REPUBLIC OF KENYA

MINISTRY OF WATER DEVELOPMENT

SAMBURU

DISTRICT WATER DEVELOPMENT STUDY

1993 - 2013

PART 2

EXISTING SUPPLY, TECHNOLOGY OPTIONS AND COSTS

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WRAP

WATER RESOURCES ASSESSMENT & PLANNING

TNO – INSTITUTE
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PREFACE

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

APPENDICES

1. WRAP Inventory Sheets for Existing Water Supplies
   Operational Charts of MoWD Water Supplies

2. Inventory of Infrastructure (by MPND)

3. Inventory of Existing Water Supplies in Samburu District

4. Unit Costs of Water Supplies: Source Data

5. Details and Costs of a Typical Water Supply

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	=	Samburu 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 Samburu District Water Development Study. Part 2 presents an inventory of existing water supply in Samburu District, the analysis of and recommendation on water supply options and technologies for Samburu 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 Samburu District.

The inventory of existing water supply was carried out by collecting data from the files of the MoWD (Operational Charts of MoWD supplies) 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, the trading centres and the dispersed rural population on the fringes of these settlements. The population outside the reach of the settlements relies for its' drinking water supply on unprotected sources such as dams, pans, springs and wells dug in the dry river beds. On estimate, the overall coverage by protected water supply is 30%, with urban coverage at 64%, and rural coverage at 15%.

However, these percentages do not indicate the supply level. This is particularly low for the three urban areas Wamba, Baragoi and Sukuta Marmar at 7 lpcd. For Maralal this figure is 52 lpcd, for the rural schemes 31 lpcd.

All protected water supply systems in Samburu are piped systems, drawing water from boreholes, dams, springs and rivers. Most of the schemes are pumped schemes, and only in a few cases the water is being treated. The developed capacity of the schemes may be estimated at 126 m^3/hr, i.e 17% of the calculated 1988 total water demand (if assuming a 12-hour supply period).

Of 31 schemes, 10 are reportedly in good working condition, 8 are fair, another 6 are in poor condition, whilst 3 are under construction and 2 are out of order. On 2 schemes no performance is available. The 4 urban systems are in poor to good condition.

Fourteen of the 31 schemes are owned and operated by the MoWD, 10 are owned and operated by other ministries or by institutions, whilst 7 schemes are either partially or wholly operated by the users. The schemes operated by the MoWD serve 82% of all beneficiaries and 49% of the beneficiaries outside the 4 urban areas.

Financial records are available for some MoWD schemes only and even then often incomplete, because maintenance costs were not available. The operation cost are around 30 to 50 Shs per beneficiary per year, and between 2.5 and 4 Shs per m^3 produced. The operation costs appear to be low, possibly due to understaffing, which may explain the poor condition of the MoWD water supplies.

In general the service level from the unprotected sources is quite low, as they are widely spaced apart and as people and animals are forced to take water directly from the source. Many unprotected sources,such as dams and pans usually contain water during part of the year only. Over 4000 km^2 or 25% of the district is not within 10 km reach of these temporary sources.

Erosion is rampant in parts of the District and many dams and pans are badly silted The dams and pans are usually not fenced and animals and people take wate directly. The poor condition of some of the dams can be explained from this Supervision of the structures is almost non-existent and regular maintenance, eg. by desilting, is not carried out.

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 poorly developed infrastructure, the limited availability of local staff, the low density of the population and the limited chances of effective cost recovery.

Five types supply areas were defined. The recommended technologies are:

Supply Area	Source Development	Water Supply Development 1)	Feasi-bility 2)
Urban Areas	Dug/Drilled wells	Motorized pump, Storage, Distr.	++
	Spring protection	Storage, distribution	+
	Surface Water Intake	Treatment, storage, distrib.	+
	Roof Catchment	Gutters, storage (individual)	+
Rural Centres	Dug/Drilled Well 3)	Windmill, storage	++
	Dug/Drilled Well	Hand pumps	++
	Sub-surface Dam	Dug Well + Hand pump	++
	Spring Protection	Storage	+
	Roof Catchment	Gutters, storage (individual)	+
	Rock Catchment	Storage	+
Rural Institution	Dug/Drilled wells 3)	Hand pumps (small units)	++
	Dug/Drilled well 3)	Windmill + storage (large units)	++
	Sub-surface Dam	Dug Well + Hand pump	++
	Spring protection	Storage	+
	Roof Catchment	Gutters, storage (individual)	+
	Rock Catchment	Storage	+
Dispersed Rural Population	Spring protection	Storage	++
	Rock Catchment	Storage	+
	Dug/Drilled Well 3)	Hand pump	+
	Sub-surface Dam	Dug Well + Hand pump	+
Rural Livestock	Deepening Depressions	-	++
	Dug/Drilled well 4)	Windmill, storage, trough	++
	Dam construction 4)	Fencing, trough	+

1) Development shown in decreasing order of suitability for each type of supply area
2) Feasibility with regards to availability of water resources
3) Dug wells in aquifer, or in storage provide by sub-surface dam
4) Maybe used also for supply of rural population, provided adequate measures are taken

WRAP determined the typical properties and components of the water supply technologies selected for Samburu 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 21 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 with handpumps, followed by surface water weirs with small gravity distribution systems. Boreholes with handpumps are expensive due to the costs of the borehole and the ranking of this system may be low if the total yield is small.

The outcome of the comparison of boreholes and dug wells equipped with windmills or motorpumps depends on the total yield of the system. Systems with a windmill benefit from a low discount rate, because of the relatively low O & M costs. Supplies from boreholes are generally expensive, due to the high construction costs of boreholes in Samburu and will therefore have a low ranking in case of a low total yield.

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.

