Water Supply: .....

Organization: o MoWD o Council o Mission o Self Help o Other .....

District ..... Division .....

Location ..... Sub-Location .....

Map-Sheet (50 000) ..... Coordinates (UTM) X ..... Y .....

Raw Water Source: o Borehole o Shallow Well o Spring o Waterhole o Rain
o River o Lake o Dam o Pan o Rock Catchment o Other .....

Pumping Plant: o Electrical o Diesel o Handpump o Gravity o Manual
o Other .....

Discharge: Design ..... m^3/d Present ..... m^3/d

Raw Water: Storage ..... m^3 Conveyance ..... km

Clear Water: Storage ..... m^3 Distribution ..... km

Treatment: o None o Chlorination o Full o Other .....

Water Quality: o Good o High TDS o Turbid o High F o Not known
o Contamination .....

Facilities: Workshop ..... Housing ..... Laboratory ..... Office .....
Other .....

Consumer Supply Points: Individual ..... Metered no. ..... Non-metered no. .....
Kiosks ..... Cattle-troughs ..... -dips ..... Communal Waterpoints .....
Other .....

Population Served ..... Livestock ..... Irrigation .....

Commercial Establishments / Institutions Served No.: .....

.....

Operational Reliability: o Good o Medium o Bad (more on sheet 3)

.....

Project Type .....

Year of Commissioning .....

Cost at Commissioning Time .....

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT
Ministry of Water Development

WATER SUPPLY INSPECTION FORM **SHEET 2.1**
for surface water sources

1. Name of Supply: . . . . . .
2. Location: . . . . . .
3. Source: dam / pan / weir / water hole / river / lake / rock catchment / roof catchment / other: . . . . . .

4. Technical Information:

Intake structure: dam / weir / pipe / other: . . . . . .
structure material: clay / rocks / concrete / bricks / metal / other: . . . . . .
structure size: width m., height m., diameter m.
Intake storage capacity: m^3

Pumping plant: electrical / diesel / petrol / hand / gravity / none / other: . . . . . .
Discharge (estimate): m^3/day or litre/sec.

Constructed by: . . . . . .
Year of construction: 19 . .

5. Condition of Works:

Intake: good / fair / poor
Erosion: much/moderate/little/none
Spillway: silted/eroded/good/not present
Reeds: much/moderate/little/none
Dam silted: much/moderate/little/none
Leakage: much/moderate/little/none
Outlet pipe: working/not working/not pres.
Fence: good/damaged/not present

Required rehabilitation:
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

Pumping plant:
Pump: good / fair / poor
Engine: good / fair / poor

Required rehabilitation:
. . . . . .
. . . . . .
. . . . . .
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. . . . . .
. . . . . .

continue on other side

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT
Ministry of Water Development

WATER SUPPLY INSPECTION FORM for groundwater sources

SHEET 2.2

1. Name of Supply: . . . . . .
2. Location: . . . . . .
3. Source: borehole / dug well / spring / other: . . . . . .

4. Technical Information: (to be copied from inventory sheets)

Width / diameter: m. Depth: m.
Water level: m.
Discharge (estimate): m^3/day or litre/sec.
Well / borehole lining: yes/no
Type of lining: concrete / bricks / steel casing / pvc casing / . . . . . .

Pump present: yes/no Type: handpump / submersible / reciprocating / centrifugal / other: . . . . . .
Pumping plant: electrical / diesel / petrol / hand / other: . . . . . .
Discharge (estimate): m^3/day or litre/sec.

Constructed by: . . . . . .
Year of construction: 19 . .

5. Condition of Works:

	Borehole	Dug well	Spring
General structure:	good/fair/poor	good/fair/poor	good/fair/poor
Lining:	good/fair/poor	good/fair/poor	
Slab:	good/fair/poor	good/fair/poor	good/fair/poor
Structure/slab undermined:	yes/no yes/no	yes/no	
Cover/cap:	good/fair/poor	good/fair/poor	good/fair/poor
Casing:	good/fair/poor		
Screen:	good/fair/poor		
Leakage sides:	yes/no yes/no	yes/no	
Leakage underneath:	yes/no yes/no	yes/no	
Proper excess water drainage:	yes/no yes/no	yes/no	
Overflow pipe present:			yes/no
Protection agst. surf. water:	good/fair/poor	good/fair/poor	good/fair/poor
Fence: yes/no	good/fair/poor	good/fair/poor	good/fair/poor

Pumping plant:
Pump: good / fair / poor
Engine: good / fair / poor
Pump-engine connection: good / fair / poor

Required rehabilitation:

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WATER RESOURCES ASSESSMENT AND PLANNING PROJECT
Ministry of Water Development

WATER SUPPLY INSPECTION FORM **SHEET 2.3**
for distribution system

1 . Name of Supply: . . . . . .
2 . Location: . . . . . .

3 . Technical Information:

Distribution system: Total pipe length: km.
Pipe diameters: inches/mm.

Booster pumps: yes/no Number of pumps:
Pump Capacity: m^3/hr

Storage: yes/no Type: tank/other Number of tanks:
Storage capacity: m^3

Treatment plant: yes/no Type:

4 . Condition of Works:

Distribution system:
In operation?: yes/no, because . . . . . .
. . . . . .

General condition:
pipes: good/fair/poor
valves: good/fair/poor
taps: good/fair/poor
meters: good/fair/poor
pumps: good/fair/poor
storage: good/fair/poor
treatment: good/fair/poor

5 . Appraisal of facility: Comments

Supply:
Domestic: Adequate / Not adequate / None . . . . . .
Livestock: Adequate / Not adequate / None . . . . . .
Irrigation: Adequate / Not adequate / None . . . . . .

Water pressure: Sufficient / Not sufficient . . . . . .

Water quality:
Domestic: Acceptable / Not acceptable . . . . . .
Livestock: Acceptable / Not acceptable . . . . . .
Irrigation: Acceptable / Not acceptable . . . . . .

Rehabilitation works required?: yes/no
(Specify requirements on seperate quantities form)

. . . . . .
. . . . . .
. . . . . .
. . . . . continue on other side

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT

-Survey of Existing Water Supplies-

OPERATIONAL INVENTORY **SHEET 3**

Name of Water Supply: .....

Organization responsible for operation: .....

Organization responsible for maintenance: .....

Operation staff:

Designation	Task	Training Level

Maintenance: How often ? .....

Who pays for maintenance ? .....

Operation: How many working hours per day ? .....

How many days per month is supply working on average ? .....

How is fuel supply ? .....

Operation Reliability .....

Reliability of Pumps .....

Reliability of Conveyance .....

Reliability of Distribution .....

Reliability of Treatment .....

Causes of malfunctioning .....

.....

.....

.....

.....

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT

-Survey of Existing Water Supplies-

FINANCIAL INVENTORY **SHEET 4**

Date of Field Check:

Name of Water Supply: .....

	Year of Commissioning	Cost	Capacity
Intake			m3
Treatment Works			m3/d
Pipelines			km
Storage			m3
Dams/Pans			m3

Total Revenue Collected per month ..... Ksh

Flat rate per connection ..... Ksh/month No. of connections: .....

Metered Consumption Rate ..... Ksh/m^3 No. of metered connections: .....

Total Operational Costs per month ..... Ksh

Electric Power Consumption Cost per month ..... Ksh

Diesel Consumption cost per month ..... Ksh

Chemicals cost per month ..... Ksh

Staff / Labour Costs per month ..... Ksh

Maintenance Costs: Labour ..... Ksh

Spare Parts ..... Ksh

Other ..... Ksh

Other Sources of funds: state:

WATER SUPPLY OPERATION CHART - SECTION 1

EMBU WATER SUPPLY — JULY — MONTH — YEAR 1989

DAY	CHEMICAL DOSING: CHLORINE DOSAGE P.P.M.	CHLORINE WEIGHT (GRAMS)	ALUM SULPHATE DOSAGE P.P.M.	ALUM SULPHATE WEIGHT KILOGRAM	LIME AND/OR SODA-ASH PRETREATMENT DOSAGE P.P.M.	PRETREATMENT WEIGHT KILOGRAM	CONDITIONING DOSAGE P.P.M.	CONDITIONING WEIGHT KILOGRAM	RESIDUAL CHLORINE MORNING 8-0 A.M 10 MIN.	MORNING 8-0 A.M 60 MIN.	AFTERNOON 4-0 P.M. 10 MIN.	AFTERNOON 4-0 P.M. 60 MIN.	TURBIDITY P.P.M. RAW WATER	TURBIDITY P.P.M. TREATED WATER	P.H. VALUES RAW WATER	P.H. VALUES TREATED WATER SAMPLE POINT	CALCIUM STABILITY (WEEKLY) RAW WATER ORIGINAL PH	RAW WATER ORIGINAL TOTAL ALK	RAW WATER FINAL PH	RAW WATER FINAL TOTAL ALK	TREATED WATER ORIGINAL PH	TREATED WATER ORIGINAL TOTAL ALK	TREATED WATER FINAL PH	TREATED WATER FINAL TOTAL ALK	ALKALINITY (PPM) (WEEKLY) RAW WATER PHEN PHTH	RAW WATER TOTAL	TREATED WATER SAMPLE POINT PHEN PHTH	TREATED WATER SAMPLE POINT TOTAL
25	0.8	7.5	48	52			8	12	0.6	0.4	0.5	0.3	50	7	6.8	7.0												
26	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	50	7	6.8	7.0												
27	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	60	7	6.8	7.0											NIL	8	NIL	10
28	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	50	7	6.8	7.0												
29	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0	6.8	6			7.0	8						
30	0.8	7.5	48	52			8	12	0.6	0.4	0.4	0.2	40	7	6.8	7.0			8.2	28			8.4	30				
31																												
1	0.8	7.5	48	52			8	12	0.6	0.4	0.5	0.3	40	7	6.8	7.0												
2	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
3	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
4	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
5	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0	6.8	6			7.0	8						
6	0.8	7.5	48	52			8	12	0.6	0.5	0.5	0.3	40	7	6.8	7.0												
7	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0			8.2	28			8.4	30				
8	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
9	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
10	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
11	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
12	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0	6.8	8			7.0	10						
13	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
14	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0			8.4	30			8.6	32				
15	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
16	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
17	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	8	NIL	10
18	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
19	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0	6.8	6			7.0	8						
20	0.8	7.5	48	52			8	12	0.6	0.3	0.5	0.3	40	7	6.8	7.0												
21	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0			8.4	30			8.6	32				
22	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
23	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
24	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
TOTAL	Kgr. 72	Gr. 500	Kgr. 1	Gr. 560	Kgr.	Gr.	Kgr. 360	Gr. 000																				

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Water Resources Assessment and Planning Project

APPENDIX 1

WRAP - INVENTORY SHEETS FOR EXISTING WATER SUPPLIES

OPERATIONAL CHARTS OF MOWD WATER SUPPLIES

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT

-Survey of Existing Water Supplies-

GENERAL INVENTORY **SHEET 1**

Date of Field Check:

Name of Water Supply: .....

Organization: o MoWD o Council o Mission o Self Help o Other .....

District ..... Division .....

Location ..... Sub-Location .....

Map-Sheet (50 000) ..... Coordinates (UTM) X ..... Y .....

Raw Water Source: o Borehole o Shallow Well o Spring o Waterhole o Rain
o River o Lake o Dam o Pan o Rock Catchment o Other .....

Pumping Plant: o Electrical o Diesel o Handpump o Gravity o Manual
o Other .....

Discharge: Design ..... m^3/d Present ..... m^3/d

Raw Water: Storage ..... m^3 Conveyance ..... km

Clear Water: Storage ..... m^3 Distribution ..... km

Treatment: o None o Chlorination o Full o Other .....

Water Quality: o Good o High TDS o Turbid o High F o Not known
o Contamination .....

Facilities: Workshop ..... Housing ..... Laboratory ..... Office .....
Other .....

Consumer Supply Points: Individual ..... Metered no. ..... Non-metered no. .....
Kiosks ..... Cattle-troughs ..... -dips ..... Communal Waterpoints .....
Other .....

Population Served ..... Livestock ..... Irrigation .....

Commercial Establishments / Institutions Served No.: .....

.....

Operational Reliability: o Good o Medium o Bad (more on sheet 3)

.....

Project Type .....

Year of Commissioning .....

Cost at Commissioning Time .....

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT
Ministry of Water Development

WATER SUPPLY INSPECTION FORM for groundwater sources

SHEET 2.2

1. Name of Supply: . . . . . .
2. Location: . . . . . .
3. Source: borehole / dug well / spring / other: . . . . . .

4. Technical Information: (to be copied from inventory sheets)

Width / diameter: m. Depth: m.
Water level: m.
Discharge (estimate): m^3/day or litre/sec.
Well / borehole lining: yes/no
Type of lining: concrete / bricks / steel casing / pvc casing / . . . . . .

Pump present: yes/no Type: handpump / submersible / reciprocating / centrifugal / other: . . . . . .
Pumping plant: electrical / diesel / petrol / hand / other: . . . . . .
Discharge (estimate): m^3/day or litre/sec.

Constructed by: . . . . . .
Year of construction: 19 . .

5. Condition of Works:

	Borehole	Dug well	Spring
General structure:	good/fair/poor	good/fair/poor	good/fair/poor
Lining:	good/fair/poor	good/fair/poor	
Slab:	good/fair/poor	good/fair/poor	good/fair/poor
Structure/slab undermined:	yes/no yes/no	yes/no	
Cover/cap:	good/fair/poor	good/fair/poor	good/fair/poor
Casing:	good/fair/poor		
Screen:	good/fair/poor		
Leakage sides:	yes/no yes/no	yes/no	
Leakage underneath:	yes/no yes/no	yes/no	
Proper excess water drainage:	yes/no yes/no	yes/no	
Overflow pipe present:			yes/no
Protection agst. surf. water:	good/fair/poor	good/fair/poor	good/fair/poor
Fence: yes/no	good/fair/poor	good/fair/poor	good/fair/poor

Pumping plant:
Pump: good / fair / poor
Engine: good / fair / poor
Pump-engine connection: good / fair / poor

Required rehabilitation:

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

. . . . . continue on other side

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT

-Survey of Existing Water Supplies-

OPERATIONAL INVENTORY **SHEET 3**

Name of Water Supply: .....

Organization responsible for operation: .....

Organization responsible for maintenance: .....

Operation staff:

Designation	Task	Training Level

Maintenance: How often ? .....

Who pays for maintenance ? .....

Operation: How many working hours per day ? .....

How many days per month is supply working on average ? .....

How is fuel supply ? .....

Operation Reliability .....

Reliability of Pumps .....

Reliability of Conveyance .....

Reliability of Distribution .....

Reliability of Treatment .....

Causes of malfunctioning .....

.....

.....

.....

.....

WATER SUPPLY OPERATION CHART - SECTION 1

EMBU WATER SUPPLY — JULY — MONTH — YEAR 1989

DAY	CHEMICAL DOSING: CHLORINE DOSAGE P.P.M.	CHLORINE WEIGHT (GRAMS)	ALUM SULPHATE DOSAGE P.P.M.	ALUM SULPHATE WEIGHT KILOGRAM	LIME AND/OR SODA-ASH PRETREATMENT DOSAGE P.P.M.	PRETREATMENT WEIGHT KILOGRAM	CONDITIONING DOSAGE P.P.M.	CONDITIONING WEIGHT KILOGRAM	RESIDUAL CHLORINE MORNING 8-0 A.M 10 MIN.	MORNING 8-0 A.M 60 MIN.	AFTERNOON 4-0 P.M. 10 MIN.	AFTERNOON 4-0 P.M. 60 MIN.	TURBIDITY P.P.M. RAW WATER	TURBIDITY P.P.M. TREATED WATER	P.H. VALUES RAW WATER	P.H. VALUES TREATED WATER SAMPLE POINT	CALCIUM STABILITY (WEEKLY) RAW WATER ORIGINAL PH	RAW WATER ORIGINAL TOTAL ALK	RAW WATER FINAL PH	RAW WATER FINAL TOTAL ALK	TREATED WATER ORIGINAL PH	TREATED WATER ORIGINAL TOTAL ALK	TREATED WATER FINAL PH	TREATED WATER FINAL TOTAL ALK	ALKALINITY (PPM) (WEEKLY) RAW WATER PHEN PHTH	RAW WATER TOTAL	TREATED WATER SAMPLE POINT PHEN PHTH	TREATED WATER SAMPLE POINT TOTAL
25	0.8	7.5	48	52			8	12	0.6	0.4	0.5	0.3	50	7	6.8	7.0												
26	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	50	7	6.8	7.0												
27	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	60	7	6.8	7.0											NIL	8	NIL	10
28	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	50	7	6.8	7.0												
29	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0	6.8	6			7.0	8						
30	0.8	7.5	48	52			8	12	0.6	0.4	0.4	0.2	40	7	6.8	7.0			8.2	28			8.4	30				
31																												
1	0.8	7.5	48	52			8	12	0.6	0.4	0.5	0.3	40	7	6.8	7.0												
2	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
3	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
4	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
5	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0	6.8	6			7.0	8						
6	0.8	7.5	48	52			8	12	0.6	0.5	0.5	0.3	40	7	6.8	7.0												
7	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0			8.2	28			8.4	30				
8	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
9	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
10	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
11	0.8	7.5	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
12	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0	6.8	8			7.0	10						
13	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
14	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0			8.4	30			8.6	32				
15	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
16	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
17	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	8	NIL	10
18	0.8	7.5	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
19	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0	6.8	6			7.0	8						
20	0.8	7.5	48	52			8	12	0.6	0.3	0.5	0.3	40	7	6.8	7.0												
21	0.8	7.5	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0			8.4	30			8.6	32				
22	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
23	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
24	0.8	7.5	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0											NIL	6	NIL	8
TOTAL	Kgr. 72	Gr. 500	Kgr. 1	Gr. 560	Kgr.	Gr.	Kgr. 360	Gr. 000																				

WATER SUPPLY OPERATION CHART – SECTION 2

EMBU URBAN WATER SUPPLY — JULY — MONTH — 1989 YEAR

PUMPING PLANT

DAY	PRIME MOVERS: ENGINES, ELEC. MOTORS, GENERATING SETS, TURBINES, — No. 1 DRIVING PUMP No/s — MAKE:- — SIZE:-			PRIME MOVERS — No. 2 DRIVING PUMP No/s — MAKE:- — SIZE:-			PRIME MOVERS — No. 3 DRIVING PUMP No/s — MAKE:- — SIZE:-			PRIME MOVERS — No. 4 DRIVING PUMP No/s — MAKE:- — SIZE:-		
	HRS RUN	FUEL LITRE OR K.W. HRS	LUB OIL LITRES	HRS RUN	FUEL LITRE OR K.W. HRS.	LUB. OIL LITRES	HRS RUN	FUEL LITRE OR K.W HRS.	LUB. OIL LITRES	HRS RUN	FUEL LITRE OR K.W. HRS.	LUB OIL LITRE
26												
27												
28												
29												
30												
31												
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
TOTAL												

DAY	PUMPS: SURFACE:- INCLUDING HYDRAMS, BOREHOLE:- INCLUDING AIRLIFT COMPRESSORS, AND GRAVITY SUPPLIES — No. KAPINGAZI RAW WATER/~~PURE WATER~~ (DELETE DUTY NOT APPLICABLE) — MAKE:- GRAVITY — SIZE:- 150MM							No. NGANDORI ~~RAW WATER~~/PURE WATER (DELETE DUTY NOT APPLICABLE) — MAKE:- GRAVITY — SIZE:- 150MM							No. RAW WATER/PURE WATER (DELETE DUTY NOT APPLICABLE) — MAKE:- — SIZE:-							No. RAW WATER/PURE WATER (DELETE DUTY NOT APPLICABLE) — MAKE:- — SIZE:-						
	HRS RUN	VOLUMETRIC TEST M3/hr	B/H WATER LEVEL B.S. FT.	AMPS	VOLTS	K.W. HRS. OR LUB OIL LITRE	HRS RUN	VOLUMETRIC TEST M3/hr	B/H WATER LEVEL B.S. FT.	AMPS	VOLTS	K.W. HRS. OR LUB OIL LITRE	HRS. RUN	VOLUMETRIC TEST M3/hr	B/H WATER LEVEL B.S. METRE	AMPS	VOLTS	K.W. HRS OR LUB. OIL LITRE	HRS. RUN	VOLUMETRIC TEST M3/hr	B/H WATER LEVEL B.S. LITRE	AMPS	VOLTS	K.W. HRS OR LUB OIL LITRE
26	24						24																	
27	24	22					24	110																
28	24						24																	
29	24						24																	
30	24						24																	
31	–						–																	
1	24						24																	
2	24						24																	
3	24						24																	
4	24	20					24	110																
5	24						24																	
6	24						24																	
7	24						24																	
8	24						24																	
9	24						24																	
10	24						24																	
11	24	22					24	100																
12	24						24																	
13	24						24																	
14	24						24																	
15	24						24																	
16	24						24																	
17	24						24																	
18	24	20					24	110																
19	24						24																	
20	24						24																	
21	24						24																	
22	24						24																	
23	24						24																	
24	24						24																	
TOTAL	720						720																	

WATER SUPPLY OPERATION CHART - SECTION 3.

EMBU URBAN ... WATER SUPPLY ... JULY ... MONTH ... YEAR 1989

DAY	WASTE WATER. IF MASTER METER IS ON RAW WATER MAIN COLS. A.B.C. ONLY. IF MASTER METER IS ON PURIFIED WATER MAIN, COLS A. & B. ONLY. A FILTERS. (WASH WATER)	B RESERVOIR.	C COAG. BASIN.	MASTER METERS. METER NO. IV INDEX READING. 8.0. A.M.	QUANTITY PASSED M³.	METER NO. V INDEX READING. 8.0. A.M.	QUANTITY PASSED M³	METER NO. VI INDEX READING 8.0. A.M.	QUANTITY PASSED M³
				MASTER METER READING - LAST DAY PRECEEDING MONTH.					
25				483614		116850		433	
26				483635	21	116850	—	433	—
27				483647	12	116850	—	433	—
28				483678	31	116850	—	433	—
29				483689	11	116850	—	433	—
30				483898	209	116850	—	433	—
31				484044	146	116850	—	433	—
1	—			—	—	—	—	—	—
2				484184	140	116850	—	433	—
3				484328	144	116850	—	433	—
4				484407	79	116850	—	433	—
5				484571	104	116850	—	433	—
6				484639	128	116850	—	433	—
7				484773	134	116850	—	433	—
8				484848	75	116850	—	433	—
9				484968	120	116850	—	433	—
10				485101	133	116850	—	433	—
11				485174	73	116850	—	433	—
12				485240	66	116850	—	433	—
13				485284	44	116850	—	433	—
14				485423	139	116850	—	433	—
15				485578	155	116850	—	433	—
16				485733	155	116850	—	433	—
17				485880	147	116850	—	433	—
18				486037	157	116850	—	433	—
19				486190	153	116850	—	433	—
20				486338	148	116850	—	433	—
21				486480	142	116850	—	433	—
22				486615	135	116850	—	433	—
23				486750	135	116850	—	433	—
24				486889	139	116850	—	433	—
TOTAL				487020	131	117538	688	433	—
					3406		688		206

Av. Ass.

METERS ALLOCATED TO THE SUPPLY

SIZE MILLIMETRES	12	20	25	38	50	63 75	100 PLAIN	100 COMB	150 PLAIN	150 COMB
MASTER No.										
ON WATER SUPPLY "										
ON CONNECTIONS. "										
SERVICEABLE IN STORE "										
UNSERVICEABLE. "										
SENT FOR REPAIR "										
TOTAL . "										

CONSUMERS.

CONSUMERS ON METERD CONNECTIONS No.	
" ON FLAT RATE CONNECTIONS "	
TOTAL CONSUMERS "	

WATER PRODUCED, USED, SOLD AND UNACCOUNTED FOR.

TOTAL WATER SOLD THRO' METERS M³	
" " " FLAT RATE "	
" " " AVERAGE ASSESMENT. "	
TOTAL WATER SOLD "	
1. MASTER METERS COMBINED TOTAL. M³	
2. TOTAL WASTE WATER. M³	
3. WATER AVAILABLE FOR SALE (1-2). "	
4. TOTAL WATER SOLD. "	
5. BALANCE UNACCOUNTED FOR (3-4). "	
PERCENTAGE UN-ACCOUNTED FOR (LINE 5 × 100) / LINE 1 " × 100	%
AVERAGE WATER PRODUCED M³ P.D.	
" " SOLD M³ P.D.	

REMARKS ON LOSSES CAUSED BY BURSTS AND FROM OTHER CAUSES.

WATER SUPPLY OPERATION CHART SECTION 4.

EMBU WATER SUPPLY. MONTH JULY YEAR 1989

ITEM	COST OF OPERATION PER MONTH. QUANTITY USED. kg.	RATE. Per kg.	TOTAL. Shgs.	Cts.	BALANCE OF STORES. BALANCE B/F. kg	QUANTITY RECEIVED. kg.	BALANCE C/F. kg.
PURCHASE OF WATER..... m^3 @.....							
CHEMICALS: Alum.	1560.000	4.75	7308	00	116.000	1500.000	56.000
Soda Ash.	360.000	2.12	763	20	—	400.000	40.000
Hydrated Lime							
Chlorine Gas or Trop. Chloride of Lime.	225.000	10.25	2,306	25	15.000	250.000	40.000
other chemicals.	Litre	Per Litre	—	—	Litre	Litre	Litre
FUEL: Diesel (Not For Transport.)							
Lub. Oil. (" " ")							
Petrol. (" " ")							
Electricity Units.	480	0.99	475	20			
MISC: Uniforms.	Lump Sum For Month						
Painting	" " " "						
Sundry Items. (See Notes.)	" " " "						
SALARIES FUEL SHIFT	" " " "		3560	00			
TRANSPORT: Fuelling. P.O.L. (Lump Sum)	" " " "		200	00			
DEFAULT SHIFT	" " " "						
OVERHEADS: Provincial Engineer .....%. (See Notes)	" " " "						
Water Supt.....%. (See Notes)	" " " "						

OPERATOR – STATE ANY PLANT MAINTENANCE REQUIRED.

for W.S.O. 'C

SIGN.

REMARKS. S.I.W.S.

STAFF: ALL WORKS PAID OPERATION STAFF (Excluding All Operators.)

NAME.	DUTY.		
1. ZAKARIA M'REMBUNA	CHITTAMDANTS	1140	00
2. CHARLES KABIRU	"	920	00
3. MOSES K. MUGANE	"	960	00
4. REUBEN K. MUCHIRI	"	1190	00
5. MAINA GATERI	"	1130	00
6. WILSON MUGWE	SS	1150	00
7. ANTONY NJERU	"	1150	00
8. NELSON KARIUKI	"	1120	00
9. CHARLES KANGUHO	"	1120	00
10. SAMSON MIRUCHI	PIPE FITTER	1570	00
Divisional costs: (see Notes.)			
TOTAL COSTS CHARGED TO O. & M. S. E.		36744	65

METERS – COST OF REPAIRS CHARGED TO METER REPAIR S. E. FOR MONTH.

DISTRICT WATER OFFICER
P.O. Box 542, EMBU
30/8/89

SIGN

Provincial Water Engineer/ Officer Remarks

OPERATORS – HEAD OFFICE & WORKS PAID.

NAME	GRADE	H.O. or W.P.	Salary For Month Shgs.	Cts.
GEORGE M KIUNJURI	I		2250	00
STEPHEN K MURIITHIA	II		1740	00
EPHANIUS K. GITHINJI	II	W/P	1520	00
PETER K. NJUGUNA	II		1520	00
STEPHEN MAITHERIA	I		1240	00
MERCY K. MWARANIA	I		1260	00

EXPENDITURE & REVENUE	Shgs.	Cts.	£.
TOTAL EXPENDITURE, EX-LEDGER: (incl. Liabilities) SINCE 1st JULY.	36744	65	1224.4235
REVENUE EARNED DURING MONTH:	1624	90	54.13
REVENUE EARNED SINCE 1st JULY:	10844	40	361.48

P. O. Box 40-60200
15/9/89

SIGN.

P.T.O. FOR DETAILS OF SUNDRY ITEMS PURCHASED.

NOTES: SUNDRY ITEMS: This covers any items for which specific headings have not been provided. Details of items purchased to be shown on reverse.

OVERHEADS: (a) Provincial Water Engineer. Show the percentages retained by the P.W.E. of the annual O.&M. funds issued. The amounts to be entered in the Total column are ¼ of the actual amounts retained for the whole year.

(b) Divisional. Enter in the Total column the apportionment to the supply for the month of the salaries of all workspaid Divisional clerical and break-down staff. (See also note 4 on cover sheet.)

APPENDIX 2

STATUS OF EXISTING WATER SUPPLIES

APPENDIX 2

STATUS OF EXISTING WATER SUPPLIES

Timau Division

Tigania Division

Igembe Division / Ntonyiri Division

North Imenti Division

Central Imenti Division

South Imenti Division

Nithi Division

Tharaka Division

TIMAU DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 popu.	Status in November 1990
1.1	Timau	Kithithina	Timau Spring	MoWD	9	2,878	Operational under MoWD
1.2	Miarage	Ontulili	Liki River	Self Help	6	480	Completed but intake needs to be moved upstream to enable water flow.
1.3	Mukuria	Ontulili	Liki River	Self Help	5	400	Completed and operational In good condition
1.4	Katheri Ontilili	Ontulili	Ontulili River	Self Help	6	450	Started only intake and 1.2 km being piped
1.5	Nyakario	Ontulili	Ontulili River	Self Help	5	400	Completed and Operating In good condition
1.6	Timau Kararu	Kithithina	Ontulili River	Self Help	6	1,920	Not started survey and design is done.
1.7	Sirimoni	Kithithina	Sirimon River	Self Help	3	960	Started but not completed. Operational, On-going
1.8	Muguna Timau	Kithithina	Timau River	Self Help/RDF	6	300	Completed, but not operational Overlapping with Timau Water Supply
1.9	King'uru	Ngusishi	Timau River	Self Help/MoWD	3	200	Completed and Operational On-going
1.10	Kithima Kiamunyi	Ngusishi	Timau River	Self Help	5	325	Intake completed
1.11	Mwimenyi	Buuri	Kisima spring	Self Help	2	100	Not started. It is a pumping system by a hydram pump.
1.12	Ngarendare	Ngare Ndare	Kisima spring	Self Help	3	350	Started existing through furrow system. Started operational but not completed.
1.13	Mithatene	Buuri	Mithatene spring	Self Help	3	140	
1.14	Marania Ntirimiti	Buuri	Lungushi R.	Self Help	25	600	Started, operational but not fully completed.

Timau Division (Cont.)

(CONT.) TIMAU DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 popu.	Status in November 1990
1.15	Ndurumuru	Buuri	Ndurumuru Spring	Self Help	5	200	Started, operational but not completed.
1.16	Kithithina Umoja				-	-	Proposed

TIGANIA DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
2.1	Tigania	Tigania Division	Mukurwe Springs	MoWD/SIDA	60	38,600	Completed MoWD the project is under rehabilitation by GOK
2.2	Charuru	Kitheo	Riutu River	Self Help	2	1,000	Started but not completed, not operational.
2.3	Mbeu	Mbeu	Kihondo River	Self Help	1	300	Started not operational fails to work. It is a pumping system.
2.4	K.K. Mwethe	Kitheo/Kigucwa	Riutu River	Self Help/RDF	8	4,200	Completed and operational. It requires rehabilitation of intake and extension of works
2.5	Athwana Ngwataniro	Mikinduri	Kithiu River	Self Help	3	3,500	Started only the intake is done.
2.6	Ametho	Kigucwa	Thangatha River	Diocese	1	700	Started but not completed. The project is under diocese of Meru.
2.7	Nairiri	Kianjai	Extension of Tigania Water Supply	Self Help/RDF	-	-	Branch line from Tigania water supply
2.8	Kamberia	Akithii/Mituntu	Spring	Diocese/Self Help	60	12,100	In operation, on-going
2.9	Mbaranga	Kitharene	River	Diocese	5	3,600	Completed 1st & 2nd phase, 3rd phase proposed
2.10	Lailuba	Athwana/Athanja	River	Diocese	3	1,000	Phase II under construction
2.11	Mikinduri Girls	Kiguchwa	River	Diocese	2	750	Phase II proposed
2.12	Lanyiro	Muthara Loc.	River	Methodist Church	5	1,150	Operational
2.13	Itundu	Karama Loc.	Spring	Self Help	-	-	Started but not completed
2.14	Tigania Miss. Hospital	Muthara/Akithii	Spring	Mission/Self Help	4	2,500	In good condition - proposed extension

IGEMBE DIVISION/NTONYIRI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 Popu.	Status in November 1990
3.1	Maua	Amwathi	River	MoWD	3	3,500	Completed and operational Supply inadequate
3.2	Tuuru/Liliaba	Kangeta Loc. Njia Loc. Ntonyiri Div.	Lilliaba River Ura River Amwamba River	Diocese/Self Help	550	100,000	Phase 1, II and III is completed. Phase IV under construction. Operation, but supply needs to be increased.
3.3	Kaweru	Antubetwe Njoune /Kanjoo/ Athiru Ruujine	Kilindo Springs	Self Help/PLAN	50	6,500	Completed and operational
3.4	Mbita	Kiegoi	Mathai of Ura River	Self Help	1	360	Completed and operational
3.5	Kauma	Auki	Kauma Spring	Self Help/CARE	1	300	Completed and operational. Funded by CARE.
3.6	Kiraone		Springs	Self Help	3	1,000	Surveyed and designed but not started.
3.7	Nkinyanga	Liliaba	Spring	Self Help	4	-	Operational, but source is limited
3.8	Akachiu	Amungenti	Spring	Self Help/PLAN	10	2,200	Operational
3.9	Amwamba	Auki	River	Self Help/PLAN	8	6,800	Operational
3.10	Athi	Kirindine	Spring	Self Help/PLAN	10	1,600	Operational
3.11	Mukine	Kiegoi/Amwathi	River	Self Help/PLAN	2	700	Operational
3.12	Kanjara/Muthathene	Kiegoi	River	Self Help/PLAN	2	400	Operational
3.13	Ntingirai	Kiegoi	River	Self Help/PLAN	7	2,500	Under Construction
3.14	Gitwe	Burieruri	Spring	Self Help/PLAN	4	3,000	Operational
3.15	Murimi	Antubetwe Njoune	Spring	Self Help/PLAN	5	2,500	Operational
3.16	Gitura 4K Club	Amwathi	Spring	Self Help/PLAN	-	2,200	Operational
3.17	Ngongone	Athiru Gaiti	Spring	Self Help/PLAN	5	900	Operational

Status of Existing Water Supplies

Appendix 2

Igembe Division / Ntonyiri Division (Cont.)

(CONT.) IGEMBE DIVISION/NTONYIRI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
3.18	Bwathu	Athiru Gaiti	Spring	Self Help/PLAN	5	950	Operational
3.19	Nthambiro	Kanjoo	Spring	Self Help/PLAN/Diocese	-	-	Operational but O & M Poor
3.20	Rwaene	Amwathi	Spring	Self Help/PLAN	-	-	Operational in good condition
3.21	Mathawe	Auki	Spring	Self Help/PLAN	2	2,190	Under Construction
3.22	Muhorone	Kiegoi/Akachiu	Spring	Self Help/PLAN	2	1,890	Proposed
3.23	K. K. Karui	Kiegoi	Spring	Self Help/PLAN	-	710	Under construction
3.24	Kimuthi	Kangeta	Spring	Self Help/PLAN	-	-	Under construction
3.25	Kithetu - Miori	Amwathi		Self Help/Plan	18	8,000	Proposed/Under Construction
3.26	Ankiama	Amungenti		Self Help/Plan	2	400	Proposed
3.27	Katheleu	Akirangondu	Spring	Self Help/Plan	4	2,500	Proposed
3.28	Muthathene (Athiru Roujine)	Athiru-Roujine	Spring	Self Help	40	6,000	Old pipe line to be rehabilitated. New project to run parallel with the old one with separate intake to cover a larger area

NORTH IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	Popu. 1988	Status in November 1990
4.1	Meru Water Supply	Meru Town/Upper Igoki/ Mulathankari	Kathita River Gataboro Spring	MoWD-Municipal Council	25	26,790	Requires expansion
4.2	Nkabune Water Supply	Lower Igoki/ Nkabune	Kathita River	MoWD/SIDA	10	10,000	Good condition
4.3	Ruiri Water Project	Ruiri	Ngarenaro Furrow	Self Help	28	6,000	Completed and operational but it requires rehabilitation of distribution system.
4.4	Naari/Kirua Water Supply	Naari/Kirua	Ngarenaro furrow	Self Help/MoWD	44	9,200	Phase I, II, III and part of IV constructed and operational On going
4.5	Mworogo Water Project	Mpuri	Kathita River	Self Help	3	1,500	Started not completed not operational
4.6	Kithoka Mutethia	Munithu	Gachiumo River	Self Help	8	2,500	Completed and operational requires rehabilitation
4.7	Ngirote Gietu	Munithu	Kithoka Spring	Self Help	1	500	Completed and operational In good condition
4.8	Runongone Water Project	Munithu	Gachiuma	Self Help	2	500	Completed and operational Requires rehabil. of intake
4.9	Lower Chugu	Chugu	Gachiuma	Self Help	2	1,000	Completed and Operational Requires rehabilitation
4.10	Muguna Kironya	Naari	Murongo river Tributary of Kathita River	Self Help	2	400	Completed and operational In good condition
4.11	Ndekero Women Group	Thuura	Ndekero Spring	Self Help/CARE	1	300	Completed and operational funded by CARE. In good condition
4.12	Giaki Thuura Water Project	Giaki	Kathita River	Self Help	10	3,000	Started but not completed Pipe size too small. Halfway the main line
4.13	Gachua Water Project	Kiburine	Kathita River	Self Help	10	2,000	Started-intake and 400 pipes 8" PVC and GI are laid.

Status of Existing Water Supplies

Appendix 2

North Imenti Division (Cont.)

(CONT.) NORTH IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
4.14	Mbuta Water Project	Kiburine	Kuuru River	Self Help	2	1,000	Completed and operational rehabilitation is required, hydraulic problem
4.15	Kiburine Water Project	Kiburine	Kuuru River	Self Help	3	1,000	Competed and Operational In good condition
4.16	Nyota Water Project	Thuura	Kathita River	Self Help	8	2,500	Started not completed, partly operational, on going
4.17	Muguna/Igoki/Nkabune Water Project		Kathita	Self Help	10	3,000	Not started, area covered by Nkabune water supply
4.18	Kibachia Water Project	Ntima	Kibachia River	Self Help	0.5	200	Completed and Operational In good condition
4.19	Muguna/Mutethia Water Project (Muguna 'B')	Thuura	Gachiuma River	Self Help	6	2,500	Started but not completed partly operational
4.20	Kangere Water Project	Munithu	Kinyarita River	Self Help	1	500	Started not completed partly operational.
4.21	Nkoune Water Project	Igoki	Spring	Self Help	0.5	200	Completed and Operational In good condition
4.22	Muguna Kithiu	Mulathankari	Spring	Self Help	1	500	Started partly operational but not completed.
4.23	Mwiteria Water Project	Upper Igoki	Kathita	Self Help	2	1,000	Completed and operational In good condition
4.24	Gakurumbi Water Project	Upper Igoki	Gachiuma	Self Help	1	500	Not started the project was designed to pump water from the same point with Gitoro technical source of water Area to be covered with an alternative source
4.25	Karika Mbui Gitebe W/P	Ng'onyi	Kanyuango Riv.	Self Help	3	1,200	Completed and Operational

CENTRAL IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 Popu.	Status in November 1990
5.1	Katheri/Nthimbiri Water Project	Katheri	Kathita Munyi	Self Help	5	5,800	Started they use water furrow Piping proposed
5.2	Kibirichia Water Project	Kiamiogo	Ngarenaro Furrow	Self Help	11	4,000	Not started, proposed
5.3	Kibarenyeki Water Project	Githongo	Mariara Spring	Self Help	5	1,800	Compeleted and Operational rehabilitation of gravity main is required.
5.4	Magundu Water Project	Katheri	Kathita	Self Help	2	2,000	Completed and operational. Rehabilitation required. Overutilized
5.5	Ntumburi Water Project	Ntumburi	Kisima Spring	Self Help/EEC	40	5,000	Completed and operational, demand larger than capacity
5.6	Ciantere Water Project	Mboroga	Spring	Self Help	3	1,000	Started but not complete
5.7	Gakumbo Water Project	Katheri	Kathita	Self Help	1	600	Completed and operational rehabilitation of Gravity main required.
5.8	Mboroko Water Project	Katheri	Rwairi River	Self Help	1	300	Completed and operational In good condition
5.9	Muguna/Katheri W/P (part of Katheri Nthimbiri)	Katheri	Kathita	Self Help	3	900	All distribution lines and 50,000 tank and 3/4 of gravity main is done. Operating through furrow,almost complete
5.10	Rwairi Katheri W/P (part of Katheri Nthimb)	Katheri	Rwaire River	Self Help	1	300	Completed and operational.
5.11	Nkukumo Water Project	Githongo	Mariara River	Self Help	1	500	Completed and operational In good condition
5.12	Kariene Barangu Water Project	Mariene	Lueye River	Self Help	2	1,000	Completed and operational In good condition
5.13	Kariene Water Project	Kariene	Gataunga River	Self Help	1	500	Completed and Operational In good condition

(CONT.) CENTRAL IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
5.14	Gaitu/Gaguma Water Project	Ruiga/Gaitu	Mariara	Self Help	3	6,000	Started phase I is completed and is operational. Phase II is started but not yet complete
5.15	Ciontare Water Project	Kaongo	Mariara River	Self Help	4	1,450	Completed and Operational In good condition
5.16	Mutethia `A' Water Project	Kariene	Njue River	Self Help	2	700	Completed and Operational In good condition
5.17	Kieguchia/Gatimbi Water Project	Kariene	Thingithu River	Self Help	10	6,000	Started only intake started but not completed. It was a proposed project to cover the whole area. Several small existing project are there in the same proposed area.
5.18	Mututa Mujwa Water Proj.	Igane	Thingithu River	Self Help	9	3,200	Operational and completed
5.19	Central Abothuguchi Water Project	Ruiga	Mariara River	Self Help	16	7,500	Completed and operational
5.20	Kanja Women Group Water Project	Kaongo	Mariara River	Self Help/RDF	7	2,000	Started not completed not operational
5.21	Mutura Women Group Water project	Gaitu	Mariara River	Self Help	2	500	Completed and Operational partly. On going
5.22	Njuthine Water Project	Gaitu	Mariara River	Self Help	2	230	Started partly operational On going
5.23	Muguna Mbajone Water Project	Giaki/Gaitu	Kathita	Self Help	2	500	Started not much has been done not operational - Intake complete. Piping started
5.24	Kathita Gankau Water Project	Katheri	Kathita	Self Help	6	1,700	Started but not completed not operational.
5.25	Weru Water Project	Katheri	Kathita	Self Help	1	400	Started but not completed not operational.

(CONT.) CENTRAL IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
5.26	Ithambara Water Project	Githongo	Mariara River	Self Help	-	-	Started not much has been done. This project is over-lapping with Kibaranyeki W/P
5.27	Kirima/Kiarangu Water Project	Katheri	Kathita River	Self Help	2	600	Not started currently they use Katheri furrow
5.28	Korone Water Project	Ng'onyi	Lueye Stream	Self Help	1	400	Completed and Operational In good condition
5.29	Kirima Kianthi Water project	Katheri	Kathita	Self Help	-	-	Not started
5.30	Ngunga Makandune Water Project	Makandune	Thingithu River	Self Help	5	1,500	Started with intake complete On-going
5.31	Kirie Ngumari Water Project	Githongo	Spring	Self Help	-	-	Completed and Operational
5.32	Matinya Kinungo Water Project	Kithirune	Tributary of Thingithu Riv.	Self Help	2	700	Completed and operational intake need to be renovated
5.33	Kiamiogo (part of Kibirichia W/P)	Kiamiogo	River Kazita	Self Help	18	5,000	- Survey and design done - Implementation not started
5.34	Kathangira (part of Kibirichia W/P)	Kimbo	Spring joining river Ruguso downstream	Self Help	3	2,000	- Intake complete
5.35	Karaene	Mwanganthia Loc.	River Mariara	Self Help	-	-	- Survey and design done - Implementation not started

SOUTH IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
6.1	Nkubu Water Supply	Kathera	Thingithu River	MoWD	2	3,665	Treatment and intake to be improved
6.2	Mwimbi Water Supply	Mitine/Igoji Location/ Chogoria	Mutonga River	MoWD	60	32,000	
6.3	Kanyakine Water Supply	Kanyakine	Mathanjwi River	MoWD	15	4,200	Requires rehabilitation
6.4	Mitunguu Water Supply	Kirendene South Tharaka Location	Thingithu River	MoWD/SIDA	45	5,100	
6.5	Taita Muguru Water Project	Kathera	Tributary of Thingithu River	Self Help	4	(910)	Almost completed and operational Tanks and some part of distribution to be done
6.6	Kithino Mari Water Project	Kothine	Kithino River	Self Help	4	3,180	Completed and Operational Under an adequate flow intake need to be raised upstream.
6.7	Lower Kithangari Water Project	Kanyakine Loc.	Mathanji River	Self Help	24	6,000	Completed and operational Requires rehabilitation
6.8	Ithima Ithambara Water Project	Mikumbune	Ithima springs	Self Help	3	1,500	Started and Operational but not completed, intake requires rehabilitation
6.9	Muchege Water Project	Mikumbune	Thingithu Rriver	Self Help	3	1,500	Completed and operational In good condition.
6.10	Mwirangara Water Project	Kathera	Spring	Self Help	2	1,000	Completed and operational In good condition
6.11	Mutethia Kirugwa Water Project	Upper Chure	Kithino River	Self Help	4	1,800	Started not completed not operational
6.12	Gikui Mweru Water Proj.	Gikui/Mweru	Mutonga River	Self Help	10	8,000	Started only intake constructed
6.13	Maigene Water Project	Nkuene Loc.	Thagara River (Kithinu River)	Self Help	2	1,500	Started but not completed New intake to be constructed

South Imenti Division (Cont.)