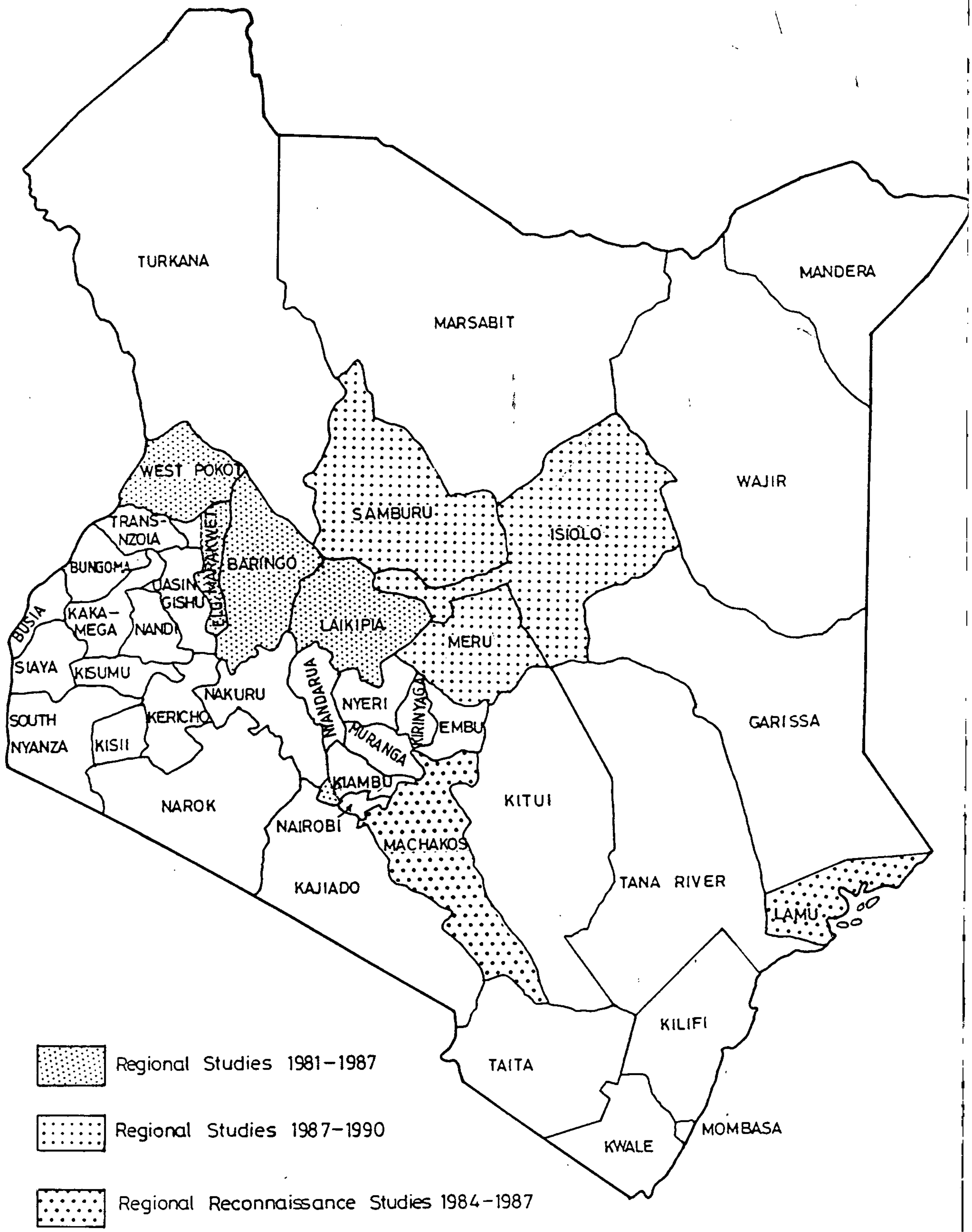
The unit cost analysis provides rates per beneficiary and per m^3 produced for each supply technology. Examples of some of the technology options for domestic supply are shown in the table:

Source Development	Supply Development	Total Capital Cost (Shs)	Capital Cost/ Capita (Shs)	Annual Cost/ Capita (Shs)	Unit Cost Rate: 10% (Shs/m^3)
Boreholes (3)	Pumps, Storage, Chlorination, Distrib.	5,768,750	1,150	105	15.6
Borehole	Windmill, Storage, Limited Distribution	1,131,250	2,265	32	22.5
Borehole	Handpump	375,000	1,875	17.5	12.5
Dug Well	Handpump	112,500	560	2.5	4.1
Spring	Pump, Storage, Chlorination, Distribution	4,800,000	960	60	11.0
	Storage, Limited Distribution	210,000	420	56	6.9
	Storage, One Outlet	25,000	125	2.5	0.9
Surface Water Intake	Weir, Treatment, Storage, Distribution	6,250,000	1,250	155	19.8
	Chlorination, Storage, Limit. Distrib.	400,000	1,865	76	11.0

The unit costs were also calculated for combined domestic-livestock supply and for livestock supply only. The cost per capita for the combined supply is higher, but the unit cost per m^3 is lower. Options where domestic and non-domestic supply can be combined should be preferred, especially in the rural areas where the number of users per facility is small, due to the dispersion of the population. It may even be so that participation of the community can only be expected, if water supply for the livestock is included.

In general springs and dug wells are the cheapest water supply technologies. Boreholes are more expensive, due to the high construction cost in Samburu District. Surface water intakes are economic if the supply is by gravity, but these are feasible at a few locations only. The supply for urban areas using a dam is very expensive.

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 Samburu 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 Samburu 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 Samburu 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 projections of 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.