(CONT.) SOUTH IMENTI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 Popu.	Status in November 1990
6.14	Igandene Water Project	Upper Kiungone	Spring	Self Help	1	200	Not started
6.15	Kirukangwi Water Project	Uruku	Thingithu	Self Help	1	720	Started not completed, partly operational

NITHI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km²)	1988 Popu.	Status in November 1990
7.1	Chuka Water Supply	Chuka	Tungu River	MoWD	4	5,314	In good condition
7.2	Karingani Water Supply	Mugirirwa/ Mwonga/Kabuboni	Tungu River	MoWD	23	12,400	Rehabilitation needed
7.3	Murugi/Mugumango Water Project	Murugi/Mugumago	Mara River	Self Help/CHF	35	14,700	Completed and operational/ funded by the Canadian Hunger Foundation, requires rehabi- litation, change of intake point.
7.4	Gantaraki Water Project	Murugi/Iriga		Self Help	12	5,000	Started but not completed it is operational.
7.5	Mutindwa West East Water Project	Murugi	South Mara river	Self Help	1	400	Completed and operational In good condition
7.6	Gianchugu Water Project	Chogoria	Maramanyi	Self Help	1	400	Started, 3 1/2 km of gravity main is done, not operational
7.7	Magumone Water Project	Magumone Loc.	Gituambuki	Self Help/MoWD /EEC	45	19,000	Water not used. Started, under construction. Intake + Main Storage Tank + Main Distribution is ready. Not operational.
7.8	Iruma Magutune Water Project	Iruma/ Magutuuni	Mutonga	Self Help	15	7,000	Not started. Designed/Not operational
7.9	Makuri Water Project	Chogoria	Maramanyi River	Self Help	1	400	Completed and operational. Requires rehabilitation
7.10	Mbogori Water Project	Chogoria	Mara River	Self Help	1	400	Started, half-way done, not operational.
7.11	4K Water project		Mara	Self Help	6	1,500	Started but not completed and operational.
7.12	Rwanchege Kiene Water Project	Murugi	Kamana River	Self Help	2	600	Completed and Operational In good condition
7.13	Gatua Karimba Water	Gatua/Karimba/ Ndagani	Tuugu	Self Help/GOK	35	13,700	Started, but very little was done

Status of Existing Water Supplies

Nithi Division (Cont.)

(Cont.) NITHI DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 Popu.	Status in November 1990
7.14	Kathwana Presidential Site	Mutino	Mara River	GOK	5	1,000	Proposed, not started
7.15	Kairuni Kiraro	Kaaria	Mutonga River	Self Help	5	4,000	Extension of Mwimbi Water Supply

THARAKA DIVISION

S/NO	Name of Water Supply Project	Sub-Location	Source	Owner/Assisting Agency	Area (Km^2)	1988 popu.	Status in November 1990
8.1	Ng'urwe Gakirwe Water Project. Irrigation + domestic water	Tunyai	Kithino	Diocese/Self Help	20	1,650	Phase I and IIA completed and operational funded by Italian Government Phase IIB under Construction.
8.2	Kazita Gatunga	Gatunga/Kanjoro Kathangachini	Kathita	Diocese/Self Help	20	(3,000)	Started not completed on going under Diocese of Meru.
8.3	Kibung'a	Kianuri/Turima	Kathita	Self Help	10	1,000	Not started. No funds
8.4	Gachiongo	N. Tharaka	Thangatha	Self Help	-	(3,000)	Water Furrow
8.5	Manyirani	Turima	Kathita	Self Help	3	1,000	Operational, not complete. Supply from reciprocating pump driven by water wheel
8.6	Diairi	Marimanti	Kathita	Self Help	4	1,200	Not started. Pipes on site Hydram supply.
8.7	Mitunguu/Tunyai Forrow	S.Tharaka Loc.	Thingithu River	Self Help	(20)	6,500	Old water supply, recently rehabilitated.
8.8	Nkondi Furrow	Nkondi	Kuuru River Thanantu River	Self Help	10	-	Operational. Old project Poor water quality
8.9	Nkondi Solar	Nkondi	Borehole	Self Help/MoWD	-	2,000	Under construction

APPENDIX 3

INVENTORY OF EXISTING WATER SUPPLIES IN MERU DISTRICT

APPENDIX 3

INVENTORY OF EXISTING WATER SUPPLY IN MERU DISTRICT

3.1 Introduction

3.2 Public Urban Water Supplies

- 3.2.1 Maua Water Supply
- 3.2.2 Nkubu Water Supply
- 3.2.3 Meru Water Supply
- 3.2.4 Chuka Water Supply

3.3 Public Rural Water Supplies

- 3.3.1 Kanyakine Water Supply
- 3.3.2 Mitunguu Water Supply
- 3.3.3 Nkabune Water Supply
- 3.3.4 Tigania Water Supply
- 3.3.5 Mwimbi Water Supply
- 3.3.6 Karingani Water Supply
- 3.3.7 Timau Water Supply

3.4 Private/Self-Help Water Supplies

- 3.4.1 Ntumburi Water Project
- 3.4.2 Ng'uru Gakirwe Water Project
- 3.4.3 Tuuru Water Scheme
- 3.4.4 Murugi Mugumango Water Society
- 3.4.5 Kithinu - Mari Water Project
- 3.4.6 Taita/Muguru Water Project
- 3.4.7 Maigene Water Project
- 3.4.8 Mwirangara Water Project
- 3.4.9 Mitunguu - Tunyai - Muthangacwe Water Furrow
- 3.4.10 Munyaka Gitiri Water Project
- 3.4.11 Mitunguu Irrigation Scheme

APPENDIX 3: INVENTORY OF EXISTING WATER SUPPLIES IN MERU DISTRICT

3.1 Introduction

In this appendix are described some of the existing water supplies in Meru District, all of which were visited by a WRAD planning team. Each water supply is described as per the following headings.

(a) Technical description
(b) Potential and actually served beneficiaries
(c) Livestock Use
(d) Functional Analysis
(e) Financial Analysis
(f) Institutional Analysis

3.2 Public Urban Water Supplies

3.2.1 Maua Water Supply

Technical Description: This water supply serves Maua township and its environs. The supply was commissioned in 1957 and the permit was renewed in 1975.
The treatment works are located about 1 km from Maua town and has a river source. The total supply storage is 45 m^3. The design capacity is 169 m^3/day.

Potential and Actually Served Beneficiaries: The supply currently serves a population of about 3,500 people. There are at present about 242 individual connections all of which are metered. However, only 160 of these are operational as the balance has been disconnected for non-payment.
Besides Maua township the supply serves the following institutions: Maua Girls' Secondary School, Maua Primary School, Maua Polytechnic (rural), Maua Police Station, and Maua D.O's Office. This supply also augments Maua Hospital who have an inadequate private water supply system. The area served is 3 km^2.

Livestock Use: The average livestock population in Meru district is 1 Livestock Unit (L.U) per family where a family is taken to be six (6) people. Therefore, since the population served by this water supply is 3,500, there are 583 L.U as per the current human population.

Functional Analysis: The supply is operational throughout the year. It, however, is in very poor condition and is grossly inadequate.
The intake is too old and too small for the growing population. The treatment works are also in very poor condition as the filter is broken down and so has the backwash pump and the master meter. The chlorination chamber is also leaking badly.
Added to these is the poor condition of the piping of the main distribution lines. There are frequent bursts as these pipes are now over 30 years old and are rusty.
Given the above observations it is clear that the system requires major rehabilitation which will include replacement of all unserviceable parts of the same. The system also requires expansion to be able to cater for the growing population.

Financial Analysis: The revenue collected during the year 1989 was Ksh. 26,663 while total revenue billed to consumers was about Ksh. 75,525. The staff and labour cost was Ksh. 89,880 and that of chemicals was Ksh. 11,400 per year. This gives the total operational cost for the year as Ksh. 101,280. This shows that the total revenue collected caters only for about 25% of the total operational cost. The MoWD then has to meet the balance in operational cost as they are the operating agency.

Institutional Analysis: Maua water supply has a workforce of 7 members of staff as tabulated:

Designation	Number
Water Supply Operator (WSO)	1
Pipe-fitter (P/F)	1
Subordinate Staff (SS)	5

Information obtained from the DWE's office, Meru, indicates that the water supply requires one Inspector Water Supplies, one Water Supply Operator (WSO) and 2 Subordinate Staff (SS).
All the staff in the water supply are responsible to the Water Supply Operator (WSO) who in turn is responsible to the DWE.

3.2.2 Nkubu Water Supply

Technical Description: This water supply serves Nkubu township and 10 institutions.
The water supply is situated in Nkuene Location of South Imenti Division.
The supply has a daily production of 314 m^3/day and a clear water storage of 125 m^3. The distribution system totals about 10 km of piping.

Potential and Actually Served Beneficiaries: The population served by this supply is estimated at 3,665. There are 215 individual connections all of which are metered. These include 10 institutions. The supply covers an area of about 2 km^2.

Livestock Use: There is no data on the number of livestock in the supply area. However, a figure of 611 livestock units (L.U) was arrived at by assuming one livestock unit per family and a family to be 6 people since the population served is 3,665.

Functional Analysis: The water supply operates throughout the year and has good operational reliability. It has an electric pump system and a diesel stand-by engine. There is need to modernise the chemical dosing plant as one filter is not functioning optimally. The intake should also be improved. The causes of malfunction are siltation at the intake and occasional lack of chemicals.

Financial Analysis: Nkubu Water Supply earned a revenue of Ksh. 193,447 during the year 1989 but only Ksh. 151,318 was collected. The total operation and maintenance cost amounted to Ksh. 288,000 for the same period. The revenue collected was 52% of the total operation cost. This clearly shows that the water supply is not self-sustaining as the MoWD has to supplement the extra cost.

Institutional Analysis: The water supply has a staff of 14 people. There is a Water Supply Operator trained at KEWI and a clerical officer who is training on the job. The other 12 are Subordinate Staff who perform miscellaneous duties which include chemical attendance, line patrolling, pump attendance, meter reading, and pipe fitting. These people are employed by the MoWD and work directly under the District Water Engineer.

3.2.3 Meru Water Supply

Technical Description: This water supply is the largest urban water supply in the District and serves Meru town. Meru Water Supply draws its water from two intakes, one on the Kazita river and the other on the Gatabora river. Both of these intakes deliver water to the treatment works by gravity systems. Rapid sand filtration and chlorination are the only forms of treatment done on the water. As at the end 1989 the combined extraction of both intakes was 4,735 m^3/day as opposed to 4,500 m^3/day design discharge. The clear water storage was 1,597.5 m^3.

Potential and Actually Served Beneficiaries: According to the 1979 census the urban population of Meru town and its environs was 18,518. This was projected to have reached the 27,863 mark by the end of 1988. The Meru water supply served, as at the end of 1988, a population estimated at 72,000 people and covered an area of 25 square km. Meru water supply has 2,925 metered connections and 30 nonmetered ones.

Livestock Use: There are 4,981 livestock units (L.U) in the area served by the Meru Water supply. The majority of these are grade cows. There are also sheep and goats as well as a few donkeys.

Functional Analysis: Meru Water Supply is operational throughout the year. It is, however, overutilised and is still not able to adequately meet the present demand. This implies that although the supply was recently rehabilitated (1987) it requires expansion to be able to adequately serve the current population.

Financial Analysis: The revenue earned by this water supply in 1989 was Ksh. 1,718,736 for bulk water sale. However, the Meru Municipal Council are the water undertakers in the municipal area and they therefore bill and collect revenue from the consumers. The total O & M expenditure for the year

excluding personnel cost was Ksh. 87,600. It was, however, not possible to determine the percentage of the O & M and staff costs met by the amount of revenue collected as data on the staff costs and revenue collected were not readily available.

Institutional Analysis: Meru Water Supply has a work force of 16 members of staff all employed by the MoWD. These include 4 Water Supply Operators and 12 Subordinate Staff who have various duties ranging from chemical attendance to pipe-fitting.
All the staff are responsible to the Water Supply Officer in charge of the Water Supply who in turn is responsible to the DWE.

3.2.4 Chuka Water Supply

Technical Description: Chuka water supply is an urban scheme which has no intake of its own. This scheme gets all its water from Karingani Rural Water Scheme. This water scheme was commissioned in 1977 and has at present a daily distribution capacity of 415 m^3/day and a storage of 700 m^3. Chlorination is the only form of treatment and the scheme is operated by a gravity system.

Potential and Actually Served Beneficiaries: This scheme serves a population of 5,314 with 350 individual connections all of which are metered. The scheme covers an area of 4 km^2.

Livestock Use: Livestock data for this scheme were not available and estimation was impossible given that this is an urban scheme.

Functional Analysis: The water supply operates throughout the year and has good operational reliability. This scheme is in good working condition but requires expansion to be able to better meet the ever increasing demand.
The water is chlorinated at the Karingani treatment works before being fed into the Chuka distribution system.

Financial Analysis: Revenue billed to he consumers during the calendar year 1989 was Ksh. 218,782 while the revenue collected amounted to Ksh. 219,111 during the same period. The revenue collected is more than that billed and this explained by the fact that some of the revenue collected in 1989 had been billed to the consumers in 1988. This makes Chuka water supply second only to Nkabune water supply in revenue collection efficiency.
Data on staff salaries an operation and maintenance costs were not available.

Institutional Analysis: Chuka water supply is manned by a staff of 8 people who include an operator water supplies, a pipe fitter, a clerical officer and 5 Subordinate Staff who are linepatrollers, plumbers, and masons. The water supply requires an Inspector Water Supplies to be posted there immediately. All the staff at the water supply are responsible to the DWE through the operator in-charge of the supply.

3.3 Public Rural Water Supplies

3.3.1 Kanyakine Water Supply

Technical Description: This is a rural water supply with a gravity cum diesel pumping system and a river source. The supply has an intake situated about 4.5 km from the treatment works and has a production of 270 m^3/day and a storage of 260 m^3. The main distribution lines have a total length of 32 km.

Potential and Actually Served Beneficiaries: Currently the supply serves a population of 4,200. There are 437 individual connections but only 225 of these are operational while the rest are disconnected due to non-payment. All connections are metered.
There are 8 institutions in the served area and the supply covers 15 km^2.

Livestock Use: No data was available on the number of livestock in the supply area. This necessitated an estimation using the present population and a ratio of 1 L.U. per family where a family is taken to be six (6) people. This gives us a livestock unit figure of 700 from a human population of 4,200.

Functional Analysis: The supply is operational throughout the year. Operational reliability is good as

long as there is a regular supply of diesel. However, water distribution is done on a rationing basis due to insufficient pressures.
This water supply is generally in poor condition and does not meet the demand of the served area. It therefore requires major rehabilitation and expansion including new treatment works and intake.
The major causes of malfunctioning in this supply are engine breakdowns, and irregular fuel and chemical supply.

Financial Analysis: The revenue collected during the year 1989 was Ksh. 60,869 while that earned was Ksh. 62,921. Fuel and chemical costs for the same period amounted to Ksh. 38,592 while staff/labour costs amounted to Ksh. 180,000 during the same period. The revenue collected amounted to only 28% of the total operation and maintenance cost thereby implying that the MoWD has to highly subsidize this scheme in order for it to remain operational.

Institutional Analysis: This water supply is operated by the MoWD through the District Water Office. There are 11 members of staff attached to this supply who are resident at the works. These include a Water Supply Operator, a pipe fitter, a revenue clerk, and 7 Subordinate Staff with miscellaneous duties. All of these except the pipe fitter are training on the job. The pipe fitter has Trade Test III. The water supply needs an Inspector Water Supplies and 4 more Subordinate Staff as line patrollers.
All these staff, being employees of the MoWD, are directly responsible to the DWE.

3.3.2 Mitunguu Water Supply

This is a rural water supply scheme with a gravity system. It has a river source and production of 624 m^3/day and a clear water storage capacity of 250 m^3.

Potential and Actually Served Beneficiaries: The area served is 45 km^2 and has a population of 5,100. There are 3 market centres, 4 day and 2 boarding primary schools as well as 2 boarding secondary schools in the served area. There are 394 individual connections all of which are metered. This scheme also has 3 kiosks, 1 cattle-trough, 1 cattle dip and 9 communal water points.

Livestock Use: Livestock population data for the area was not readily available and had to be derived from the human population. Given that the average size of a family is 6 people and that a family has 1.0 L.U, then there are 1,247 L.U. in the served area.

Functional Analysis: This scheme is operational throughout the year and has good reliability with respect to operation, pumps and conveyance. Distribution and treatment reliability are fair and satisfactory respectively.
The scheme has full treatment. Causes of malfunctioning are inadequate chemical supply, clogging of filters, siltation and poor screening at the intake. There are also frequent pipe bursts in the Chiokarige area where there are PVC pipes. These should be replaced with GI pipes.

Financial Analysis: The revenue earned during the calender year 1989 was Ksh. 170,550 while that collected during the same period amounted to Ksh. 160,187. Fuel and chemicals cost at total of Ksh. 57,192 while staff/labour costs amounted to Ksh. 263,440 for the same period.
Since the O & M cost is much too high compared to the revenue collected form this scheme the MoWD has to meet the extra financial requirement so that the former can be able to run comfortably.

Institutional Analysis: This scheme is operated by MoWD staff through the District Water Office. There are 10 members of staff attached to the scheme some of who are resident at the treatment works. These are a Water Supply Operator Grade IIA, 2 chemical attendants who are training on the job, 6 line patrollers and 1 clerical officer.
The water supply requires one Inspector Water Supplies, one Water Supply Operator and 6 more Subordinate Staff as line patrollers.

3.3.3 Nkabune Water Supply

Nkabune water supply scheme is a small gravity scheme with a river source. It is a rural scheme with a production of 293 m^3/day and a clear water storage capacity of 100 m^3. The treatment works is 4 km from the intake and conveyance is through a 75 mm diameter pipe.

Potential and Actually Served Beneficiaries: The scheme currently serves a population of 10,000

people. There are 304 individual connections all of which are metered. Of these only 270 are operational as 34 have been disconnected due to non-payment. The scheme also has 20 water kiosks and 2 cattle-troughs.
This scheme serves an area of 10 km² which includes 9 institutions.

Livestock Use: The served area has an estimated 1,000 livestock units.

Functional Analysis: This water supply scheme operates about 22 hours per day throughout the year. Operational reliability is good. The condition of the works is also good as the scheme has been undergoing rehabilitation since 1985 which is due to be completed later this year (1989). The rehabilitation work has been financed by SIDA through MoWD.
The scheme has a full treatment plant whose treatment reliability is good.
Maintenance is regular as and when the need arises.
Fuel supply for backwashing pump is also regular.
The scheme is grossly understaffed as only a water supply attendant operates the whole system with no assistance. The situation is worsened by the fact that this attendant is training on the job.
Lack of transport and fast communication is another cause of malfunctioning.

Financial Analysis: Information on the cost at the time of commissioning was not available. However, the scheme is under rehabilitation and the estimated cost of the new intake is Ksh. 1.2 million while that of the new storage tank with a capacity of 50 m^3 is Ksh. 260,000.
The total revenue collected during 1989 Ksh. 78,901 while revenue billed for the same period was Ksh. 71,036. Data on the cost of chemicals and labour costs for the year were not available.

Institutional Analysis: This scheme is operated by the MoWD through the DWE. There are 2 WSO's, one Assistant Hydrologist, 5 Subordinate Staff giving a total of 8 members of staff.
Fuel is supplied from the District Water Office as and when the need arises.
The water supply, however, needs one Inspector Water Supplies, one Water Supply Operator and 4 more Subordinate Staff as line patrollers.

3.3.4 Tigania Water Supply

Technical Description: Tigania Water Supply is the third largest rural water supply scheme serving about five market centres, and approximately 27 institutions. It serves an estimated area of approx 60 km². The total distribution length is 50.8 km. Presently there are two lines (parallel) and a third proposed so as to increase the total supply. Both the new line and the old line, have their source from a spring. The old line delivers 860 m^3/day whereas the second line delivers 1,144 m^3/day. The third source is river Liutu which is expected to join the existing distribution line at Nchoro. (Detail of capacity not available). The total clear water storage is 324 m^3. Other additional tanks (BPT's) increase the storage (total) to 462 m^3. The springs estimated yield is 2,004 m^3/day.

Potential and Actually Served Beneficiaries: The supply serves five (5) market centres, and 27 institutions all with a population estimated at 38,600. The supply has 681 individual connections, of which 329 are metered, 135 are non-metered and 154 are disconnected due to non-payments etc. It serves two cattle dips, and 42 communal water points which are currently not in use.

Livestock Use: Data not available.

Functional Analysis: This is a very reliable water supply through out the year. The total yield from the source is 2004 m^3/day. The raw water quality is good requiring only chlorination. Apparently the second line delivers the water straight to the storage tank by passing the chlorination chambers. The chlorination units (2) are out of order and need replacement.

Financial Analysis: In 1989 Tigania Water Supply earned a revenue of Ksh. 134,073 but only Ksh. 60,671 was collected during the same period. The operation and maintenance costs excluding staff salaries amounted to Ksh. 228,240 during that period.

Institutional Analysis: This water supply scheme is operated and maintained by MoWD. The operating staff comprises of 1 operator Grade IIA, 1. Assistant Operator (Grade III), 2 clerical officers (EACE) employed by SIDA WUTP whose task is billing and revenue collection, 3 pipe fitters (Grade III) and 8 Sub-Ordinate Staff (SS) whose activities include chemical attendants, line patrollers, watchman and other miscellaneous activities.

3.3.5 Mwimbi Water Supply

Technical Description: Mwimbi Water supply is a rural scheme with a river intake and a gravity system. It has a design capacity of 372 m^3/day while the present production is 4290 m^3/day. This clearly shows that the scheme has been stretched many times over its design capacity. This scheme has a storage capacity of 325 m^3 and 65 km of piping for distribution. Chlorination and sedimentation are the forms of treatment done on the water here. This scheme covers an area of 60 km^2
The water supply has one double-unit grade 9 house, an office and a laboratory.