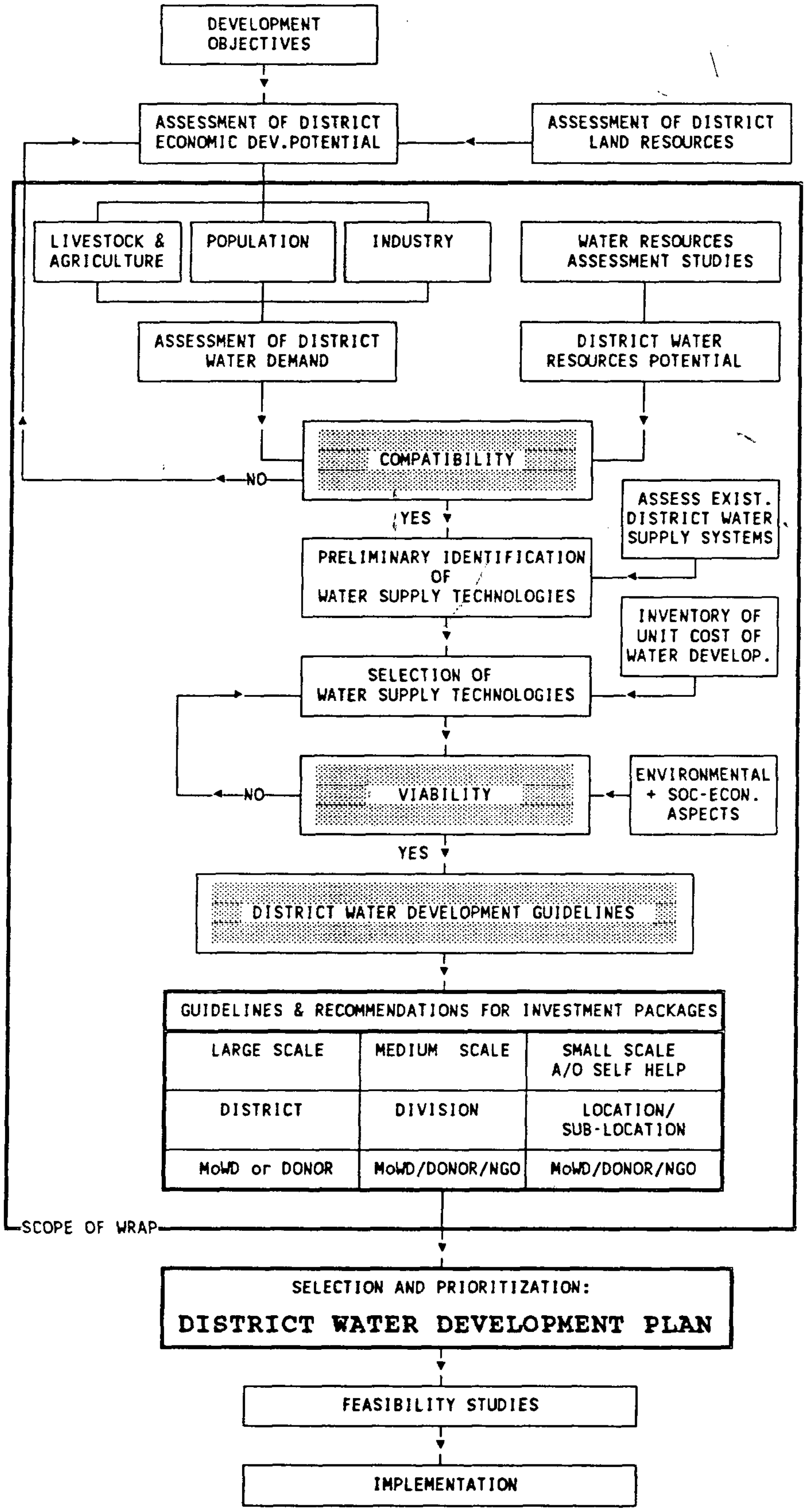


Figure 2.1 Model for Preparation of District Water Development Plan

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, 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, 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 the smallest planning unit: the sub-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 analyses, results and conclusions arrived at 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 Samburu 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 very 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 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 information obtained from the MoWD-office in Maralal and was checked and if necessary corrected by comparison with the population projections for 1988 by WRAP. 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 sub-location 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 in a particular sub-location. This information is presented on the district map using 3 categories: 0-30%, 30-60% and 60-100% coverage.

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 Samburu 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 itself. 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 Marsabit) is available at the District Water Office from the water permit which needs to be issued for each water supply. However in Samburu District no useful information could be obtained from the few permits which were available.

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 were 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.
An important 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 (see example in Appendix 2).

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 Samburu District.

The analysis of feasible water supply options for Samburu 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 Manyatta's
    - industries and 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 nomadic population
    - industries and tourist lodges: large point supply of high required reliability
    - livestock: supply for varying number of animals
    - wildlife: supply for free moving animals
    - agriculture: supply for irrigation
- the type of water sources in the district
    - large areas with little rainfall and/or long dry periods
    - few perennial rivers or springs
    - poor groundwater potential, especially in Basement areas, resulting in low borehole yields and sometimes unsuitable water quality.
- the poorly developed physical infrastructure, resulting in poor accessibility and serviceability of water supply systems
- the limited availability of local staff with adequate training in operation and maintenance of water supplies
- the limited chance of effective recovery of costs of operation and maintenance (assuming that costs of construction of supplies are covered by eg. donors)

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

- industries of a significant size are not present in the district and plans for new such industries are not known; furthermore industries are expected to be supplied through existing urban water supplies (eg. at Maralal), 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 in the higher elevated parts of the district, but also uses manmade dams and pans. Such facilities may not always be reached, because fences are recommended. Therefore separate water points for wildlife may be considered, if such demand exists.

- irrigated agriculture is currently practised on a very small scale at South Horr and Amaiya. Plans for additional irrigation in the District are not known and also do not seem feasible on the short term, therefore water supply for irrigation has not been included.

Note: Since the design covers a period of 20 years, industrial and irrigation activities may spring up, hence both activities need consideration in the long term.

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:

   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:

   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

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

The availability of protected water supply for domestic purposes is restricted mainly to the towns, the trading centres and the dispersed rural population on the fringes of these settlements. The 31 existing supplies are mostly located in a narrow band on either side of the C77/78/79 primary roads. The population outside the reach of the settlements relies for its' drinking water supply on unprotected sources such as dams, pans, springs and wells dug in the dry river beds.

On estimate, the overall coverage by protected water supply (including supplies under construction) is 30%, with urban coverage at 64%, and rural coverage at 15%. However, these percentages should be considered as approximate, because the population served was not actually counted (paragraph 3.2).

Table 4.1 Estimated Protected Water Supply Coverage (1988)

Samburu District	Urban (4 towns) 1)	Rural	Total
Total population	28,710	69,580	98,290
Served Population	18,250	10,766	29,016
Service Coverage (%)	64	15	30

Note: 1) Urban centres are settlements with more than 2000 inhabitants. In Samburu these are Maralal (18,000), Wamba (5,095), Baragoi (3,365) and Sukuta Marmar (2,250)

2) The Maralal supply alone covers 10,000 population (estimate)

Water supply coverage was investigated on sub-location basis and found to be very unevenly distributed. Protected water supply coverage is 0% in 41 sub-locations, 0 - 30% in 5 sub-locations, 30-60% in 11 sub-locations, and in excess of 60% in 12 sub-locations only.

Table 4.2 Estimated Protected Water Supply Coverage in 69 Sub-locations (1988)

Samburu District	Sub-locations					% of Pop. Covered
	Total Number	Number with water supply coverage				
		0%	0-30%	30-60%	60-100%	
Baragoi Division	20	14	1	3	2	21
Lorroki Division	29	15	3	5	6	36
Wamba Division	20	12	1	3	4	27
District	69	41	5	11	12	30

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 (in urban areas of Wamba, Baragoi and Sukuta Marmar only 7 lpcd). 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.

The area covered by protected water supply amounts to about 250 km², i.e only 1.2% of the total area of the district. This low figure indicates that especially the rural population has to walk long distances, if they want to use a protected water supply.

The above data are shown also in plate 1. The shadings in plate 1 should not be misinterpreted to show areal coverage of water supply. In fact, within the shaded areas, existing supplies only cover a small area.

4.1.2 Unprotected Water Supply Coverage

About 99% of Samburu District area has no protected water supplies. This implies that the majority of the people (about 70%) and almost the entire livestock rely on unprotected sources for their water supply. From table 4.1 above, it can be seen that 36% of the urban population and about 85% of the rural population rely on unprotected water sources. These unprotected sources are very widely distributed in the district. It can be expected that pollution in these sources is quite high (especially for dams/pans) as animals drink directly from them.

The Range Management Handbook (MoLD, in preparation) describes the water supply coverage for livestock in terms of maximum walking distance from the watering point to the grazing area (Bake, 1989). In easily accessible terrain this distance is 10 km to sometimes 15 km. According this approach the livestock water supply coverage from permanent water sources (perennial springs, streams lakes and boreholes) is about 35% of Samburu District. And the livestock water supply coverage from temporary sources (also including dams, pans, water holes and dug wells) is about 75% of Samburu District (Plate 2)

4.2 <u>Assessment of Protected Water Supply</u>

The assessment of protected 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. The findings are summarised in tables 4.11 and 4.12. Detailed assessments per scheme are enclosed in Appendix 3.

4.2.1 Technical Description

All protected water supply systems in Samburu are piped systems, drawing water from boreholes, dams, springs and rivers. Most of the schemes are pumped schemes, and only in a few cases the water is being treated. The developed capacity of the schemes may be estimated at 126 m³/hr, i.e 17% of the calculated 1988 total water demand (if assuming a 12-hour supply period).

Table 4.3 Summary Technical Description of Protected Water Supply

Source	Total No. of Schemes	No. of Schemes		No. of Schemes		Developed Capacity (m^3/h) [3]
		Gravity	Pumped [1]	With Treatment	Without Treatment	
Borehole	14	-	14 (3)	1 [2]	13	34
Dam	4	1	3 (-)	2	2	54
Springs	6	4	2 (-)	1 [2]	5	18
Rivers	7	4	3 (1)	1	6	20
	31	9	22 (4)	5	26	126

Notes: 1) Figures between brackets show no. of schemes where energy is other than fossil fuel, e.g. water (1 no), wind (2 (no), solar energy (1 no).

2) Treatment consists of chlorination only

3) The developed capacity was estimated for the supplies without data.

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 23 supplies, however, the number of beneficiaries per unit can be only estimated. It would seem that of all beneficiaries roughly one third receives water through communal connections, and two-third through house connections. The large number of inhabitants assumed to be supplied from one house connection may be understood from the fact that in most cases these connections are serving not only one family but rather a group of houses.

Table 4.4 Estimated Service Level (1988)

	Type of Service Connection				Total
	Communal		Individual		
	Communal Water Point	Kiosk	Metered Connection	Non-Metered Connection	
No. of Connections	36	12	531	199	778
Beneficiaries/Connect.	225		25		-
Total No. Beneficiaries	10,800		18,250		29,016
Percentage	37		63		100

Water production is on record for 4 urban schemes and for 7 rural schemes. The average water production per beneficiary is 31 lpcd. For Maralal this figure is 52 lpcd, for the other urban systems 7 lpcd, and for the rural schemes 31 lpcd. The figures for the 3 urban areas are particularly low. This may be due to an overestimation of the number of beneficiaries, poor working condition of the system, or more likely to the inadequacy of the water distribution system.