Potential and Actually Served Beneficiaries: This water supply serves a population of 32,000 with a total number of 1516 individual connections. Of these 327 are metered while 1189 are flat rate connections.
The area covered by this supply, the number of market centres and institutions served are not known.

Livestock use: Data on livestock in the supply area were not available. However, a figure of 2,525 livestock units was estimated using the population figures in the supply area.

Functional Analysis: This water supply is operational throughout the year. Data on the working condition of this scheme were not available thus making it impossible to determine if and what magnitude of expansion and/or rehabilitation were required.

Financial Analysis: Revenue collected during the calendar year 1988 was Ksh. 244,263 as opposed to Ksh. 273,226, the revenue billed to the consumers during the same period. This shows a very high revenue collection, i.e 89%, compared to most other public water supplies which are below the 50% mark.
Data on operation and maintenance costs and staff salaries were not available.

Institutional Analysis: The water supply is run by a water supplies operator who has 2 clerical officers and 13 Subordinate Staff under him. The Subordinate Staff have various duties which include linepatrolling, plumbing, pipe fitting and chemical attendance.
All these staff, through the Water Supply Operator, are responsible to the District Water Engineer.

3.3.6 Karingani Water Supply

Technical Description: This is a large rural scheme commissioned in 1970. It is a gravity scheme with a river source. This scheme has a production of 5,900 m^3 per day but the storage capacity is not known. The length of the piping in the distribution network is also unknown. The treatment done is chlorination. Karingani Water Supply covers an area of 23 km^2.

Potential and Actually Served Beneficiaries: Karingani Water Supply serves an estimated population of 12,400. The area covered by the scheme is not known. There were 2,972 individual connections in 1988 and only 732 of these were metered. The number of institutions and market centres served by this water supply is not known.

Livestock Use: Data on livestock were not available but an estimate was done using population figures. There are an estimated 4,000 livestock units in the supply area.

Functional Analysis: The scheme is operational throughout the year. The main problems in this scheme is water shortage. This problem is partly due to the fact that the scheme also supplies Chuka Town which is a fast growing town, soon to become an district headquarter. The other reason is that the distribution lines for the self-help financed phase II were laid down without any design plan resulting to small diameter lines.
This water supply is under rehabilitation through the Water Use Test Project with the aim of solving the problems discussed above.

Financial Analysis: This scheme earned a revenue of Ksh. 407,961 during the year 1989 out of which only Ksh. 252,188 was collected. There are difficulties in trying to get the consumers to clear their bills especially in the self-help financed part of the scheme. This is so because they say that they should pay a lower charge than those whose part of the scheme was financed by the government. This is a serous problem which should be looked into so that more revenue can be earned and collected thereby enabling the scheme to be self sustaining.

Institutional Analysis: Karingani Water Supply has 20 members of staff who are headed by an Inspector Water Supplies. They range from pipe fitters to clerical officers and Subordinate Staff who work as line patrollers and masons. All these people are responsible to the DWE through the Inspector Water Supplies.

3.3.7 Timau Water Supply

Technical Description: Timau water supply is a small rural water scheme in Timau Division of Meru District. This scheme was commissioned in 1978 and has a river intake with a production of 130 m^3/day. It has a storage capacity of 500 m^3 and a distribution network of 41.5 km of piping. This is a gravity system with no treatment at all.

Potential and Actually Served Beneficiaries: This water supply serves a population of 2,878 with 315 individual connections. Of these connections 311 are metered while the other 4 are not. The scheme covers an area of 9 km^2.

Livestock Use: The served area has a total of 480 livestock units. However details of a breakdown into cows, sheep, goats etc were not available.

Functional Analysis: Timau water supply is not in a very satisfactory working condition. The scheme requires additional storage and replacement of the corroded G.I. pipes which burst frequently due to the extended use and high pressures in the gravity system. The scheme is operational throughout the year.

Financial Analysis: Revenue billed during the year 1989 was Ksh. 100,247 while revenue collected for the year was Ksh. 63,343. Data on the operation and maintenance costs as well as that on staff salaries were not available. This made it impossible to estimate how much of the cost of running this water supply was met by the revenue collected.

Institutional Analysis: Timau water supply has a workforce of 4 members of staff. All these people are Subordinate Staff with no training in water supply operation. It is therefore clear that this water supply is grossly understaffed.
This water supply requires the services of 1 Inspector Water Supplies and an additional Subordinate Staff as a linepatroller.

3.4 Private/Self-Help Water Supplies

All private/self-help schemes in Meru District belong to the category of rural water supplies. All the piped ones are protected but have no treatment. All the schemes described here get their water from surface sources.

3.4.1 Ntumburi Water Project

Technical Description: This is a rural self-help water project in Central Imenti Division. The scheme has a gravity system with a conveyance of 13 km of 4 inches diameter pipe to the first storage tank and 42 km of main distribution lines. The project has a present storage capacity of 225 m^3 and a production of 743 m^3/day. The water source is a spring situated on Kisima Farm.

Potential and Actually Served Beneficiaries: This scheme currently serves a population of 5,000 people. There are 50 communal water points, 1 cattle-trough and 3 cattle dips in the served area. The scheme also serves 7 schools, 14 churches and is expected to serve 3 proposed Health Centres. The total area covered by the scheme is 40 km^2.

Livestock Use: The livestock population averages 3 cows and 7 sheep and goats per family where a family is taken to be 6 people. This gives a figure of 5,000 cows and 11,666 sheep and goats in the served area.

Functional Analysis: The scheme operates throughout the year and has good operation reliability. The distribution network is in good condition as construction is still going on and the project is still new. The quality of the raw water is good in terms of colour and turbidity. No treatment is done.
Maintenance is rare except when there are pipe bursts due to excessive pressures.

Financial Analysis: The first part of the project, which is now operational, was constructed at an estimated cost of Ksh. 7.0 million. Of this amount the local community contributed 25% while the MoWD and the EEC contributed 25% and 50% respectively. The EEC channelled their part through MoWD. Staff and labour costs amount to Ksh. 3,000 while spares cost Ksh. 1,000 per month. This gives a monthly O & M cost of Ksh. 4,000.
Revenue collection is not regular as people join the project at their own leisure. All members are required to pay a membership fee of Ksh. 1,200 once and for all. This means that revenue generation is not reliable as membership subscription can not be predicted.
The community are planning to install metered connections in the near future. This will serve to bring water closer to the people as well as being a source of revenue on a regular basis.

Institutional Analysis: As this is a self-help project, it is run by the local people. A committee has been elected which oversees the operation of the scheme. These include the chairman, treasurer, and secretary. The scheme has also employed 2 masons trained in a local polytechnic and a pipe fitter who is training on the job.

3.4.2 Ng'uru Gakirwe Water Project

Technical Description: The project is situated in Tunyai Sub-location, South Tharaka Location, Tharaka Division of Meru District. It was commissioned in June 1989 and has a daily water production of 6,000 m^3 and a storage capacity of 25 m^3, a break-pressure tank. The piping consists of 17.5 km of conveyance and 12.0 km of distribution.
The intake structure is a concrete weir 11 meters wide and 1.5 meters high.

Potential and Actually Served Beneficiaries: This project serves an estimated population of 1,650 people living in 137 plots. There are 260 flat rate individual connections. The project is sub-divided into three phases namely I, IIA and IIB. Phases I and IIA are complete and commissioned while phase IIB is under construction. The completed phases cover an area of 20 km^2.

Livestock Use: Livestock data on this project were not available. From population figures, the area was estimated to have about 350 Livestock Units.

Functional Analysis: The completed phases i.e I and IIA of this project are operational throughout the year. As the scheme was commissioned recently (1989) it is quite new and in very good working condition. The supply is adequate for domestic consumption as well as for irrigation and livestock. No rehabilitation is required.

Financial Analysis: The consumers in this scheme pay a fixed fee of Ksh. 200 per year per connection. The total revenue collected per year is Ksh. 52,000 while the total operational cost per year is Ksh. 350,000. The balance of Ksh. 298,000 is provided by the Diocese of Meru.
The cost of the project at the time of commissioning was Ksh. 21,625,000. Of this amount Ksh. 6 million was spent on the intake and housing while Ksh. 15 million was spent on the piping and a break-pressure tank.

Institutional Analysis: The project is run by the Catholic Diocese of Meru who have employed 6 people to operate the system. These include a Manager, who is in-charge, a technician, a clerk, an intake attendant and two watchmen.

3.4.3 Tuuru Water Scheme

Technical Description: Tuuru water scheme was commissioned in 1969 and has 3 intakes all of which are in the Nyambeni Forest. They are the upper Ura, the lower Ura, and the Amwamba spring. However, only the Amwamba source has so far been connected to the distribution system. The lower Ura source has been used only twice during drought, (once in 1977 and again in 1984), while the upper Ura source has never been used at all. The Amwamba intake is augmented by a series of two (2) tunnels dug into the mountain range. There are another two tunnels which are connected to the Ura intakes. The scheme also has three emergency wells. The total distribution capacity of this scheme is 1,700 m^3 per day.
The water supply system has a main storage of 20 reservoirs with a total capacity of 2,500 m^3. Local small storage tanks have a total capacity of 1500 m^3. This gives a grand total of 4,000 m^3 of storage.
The main distribution pipeline has a length of approximately 190 km. The total length of the minor distribution lines is not known.

Potential and Actually Served Beneficiaries: The scheme currently serves a population of approximately 100,000 which includes all of Ntonyiri Division and part of Igembe Division. The scheme covers an area of 550 km². There are at present 730 individual connections all of which are metered. There are also 86 kiosks in the served area from where those without private connection buy their water. The scheme also serves 15 institutions and 5 cattle dips in addition to the rural population.

Livestock Use: Cattle in the served area are generally in poor condition as they receive only about half the specific daily water requirement. The average number of animals per family is 1.5 livestock units (L.U), hence the total number of L.U in the area is approximately 30,000. This number gives a daily water need of 2,000 m^3.
There is no potential for livestock population increase mainly because of lack of enough water and low carrying capacity of the grazing land.

Functional Analysis: Tuuru water scheme is operational throughout the year. It is in good condition but is grossly inadequate for the huge population which is growing rapidly.
Of the three fully constructed intakes only one is in fulltime use and a second one has been used only twice during drought while the third one has never been used. These two unused intakes (i.e the upper and lower Ura) are referred to by the Diocese of Meru as spare intakes. This, however, gives a wrong impression of the water supply situation as the community in the supply area are far from having a sufficient supply of water even for their domestic use. There is, therefore, the need to expand the distribution system using these 'spare intakes' in order to augment the already grossly insufficient existing supply.

Financial Analysis: A look at the Tuuru Water Scheme Field Evaluation report shows that the financial standing of the project is very good. This is so because the expenditure incurred is less than the revenue earned/collected and this is an example of the best managed schemes/projects.
Below is a budget estimate for the financial year 1988-89 which was extracted from the Tuuru water scheme field evaluation report, published in September 1989.

PROPOSED BUDGET - JULY 88 - 89	Ksh
Proposed Income	
1. Water consumption from the existing private and Public Institutions	300,000
2. Water consumptions from the anticipated new 100 Private connections	52,500
3. Water consumptions from active Kiosks	414,000
4. Income from membership fees for the proposed new 100 Private connections	330,000
5. Profit from the Petrol Station at an estimated net profit per month of Ksh. 6,000	72,000
Total Estimated Income	1,168,000
Proposed Expenditure	
1. Salary of Administration Staff	168,000
2. Salary of Field Staff	90,000
3. Vehicles Maintenance (running only)	85,000
4. Rent of Office and Quarters	61,800
5. Maintenance of intake and pipelines	120,000
6. Stationery, Telephone, Postage	24,000
7. Refunds of old membership fees	10,000
8. Construction of 12 new Kiosks	48,000
9. Construction of 5 new storage tanks	115,000
10. Repayment of existing external debtors	204,594
11. Repayment of Debts to Mukululu Camp and to the Diocese of Meru	240,000
Total Estimate Expenditures	1,166,394
Income expected over expenditure Ksh. 1,606	

Institutional Analysis: The Tuuru Water Scheme is a highly organised scheme run by the Diocese of Meru who have employed administrative and field staff of an unspecified number. Key posts in the administration of the scheme include water coordinator, Executive Secretary, Public Relations Officer, Superintending Engineer, Administrative Manager, and Diocesan Water Engineer. Others include storekeepers, Technicians/surveyors, line patrollers, Drivers/Mechanics, Clerks/Typists, Plumbers/Masons, Carpenters, Maintenance Supervisor, Cleaners and Night watchmen.
The scheme requires an additional Water Engineer, Field Manager and a Typist/Cashier urgently. In the

long term (i.e 3 years and beyond) their will a line patroller, an Administrator/storekeeper, a plumber/mason and a water Engineer required in addition to those mentioned above.
The process of invoicing the consumers is complicated by the long distances and transport difficulties. There are, however, proposals to shorter this process by asking the line-patrollers to write the invoices directly in the field.
All consumers getting water from one kiosk are organised in a tap committee. This committee and the people are charged with the responsibility of electing a kiosk holder. The kiosk holder is a partner of the Tuuru Water Scheme. Both the kiosk holder and the Tuuru water scheme have rights and obligations which are laid down in a contract document between the two parties.

3.4.4 Murugi Mugumango Water Society

Technical Description: This scheme has two intakes, one at Kamara River and the other at South Mara River, and is operated by gravity. It serves a rural population and the distance from the intake to the first consumer is 32 km. The total length of the distribution system is, however, not known but the main line extends over a distance 60 km from the western to eastern ends of the project area.
The scheme has a production capacity of 1690 m^3/day and a storage of 360 m^3.
There are plans to construct a new permanent intake higher upstream on the South Mara River with an 8" diameter pipe to the existing storage tank at Baragu. There are also plans to construct an additional 3 storage tanks each with a capacity of 100 m^3.
The scheme has no treatment works.

Potential and Actually Served Beneficiaries: The scheme covers an area of 140 km^2 and serves a population estimated at 14,700 people. There are 1187 individual connections all of which are metered. The scheme covers an area of approximately 35 km^2.

Livestock Use: There are no data on livestock. A figure of 4,666 L.U was, however, reached by assuming 1 L.U per family and taking a family to be 6 persons.

Functional Analysis: The scheme is operational throughout the year. Operational reliability is very good compared to most other self-help schemes.
The scheme has no treatment and the water quality is reported to be good by the consumers. The water is not turbid as the intake is in the forest where there is little or no erosion.
The distribution network is in good condition there being only occasional accidental bursts.

Financial Analysis: At the inception of the society, the pioneer individual members were required to pay Ksh. 3,050 while institutions paid Ksh. 6,843. However late applicants were required to pay a penalty of Ksh. 200 and labour charge of Ksh. 900 in addition to Ksh. 3,050 the total charge coming to Ksh. 4,150.
This water society has a well organised billing and revenue collection system which ensures the recovery of debts owed to it by the members. The society charges Ksh. 20.00 per month for consumptions of upto 30 m^3 a month and thereafter Ksh 2.00 for every extra cubic meter to individual members. Institutions pay Ksh. 100.00 for the first 30 m^3 per month and Ksh. 3.00 for every extra cubic meter. The expected revenue per month is about Ksh. 45,000 while the revenue collected averages Ksh. 30,000.
Staff salaries account for an average of Ksh. 25,000 per month while operation and maintenance (mainly repairing standpipes and cleaning) amount to between Ksh. 5,000 and 8,000 for the same period. Any surplus revenue is kept in bank accounts operated by the society and is intended to cover recurrent costs as well as being a source of major expenditure such as system expansion and/or replacement.

Institutional Analysis: The society has eighteen (18) permanent staff who include a Manager, an Assistant Manager, clerical and technical staff. All these are employed by the society and are supervised by a management committee.
The management committee is elected annually at the society's Annual General Meeting (AGM). This committee has eight (8) elected members and an additional four (4) co-opted women members. The committee meets monthly.
The society has an executive committee made up of the chairman, vice-chairman, secretary and Treasurer of the Management committee. This group meets periodically to discuss and resolve society issues.

3.4.5 Kithinu - Mari Water Project

Technical Description: Kithinu - Mari Water Project is situated in Kothine Sub-location, Igoki Location, South Imenti Division of Meru District. The scheme has a river source and is a gravity system. The scheme has an abstraction of 430 m^3 per day and a storage capacity of 318 m^3. The conveyance is 2.06 km while the minor distribution lines are about 19 km long in total.
The quality of the water is acceptable by the consumers for domestic use as well as for livestock. No treatment is done on the water.

Potential and Actually Served Beneficiaries: The scheme serves a population of 3,180, with 536 non-metered individual connections. There are 2 market centres, 3 schools and a health centre in the served area. The total area served is approximately 4 km^2.

Livestock Use: The served area has a livestock population 1,590 large stock i.e cows and 2,650 small stock i.e sheep and goats.

Functional Analysis: This scheme is operational throughout the year and has a reliability which is satisfactory. The present demand is much higher than the original design capacity, hence the supply is inadequate for the current population served. This clearly implies that the scheme should be expanded to be able to adequately meet the present demand.
The present system requires an additional intake and new service lines with increased diameters for better efficiency.
Siltation at the intake and occasional pipe bursts are the major causes of malfunctioning in this scheme.

Financial Analysis: The only financial records available were those of the cot at thew time of construction, Ksh. 155,000 by 1979, and the monthly casual labour cost of Ksh. 360.

Institutional Analysis: This scheme is run by an elected committee of seven members who are headed by a chairman. This committee supervises a plumber who is employed on permanent basis and does field and office duties. There are also 8 pipe fitters who work under the plumber all of whom are casual labourers.
The committee also mobilises general members and communicates any developments to the latter.

3.4.6 Taita/Muguru Water Project

Technical Description: Taita/Muguru water project is located in Kathera Sub-location, Nkuene Location, South Imenti Division, Meru District. It is a rural scheme with a river source and a gravity system abstracting 90 m^3 of water per day. The length of conveyance piping is 0.116 km while the total length of the distribution lines is 16 km. This scheme has neither storage nor treatment.

Potential and Actually Served Beneficiaries: The population in the served area is 6,000 people out of whom only 910 are served. There are 160 non-metered individual connections in the served area. 3 schools are also beneficiaries of this scheme. The area covered by this scheme is not known.

Livestock Use: Data on the livestock in this supply area were not available. It was, however, estiamted using the human population figures that there are about 1,000 L.U. out of which only 200 L.U are served by this scheme.

Functional Analysis: The scheme is operational throughout the year. The scheme is presently just adequate for the currently subscribed members. It however requires the increase of conveyance pipe diameter, intake capacity and storage to be a able to cater for the rapidly increasing membership. There is also a need to install gate valves and air valves to be able to regulate flow and remove air locks from the distribution system.
The pressure is presently sufficient and the water quality is acceptable both for domestic and livestock use. There is no irrigation done in the supply area as the water is not adequate for this purpose.

Financial Analysis: Financial records in this scheme were almost entirely lacking as the members meet the costs of maintenance if and when they arise and do not do any documentation. The only record available was that of the cost at the time of commissioning, Ksh. 60,000, in 1974. This cost was, however, not accompanied by any details and therefore serves little or no purpose for our study.

Institutional Analysis: Taita/Muguru Water Project is managed by a committee of 5 members elected from among the general membership. These people mobilise the rest of the members who provide labour and/or materials on a self-help basis whenever there is construction or maintenance work to be done.

3.4.7 Maigene Water Project

Technical Description: Maigene water project is a self-help scheme in Kigane Sub-location, Nkuene Location of South Imenti Division. The scheme was commissioned in 1976 with its first intake on Thagara river and later a second intake on Kithinu river in 1986. The water production of the scheme is 112.5 m^3 per day and the storage capacity is 136.4 m^3.

Potential and Actually Served Beneficiaries: This scheme serves a population of about 1,500 people. There are 80 individual connections all of which are not metered. The area covered by this scheme is not known but there are 10.8 km of piping network for the distribution. There are in addition 1 school, 1 market centre and 2 churches served by this scheme. The area covered by the scheme is approximately 2 km^2.

Livestock Use: There are 150 grade cows and 750 sheep and goats in the served area.

Functional Analysis: This scheme is operational throughout the year. It is, however, inadequate due to small pipe diameter from source. This project is using a 75 mm pipe which is delivering 2 litres per second although the pipe can deliver 4.5 litres per second at full capacity. This is still below the present population water requirement of 9.5 litres per second. The water scheme should therefore design for a 150 mm pipe which will deliver 15 to 20 litres per second at full capacity and therefore be able to serve an even bigger population.

Financial Analysis: The only income expected from the consumers is the membership fee which they pay once and for all on joining the water Association. There were, however, no records on the prescribed amount. The scheme received a sum of U.S. $1,500 as aid from the USAID during the construction period.
At the time of commissioning (1976) the scheme had spent a sum of Ksh. 40,000 which included the donation mentioned above. Ksh. 5,000 went to the construction of the intake while Ksh. 35,000 went to the piping. Later in 1979 three tanks with a total storage capacity of 136.4 m^3 were constructed at a cost of Ksh. 16,000.
The only regular cost incurred by the scheme is the operational and maintenance cost which averages Ksh. 200 per month.

Institutional Analysis: This scheme is run by a committee of seven (7) people who are elected by the members. The committee is headed by a chairman who is assisted by a secretary and a treasurer and four (4) other members who have no specific duties. The general task of this committee is, to mobilise the other members of the project whenever there is some construction or maintenance work to be carried out. This committee is a voluntary task force and therefore does not earn any salary from the projects treasury.

3.4.8 Mwirangara Water Project

Technical Description: This scheme is located in Kigane Sub-location, Nkuene Location, South Imenti Division of Meru District. The scheme has a river intake with a gravity system. The storage capacity is 96 m^3 but there were no records on the amount abstracted daily.
There have been cases of amoeba reported and despite this fact no treatment is done on the water before it is delivered to the consumers. They however have been advised to boil the water before drinking it.

Potential and Actually Served Beneficiaries: Mwirangara water project serves an estimated population of 3,000 people with 500 non-metered individual connections. There were no records on the area covered by this scheme. The total area covered by this scheme is 2 km^2.
This scheme also serves a Secondary School, a Primary School and 2 churches.

Functional Analysis: The scheme is operational throughout the year. The scheme, however, requires expansion as the water is neither adequate for domestic, livestock nor minor irrigation. There is an

additional intake and piping required to augment the present one. The present intake also requires to be moved higher upstream to avoid pollution from coffee waste from a nearby factory. Additional storage should also be constructed. There are notably low pressures in the taps during the dry season.

Financial Analysis: The construction cost of the scheme at the time of commissioning, 1976 was Ksh. 438,000. The cost as at June 1989 was Ksh. 488,708 which showed an additional Ksh. 50,708.
The scheme has no regular source of revenue as they do not sell water to the consumers. Labour is provided by the consumers free of charge and there are therefore no costs incurred.