Table 4.5 Estimated Supply Level (1988)

		Production (m^3/yr)	No. of Beneficiaries	Water Production per Beneficiary (lpcd)		
				Average	Range	
					Minimum	Maximum
Urban Schemes	- Maralal	190,000	10,000	52	n.a	n.a
	- 3 Others	21,341	8,500	7	4	8
7 Rural Schemes		69,960	6,280	31	15	80
All Schemes		281,301	24,780	31	4	80

Note: 1) Archer's Post also supplies water to Isiolo District, which is included in the above figures

2) Loijok water supply is included, although it is out of order.

4.2.3 Functioning of the Systems

Of 31 schemes, 10 are reportedly in good working condition, 8 in fair working condition, another 6 are in poor condition, whilst 3 are under construction and 2 are out of order. On 2 schemes no performance is available. The 4 urban systems are in poor to good condition.

The reliability of the schemes, expressed in the number of days without water varies widely. For the 16 schemes with available data the average number of days without water is 73 (20%). For the 4 urban schemes alone this average is 38 (10%). Four of the rural schemes (all pumped) are permanently or semi-permanently in disorder. This is due to mechanical failures, fuel shortage, and poor design (damage by flooding). The other 10 rural schemes are on average 56 days without water.

Table 4.6 Reliability of the Water Supply Systems

	No. of Schemes	No. of Days/yr without water		
		Average	Range	
			Minimum	Maximum
Urban Schemes	4	38	5	60
Rural Schemes	10	56	0	120
Rural Schemes	2	225	100	270
Total	16	73	0	270

There are no reports on the bacteriological quality of water being distributed. The effectiveness of the schemes in terms of providing protected water supply quality can therefore not be established. Quality may certainly be doubted for the 6 river schemes and the one dam scheme that have no treatment at all.

4.2.4 Financial Performance

Financial records are available for some schemes only and even then often incomplete. The following analysis therefore must be considered as tentative. The financial records include operation costs, and revenue billed and collected. Costs of maintenance and repairs could not be obtained.

Revenue billed in urban systems covers 70% of operation costs; in rural areas this is only about 12%. Revenue collected amounts to about 75% of revenue billed. Consequently, in urban schemes 54% of operation cost are recovered, whilst in rural schemes this is only 9%. The cost of maintenance is not recovered at all.

Table 4.7 Cost Recovery in Existing Water Supplies

	No. of Schemes with Data	Annual Operat. Cost (Shs)	Annual Revenue (Shs)		Ratio of Revenue Collected to Operation Costs
			Billed	Collected	
Urban Schemes	4	571,300	395,591	308,300	0.54
Rural Schemes	12	414,100	50,460	37,713	0.09

The operation cost per beneficiary and per m³ are around 30 to 50 Shs per beneficiary per year, and between 2.5 and 4 Shs per m³. The operation costs appear to be low, which may be caused by low salary costs and low overhead costs (due to understaffing). Apparently not enough money is spent on operation and also not on maintenance, which may explain the poor condition of the MoWD water supplies.

Table 4.8 Unit Cost of Operation

	No. of Schemes With Data	Operation Costs (Shs)		Annual Operat. Costs (Shs)	Number of Beneficiaries	Production (m^3/yr)
		per m^3 produced	per year and beneficiary			
Urban Schemes	4	2.70	31	571,300	18,500	211,341
Rural Schemes	12	n.a	52	414,100	8,191	n.a
	7 1)	3.76	43	263,400	6,280	69,960

Note: 1) The group of 7 rural schemes is part of the 13 schemes in the same table.

4.2.5 Institutional Aspects

Fourteen of the 31 schemes are owned and operated by the MoWD, 10 are owned and operated by other ministries or by institutions, whilst 7 schemes are either partially or wholly operated by the users. The schemes operated by the MoWD serve 82% of all beneficiaries or if including also MoWD/Self Help supplies, 87% of all beneficiaries. Outside the 4 urban areas the MoWD serves an estimated 49% and 64% respectively of the rural population.

Table 4.9 Agencies Operating the Existing Water Supplies

Owner/Operator	No. of Schemes	Beneficiaries	
		Number	% of total
MoWD - Urban	5	18,500	64
- Rural	9	5,200	18
Other Ministries	3	1,011	3
Institutions	7	1,980	7
Private	1	150	1
Ministries/SH	5	1,675	6
Self Help	1	500	2
	31	29,016	100

The sixteen schemes operated by MoWD employ a total of about 27 personnel on site. Supervision and supplies are provided by MoWD divisional and district staff. Five rural schemes do not have employed operators; the other 11 rural schemes employ a rather high number of operators, the average being 1.4 operator per scheme or 4.4 operators per 1000 beneficiaries.

Table 4.10 Staffing of MoWD Operated Water Supplies

Type of Scheme	Number of Beneficiaries	Number of Site Staff	Number of Site Staff	
			per scheme	per 1000 Beneficiaries
Urban - Maralal	10,000	5	5	0.5
- 3 other	8,500 +	6 +	2	0.7
Urban Schemes	18,500	11	2.8	0.6
Rural - 5 Schemes [1])	2,500	0	0	0
-11 Other	3,610 +	16 +	1.4	4.4
Rural Schemes	6,110	16	1.0	2.6
All Schemes	24,610	27	1.4	1.1

Note: 1) Of these 5 schemes, 4 are borehole schemes with solar (1 no) or diesel driven (3 no) pumpsets, 1 is a gravity scheme taking water from a stream

If comparing this with the staff required as prescribed by the MoWD Design Manual, then it can be concluded that the water supplies in Samburu District are strongly understaffed.