Institutional Analysis: The scheme is run by a committee of 5 people elected by the members from among themselves. This committee is responsible for mobilising the consumers whenever there is construction or maintenance work to be done.

3.4.9 Mitunguu - Tunyai - Muthangacwe Water Furrow

Technical Description: This water scheme is an open furrow gravity system with its source on the Thingithu river in Mitunguu Location of South Imenti Division, Meru District. It serves Kirendene Sub-location in Mitunguu Location, Tunyai, Kamunyaki and Chiokariga Sub-locations in South Tharaka Location, Tharaka Division.
it is not known what amount of water is abstracted by this scheme nor are the total length of furrow and the area covered by this scheme known. There is of course, no treatment despite the fact that the furrow is open to pollution by livestock and other sources.

Potential and Actually Served Beneficiaries: This scheme serves a population in excess of 6,500 from all the four (4) Sub-locations mentioned above. Almost all the people in the served area depend entirely on this furrow for their daily water requirements. Nine schools, nine market centres and sixteen churches benefit from this scheme. The water is also used for minor irrigation. The scheme covers an area estimated at 20 km².

Livestock Use: The served area has an estiamted 5,500 head of cattle (indigenous) and 26,700 sheep and goats all of which depend on this furrow for their daily water requirements.

Functional Analysis: This scheme is grossly inadequate for the huge population and livestock numbers who depend on it as their sole means of survival. The water levels are low especially during the dry season due to high rates of evaporation and infiltration. The recommended alternative would be to pipe the water and provide storage facilities in order to reduce these losses and ensure better quality by protecting it from contaminants.

Financial Analysis: There is not much to discuss about the finances of this scheme. The only notable feature is the intake which was constructed with financial assistance from EMI in 1986 although the furrow has existed since as far back as 1928. The cost of the construction of this new intake was Ksh. 200,000.

Institutional Analysis: This scheme has a committee elected from among all the people served by the furrow. This committee has sub-committees one in each of the Sub-locations who supervise the maintenance of the section of the furrow traversing their Sub-location.

3.4.10 Munyaka Gitiri Water Project

Technical Description: This water project was commissioned in 1976. It is located in Ng'onyi Sub-location of Mitunguu Location in South Imenti Division.
The project has its intake on the Thagara River and the conveyance pipe-length is 5.61 km while that for distribution is 1.68 km. The project has no storage tank. Figures for water production per day were unavailable as the connections are not metered and neither is there a master meter. The water project has no treatment works.

Potential and Actually Served Beneficiaries: The scheme has 26 individual connections serving an estimated population of 210 people. All these connections are not metered. The supply does not serve dips, institutions or market centres.

Livestock Use: The served area has 78 large stock and 130 small stock.

Functional Analysis: The supply operates throughout the year and is in good working condition. Domestic and livestock supplies are adequate while irrigation supply is inadequate.
The water quality is acceptable for domestic, livestock and irrigation use during most of the year. This, however, is not the case in the wet season when the water has a very high level of turbidity. Water pressures are also insufficient especially during the dry season.

Financial Analysis: The project was constructed at an estimated cost of Ksh. 67,400 all of which has been raised by the served community through membership fees and organised fund raising. However, only Ksh. 46,200 of this had been spent at the time of commissioning, 1976. The balance was spent on rehabilitation in 1984 and 1986.
There were no data on membership fee which appears to be the only source of revenue for the project. Data were also lacking on the operation and maintenance costs.

Institutional Analysis: This scheme is run by a group of elected officials who do this on voluntary basis. The group consists of a chairman, secretary, treasurer and four others. The main job of these people is to mobilise the community whenever there is something required to be done. The group is accountable to the community for all the things they do and more so for the financial expenditure.

3.4.11 Mitunguu Irrigation Scheme

Technical Description: Mitunguu Irrigation Scheme is situated in Kirendene Sub-location, South Imenti Division of Meru District. This is a government scheme funded by the German Government through the Ministry of Agriculture. The scheme was commissioned in 1985.
The scheme has its intake on the Thingithu river and abstracts 34,560 m^3 per day and has a design discharge of 39,744 m^3 per day. This scheme has a rather low storage capacity of 64.4 m^3 and has 41 km of conveyance and 40 km of piping for distribution. The water quality as perceived by the consumers is good and there is no treatment done on it.

Potential and Actually Served Beneficiaries: The scheme serves a rural population of about 1,860 people with 310 non-metered individual connections. Two schools and a B.A.T factory are also served by this scheme. The area covered by this scheme is not known.

Livestock Use: There are 500 grade cows and about twice that number of indigenous cows in the served area. The number of sheep and goats is 800.

Functional Analysis: This supply is operational throughout the year and is in very good working condition and therefore does not require any rehabilitation. In fact this scheme is operating below the design capacity, being a relatively new scheme (commissioned in 1985).

Financial Analysis: The cost of the scheme at the time of commissioning (1985) was Ksh. 40 million. This cost included piping, intake structure, storage, offices and stores.
The scheme earns Ksh. 110,000 from the consumers every year (approximately Ksh. 9,200 per month) and spends Ksh. 3,050 per month on labour charges.

Institutional Analysis: The scheme is operational and maintained by the Mitunguu Farmers' co-operative society. This society has employed a staff of 3 on a permanent basis; a mechanic/driver, a Subordinate Staff and a watchman. The society also occasionally hires two casual labourers.
There is an agreement between the society and the members that the former maintain the main line while the latter maintains the minor lines to the individual connections.

APPENDIX 4

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

APPENDIX 4

UNIT COSTS OF WATER SUPPLIES:

SOURCE DATA

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply: Rural Supply Groundwater

Including: Boreholes, pump, storage, distribution

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Turima/Gampua	1988	720,000	1,220	590	Solar pump, 1 borehole
	Kitihori	1988	500,000	430	1,160	Solar pump, 1 borehole
	Nkururuni	1988	680,000	1,300	523	5 bh's, handpump, s/s dam
	Kagombe	1988	290,000	430	674	2 bh's, handpump, s/s dam
	Rwakinanga	1988	270,000	340	794	2 bh's, handpump,
	Muguko	1988	270,000	280	965	2 bh's, handpump, s/s dam
	Rukenya	1988	440,000	550	800	3 bh's, handpump, s/s dam

Supply: Rural Supply Surfacewater/Gravity

Including: Intake, main lines, storage, Treatment, Distribution

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
BISH	Chepalunga	1989	105,902,652	135,850	780	Large supply 10,050 m^3/d
McPherson	-	1984	972,118	5,150	190	Hypothetical supply, low costs of intake and storage (no treatment)
Norconsult	Gakauni	1990	2,338,250	1,200	1,950	Intake chamber, filtration, Ultimate population served 3,131
P.K.Njiru (Diploma design)	Kibauni	1989	32,000,000	33,466	956	Pumped supply, 900 m^3/d

Supply: Rural Supply Surfacewater/Hydram

Including: Hydram, Treatment, Storage tank, Distribution

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Karuma	1988	540,000	1,200	450	
	Muyoya-Kamatungu		660,000	1,500	440	

Supply: Protected Spring

Including: Spring Captation with one outlet

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	KWDP	1988	63,500	500	127	Excluding overhead
FINNIDA	KFRWSDP	1988	14,716	200	132	Excluding overhead

Supply: Protected Spring

Including: Spring Captation with off-take pipeline and water points

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
GSK	KIDP	1989	100,000	500	200	20 m^3/day
			250,000	1,250	200	50 m^3/day

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply: Boreholes

Including: Drilling, casing, development, superstructure, handpump, labour costs

Source of Data	Project Name	Year	Average Bh. Depth (m)	Total Costs	Popu.	Costs/ Capita	Remarks
LBDA	RDWS & SP	1986	65	107,500 127,470	200 200	538 637	Excluding overhead Including overhead
SIDA	Nkururuini	1988		120,000	260	460	
	KWDP	`85-`87	?	68,228	200	341	Excluding overhead
FINNIDA	KFRWSDP	1988	?	71,480 120,486	200 200	357 602	Excluding overhead Including overhead
PENCOL	CBWDP	1984	50	227,700	200	1138	
NORCONSULT	Gakauni	1990	?	240,000	175	1370	Based on 33% success rate

Supply Component: Borehole Construction,

Including: Drilling, casing, developing, testing

Source of Data	Project Name	Year	Total Costs	Depth	Costs/ m	Remarks
Diocese	of Marsabit	1989			2,100	
MoWD	Design Manual	1986	90,000	50	1,800	Large nr. in same area
GSK	KIDP	1989	150,000	50-200	3,500-5,000	Single or few holes
PENCOL	CBWDP	1984	360,000	125	2,880	150 mm diameter
		1984	470,000	125	3,760	200 mm diameter
Diocese	Baragoi		-		2,500	
	Lodokojek	1986	159,550		2,660	One borehole (24 m 150 mm Johnson screen)

Supply: Dug Wells

Including: Dug well, lining, superstructure, handpump, labour costs

Source of Data	Project Name	Year	Average Well Depth (m)	Total Costs	Popu.	Costs/ Capita	Remarks
LBDA	RDWS & SP	1986	15	37,000 54,440	200 200	185 272	Excluding overhead Including overhead
SIDA	KWDP	1985-1987	-	57,000	200	285	Excluding overhead
FINNIDA	KFRWSDP	1988	6.2	51,218 79,959	200 200	256 400	Excluding overhead Including overhead
PENCOL	CBWDP	1984	?	47,438	200	237	
GSK	KIDP	1989	?	35,000	100	350	

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply Component: Dug Wells

Including: Digging Only

Source of Data	Project Name	Year	Average Well Depth (m)	Total Costs	Popu.	Costs/ meter	Remarks
LBDA	RDWS & SP	1986	15	11,000		750	
GSK	KIDP	1989	?			1000	Including Slab
MoWD	Design Manual	1986	5-15	70,000		>5000	Concrete rings, including survey

Supply: Handdrilled Well

Source of Data	Project Name	Year	Average Well Depth (m)	Total Costs	Popu.	Costs/ meter	Remarks
MoWD	Design Manual	1986	5-15	30,000		>2000	Including survey

Supply: Rain Catchment (Roof)

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Kwale	1988	50,350	50	1,007	Including overhead
CBWDP	PENCOL	1984	14,304,000	3,700	3,866	Based on consumption of 20 l/person/day. Roof + Storage costs
GSK	Oral Information	1989	25,000			25-28 m^3 ferro cement tank & gutters
SIDA	Marimanti-Health Centre		77,000			90 m^3 tank, 138 m gutters
	Primary Sch.		95,000			112 m^3 tank, 160 m
	Marimanti				525/m^3	Tank
	Marimanti				215/m^3	Gutters

Supply: Roof Catchment Tanks

Source of Data	Project Name	Year	Type	Volume (m^3)	Costs/ m^3	Remarks
McPherson		1984	Corrugated Iron	1	890	Must be transported to site
				5	384	Not very durable
				10	354	
			Brick/Cement	1-1000	600-900	Cost assumes standard design
			Ghala Basket	1-8	2500-600	2000-3000 constructed in Kenya
			Cement Jars	1-10	500-750	Large jars need reinforcement
			Ferrocement	1-200	200-400	
			Concrete ring	1-25	350	Simpler to build than ferrocement

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply: Rain Catchment (Rock)

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Kwale	1988	?			
GSK	KIDP	1989	900/m^3			Stone masonry
			41/m^2			Stone gutters
			100,000	200	500	Complete 10 m^3/day
McPherson	Mutomo	1984	150,000	1,500	100	Storage 3,500 m^3, 15m^3/day
	Mutomo	1984	250,000	1,500	175	Costs including supervision and self help labour

Supply: Sub-Surface Dams and Sand Dams

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
PENCOL	CBWDP	1984	300,000	200	1,500	11 m^3/day
GSK	KIDP	1989	900/m^3			Stone masonry wall
			150,000	100	1,500	Sand Dam 5 m^3/day
	Kyandili	1979	30,000	1,000	30	3 m high, no community involvement
	Kalama	1980	15,000	1,000	15	3 m high, community involved
	Ethiopia	1981	66,666	800	83	38 m high, no community involvement
SIDA	Nkururuini	1988	80,000			Livestock supply
McPherson	MIDP	1984	22,000			Concrete dam, 6,500 m^3 storage
EMI-ASAL	Embu District	1984	125,000	300-400	300-400	Sand weirs, donor:ODA
Norconsult	Gakauni	1990	94,000	175	540	Dam with handpump

Supply: Pans

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
PENCOL	CBWDP	1984	2,923,000	1250	2340	50 m^3/day perennial
			950,000	(1250)	760	50 m^3/day seasonal
			1,500,000	450	3333	18 m^3/day domestic
DCU5	-	1989	Rates	60	Shs/m^3	Desilting
			Only	85	Shs/m^3	Embankment (excavation, transport, compaction)
				65	Shs/m^3	Excavation
GSK	KIDP	1989	10,000	200	50	Small earth dam, 10 m^3/day
			250,000	1,200	208	Medium earth dam, 60 m^3/day

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply Component: Distribution Systems (Groundwater)

Including: Main line, storage, Distribution Network Communal Water Points, Cattle Troughs

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Sericho	1988	1,417,600	2,000	709	8 CWP 5 troughs. Solar pump set (2 bh's)
SIDA	Dabel	1988	2,570,600	4,340	592	Part of pop. may use dug wells and handpumps
SIDA	Sololo	1988	2,250,000	9,500	(237)	Part of pop. may use other Sources (no cattle troughs)
NORAD	Mwingi	1988	5,500,000	<10,000	550	Design pop. 1995
	Iten	1988	2,000,000	4,200	(476)	Only main line, no distribution

Supply Component: Distribution Systems (Surface water/gravity)

Including: Main line, Storage, Distribution Network, Communal Water, Points, Cattle Troughs

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	South Horr	1988	1,125,000	5,400	208	20 CWP. 8 troughs
NORAD	Ol Joro Orok	1988	7,500,000	12,000	625	Design population 2005
NORAD	Ishiara	1987	4,800,000	14,000	(343)	Distribution only
SIDA	Karuma	1988	540,000	1,200	450	5 CWP, Roughing Filters

Supply Component: Distribution (pipes only)

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	South Horr.	1988	200,000	5,400	37	
	Sericho	1988	127,600	2,000	61	
	Dabel	1988	1,534,600	4,340	354	large supply area
	Sololo	1988	1,600,000	9,500	168	
	Nkabune	1988	500,000	3,000	167	extension of existing net. work
Norad	Mwingi	1988	3,000,000	10,000	300	12 km
	Ol Joro Orok	1988	7,000,000	12,000	583	28 km
SIDA	Karuma	1988	180,000	1,200	150	
	Ishiara	1987	4,800,000	14,000	343	58 km
LBDA	RDWSSP	1989	230,000	-	-	Unit cost per km²

All SIDA-costs excluding labour

Supply Component: Communal Water Points

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	South Horr.	1986	15,000			
PENCOL	CBWDP	1984	27,000			Kiosk
		1984	16,000			Hydrant
NORCONSULT	Gakauni	1990	1,500	175	9	

Supply Component: Cattle Troughs

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	South Horr	1986	25,000			
GSK	KIDP	1989	1,000			

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply Component: Surfacewater Intake

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Nkabune	1988	200,000	6,000	33	? m^3/day
	South Horr	1988	120,000	5,400	22	192 m^3/day
Norad	Ol Joro Orok	1988	11,900,000	12,000	992	Concrete Dam, 2500 m^3/day
	Ena	1988	2,000,000	44,000	45	2700 m^3/day
	Sagana	1988	500,000	-	-	-
NORCONSULT	Gakauni	1990	70,000	1,200	58	Intake chamber
MoWD (Meru)	Kiamiogo/Kimuri	1990	104,000			Materials only, excluding contingencies 5900 m^3/day Trapping weir and diversion box
	Katheri Ontulili	1990	60,000			Materials and labour, excluding contingencies 2160 m^3/day
	Gatabora (ASK)	1990	52,000			Materials, labour, contingencies, 750 m^3/day

Supply Component: Treatment

Including: Chlorination only

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Costs/ m^3/day	Remarks
Norad	Mwingi	1988	100,000	10,000	10	143	Gw source, Prod. 700 m^3/day
	Meru	1988	500,000	95,000	5	50	Sw source 10000 m^3/day
	Iten	1988	100,000	4,200	24	182	Gw source 550 m^3/day

Supply Component: Treatment

Including: Filters

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Karuma	1988	220,000	1,200	185	Horizontal roughing filters incl. 50m^3 tank
Norconsult	Gakauni	1990	400,000	1,200	333	

Supply Component: Treatment

Including: Full Treatment

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Costs/ m^3/day	Remarks
Norad	Ol Joro Orok	1988	5,600,000	12,000	467	2,240	Sw source, 2500 m^3/day
	Ena	1987	6,000,000	44,000	136	2,222	Sw source, 2,700 m^3/day
MoWD	Design Manual	1986	15,000,000			1,500	Capacity 10000 m^3/day
			14,000,000			1,750	8000 m^3/day
			12,300,000			2,050	6000 m^3/day
			10,800,000			2,700	4000 m^3/day
			7,600,000			3,800	2000 m^3/day
H.Humpr.	Maralal W.S.	1976	2,700,000	11,000	250	1,561	1729 m^3/day
	Kisima W.S.						

Supply Component: Motor Pump

Including: Diesel Generator - Pump

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
ODA	Kijito Wind-pump	1989	123,255			Excluding installation
	Evaluation		150,975			Including installation
GSK	Kitui/Danida	1989	150,000			50 m^3/day
Diocese of Marsabit	Baragoi	1988	82,450			
	Nanyuki	19?	67,475			excluding generator
	Lodokojek	1987	128,750			excluding generator (including 1500m cable)
	Wamba	1987	181,015			including generator
Wiggles-worth	Quotation	1989	176,650			1 m^3/hr, 75 m head
			209,850			3 m^3/hr, 75 m head
			273,600			5 m^3/hr, 75 m head
			325,600			8 m^3/hr, 75 m head
			383,600			12 m^3/hr, 75 m head

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply Component: Storage Tanks

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ m^3	Remarks
MoWD	Design Manual (Concrete Tanks)	1986	280,000		2,800	100 m^3 (excluding contingencies
			440,000		2,200	200 m^3 (")
			720,000		1,800	400 m^3 (")
			1,040,000		1,300	800 m^3 (")
			1,260,000		1,050	1200 m^3 (")
ODA	Kijito Wind-Pump Evaluation				480	
Warren	Quotation	1986	72,068			32 m^3 tank (Pressed steel)
			62,800			Tower 4 m
SIDA	South Horr	1988	75,000		3,000	25 m^3 tank
			300,000			100 m^3 tank
	Dabel	1988	675,000		3,000	225 m^3 (3 tanks)
Pencol	CBWDP	1984	70,000		7,000	10 m^3
			104,000		4,160	25 m^3
			150,000		3,000	50 m^3
			257,000		2,570	100 m^3
			463,000		2,315	200 m^3
			670,000		2,233	300 m^3
			1,087,000		2,174	500 m^3
			1,704,000		2,130	800 m^3
			1,826,000		1,521	1200 m^3
Norad	Mwingi	1988	2,500,000		5,000	500 m^3
	Garissa	1989	3,000,000		7,500	400 m^3
Norconsult	Gakauni	1990	50,000		1,000	50 m^3
SIDA	Marimanti	1988			525	Roof tank

Supply Component: Hydram

Including: Hydram, pumphouse

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
SIDA	Karuma	1988	100,000	1200		

Supply Component: Solar Pump

Source of Data	Year	Total Costs	Remarks
Davis & Shirtliff	1989	325,000	complete, 2 m^3/hr, 30 m head, 21 modules (excl. installation)
	1989	90,000	submersible pump, inverter, connectors
	1989	9,500	solar module (ARCO)
	1989	8,000	support structure for 7 modules
McPherson	1984	210,000	complete, 35 panels, 65-105 m^3/day (excluding installation)
Norconsult	1990	300,000	solar pump, panels, etc.
Norconsult	1990	1,427,000	borehole with solar pump, storage, distribution

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

Supply Component: Windmill

Including: Kijito Windmill, Pump and Stuffing Box, Installation

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
ODA	Kijito Windpump Evaluation	1989	133,155 172,260 234,135 269,940			3.7 m rotor 4.9 m rotor 6.0 m rotor 7.5 m rotor
Diocese	Marsabit		226,492			6.0 m rotor

Supply Component: Handpump

Source of Data	Project Name	Year	Total Costs	Remarks
SIDA	KWDP	1988	14,000	Afridev pump
Warren	Quotation	1988	23,670	Mono pump, depth 5.2 m
GSK	KIDP	1989	10,000	
MoWD	Design Manual	1986	20,000	Depth up to 20 m
LBDA	Siaya District	1988	14,218	SWN-handpump duty free imported, well 10 m deep
			16,293	SWN-handpump duty free imported, well 15 m deep
			18,368	SWN-handpump duty free imported, well 20 m deep
			23,520	SWN-handpump duty free imported, borehole 50 m deep
			27,670	SWN-handpump duty free imported, borehole 60 m deep
			31,820	SWN-handpump duty free imported, borehole 70 m deep

Supply Component: Handpump

Including: Handpump + Superstructure on Dug well + Installation

Source of Data	Project Name	Year	Total Costs	Remarks
LBDA	Siaya District	1988	34,218	SWN-handpump duty free imported, well 10 m deep
			36,293	SWN-handpump duty free imported, well 15 m deep
			38,368	SWN-handpump duty free imported, well 20 m deep

Supply Component: Handpump

Including: Handpump + Superstructure on Borehole + Installation

Source of Data	Project Name	Year	Total Costs	Remarks
LBDA	Siaya District	1988	43,520	SWN-handpump duty free imported, borehole 50 m deep
			47,670	SWN-handpump duty free imported, borehole 60 m deep
			51,820	SWN-handpump duty free imported, borehole 70 m deep
MoWD	Design Manual	1986	20,000	

APPENDIX 5

DETAILS AND COSTS OF A TYPICAL WATER SUPPLY

Using:

- A Borehole (depth 40 m.)
- A Borehole (depth 100 m. and 250 m.)
- A Surface Water Intake
- A Spring
- A Dug Well

Details and Costs of a Typical Water Supply using a Borehole (depth 40 m.)

Yield of Supply	600 m^3/day	200 m^3/day	100 m^3/day	100 m^3/day	20 m^3/day	20 m^3/day	5-10 m^3/day
Boreholes	2 nr. (1 stand-by)	2 nr. (1 stand-by)	2 nr. (1 stand-by)	2 nr. (1 stand-by)	1 nr.	1 nr.	1 nr.
Borehole Depth	40 m.	40 m.	40 m.	40 m.	40 m.	40 m.	40 m.
Borehole Yield	30 m^3/hr	10 m^3/hr	5 m^3/hr	5 m^3/hr	2 m^3/hr	2-5 m^3/hr	2 m^3/hr
Pump Plant	2 Electrical subm.	2 Electrical subm.	Electrical Subm.	Solar pump	Solar pump	Windmill	Handpump
Main Lines	0.5 km	0.5 km	200 m	200 m	500 m.	500 m.	-
Treatment	Chlorination only	Chlorination only	Chlorination only	Chlorination only	-	-	-
Storage	600 m^3	200 m^3	100 m^3	300 m^3	60 m^3	60 m^3	-
Distribution	.... km	.... km	.... km	.... km	-	-	
Communal Water points	30 nr.	10 nr.	10 nr.	10 nr.	3 nr.	3 nr.	-
Individual Connections	1200 nr.	400 nr.	200 nr.	200 nr.	-	-	-
Capital Costs							
Boreholes	200,000 Shs	200,000 Shs	200,000 Shs	200,000 Shs	100,000 Shs	100,000 Shs	100,000 Shs
Pump Plant	600,000 Shs	300,000 Shs	125,000 Shs	400,000 Shs	300,000 Shs	235,000 Shs	20,000 Shs
Superstructure	-	-	-	-	-	-	10,000 Shs
Main Lines	200,000 Shs	200,000 Shs	50,000 Shs	50,000 Shs	125,000 Shs	125,000 Shs	-
Treatment	100,000 Shs	40,000 Shs	40,000 Shs	40,000 Shs	-	-	-
Storage	1,800,000 Shs	600,000 Shs	300,000 Shs	900,000 Shs	180,000 Shs	180,000 Shs	-
Distribution	3,000,000 Shs	1,000,000 Shs	500,000 Shs	500,000 Shs	-	-	-
Communal Water Points	450,000 Shs	150,000 Shs	150,000 Shs	150,000 Shs	45,000 Shs	45,000 Shs	-
Individual Connections	2,400,000 Shs	800,000 Shs	400,000 shs	400,000 shs	-	-	-
Cattle Troughs	-	-	-	-	-	-	-
Buildings	800,000 Shs	400,000 Shs	200,000 Shs	200,000 Shs	150,000 Shs	150,000 Shs	-
Fencing	100,000 Shs	100,000 Shs	50,000 Shs	50,000 Shs	25,000 Shs	25,000 Shs	20,000 Shs
Contingencies (25%)	2,412,500 Shs	947,500 Shs	503,750 Shs	722,500 Shs	231,250 Shs	215,000 Shs	37,500 Shs
Total construction Costs	12,062,500 Shs	4,737,500 Shs	2,518,750 Shs	3,612,500 Shs	1,156,250 Shs	1,075,000 Shs	187,500 Shs
Costs per m^3/day	20,100 Shs	23,700 Shs	25,200 Shs	36,125 Shs	57,800 Shs	53,750 Shs	(25,000 Shs)
Operational Costs							
Salaries	600,000 Shs/yr	240,000 Shs/yr	120,000 Shs/yr	120,000 Shs/yr	12,000 Shs/yr	12,000 Shs/yr	-
Energy	600,000 Shs/yr	200,000 Shs/yr	100,000 Shs/yr	-	-	-	-
Chemicals	75,000 Shs/yr	25,000 Shs/yr	12,500 Shs/yr	12,500 Shs/yr	-	-	-
Maintenance	144,625 Shs/yr	59,375 Shs/yr	30,188 Shs/yr	40,125 Shs/yr	12,765 Shs/yr	5,375 Shs/yr	1,875 Shs/yr
Total O&M Costs	1,419,625 Shs/yr	524,375 Shs/yr	262,688 Shs/yr	172,625 Shs/yr	24,765 Shs/yr	17,775 Shs/yr	1,875 Shs/yr

Details and Costs of a Typical Water Supply using a Borehole (depth 100 m. and 250 m.)

Yield of Supply	600 m^3/day	200 m^3/day	100 m^3/day	100 m^3/day	20 m^3/day	20 m^3/day	400 m^3/day
Boreholes	2 nr. (1 stand-by)	2 nr. (1 stand-by)	2 nr. (1 stand-by)	2 nr. (1 stand-by)	1 nr.	1 nr.	2 nr.
Borehole Depth	100 m.	100 m.	100 m.	100 m.	100 m.	100 m.	250 m.
Borehole Yield	30 m^3/hr	10 m^3/hr	5 m^3/hr	5 m^3/hr	2 m^3/hr	2-5 m^3/hr	20 m^3/hr
Pump Plant	2 Electrical subm.	2 Electrical subm.	Electrical Subm.	Solar pump	Solar pump	Electr. Subm.	Electr. Subm.
Main Lines	0.5 km	0.5 km	200 m	200 m	500 m.	500 m.	0.5 km
Treatment	Chlorination only	Chlorination only	Chlorination only	Chlorination only	-	-	Chlorin. only
Storage	600 m^3	200 m^3	100 m^3	300 m^3	60 m^3	20 m^3	400 m^3
Distribution	.... km	.... km	.... km	.... km	-	-	.... km
Communal Water points	30 nr.	10 nr.	10 nr.	10 nr.	3 nr.	3 nr.	20 nr.
Individual Connections	1200 nr.	400 nr.	200 nr.	200 nr.	-	-	800 nr.
Capital Costs							
Boreholes	500,000 Shs	500,000 Shs	500,000 Shs	500,000 Shs	250,000 Shs	250,000 Shs	1,250,000 Shs
Pump Plant	800,000 Shs	400,000 Shs	175,000 Shs	750,000 Shs (?)	500,000 Shs	100,000 Shs	800,000 Shs
Superstructure	-	-	-	-	-	-	-
Main Lines	200,000 Shs	200,000 Shs	50,000 Shs	50,000 Shs	125,000 Shs	125,000 Shs	200,000 Shs
Treatment	100,000 Shs	40,000 Shs	40,000 Shs	40,000 Shs	-	-	70,000 Shs
Storage	1,800,000 Shs	600,000 Shs	300,000 Shs	900,000 Shs	180,000 Shs	60,000 Shs	1,200,000 Shs
Distribution	3,000,000 Shs	1,000,000 Shs	500,000 Shs	500,000 Shs	-	-	2,000,000 Shs
Communal Water Points	450,000 Shs	150,000 Shs	150,000 Shs	150,000 Shs	45,000 Shs	45,000 Shs	300,000 Shs
Individual Connections	2,400,000 Shs	800,000 Shs	400,000 shs	400,000 shs	-	-	800,000 Shs
Cattle Troughs	-	-	-	-	-	-	-
Buildings	800,000 Shs	400,000 Shs	200,000 Shs	200,000 Shs	150,000 Shs	150,000 Shs	400,000 Shs
Fencing	100,000 Shs	100,000 Shs	50,000 Shs	50,000 Shs	25,000 Shs	25,000 Shs	100,000 Shs
Contingencies (25%)	1,537,500 Shs	1,047,500 Shs	591,250 Shs	885,000 Shs	318,750 Shs	188,750 Shs	1,780,000 Shs
Total construction Costs	12,687,500 Shs	5,237,500 Shs	2,956,250 Shs	4,425,000 Shs	1,593,750 Shs	943,750 Shs	8,900,000 Shs
Costs per m^3/day	21,150 Shs	26,200 Shs	29,600 Shs	44,250 Shs	80,000 Shs	47,000 Shs	22,250 Shs
Operational Costs							
Salaries	240,000 Shs/yr						
Energy	300,000 Shs/yr						
Chemicals	25,000 Shs/yr						
Maintenance	68,375 Shs/yr						
Total O&M Costs	633,375 Shs/yr						

Details and Costs of a Typical Water Supply using a Surface Water Intake

Yield of Supply	200 m³/day	200 m³/day	200 m³/day	1000 m³/day
Intake Structure	Dam: 100,000 m³	Weir	Weir	Weir
Treatment	Full	Full	Full	Full
Pump Plant	Diesel / Electric	Diesel / Electric	Gravity	Gravity
Pump Capacity	10 m³/hr	10 m³/hr	-	-
Main Lines	2 km	2 km	2 km	2 km
Storage	100 m³	200 m³	200 m³	1000 m³
Distribution	... km	... km	... km	... km
Communal Water points	10 nr.	10 nr.	10 nr.	50 nr.
Individual Connections	400 nr.	400 nr.	400 nr.	2,000 nr.
Capital Costs				
Intake Structure	5,000,000 Shs	200,000 Shs	200,000 Shs	500,000 Shs
Treatment	1,000,000 Shs	1,000,000 Shs	1,000,000 Shs	2,000,000 Shs
Pump Plant	500,000 Shs	500,000 Shs	-	-
Main Lines	500,000 Shs	500,000 Shs	500,000 Shs	1,500,000 Shs
Storage	300,000 Shs	600,000 Shs	600,000 Shs	3,000,000 Shs
Distribution	1,000,000 Shs	1,000,000 Shs	1,000,000 Shs	5,000,000 Shs
Communal Water points	150,000 Shs	150,000 Shs	150,000 Shs	750,000 Shs
Individual Connections	800,000 Shs	800,000 Shs	800,000 Shs	4,000,000 Shs
Buildings	400,000 Shs	400,000 Shs	400,000 Shs	800,000 Shs
Fencing	100,000 Shs	100,000 Shs	100,000 Shs	200,000 Shs
Contingencies (25%)	2,437,500 Shs	1,312,500 Shs	1,187,500 Shs	4,437,000 Shs
Total construction Cost	12,187,500 Shs	6,562,500 Shs	5,937,500 Shs	22,187,500 Shs
Costs per m³/day	61,000 Shs	33,000 Shs	29,700 Shs	22,188 Shs
Operational costs				
Salaries	300,000 Shs/yr	300,000 Shs/yr	264,000 Shs/yr	800,000 Shs/yr
Energy	100,000 Shs/yr	100,000 Shs/yr	-	-
Chemical	400,000 Shs/yr	400,000 Shs/yr	400,000 Shs/yr	2,000,000 Shs/yr
Maintenance	141,875 Shs/yr	85,625 Shs/yr	59,375 Shs/yr	221,888 Shs/yr
Total O&M Costs	941,875 Shs/yr	885,625 Shs/yr	723,375 Shs/yr	3,021,888 Shs/yr

Yield of Supply	40 m³/day	40 m³/day	40 m³/day	10 m³/day
Intake structure	Weir	Intake chamber	Intake chamber	Intake chamber
Treatment	Filtr. and Chlor.	Filtr. and Chlor.	Filtr. and Chlor.	-
Pump Plant	-	-	Hydram	Gravity
Pump Capacity	Gravity	Gravity	5 m³/hr	
Main Lines	1 km	1 km	1 km	1 km
Storage	40 m³	40 m³	40 m³	10 m³
Distribution	-	-	-	-
Comm. Water points	6 nr.	6 nr.	6 nr.	1 nr.
Indiv. Connections	-	-	-	-
Capital Costs				
Intake structure	100,000 Shs	70,000 Shs	70,000 Shs	50,000 Shs
Treatment	400,000 Shs	400,000 Shs	400,000 Shs	-
Pump Plant	-	-	100,000 Shs	-
Main Lines	250,000 Shs	250,000 Shs	250,000 Shs	150,000 Shs
Storage	120,000 Shs	120,000 Shs	120,000 Shs	30,000 Shs
Distribution	-	-	-	-
Comm. Water points	90,000 Shs	90,000 Shs	90,000 Shs	15,000 Shs
Indiv. Connections	-	-	-	-
Buildings	150,000 Shs	150,000 Shs	150,000 Shs	-
Fencing	30,000 Shs	30,000 Shs	30,000 Shs	20,000 Shs
Contingencies (25%)	285,000 Shs	277,500 Shs	302,500 Shs	66,250 Shs
Total construction Cost	1,425,000 Shs	1,387,500 Shs	1,512,500 Shs	331,250 Shs
Costs per m³/day	35,600 Shs	34,700 Shs	37,800 Shs	33,125 Shs
Operational costs				
Salaries	48,000 Shs/yr	48,000 Shs/yr	60,000 Shs/yr	12,000 Shs/yr
Energy	-	-	-	-
Chemical	5,000 Shs/yr	5,000 Shs/yr	5,000 Shs/yr	-
Maintenance	14,250 Shs/yr	13,875 Shs/yr	19,125 Shs/yr	3,313 Shs/yr
Total O&M Costs	67,250 Shs/yr	66,875 Shs/yr	84,125 Shs/yr	15,313 Shs/yr

Details and Costs of a Typical Water Supply using a Spring

Yield of Supply	200 m^3/day	100 m^3/day	40 m^3/day	10 m^3/day
Spring Protection				
Treatment	Chlorination only	Chlorination only	-	-
Pump Plant	Gravity	Gravity	Gravity	Gravity
Pump Capacity	-	-	-	-
Main Lines	2 km	1 km	1 km	-
Storage	200 m^3	100 m^3	40 m^3	-
Distribution	.... km	.... km	-	-
Comm. Water points	10 nr.	10 nr.	6 nr.	1
Indiv. Connections	400 nr.	200 nr.	-	-
Capital Costs				
Spring Protection	400,000 Shs	200,000 Shs	100,000 Shs	30,000 Shs
Main Lines	500,000 Shs	250,000 Shs	250,000 Shs	-
Treatment	40,000 Shs	-	-	-
Pump Plant	-	-	-	-
Storage	600,000 Shs	300,000 Shs	120,000 Shs	-
Distribution	1,000,000 Shs	500,000 Shs	-	-
Comm. Water points	150,000 Shs	150,000 Shs	90,000 Shs	-
Indiv. Connections	800,000 Shs	400,000 Shs	-	-
Buildings	400,000 Shs	200,000 Shs	150,000 Shs	-
Fencing	100,000 Shs	50,000 Shs	30,000 Shs	-
Contingencies (25%)	997,500 Shs	512,500 Shs	185,000 Shs	7,500 Shs
Total construction Costs	4,987,500 Shs	2,562,500 Shs	925,000 Shs	37,500 Shs
Costs per m^3/day	24,940 Shs	25,625 Shs	23,125 Shs	3,750 Shs
Operational Costs				
Salaries	180,000 Shs/yr	96,000 Shs/yr	36,000 Shs/yr	-
Energy	-	-	-	-
Chemicals	25,000 Shs/yr	12,500 Shs/yr	-	-
Maintenance	99,750 Shs/yr	51,250 Shs/yr	18,500 Shs/yr	500 Shs/yr
Total O&M Costs	304,750 Shs/yr	159,750 Shs/yr	54,500 Shs/yr	500 Shs/yr

Details and Costs of a Typical Water Supply using a Dug Well

Yield of Supply	20 m^3/day	5-10 m^3/day
Dug Wells	1 nr.	1 nr.
Dug Well Yield	>3 m^3/hr	> 1 m^3/hr
Dug Well Depth	10 m.	10 m.
Superstructure		
Pump Plant	Windmill	Handpump
Main Lines	200 m	-
Storage	60 m^3	-
Distribution	-	-
Communal Water points	3 nr.	-
Individual Connections	-	-
Capital Costs		
Dug Wells	30,000 Shs	30,000 Shs
Superstructure	20,000 Shs	20,000 Shs
Pump Plant	235,000 Shs	20,000 Shs
Main Lines	50,000 Shs	-
Storage	180,000 Shs	-
Distribution	-	-
Communal Water points	45,000 Shs	-
Individual Connections	-	-
Cattle Troughs	-	-
Buildings	200,000 Shs	-
Fencing	50,000 Shs	20,000 Shs
Contingencies (25%)	202,500 Shs	22,500 Shs
Total construction Cost	1,012,500 Shs	112,500 Shs
Costs per m^3/day	50,625 Shs	15,000 Shs
Operational Costs		
Salaries	12,000 Shs/yr	-
Energy	-	-
Chemicals	-	-
Maintenance	5,063 Shs/yr	500 Shs/yr
Total O&M Costs	17,063 Shs/yr	500 Shs/yr

Note: The combination dug well-windmill will yield a daily production, which can be estimated from Figure 6.1:

Average windspeed (m/s)	1.5	3.0	2.5	3.0
Total head (m)	15	15	50	50
Volume (m^3/day)	30	60	15	25

APPENDIX 6

OPERATION AND MAINTENANCE COSTS

APPENDIX 6

OPERATION AND MAINTENANCE COSTS

- Annual Maintenance Costs as Percentage of Construction Costs
- References of Operation and Maintenance Costs

Annual Maintenance Costs as Percentage of Construction Costs

Water Supply Component	Economic Lifetime Years	Annual Maintenance Costs in %
- Dams	40	0.5
- Intake works, including boreholes: Mass concrete structures, such as intakes, underground pits, culverts, etc.	40	1
- Earthworks generally	40	1
- Boreholes and wells	20	1
- Pumps:		
Hydrams and Hydrostats	15	5
Other pumps	10	5
- Power		
Diesel Engines	10	5
Engine and pump sets petrol paraffin	5	5
Electric motors, cables and switch gears	10	5
- Piping:		
All types	30	1
- Treatment Works:		
Treatment works in masonry or reinforced concrete	30	1
- Reservoirs:		
Storage tanks in masonry or reinforced concrete	30	1
Storage tanks, sectional steel including towers	20	2
Storage tanks, corrugated galvanized steel (C.G.S.) on timber stands	10	2
- Building:		
Building C.G.S. on timber	20	1
Building, masonry	30	1
- Miscellaneous structures and items: Communal water points (CWP)	10	5
Water kiosks, latrines, licensed retailer points etc.	20	2
Gantries, steelwork etc	20	2
Permanent tools and plant not mentioned elsewhere	10	2
Water meters	10	5
- Chemical Apparatus:		
Chemical dosing gear	10	5
Instruments and testing apparatus	5	5
- Roads, fences etc.		
Roads of access, general	30	1
Fences, G.S. wire or mesh on timber	10	1
Fences, G.S. wire or mesh on concrete posts	20	1

Source: MoWD, Design Manual, 1986

Operation and Maintenance Costs: Source Data

Project/Source Information	Short Description	Population	O & M Costs (Shs/m^3)
	Surface Water Source:		
SIDA - South-Horr	Gravity, 20 cwp, 8 troughs	5,400	4 *
Chepalunga	Gravity (7% pumping), 4330 km^2	135,850	1.6 *
P.K. Njiru (Diploma design)	Pumped scheme, operation costs: pumps	33,466	5.6
	treatment	33,466	1.4
	salaries	33,466	.5
	total	33,466	7.5
	maintenance costs: 2% of capital costs	33,466	2.0
	total O&M		9.5
Norconsult-Gakauni	Gravity, intake chamber, filtration, storage, piped distribution	1,863	15.5 Shs/pop.
	Groundwater Source:		
SIDA - Sericho	6 boreholes, solar pump, 8 cwp, 5 troughs	2,000	11.8 *
- Dabel	5 boreholes, handpumps, motorpumps	4,340	11.8 *
- Sololo	boreholes, dug wells, solar/motor pump	9,500	10 *
LBDA - RDWS & SP	Dug wells, handpump	200	17
FINNIDA - KFRWSDP	Dug well, handpump		500-1000 Shs/well
SIDA - KWDP	Handpump		200 Shs/pump
Norconsult-Gakauni	Handpump on borehole	1,200	9.4 Shs/pop.
	Solar pump on borehole	1,200	9.5 Shs/pop.

* O & M costs include depreciation

APPENDIX 7

COST EFFECTIVENESS ANALYSIS

APPENDIX 7

COST EFFECTIVENESS ANALYSIS

Urban Supply from Boreholes with Pumps
Urban Supply from Boreholes with Pumps
Urban Supply from Boreholes with Pumps
Urban Supply from Boreholes with Pumps
Rural Supply from Boreholes with Pumps
Urban Supply from Boreholes with Solar Pumps
Rural Supply from Boreholes with Solar Pumps
Rural Supply from Boreholes with Windmills
Rural Supply from a Borehole with a Handpump

Rural Supply from a Dug Well with a Windmill
Rural Supply from a Dug Well with a Handpump

Urban Supply from a Spring
Urban Supply from a Spring
Rural Supply from a Spring
Rural Supply from a Spring

Urban Supply from a Surface Water Dam
Urban Supply from a Surface Water Weir with Pumping
Rural Supply from a Surface Water Weir
Rural Supply from a Surface Water Weir
Rural Supply from a Surface Water Intake Chamber
Rural Supply from a Surface Water Intake Chamber with Hydram
Rural Supply from a Surface Water Intake Chamber

Urban Supply from Boreholes with Pumps

Appendix 7

Technology: 2 Boreholes (40 m. deep) with Motorpump, Distribution, 600 m3 Storage, Chlorination

Capital cost: 12,062,500 Shs
Annual Costs: 1,419,625 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 600,000 for motorpumps every 15 years (incl. stand-by pump)

Annual Yield: 600 m3/day * 365 = 219000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	219000	12,062,500	1,419,625	13,482,125	61.6	13,482,125	61.6	13,482,125	61.6
1	219000		1,419,625	1,352,024	6.2	1,290,568	5.9	1,234,457	5.6
2	219000		1,419,625	1,287,642	5.9	1,173,244	5.4	1,073,440	4.9
3	219000		1,419,625	1,226,325	5.6	1,066,585	4.9	933,426	4.3
4	219000		1,419,625	1,167,929	5.3	969,623	4.4	811,675	3.7
5	219000		1,419,625	1,112,313	5.1	881,475	4.0	705,805	3.2
6	219000		1,419,625	1,059,346	4.8	801,341	3.7	613,743	2.8
7	219000		1,419,625	1,008,901	4.6	728,492	3.3	533,690	2.4
8	219000		1,419,625	960,858	4.4	662,266	3.0	464,078	2.1
9	219000		1,419,625	915,103	4.2	602,060	2.7	403,546	1.8
10	219000		1,419,625	871,527	4.0	547,327	2.5	350,910	1.6
11	219000		1,419,625	830,025	3.8	497,570	2.3	305,139	1.4
12	219000		1,419,625	790,500	3.6	452,336	2.1	265,338	1.2
13	219000		1,419,625	752,857	3.4	411,215	1.9	230,729	1.1
14	219000		1,419,625	717,007	3.3	373,832	1.7	200,634	0.9
15	219000	600,000	1,419,625	971,474	4.4	483,482	2.2	248,201	1.1
16	219000		1,419,625	650,347	3.0	308,952	1.4	151,708	0.7
17	219000		1,419,625	619,378	2.8	280,865	1.3	131,920	0.6
18	219000		1,419,625	589,884	2.7	255,332	1.2	114,713	0.5
19	219000		1,419,625	561,794	2.6	232,120	1.1	99,750	0.5
20	219000		1,419,625	535,042	2.4	211,018	1.0	86,739	0.4
Total	4,599,000	12,662,500	29,812,125	31,462,401	143.7	25,711,828	117.4	22,441,765	102.5