Table 4.11 Existing Water Supplies in Samburu District: Technical Data

NAME OF SUPPLY	SUB-LOCATION	SOURCE	OWNER	YEAR COMM.	YIELD (SOURCE) (m^3/hr)	PUMP PLANT	INSTALLED CAPACITY (m^3/hr)	STORAGE (m^3)	PIPES (km)	QUALITY SOURCE	TREAT-MENT	1988 POPUL. SERVED	METER CONNC.	NON-METERED CONNC.	KIOSKS	CWP	AREA (km^2)	CATTLE TROUGH /DIP	WORK COND.
LORROKI																			
Maralal	Maralal	Dam	MoWD	1986	-	EP	49	970	43	OP	Full	10,000	347	1	4	1	50	0	1
Suguta Marmar	Suguta Marmar	SP	MoWD	1951	-	DP	(2.8)	50	5.5	OK	No	2,500	8	35	0	0	6	2	3
Bauwa	Lkilorit	BH	MoWD/SH	1985	4	EP	3	22.5	5	OK	No	500	0	-	0	3	16	Dip	2
Poro	Poro	Dam	MoWD/SH	UC	-	DP	-	45	2	OP	No	500	0	-	0	-	8	-	2
Sirata Oirobi	Sirata Oirobi	BH	MoWD	1973	2.2	DP	1.4	22.5	3.5	OK	No	500	19	4	1	1	6.5	-	2
Amaiya	Amaiya	River	MoA/SH	1978	-	Gr	-	0	8	OP	No	175	0	0	0	2	-	0	2
Amaiya	Amaiya	River	Miss	1978	-	HD	-	-	6.5	OP	-	10	0	-	-	1	-	0	1
Kirimun	Kirimun	SP	MoLD/NYS	1960	(20)	DP	-	200	6	OK	No	400	1	6	0	0	-	2	1
Kisima	Mbaringon	Dam	MoWD	UC	-	DP	0.4	100	11.4	OP	Full	700	10	0	0	2	-	-	UC
Longewan	Longewan	BH	SH	1952	2.5	DP	1.8	45	0.4	OK	No	500	0	0	0	1	-	2	3
Lodokojek	Lodokojek	BH	Miss	UC	-	EP	-	-	-	-	No	(200)	0	-	-	-	-	0	1
Barsaloi	Barsaloi	River	Miss	UC	-	-	-	-	-	-	-	(20)	-	-	-	-	-	-	-
Opiroi	Opiroi	SP	School	-	-	Gr	-	2	0.4	OK	No	(150)	-	-	-	1	-	0	2
BARAGOI																			
Baragoi	Baragoi	BH	MoWD	1974	0.9	DP	3	45	3.5	OK	No	3,000	17	0	1	0	12	1	3
Baragoi Sec. Sch.	Baragoi	BH	School	1977	1.73	WM	-	20	1.5	NOK	No	400	0	5	0	2	-	0	2
Marti	Kalele	BH	MoWD	1952	0.68	DP	-	24	2.0	OK	No	500	0	2	2	1	11	1	3
Tuum	Tuum	River	MoWD/SH	1988	16.2	Gr	-	22.5	4	OK	No	500	0	12	0	0	-	0	1
Lesirikan	Lesirikan	BH	MoWD/DDC	UC	5.5	S	3.2	50	0.6	-	No	700	0	0	0	1	2.6	-	3
South Horr	South Horr	River	Miss	-	-	Gr	-	-	-	OK	No	(800)	-	-	-	2	-	0	1
South Horr	South Horr	River	MoWD/SH	UC	746	Gr	-	100	1	OK	Sed	-	100	10	-	10	75	3	UC
Ngoronot	Ngoronot	SP	Miss	-	-	Gr	-	-	-	-	-	(400)	-	-	-	1	-	-	-
WAMBA																			
Wamba	Wamba	SP	MoWD	UC	(1)	Gr	-	200	7.6	OK	No	-	-	3	0	2	15	-	UC
Wamba	Wamba	BH	MoWD	1982	6.8	DP	4.1	No	3	OK	No	(3,000)	0	30	0	1	15	-	3/UC
Lodungokwe	Lpus	BH	MoWD	1978	4.0	DP	2.2	45	4.5	Saline	No	800	17	0	1	0	10	-	2
Loijok	Lerata	BH	MoWD	1974	2.5/4.8	DP	1.5	45	0.1	OK	No	(450)	0	0	0	1	26	0	4
Lerata	Lerata	BH	MoWD	1974	2.27	WM	(1.6)	150	0.1	Saline	No	350	0	0	0	1	11	1	1
Naisunyai	Lerata	Dam	MoWD	1981	-	HP	-	-	-	OP	No	(300)	-	-	-	1	-	1	1
Samburu Lodge	Archer's Post	BH	Priv.	-	-	EP	-	40	3	OK	Cl	150(1500)	0	75	0	0	-	0	1
West Gate	Archer's Post	River	CC	1980	-	PP	-	-	1	OP	Full	111	0	13	0	0	-	0	4
Archer's Post	Archer's Post	SP	MoWD	1986	-	DP	7.5	437	12	OK	Cl	900(3180)	12	3	3	0	28	Dip	1
Serolipi	Serolipi	BH	Police	1971	3.57	DP	-	50	2	NOK	No	500	0	0	0	1	1	0	2

BH = Borehole
SP = Spring
EP = Electrical Pump
DP = Diesel Pump
S = Solar Pump
PP = Petrol Pump
HD = Hydram
Hp = Hand pump
Gr = Gravity

WM = Windmill
CC = County Council
Miss = Mission
SH = Self Help
MoLD = Min. of Live Stock dev.
MoA = Min. of Agriculture
MoWD = Min. of Water Development
NYS = National Youth Service

CWP = Communal Water Points
OP = Organic Pollution
OK = Good Water Quality
NOK = Not Good Quality
Cl = Chlorination
Sed = Sedimentation
UC = Uncommissioned or Under Construction

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

WORKING CONDITION:

1 = Good
2 = Fair
3 = Poor
4 = Not Working

Table 4.12 Existing Water Supplies in Samburu District: Operational Data

Name of Supply	Sub-Location	Maintenance Agency	Utilization		Average Walking Distance (Km)	Rates Flat/ Metered	Water Produced (m^3/y)	Water Sold (m^3/y)	Revenue Billed (Year)	Revenue Collected (Year)	Cost of Operation (Shs/Year)	No. of Days Without Water per Year	Source of Information
			Households	Livestock									
Lorroki													
Maralal	Maralal	MoWD	2000	0	0.5	M	190,000	178,000	383,000	(301,500)	429,000	5	'87-'88/Visit
Suguta Marmar	Suguta Marmar	MoWD	500	0	1.2	F	8,064	0	0	0	(17,800)	29	MPND/Visit
Bauwa	Lkilorit	MoWD/SH	100	-	1.5	F	7,160	0	0	0	18,200	60	MPND/Visit
Poro	Poro	MoWD/SH	100	900	1.5	F	9,200	0	0	0	16,000	48	MPND/Visit
Sirata Oirobi	Sirata Oirobi	MoWD	100	80	2.5	M	2,800	2,630	5,400	-	80,000	60	'87-'88/Visit
Amaiya	Amaiya	MoA/SH	35	0	-	-	-	0	0	0	-	-	Visit
Amaiya	Amaiya	Miss	1	0	0.1	-	-	0	0	0	-	-	Visit
Kirimun	Kirimun	MoLD	80	1300	-	-	-	0	0	0	56,400	60	Visit
Kisima	Mbaringon	MoWD	150	0	1.0	M	0	0	0	0	-	UC	Visit
Longewan	Longewan	SH/MoWD	100	2000	2.0	-	-	0	0	0	-	270	Diocese
Lodokojek	Lodokojek	Miss	40	-	-	-	-	-	-	-	-	-	Diocese
Barsaloi	Barsaloi	Miss	1	-	-	-	-	-	-	-	-	-	Diocese
Opiroi	Opiroi	-	40	-	-	-	-	-	-	-	-	-	Visit
Baragoi													
Baragoi	Baragoi	MoWD	600	130	2.8	M	4,117	4,024	12,591	6,800	46,500	60	'85-'86/Visit
Baragoi Sec. Sch.	Baragoi	School	80	0	-	F	-	-	900	900	25,800	120	Visit
Marti	Kalele	MoWD	100	1200	4	F	-	-	0	0	26,500	180	'86-'87/Visit
Tuum	Tuum	MoWD/SH	100	50	3.5	F	-	-	0	0	-	60	Visit
Lesirikan	Lesirikan	DDC	150	50	2	M	-	0	0	0	-	UC	Visit
South Horr	South Horr	Miss	160	0	-	F	-	0	0	0	-	-	Visit
South Horr	South Horr	MoWD/SH	-	-	-	-	-	-	-	-	-	UC	Visit
Ngoronot	Ngoronot	Miss	80	-	-	-	-	-	-	-	-	-	Diocese
Wamba													
Wamba	Wamba	MoWD		0	2.5	F	-	-	0	0	-	-	Visit
Wamba	Wamba	MoWD	600	0	2.5	F	9,160	0	0	0	78,000	60	MPND/Visit
Lodungokwe	Lpus	MoWD	160	100	3.0	M	8,700	-	(2,160)	(3,813)	24,500	60	'85-'86/Visit
Loijok	Lerata	MoWD	60	1100	3.0	F	9,900	-	0	0	26,000	365	MPND
Lerata	Lerata	MoWD	80	1000	3.5	-	10,200	-	-	-	18,700	(30)	MPND/Visit
Naisunyai	Lerata	MoWD	60	(1000)	5	-	-		-	-	-	-	Visit
Samburu Lodge	Archer's Post	Private	75*	0	0	-	-	-	-	-	-	0	Visit
West Gate	Archer's Post	CC	25	0	-	-	-	-	-	-	22,000	365	Visit
Archer's Post	Archer's Post	MoWD	180	0	-	M	22,000	20,750	42,000	(33,000)	80,000	60	'88-'89/Visit
Serolipi	Serolipi	Police	100	0	-	-	-		-	-	(20,000)	-	Visit

KEY

MoWD = Ministry of Water
SH = Self Help
DDC = District Development Committee
CC = County Council
MoA = Ministry of Agriculture
Miss = Missionary
MoLD = Ministry of Livestock Development
* = Cottages

- = No data available
( ) = Data not accurate

Source of Information:

'87-'88 = Data from Operational Chart
MPND = Data from Inventory Ministry of Planning & National Dev.
Visit = Data Collected from Field visit

4.3 Assessment of Unprotected Water Supply

The assessment of the unprotected water supply is described here in general, mainly covering the functioning of this type of supply.

4.3.1 Technical Description

The unprotected water supplies are mainly rivers, dams, pans and wells dug in the dry river beds (laggas). These open water sources are generally satisfactory in their chemical status, but have high turbidity and organic matter. Chemical data of some of the sources are summarized in Part 1.