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	143.7	117.4	102.5

Urban Supply from Boreholes with Pumps

Appendix 7

Technology: 2 Boreholes (40 m. deep) with Motorpump, Distribution, 200 m3 Storage, Chlorination

Capital cost: 4,737,500 Shs
Annual Costs: 524,375 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 300,000 for motorpumps every 15 years (incl. stand-by pump)

Annual Yield: 200 m3/day * 365 = 73000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	73000	4,737,500	524,375	5,261,875	72.1	5,261,875	72.1	5,261,875	72.1
1	73000		524,375	499,405	6.8	476,705	6.5	455,978	6.2
2	73000		524,375	475,624	6.5	433,368	5.9	396,503	5.4
3	73000		524,375	452,975	6.2	393,971	5.4	344,785	4.7
4	73000		524,375	431,405	5.9	358,155	4.9	299,813	4.1
5	73000		524,375	410,862	5.6	325,596	4.5	260,707	3.6
6	73000		524,375	391,297	5.4	295,996	4.1	226,702	3.1
7	73000		524,375	372,664	5.1	269,087	3.7	197,132	2.7
8	73000		524,375	354,918	4.9	244,625	3.4	171,419	2.3
9	73000		524,375	338,017	4.6	222,386	3.0	149,060	2.0
10	73000		524,375	321,921	4.4	202,169	2.8	129,617	1.8
11	73000		524,375	306,591	4.2	183,790	2.5	112,711	1.5
12	73000		524,375	291,992	4.0	167,082	2.3	98,009	1.3
13	73000		524,375	278,087	3.8	151,893	2.1	85,226	1.2
14	73000		524,375	264,845	3.6	138,084	1.9	74,109	1.0
15	73000	300,000	524,375	396,538	5.4	197,349	2.7	101,311	1.4
16	73000		524,375	240,222	3.3	114,119	1.6	56,037	0.8
17	73000		524,375	228,783	3.1	103,745	1.4	48,728	0.7
18	73000		524,375	217,889	3.0	94,313	1.3	42,372	0.6
19	73000		524,375	207,513	2.8	85,740	1.2	36,845	0.5
20	73000		524,375	197,631	2.7	77,945	1.1	32,039	0.4
Total	1,533,000	5,037,500	11,011,875	11,941,052	163.6	9,797,993	134.2	8,580,980	117.5

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	163.6	134.2	117.5

Urban Supply from Boreholes with Pumps

Appendix 7

Technology: 2 boreholes (100 m. deep) with Motorpump, Distribution, 200 m3 Storage, Chlorination

Capital cost: 5,237,500 Shs
Annual Costs: 633,375 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 400,000 for motorpump every 15 years

Annual Yield: 200 m3/day * 365 = 73000 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	73000	5,237,500	633,375	5,870,875	80.4	5,870,875	80.4	5,870,875	80.4
1	73000		633,375	603,214	8.3	575,795	7.9	550,761	7.5
2	73000		633,375	574,490	7.9	523,450	7.2	478,922	6.6
3	73000		633,375	547,133	7.5	475,864	6.5	416,454	5.7
4	73000		633,375	521,079	7.1	432,604	5.9	362,134	5.0
5	73000		633,375	496,266	6.8	393,276	5.4	314,899	4.3
6	73000		633,375	472,634	6.5	357,524	4.9	273,825	3.8
7	73000		633,375	450,128	6.2	325,022	4.5	238,109	3.3
8	73000		633,375	428,693	5.9	295,474	4.0	207,051	2.8
9	73000		633,375	408,279	5.6	268,613	3.7	180,045	2.5
10	73000		633,375	388,837	5.3	244,193	3.3	156,561	2.1
11	73000		633,375	370,321	5.1	221,994	3.0	136,140	1.9
12	73000		633,375	352,687	4.8	201,813	2.8	118,382	1.6
13	73000		633,375	335,892	4.6	183,466	2.5	102,941	1.4
14	73000		633,375	319,897	4.4	166,787	2.3	89,514	1.2
15	73000	400,000	633,375	497,071	6.8	247,382	3.4	126,996	1.7
16	73000		633,375	290,156	4.0	137,841	1.9	67,685	0.9
17	73000		633,375	276,339	3.8	125,310	1.7	58,857	0.8
18	73000		633,375	263,180	3.6	113,918	1.6	51,180	0.7
19	73000		633,375	250,648	3.4	103,562	1.4	44,504	0.6
20	73000		633,375	238,712	3.3	94,147	1.3	38,699	0.5
Total	1,533,000	5,637,500	13,300,875	13,956,534	191.2	11,358,910	155.6	9,884,537	135.4

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	191.2	155.6	135.4

Technology: 2 Boreholes (40 m. deep) with Motorpump, Distribution, 100 m3 Storage, Chlorination

Capital cost: 2,518,750 Shs
Annual Costs: 262,688 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 125,000 for motorpumps every 15 years (incl. stand-by pump)

Annual Yield: 100 m3/day * 365 = 36500 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	36500	2,518,750	262,688	2,781,438	76.2	2,781,438	76.2	2,781,438	76.2
1	36500		262,688	250,179	6.9	238,807	6.5	228,424	6.3
2	36500		262,688	238,265	6.5	217,097	5.9	198,629	5.4
3	36500		262,688	226,919	6.2	197,361	5.4	172,721	4.7
4	36500		262,688	216,114	5.9	179,419	4.9	150,192	4.1
5	36500		262,688	205,823	5.6	163,108	4.5	130,602	3.6
6	36500		262,688	196,021	5.4	148,280	4.1	113,567	3.1
7	36500		262,688	186,687	5.1	134,800	3.7	98,754	2.7
8	36500		262,688	177,797	4.9	122,546	3.4	85,873	2.4
9	36500		262,688	169,331	4.6	111,405	3.1	74,672	2.0
10	36500		262,688	161,267	4.4	101,277	2.8	64,932	1.8
11	36500		262,688	153,588	4.2	92,070	2.5	56,463	1.5
12	36500		262,688	146,274	4.0	83,700	2.3	49,098	1.3
13	36500		262,688	139,309	3.8	76,091	2.1	42,694	1.2
14	36500		262,688	132,675	3.6	69,174	1.9	37,125	1.0
15	36500	125,000	262,688	186,484	5.1	92,809	2.5	47,645	1.3
16	36500		262,688	120,340	3.3	57,168	1.6	28,072	0.8
17	36500		262,688	114,610	3.1	51,971	1.4	24,410	0.7
18	36500		262,688	109,152	3.0	47,247	1.3	21,226	0.6
19	36500		262,688	103,954	2.8	42,952	1.2	18,458	0.5
20	36500		262,688	99,004	2.7	39,047	1.1	16,050	0.4
Total	766,500	2,643,750	5,516,438	6,115,232	167.5	5,047,768	138.3	4,441,047	121.7

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	167.5	138.3	121.7

Technology: 2 Boreholes with Motorpump, 40 m3 Storage, Chlorination, 6 Comm. Water Points

Capital cost: 1,687,500 Shs
Annual Costs: 106,875 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 100,000 Shs for motorpumps every 15 years (incl. stand-by pump)

Annual Yield: 40 m3/day * 365 = 14600 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	14600	1,687,500	106,875	1,794,375	122.9	1,794,375	122.9	1,794,375	122.9
1	14600		106,875	101,786	7.0	97,159	6.7	92,935	6.4
2	14600		106,875	96,939	6.6	88,326	6.0	80,813	5.5
3	14600		106,875	92,323	6.3	80,297	5.5	70,272	4.8
4	14600		106,875	87,926	6.0	72,997	5.0	61,106	4.2
5	14600		106,875	83,739	5.7	66,361	4.5	53,136	3.6
6	14600		106,875	79,752	5.5	60,328	4.1	46,205	3.2
7	14600		106,875	75,954	5.2	54,844	3.8	40,178	2.8
8	14600		106,875	72,337	5.0	49,858	3.4	34,938	2.4
9	14600		106,875	68,893	4.7	45,325	3.1	30,381	2.1
10	14600		106,875	65,612	4.5	41,205	2.8	26,418	1.8
11	14600		106,875	62,488	4.3	37,459	2.6	22,972	1.6
12	14600		106,875	59,512	4.1	34,054	2.3	19,976	1.4
13	14600		106,875	56,678	3.9	30,958	2.1	17,370	1.2
14	14600		106,875	53,979	3.7	28,144	1.9	15,105	1.0
15	14600	100,000	106,875	99,510	6.8	49,524	3.4	25,424	1.7
16	14600		106,875	48,961	3.4	23,259	1.6	11,421	0.8
17	14600		106,875	46,629	3.2	21,145	1.4	9,931	0.7
18	14600		106,875	44,409	3.0	19,222	1.3	8,636	0.6
19	14600		106,875	42,294	2.9	17,475	1.2	7,510	0.5
20	14600		106,875	40,280	2.8	15,886	1.1	6,530	0.4
Total	306,600	1,787,500	2,244,375	3,174,375	217.4	2,728,201	186.9	2,475,630	169.6

	Discount Rate		
	5 %	10 %	15 %
total cost per m3	217.4	186.9	169.6

Technology: 2 Boreholes with Solar Pump, Storage 300 m3, Chlorination, Distribution

Capital cost: 3,612,500 Shs
Annual Costs: 172,625 Shs (Maintenance + Salaries)
Replacement Costs: Pump 100,000 Shs every 10 years.

Annual Yield: 100 m3/day * 300 = 30000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/Yr (Shs/m3)	Costs (Shs)	Cost/Yr (Shs/m3)	Costs (Shs)	Cost/Yr (Shs/m3)
0	30000	3,612,500	172,625	3,785,125	126.2	3,785,125	126.2	3,785,125	126.2
1	30000		172,625	164,405	5.5	156,932	5.2	150,109	5.0
2	30000		172,625	156,576	5.2	142,665	4.8	130,529	4.4
3	30000		172,625	149,120	5.0	129,696	4.3	113,504	3.8
4	30000		172,625	142,019	4.7	117,905	3.9	98,699	3.3
5	30000		172,625	135,256	4.5	107,187	3.6	85,825	2.9
6	30000		172,625	128,815	4.3	97,442	3.2	74,631	2.5
7	30000		172,625	122,681	4.1	88,584	3.0	64,896	2.2
8	30000		172,625	116,839	3.9	80,531	2.7	56,431	1.9
9	30000		172,625	111,276	3.7	73,210	2.4	49,071	1.6
10	30000	100,000	172,625	167,368	5.6	105,109	3.5	67,389	2.2
11	30000		172,625	100,930	3.4	60,504	2.0	37,105	1.2
12	30000		172,625	96,124	3.2	55,004	1.8	32,265	1.1
13	30000		172,625	91,547	3.1	50,003	1.7	28,056	0.9
14	30000		172,625	87,187	2.9	45,458	1.5	24,397	0.8
15	30000		172,625	83,036	2.8	41,325	1.4	21,215	0.7
16	30000		172,625	79,082	2.6	37,568	1.3	18,448	0.6
17	30000		172,625	75,316	2.5	34,153	1.1	16,041	0.5
18	30000		172,625	71,729	2.4	31,048	1.0	13,949	0.5
19	30000		172,625	68,314	2.3	28,226	0.9	12,130	0.4
20	30000	100,000	172,625	102,749	3.4	40,524	1.4	16,657	0.6
Total	630,000	3,812,500	3,625,125	6,035,494	201.2	5,308,198	176.9	4,896,471	163.2

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	201.2	176.9	163.2

Technology: 2 Boreholes with Solar Pump

Capital cost: 2,312,500 Shs
Annual Costs: 49,525 Shs (Maintenance + Salaries)
Replacement Costs: Pump 60,000 Shs every 10 years.

Annual Yield: 40 m3/day * 300 = 12000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/Yr (Shs/m3)	Costs (Shs)	Cost/Yr (Shs/m3)	Costs (Shs)	Cost/Yr (Shs/m3)
0	12000	2,312,500	49,525	2,362,025	196.8	2,362,025	196.8	2,362,025	196.8
1	12000		49,525	47,167	3.9	45,023	3.8	43,065	3.6
2	12000		49,525	44,921	3.7	40,930	3.4	37,448	3.1
3	12000		49,525	42,782	3.6	37,209	3.1	32,563	2.7
4	12000		49,525	40,744	3.4	33,826	2.8	28,316	2.4
5	12000		49,525	38,804	3.2	30,751	2.6	24,623	2.1
6	12000		49,525	36,956	3.1	27,956	2.3	21,411	1.8
7	12000		49,525	35,196	2.9	25,414	2.1	18,618	1.6
8	12000		49,525	33,520	2.8	23,104	1.9	16,190	1.3
9	12000		49,525	31,924	2.7	21,003	1.8	14,078	1.2
10	12000	60,000	49,525	67,239	5.6	42,227	3.5	27,073	2.3
11	12000		49,525	28,956	2.4	17,358	1.4	10,645	0.9
12	12000		49,525	27,577	2.3	15,780	1.3	9,257	0.8
13	12000		49,525	26,264	2.2	14,346	1.2	8,049	0.7
14	12000		49,525	25,013	2.1	13,041	1.1	6,999	0.6
15	12000		49,525	23,822	2.0	11,856	1.0	6,086	0.5
16	12000		49,525	22,688	1.9	10,778	0.9	5,292	0.4
17	12000		49,525	21,608	1.8	9,798	0.8	4,602	0.4
18	12000		49,525	20,579	1.7	8,908	0.7	4,002	0.3
19	12000		49,525	19,599	1.6	8,098	0.7	3,480	0.3
20	12000	60,000	49,525	41,279	3.4	16,280	1.4	6,692	0.6
Total	252,000	2,432,500	1,040,025	3,038,664	253.2	2,815,710	234.6	2,690,515	224.2

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	253.2	234.6	224.2

Technology: 2 Boreholes with Windmill

Capital cost: 2,150,000 Shs
Annual Costs: 34,750 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 40 m3/day * 300 = 12000 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/Yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/Yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/Yr (Shs/m3)
0	12000	2,150,000	34,750	2,184,750	182.1	2,184,750	182.1	2,184,750	182.1
1	12000		34,750	33,095	2.8	31,591	2.6	30,217	2.5
2	12000		34,750	31,519	2.6	28,719	2.4	26,276	2.2
3	12000		34,750	30,018	2.5	26,108	2.2	22,849	1.9
4	12000		34,750	28,589	2.4	23,735	2.0	19,868	1.7
5	12000		34,750	27,228	2.3	21,577	1.8	17,277	1.4
6	12000		34,750	25,931	2.2	19,615	1.6	15,023	1.3
7	12000		34,750	24,696	2.1	17,832	1.5	13,064	1.1
8	12000		34,750	23,520	2.0	16,211	1.4	11,360	0.9
9	12000		34,750	22,400	1.9	14,737	1.2	9,878	0.8
10	12000		34,750	21,333	1.8	13,398	1.1	8,590	0.7
11	12000		34,750	20,318	1.7	12,180	1.0	7,469	0.6
12	12000		34,750	19,350	1.6	11,072	0.9	6,495	0.5
13	12000		34,750	18,429	1.5	10,066	0.8	5,648	0.5
14	12000		34,750	17,551	1.5	9,151	0.8	4,911	0.4
15	12000		34,750	16,715	1.4	8,319	0.7	4,271	0.4
16	12000		34,750	15,919	1.3	7,563	0.6	3,714	0.3
17	12000		34,750	15,161	1.3	6,875	0.6	3,229	0.3
18	12000		34,750	14,439	1.2	6,250	0.5	2,808	0.2
19	12000		34,750	13,752	1.1	5,682	0.5	2,442	0.2
20	12000		34,750	13,097	1.1	5,165	0.4	2,123	0.2
Total	252,000	2,150,000	729,750	2,617,812	218.2	2,480,596	206.7	2,402,262	200.2

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	218.2	206.7	200.2

Rural Supply from a Borehole with a Handpump

Appendix 7

Technology: Borehole with Handpump

Capital cost: 187,500 Shs
Annual Costs: 1,875 Shs (Maintenance of Borehole and Handpump)
Replacement Costs: Handpump 25,000 Shs - every 6 years.

Annual Yield: 10 m3/day * 365 = 3650 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	3650	187,500	1,875	189,375	51.9	189,375	51.9	189,375	51.9
1	3650		1,875	1,786	0.5	1,705	0.5	1,630	0.4
2	3650		1,875	1,701	0.5	1,550	0.4	1,418	0.4
3	3650		1,875	1,620	0.4	1,409	0.4	1,233	0.3
4	3650		1,875	1,543	0.4	1,281	0.4	1,072	0.3
5	3650		1,875	1,469	0.4	1,164	0.3	932	0.3
6	3650	25,000	1,875	20,055	5.5	15,170	4.2	11,619	3.2
7	3650		1,875	1,333	0.4	962	0.3	705	0.2
8	3650		1,875	1,269	0.3	875	0.2	613	0.2
9	3650		1,875	1,209	0.3	795	0.2	533	0.1
10	3650		1,875	1,151	0.3	723	0.2	463	0.1
11	3650		1,875	1,096	0.3	657	0.2	403	0.1
12	3650	25,000	1,875	14,965	4.1	8,563	2.3	5,023	1.4
13	3650		1,875	994	0.3	543	0.1	305	0.1
14	3650		1,875	947	0.3	494	0.1	265	0.1
15	3650		1,875	902	0.2	449	0.1	230	0.1
16	3650		1,875	859	0.2	408	0.1	200	0.1
17	3650		1,875	818	0.2	371	0.1	174	0.0
18	3650	25,000	1,875	11,167	3.1	4,834	1.3	2,172	0.6
19	3650		1,875	742	0.2	307	0.1	132	0.0
20	3650		1,875	707	0.2	279	0.1	115	0.0
Total	76,650	262,500	39,375	255,706	70.1	231,912	63.5	218,612	59.9

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	70.1	63.5	59.9

Rural Supply from a Dug Well with a Windmill

Appendix 7

Technology: Dug well with Windmill

Capital cost: 1,012,500 Shs
Annual Costs: 17,063 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 20 m3/day * 300 = 6000 m3/year

				Discount Rate 5 %		Discount Rate 10 %		Discount Rate 15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	6000	1,012,500	17,063	1,029,563	171.6	1,029,563	171.6	1,029,563	171.6
1	6000		17,063	16,250	2.7	15,511	2.6	14,837	2.5
2	6000		17,063	15,476	2.6	14,101	2.4	12,902	2.2
3	6000		17,063	14,739	2.5	12,819	2.1	11,219	1.9
4	6000		17,063	14,037	2.3	11,654	1.9	9,756	1.6
5	6000		17,063	13,369	2.2	10,594	1.8	8,483	1.4
6	6000		17,063	12,732	2.1	9,631	1.6	7,377	1.2
7	6000		17,063	12,126	2.0	8,756	1.5	6,414	1.1
8	6000		17,063	11,549	1.9	7,960	1.3	5,578	0.9
9	6000		17,063	10,999	1.8	7,236	1.2	4,850	0.8
10	6000		17,063	10,475	1.7	6,578	1.1	4,218	0.7
11	6000		17,063	9,976	1.7	5,980	1.0	3,667	0.6
12	6000		17,063	9,501	1.6	5,437	0.9	3,189	0.5
13	6000		17,063	9,049	1.5	4,942	0.8	2,773	0.5
14	6000		17,063	8,618	1.4	4,493	0.7	2,411	0.4
15	6000		17,063	8,207	1.4	4,085	0.7	2,097	0.3
16	6000		17,063	7,817	1.3	3,713	0.6	1,823	0.3
17	6000		17,063	7,444	1.2	3,376	0.6	1,586	0.3
18	6000		17,063	7,090	1.2	3,069	0.5	1,379	0.2
19	6000		17,063	6,752	1.1	2,790	0.5	1,199	0.2
20	6000		17,063	6,431	1.1	2,536	0.4	1,043	0.2
Total	126,000	1,012,500	358,313	1,242,199	207.0	1,174,825	195.8	1,136,362	189.4

	DISCOUNT RATE 5 %	DISCOUNT RATE 10 %	DISCOUNT RATE 15 %
Total Cost (Shs/m3)	207.0	195.8	189.4

Rural Supply from a Dug Well with a Handpump

Appendix 7

Technology: Dug Well with Handpump

Capital cost: 112,500 Shs
Annual Costs: 500 Shs (Maintenance)
Replacement Costs: Handpump 25,000 Shs - every 6 years.

Annual Yield: 10 m3/day * 365 = 3650 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	3650	112,500	500	113,000	31.0	113,000	31.0	113,000	31.0
1	3650		500	476	0.1	455	0.1	435	0.1
2	3650		500	454	0.1	413	0.1	378	0.1
3	3650		500	432	0.1	376	0.1	329	0.1
4	3650		500	411	0.1	342	0.1	286	0.1
5	3650		500	392	0.1	310	0.1	249	0.1
6	3650	25,000	500	19,028	5.2	14,394	3.9	11,024	3.0
7	3650		500	355	0.1	257	0.1	188	0.1
8	3650		500	338	0.1	233	0.1	163	0.0
9	3650		500	322	0.1	212	0.1	142	0.0
10	3650		500	307	0.1	193	0.1	124	0.0
11	3650		500	292	0.1	175	0.0	107	0.0
12	3650	25,000	500	14,199	3.9	8,125	2.2	4,766	1.3
13	3650		500	265	0.1	145	0.0	81	0.0
14	3650		500	253	0.1	132	0.0	71	0.0
15	3650		500	241	0.1	120	0.0	61	0.0
16	3650		500	229	0.1	109	0.0	53	0.0
17	3650		500	218	0.1	99	0.0	46	0.0
18	3650	25,000	500	10,596	2.9	4,586	1.3	2,061	0.6
19	3650		500	198	0.1	82	0.0	35	0.0
20	3650		500	188	0.1	74	0.0	31	0.0
Total	76,650	187,500	10,500	162,195	44.4	143,831	39.4	133,631	36.6

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	44.4	39.4	36.6

Urban Supply from a Spring

Appendix 7

Technology: Spring, Gravity Distribution, 200 m3 Storage, Chlorination

Capital cost: 4,987,500 Shs
Annual Costs: 304,750 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 200 m3/day * 365 = 73000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	73000	4,987,500	304,750	5,292,250	72.5	5,292,250	72.5	5,292,250	72.5
1	73000		304,750	290,238	4.0	277,045	3.8	265,000	3.6
2	73000		304,750	276,417	3.8	251,860	3.5	230,435	3.2
3	73000		304,750	263,255	3.6	228,963	3.1	200,378	2.7
4	73000		304,750	250,719	3.4	208,148	2.9	174,242	2.4
5	73000		304,750	238,780	3.3	189,226	2.6	151,515	2.1
6	73000		304,750	227,409	3.1	172,023	2.4	131,752	1.8
7	73000		304,750	216,580	3.0	156,385	2.1	114,567	1.6
8	73000		304,750	206,267	2.8	142,168	1.9	99,623	1.4
9	73000		304,750	196,445	2.7	129,244	1.8	86,629	1.2
10	73000		304,750	187,090	2.6	117,494	1.6	75,330	1.0
11	73000		304,750	178,181	2.4	106,813	1.5	65,504	0.9
12	73000		304,750	169,696	2.3	97,103	1.3	56,960	0.8
13	73000		304,750	161,615	2.2	88,275	1.2	49,530	0.7
14	73000		304,750	153,919	2.1	80,250	1.1	43,070	0.6
15	73000		304,750	146,590	2.0	72,955	1.0	37,452	0.5
16	73000		304,750	139,609	1.9	66,322	0.9	32,567	0.4
17	73000		304,750	132,961	1.8	60,293	0.8	28,319	0.4
18	73000		304,750	126,630	1.7	54,812	0.8	24,625	0.3
19	73000		304,750	120,600	1.7	49,829	0.7	21,413	0.3
20	73000		304,750	114,857	1.6	45,299	0.6	18,620	0.3
Total	1,533,000	4,987,500	6,399,750	9,090,109	124.5	7,886,759	108.0	7,199,781	98.6

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	124.5	108.0	98.6

Urban Supply from a Spring

Appendix 7

Technology: Spring, Gravity Distribution, 100 m3 Storage, Chlorination

Capital cost: 2,562,500 Shs
Annual Costs: 159,750 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 100 m3/day * 365 = 36500 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	36500	2,562,500	159,750	2,722,250	74.6	2,722,250	74.6	2,722,250	74.6
1	36500		159,750	152,143	4.2	145,227	4.0	138,913	3.8
2	36500		159,750	144,898	4.0	132,025	3.6	120,794	3.3
3	36500		159,750	137,998	3.8	120,023	3.3	105,038	2.9
4	36500		159,750	131,427	3.6	109,111	3.0	91,338	2.5
5	36500		159,750	125,168	3.4	99,192	2.7	79,424	2.2
6	36500		159,750	119,208	3.3	90,175	2.5	69,064	1.9
7	36500		159,750	113,531	3.1	81,977	2.2	60,056	1.6
8	36500		159,750	108,125	3.0	74,525	2.0	52,223	1.4
9	36500		159,750	102,976	2.8	67,750	1.9	45,411	1.2
10	36500		159,750	98,073	2.7	61,591	1.7	39,488	1.1
11	36500		159,750	93,403	2.6	55,991	1.5	34,337	0.9
12	36500		159,750	88,955	2.4	50,901	1.4	29,858	0.8
13	36500		159,750	84,719	2.3	46,274	1.3	25,964	0.7
14	36500		159,750	80,685	2.2	42,067	1.2	22,577	0.6
15	36500		159,750	76,842	2.1	38,243	1.0	19,632	0.5
16	36500		159,750	73,183	2.0	34,766	1.0	17,072	0.5
17	36500		159,750	69,698	1.9	31,606	0.9	14,845	0.4
18	36500		159,750	66,379	1.8	28,732	0.8	12,909	0.4
19	36500		159,750	63,218	1.7	26,120	0.7	11,225	0.3
20	36500		159,750	60,208	1.6	23,746	0.7	9,761	0.3
Total	766,500	2,562,500	3,354,750	4,713,088	129.1	4,082,292	111.8	3,722,178	102.0

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	129.1	111.8	102.0

Rural Supply from a Spring

Appendix 7

Technology: Spring, Gravity, 40 m3 Storage, 6 Comm. Water Points

Capital cost: 925,000 Shs
Annual Costs: 54,500 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 40 m3/day * 365 = 14600 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	14600	925,000	54,500	979,500	67.1	979,500	67.1	979,500	67.1
1	14600		54,500	51,905	3.6	49,545	3.4	47,391	3.2
2	14600		54,500	49,433	3.4	45,041	3.1	41,210	2.8
3	14600		54,500	47,079	3.2	40,947	2.8	35,835	2.5
4	14600		54,500	44,837	3.1	37,224	2.5	31,161	2.1
5	14600		54,500	42,702	2.9	33,840	2.3	27,096	1.9
6	14600		54,500	40,669	2.8	30,764	2.1	23,562	1.6
7	14600		54,500	38,732	2.7	27,967	1.9	20,489	1.4
8	14600		54,500	36,888	2.5	25,425	1.7	17,816	1.2
9	14600		54,500	35,131	2.4	23,113	1.6	15,492	1.1
10	14600		54,500	33,458	2.3	21,012	1.4	13,472	0.9
11	14600		54,500	31,865	2.2	19,102	1.3	11,714	0.8
12	14600		54,500	30,348	2.1	17,365	1.2	10,186	0.7
13	14600		54,500	28,903	2.0	15,787	1.1	8,858	0.6
14	14600		54,500	27,526	1.9	14,352	1.0	7,702	0.5
15	14600		54,500	26,215	1.8	13,047	0.9	6,698	0.5
16	14600		54,500	24,967	1.7	11,861	0.8	5,824	0.4
17	14600		54,500	23,778	1.6	10,783	0.7	5,064	0.3
18	14600		54,500	22,646	1.6	9,802	0.7	4,404	0.3
19	14600		54,500	21,568	1.5	8,911	0.6	3,829	0.3
20	14600		54,500	20,540	1.4	8,101	0.6	3,330	0.2
Total	306,600	925,000	1,144,500	1,658,690	113.6	1,443,489	98.9	1,320,634	90.5

	Discount Rate		
	5 %	10 %	15 %
Total Cost (Shs/m3)	113.6	98.9	90.5

Rural Supply from a Spring

Appendix 7

Technology: Spring

Capital cost: 37,500 Shs
Annual Costs: 500 Shs (Maintenance)
Replacement Costs: None

Annual Yield: 10 m3/day * 365 = 3650 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	3650	37,500	500	38,000	10.4	38,000	10.4	38,000	10.4
1	3650		500	476	0.1	455	0.1	435	0.1
2	3650		500	454	0.1	413	0.1	378	0.1
3	3650		500	432	0.1	376	0.1	329	0.1
4	3650		500	411	0.1	342	0.1	286	0.1
5	3650		500	392	0.1	310	0.1	249	0.1
6	3650		500	373	0.1	282	0.1	216	0.1
7	3650		500	355	0.1	257	0.1	188	0.1
8	3650		500	338	0.1	233	0.1	163	0.0
9	3650		500	322	0.1	212	0.1	142	0.0
10	3650		500	307	0.1	193	0.1	124	0.0
11	3650		500	292	0.1	175	0.0	107	0.0
12	3650		500	278	0.1	159	0.0	93	0.0
13	3650		500	265	0.1	145	0.0	81	0.0
14	3650		500	253	0.1	132	0.0	71	0.0
15	3650		500	241	0.1	120	0.0	61	0.0
16	3650		500	229	0.1	109	0.0	53	0.0
17	3650		500	218	0.1	99	0.0	46	0.0
18	3650		500	208	0.1	90	0.0	40	0.0
19	3650		500	198	0.1	82	0.0	35	0.0
20	3650		500	188	0.1	74	0.0	31	0.0
Total	76,650	37,500	10,500	44,231	12.1	42,257	11.6	41,130	11.3

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	12.1	11.6	11.3

Urban Supply from a Surface Water Dam

Appendix 7

Technology: Surface Water, Dam, Distribution, Pumping, 100 m3 Storage, Full Treatment

Capital cost: 12,187,500 Shs
Annual Costs: 941,875 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 500,000 for motorpumps every 10 years

Annual Yield: 200 m3/day * 365 = 73000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	73000	12,187,500	941,875	13,129,375	179.9	13,129,375	179.9	13,129,375	179.9
1	73000		941,875	897,024	12.3	856,250	11.7	819,022	11.2
2	73000		941,875	854,308	11.7	778,409	10.7	712,193	9.8
3	73000		941,875	813,627	11.1	707,645	9.7	619,298	8.5
4	73000		941,875	774,883	10.6	643,313	8.8	538,520	7.4
5	73000		941,875	737,984	10.1	584,830	8.0	468,278	6.4
6	73000		941,875	702,842	9.6	531,664	7.3	407,199	5.6
7	73000		941,875	669,373	9.2	483,331	6.6	354,086	4.9
8	73000		941,875	637,498	8.7	439,392	6.0	307,901	4.2
9	73000		941,875	607,141	8.3	399,447	5.5	267,740	3.7
10	73000	500,000	941,875	885,186	12.1	555,905	7.6	356,409	4.9
11	73000		941,875	550,695	7.5	330,121	4.5	202,450	2.8
12	73000		941,875	524,471	7.2	300,110	4.1	176,043	2.4
13	73000		941,875	499,496	6.8	272,828	3.7	153,081	2.1
14	73000		941,875	475,711	6.5	248,025	3.4	133,114	1.8
15	73000		941,875	453,058	6.2	225,477	3.1	115,751	1.6
16	73000		941,875	431,484	5.9	204,979	2.8	100,653	1.4
17	73000		941,875	410,937	5.6	186,345	2.6	87,525	1.2
18	73000		941,875	391,369	5.4	169,404	2.3	76,108	1.0
19	73000		941,875	372,732	5.1	154,004	2.1	66,181	0.9
20	73000	500,000	941,875	543,428	7.4	214,326	2.9	88,099	1.2
Total	1,533,000	13,187,500	19,779,375	25,362,621	347.4	21,415,181	293.4	19,179,025	262.7

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	347.4	293.4	262.7

Urban Supply from a Surface Water Weir with Pumping — Appendix 7

Technology: Surface Water, Weir, Pumping, Distribution, 200 m3 Storage, Full Treatment

Capital cost: 6,562,500 Shs
Annual Costs: 885,625 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 500,000 for motorpumps every 10 years

Annual Yield: 200 m3/day * 365 = 73000 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	73000	6,562,500	885,625	7,448,125	102.0	7,448,125	102.0	7,448,125	102.0
1	73000		885,625	843,452	11.6	805,114	11.0	770,109	10.5
2	73000		885,625	803,288	11.0	731,921	10.0	669,660	9.2
3	73000		885,625	765,036	10.5	665,383	9.1	582,313	8.0
4	73000		885,625	728,606	10.0	604,894	8.3	506,359	6.9
5	73000		885,625	693,910	9.5	549,903	7.5	440,312	6.0
6	73000		885,625	660,867	9.1	499,912	6.8	382,880	5.2
7	73000		885,625	629,397	8.6	454,466	6.2	332,939	4.6
8	73000		885,625	599,426	8.2	413,151	5.7	289,512	4.0
9	73000		885,625	570,882	7.8	375,591	5.1	251,750	3.4
10	73000	500,000	885,625	850,654	11.7	534,218	7.3	342,505	4.7
11	73000		885,625	517,807	7.1	310,406	4.3	190,359	2.6
12	73000		885,625	493,149	6.8	282,187	3.9	165,530	2.3
13	73000		885,625	469,666	6.4	256,534	3.5	143,939	2.0
14	73000		885,625	447,301	6.1	233,213	3.2	125,164	1.7
15	73000		885,625	426,001	5.8	212,012	2.9	108,838	1.5
16	73000		885,625	405,715	5.6	192,738	2.6	94,642	1.3
17	73000		885,625	386,395	5.3	175,216	2.4	82,297	1.1
18	73000		885,625	367,995	5.0	159,287	2.2	71,563	1.0
19	73000		885,625	350,472	4.8	144,807	2.0	62,229	0.9
20	73000	500,000	885,625	522,227	7.2	205,964	2.8	84,662	1.2
Total	1,533,000	7,562,500	18,598,125	18,980,371	260.0	15,255,043	209.0	13,145,688	180.1

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	260.0	209.0	180.1

Rural Supply from a Surface Water Weir

Appendix 7

Technology: Surface Water, Weir, Gravity Distribution, 200 m3 Storage, Full Treatment

Capital cost: 5,937,500 Shs
Annual Costs: 723,375 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: None

Annual Yield: 200 m3/day * 365 = 73000 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	73000	5,937,500	723,375	6,660,875	91.2	6,660,875	91.2	6,660,875	91.2
1	73000		723,375	688,929	9.4	657,614	9.0	629,022	8.6
2	73000		723,375	656,122	9.0	597,831	8.2	546,975	7.5
3	73000		723,375	624,879	8.6	543,482	7.4	475,631	6.5
4	73000		723,375	595,122	8.2	494,075	6.8	413,592	5.7
5	73000		723,375	566,783	7.8	449,159	6.2	359,645	4.9
6	73000		723,375	539,794	7.4	408,326	5.6	312,735	4.3
7	73000		723,375	514,089	7.0	371,206	5.1	271,943	3.7
8	73000		723,375	489,609	6.7	337,460	4.6	236,473	3.2
9	73000		723,375	466,294	6.4	306,782	4.2	205,628	2.8
10	73000		723,375	444,089	6.1	278,892	3.8	178,807	2.4
11	73000		723,375	422,942	5.8	253,539	3.5	155,485	2.1
12	73000		723,375	402,802	5.5	230,490	3.2	135,204	1.9
13	73000		723,375	383,621	5.3	209,536	2.9	117,569	1.6
14	73000		723,375	365,354	5.0	190,487	2.6	102,234	1.4
15	73000		723,375	347,956	4.8	173,170	2.4	88,899	1.2
16	73000		723,375	331,386	4.5	157,427	2.2	77,303	1.1
17	73000		723,375	315,606	4.3	143,116	2.0	67,220	0.9
18	73000		723,375	300,577	4.1	130,105	1.8	58,452	0.8
19	73000		723,375	286,264	3.9	118,278	1.6	50,828	0.7
20	73000		723,375	272,632	3.7	107,525	1.5	44,198	0.6
Total	1,533,000	5,937,500	15,190,875	15,675,726	214.7	12,819,374	175.6	11,188,719	153.3

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	214.7	175.6	153.3

Rural Supply from a Surface Water Weir

Appendix 7

Technology: Surface Water, Weir, Gravity Distribution, 40 m3 Storage, Filtration & Chlorination

Capital cost: 1,425,000 Shs
Annual Costs: 67,250 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 40 m3/day * 365 = 14600 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	14600	1,425,000	67,250	1,492,250	102.2	1,492,250	102.2	1,492,250	102.2
1	14600		67,250	64,048	4.4	61,136	4.2	58,478	4.0
2	14600		67,250	60,998	4.2	55,579	3.8	50,851	3.5
3	14600		67,250	58,093	4.0	50,526	3.5	44,218	3.0
4	14600		67,250	55,327	3.8	45,933	3.1	38,450	2.6
5	14600		67,250	52,692	3.6	41,757	2.9	33,435	2.3
6	14600		67,250	50,183	3.4	37,961	2.6	29,074	2.0
7	14600		67,250	47,793	3.3	34,510	2.4	25,282	1.7
8	14600		67,250	45,517	3.1	31,373	2.1	21,984	1.5
9	14600		67,250	43,350	3.0	28,521	2.0	19,117	1.3
10	14600		67,250	41,286	2.8	25,928	1.8	16,623	1.1
11	14600		67,250	39,320	2.7	23,571	1.6	14,455	1.0
12	14600		67,250	37,447	2.6	21,428	1.5	12,570	0.9
13	14600		67,250	35,664	2.4	19,480	1.3	10,930	0.7
14	14600		67,250	33,966	2.3	17,709	1.2	9,504	0.7
15	14600		67,250	32,348	2.2	16,099	1.1	8,265	0.6
16	14600		67,250	30,808	2.1	14,636	1.0	7,187	0.5
17	14600		67,250	29,341	2.0	13,305	0.9	6,249	0.4
18	14600		67,250	27,944	1.9	12,096	0.8	5,434	0.4
19	14600		67,250	26,613	1.8	10,996	0.8	4,725	0.3
20	14600		67,250	25,346	1.7	9,996	0.7	4,109	0.3
Total	306,600	1,425,000	1,412,250	2,330,334	159.6	2,064,787	141.4	1,913,190	131.0

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	159.6	141.4	131.0

Rural Supply from a Surface Water Intake Chamber

Appendix 7

Technology: Surface Water, Intake Chamber, Gravity Distribution, 40 m3 Storage, Filtration & Chlorination

Capital cost: 1,387,500 Shs
Annual Costs: 66,875 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 40 m3/day * 365 = 14600 m3/year

Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Discount Rate 5 % Costs (Shs)	5 % Cost/yr (Shs/m3)	10 % Costs (Shs)	10 % Cost/yr (Shs/m3)	15 % Costs (Shs)	15 % Cost/yr (Shs/m3)
0	14600	1,387,500	66,875	1,454,375	99.6	1,454,375	99.6	1,454,375	99.6
1	14600		66,875	63,690	4.4	60,795	4.2	58,152	4.0
2	14600		66,875	60,658	4.2	55,269	3.8	50,567	3.5
3	14600		66,875	57,769	4.0	50,244	3.4	43,971	3.0
4	14600		66,875	55,018	3.8	45,677	3.1	38,236	2.6
5	14600		66,875	52,398	3.6	41,524	2.8	33,249	2.3
6	14600		66,875	49,903	3.4	37,749	2.6	28,912	2.0
7	14600		66,875	47,527	3.3	34,317	2.4	25,141	1.7
8	14600		66,875	45,264	3.1	31,198	2.1	21,862	1.5
9	14600		66,875	43,108	3.0	28,362	1.9	19,010	1.3
10	14600		66,875	41,055	2.8	25,783	1.8	16,530	1.1
11	14600		66,875	39,100	2.7	23,439	1.6	14,374	1.0
12	14600		66,875	37,239	2.6	21,308	1.5	12,499	0.9
13	14600		66,875	35,465	2.4	19,371	1.3	10,869	0.7
14	14600		66,875	33,776	2.3	17,610	1.2	9,451	0.6
15	14600		66,875	32,168	2.2	16,009	1.1	8,219	0.6
16	14600		66,875	30,636	2.1	14,554	1.0	7,147	0.5
17	14600		66,875	29,177	2.0	13,231	0.9	6,214	0.4
18	14600		66,875	27,788	1.9	12,028	0.8	5,404	0.4
19	14600		66,875	26,465	1.8	10,935	0.7	4,699	0.3
20	14600		66,875	25,204	1.7	9,941	0.7	4,086	0.3
Total	306,600	1,387,500	1,404,375	2,287,785	156.7	2,023,720	138.6	1,872,968	128.3

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	156.7	138.6	128.3

Rural Supply from a Surface Water Intake Chamber with Hydram Appendix 7

Technology: Surface Water, Intake Chamber, Hydram, Distribution, 40 m3 Storage, Filtration & Chlorination

Capital cost: 1,512,500 Shs
Annual Costs: 84,125 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: 100,000 Shs for hydram every 15 years

Annual Yield: 40 m3/day * 365 = 14600 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	14600	1,512,500	84,125	1,596,625	109.4	1,596,625	109.4	1,596,625	109.4
1	14600		84,125	80,119	5.5	76,477	5.2	73,152	5.0
2	14600		84,125	76,304	5.2	69,525	4.8	63,611	4.4
3	14600		84,125	72,670	5.0	63,204	4.3	55,314	3.8
4	14600		84,125	69,210	4.7	57,459	3.9	48,099	3.3
5	14600		84,125	65,914	4.5	52,235	3.6	41,825	2.9
6	14600		84,125	62,775	4.3	47,486	3.3	36,370	2.5
7	14600		84,125	59,786	4.1	43,169	3.0	31,626	2.2
8	14600		84,125	56,939	3.9	39,245	2.7	27,501	1.9
9	14600		84,125	54,228	3.7	35,677	2.4	23,914	1.6
10	14600		84,125	51,645	3.5	32,434	2.2	20,794	1.4
11	14600		84,125	49,186	3.4	29,485	2.0	18,082	1.2
12	14600		84,125	46,844	3.2	26,805	1.8	15,724	1.1
13	14600		84,125	44,613	3.1	24,368	1.7	13,673	0.9
14	14600		84,125	42,489	2.9	22,153	1.5	11,889	0.8
15	14600	100,000	84,125	88,567	6.1	44,078	3.0	22,628	1.5
16	14600		84,125	38,539	2.6	18,308	1.3	8,990	0.6
17	14600		84,125	36,703	2.5	16,644	1.1	7,817	0.5
18	14600		84,125	34,956	2.4	15,131	1.0	6,798	0.5
19	14600		84,125	33,291	2.3	13,755	0.9	5,911	0.4
20	14600		84,125	31,706	2.2	12,505	0.9	5,140	0.4
Total	306,600	1,612,500	1,766,625	2,693,110	184.5	2,336,768	160.1	2,135,481	146.3

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	184.5	160.1	146.3

Rural Supply from a Surface Water Intake Chamber

Appendix 7

Technology: Surface Water, Intake Chamber, 10 m3 Storage,

Capital cost: 331,250 Shs
Annual Costs: 15,313 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 10 m3/day * 365 = 3650 m3/year

				Discount Rate					
				5 %		10 %		15 %	
Year	Annual Yield (m3)	Capital Costs (Shs)	Annual Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	3650	331,250	15,313	346,563	94.9	346,563	94.9	346,563	94.9
1	3650		15,313	14,583	4.0	13,920	3.8	13,315	3.6
2	3650		15,313	13,889	3.8	12,655	3.5	11,578	3.2
3	3650		15,313	13,228	3.6	11,505	3.2	10,068	2.8
4	3650		15,313	12,598	3.5	10,459	2.9	8,755	2.4
5	3650		15,313	11,998	3.3	9,508	2.6	7,613	2.1
6	3650		15,313	11,426	3.1	8,644	2.4	6,620	1.8
7	3650		15,313	10,882	3.0	7,858	2.2	5,757	1.6
8	3650		15,313	10,364	2.8	7,143	2.0	5,006	1.4
9	3650		15,313	9,871	2.7	6,494	1.8	4,353	1.2
10	3650		15,313	9,401	2.6	5,904	1.6	3,785	1.0
11	3650		15,313	8,953	2.5	5,367	1.5	3,291	0.9
12	3650		15,313	8,527	2.3	4,879	1.3	2,862	0.8
13	3650		15,313	8,121	2.2	4,435	1.2	2,489	0.7
14	3650		15,313	7,734	2.1	4,032	1.1	2,164	0.6
15	3650	100,000	15,313	55,467	15.2	27,605	7.6	14,171	3.9
16	3650		15,313	7,015	1.9	3,332	0.9	1,636	0.4
17	3650		15,313	6,681	1.8	3,029	0.8	1,423	0.4
18	3650		15,313	6,363	1.7	2,754	0.8	1,237	0.3
19	3650		15,313	6,060	1.7	2,504	0.7	1,076	0.3
20	3650		15,313	5,771	1.6	2,276	0.6	936	0.3
Total	76,650	431,250	321,563	585,492	160.4	500,866	137.2	454,698	124.6

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	160.4	137.2	124.6