The size of dams and pans varies considerably in Samburu District (a list with the sizes and condition of the dams and pans is included in Part 1). The ones built before 1980 are all badly silted or even destroyed. A number of dams were rehabilitated after 1980 by DCU5 and also new ones were constructed. Already some of these are badly silted. No proper measures have been taken to reduce the rate of siltation. Only in Wamba Division attempts with soil conservation have been started at a small scale by the Food Security Program (ASAL).

4.3.2 Service Level

In general the service level from the unprotected sources is quite low, as they are widely spaced apart and as people and animals are forced to take water directly from the source. Over 4000 km² or 25% of the district is not within 10 km reach of these temporary sources. Dams and pans generally contain water during part of the year only. Data on the length of these periods is unfortunately not available.

4.3.3 Functioning and Institutional Aspects of the Unprotected Supply

The dug wells in the laggas are normally dug after each rain season. The wells are generally open without any lining, therefore the depth is restricted. The wells have to be abandoned, if groundwater levels in the lagga sandy sediments drop too deep.

The dams and pans are usually not fenced and animals and people take water directly. The poor condition of many of the dams can be explained from this. Supervision of the structures is almost non-existent and regular maintenance, eg. by desilting, is not carried out.

No revenues are collected from any of the unprotected water sources.

MPND = Data from Inventory Ministry of Planning & National Dev.
Visit = Data Collected from Field visit

CC = County Council
MoA = Ministry of Agriculture
Miss = Missionary
MoLD = Ministry of Livestock Development
* = Cottages

5 WATER SUPPLY DEVELOPMENT TECHNOLOGIES

5.1 Need for Improved Water Supply

The domestic water supply coverage from protected sources is low in Samburu District. The coverage is 64% in urban areas and only 15% in rural areas.

The supply level in the urban areas of Wamba, Baragoi and Sukuta Marmar is on average only 7 lpcd. Therefore both rehabilitation and extension of the existing systems is needed to improve the coverage and service in the urban areas.

The rural areas require many new systems if coverage is to be substantially increased. These new systems are required to supply more rural settlements, and also to supply the dispersed rural population, that now depends on unprotected facilities shared with livestock. In addition, systems are required for the supply of isolated institutions in rural areas (such as schools, clinics, etc., Appendix 2, Part 1).

Table 5.1 Need for Extension of Domestic Water Supply Coverage

	No. of Schemes	Population (1988)			
		Supplied 2)	Extension of Supply 3)	New Supplies	Total
Urban Systems 1)	5	18,250	14,850	-	33,100
Rural Systems	26	10,766	6,500	47,924	65,190
Total	31	29,016	21,350	47,924	98,290

Notes: 1) Figures for urban systems include rural population on fringes of town
2) Rehabilitation of supplies is needed to improve service level
3) Population covered by extension of domestic supply is a rough estimate.

Table 5.2 Need for New Water Systems for Institutions in Rural Areas (1988)

	No.of Institution	No. of People
Rural Institutions:		
- Schools	55	7,279
- Clinics	8	n.a

The existing facilities for livestock watering cover the larger part (75%) of the Samburu area, if assuming a supply area with a radius of 10 km around each facility. The capacity of these existing facilities in numbers of livestock units (L.U) covered, is not known. In developing new livestock watering facilities, extreme caution must be exercised so as to develop water supply capacity only to the extent compatible with the availability of fodder.

Studies carried out in preparation of the Range Management Handbook (MoLD, in preparation) indicate that only 12% of the rangeland in the District is currently in good condition. The rest of the rangeland is either indicated as fair 65% or poor 23%. The studies do not provide the districts capacity for livestock in L.U. and it is therefore impossible to indicate at this stage how many additional facilities would be required for improved livestock watering.

5.2 Samburu Context

5.2.1 Settlements

Three types of settlements may be distinguished in Samburu, namely towns, rural centres and rural, single family compounds (manyattas). From population figures it would appear that about 64% of the population lives in the rural, single family compounds, 29% in towns and 7% in or near rural centres.

The towns have a central area with a number of streets lined with permanent or semi-permanent buildings, generally with galvanized steel roofs. On the periphery, in a much lesser dense setting, family compounds are situated. These compounds are of the typical Samburu type with 4 to 8 huts grouped in a yard that is surrounded by a circular thorn hedge. The huts have wattle and mud walls and roofs; in a fairly large number of compounds one or two huts are of different design with a galvanized steel roof.

The trading centres consist of one street, sometimes two. Whilst some buildings are permanent (a police station, a school, a mission post), most houses are semi-permanent; roofs are of galvanized steel sheeting. Like in the case of towns, the centres are surrounded by single family compounds. These compounds generally outnumber the (semi-) permanent houses found in the centre; unlike in the urban periphery, the huts are nearly all wattle and mud structures, sometimes roofs are thatched.

Outside the towns and trading centres, one finds only family compounds. Generally these compounds have about 4-8 huts, though occasionally larger compounds, of up to 40 huts may be seen. Huts are exclusively wattle and mud structures. The occupied compounds are scattered over the country side, and it is rather unusual to see compounds less than 500 m apart. In most areas, except in Lorroki division, the number of abandoned compounds is much larger than the occupied ones. This is evidence of the non-sedentary, livestock oriented life of most of the Samburu people. The compounds are generally situated on gently sloping ground, near a road, a dry river bed, or at the foot of a hill.

Table 5.3 Type of Settlements and Housing (1988)

Type of Settlement	Number	Average Population 1)	Population Distribution	Type of Housing 2)		
				Permanent	Semi-permanent	Non-Permanent
Town - Maralal	1	18,000	18%	+	++	+
- Others	3	3,500	11%	-	++	+
Rural Centres	17	500	7%	-	+	++
Family Compounds	1600	25-50	64%	-	-	++
District	n.a	n.a	100%	-	+	++

Notes: 1) Including population in the immediate periphery
2) Permanent: stone or brick walls, galvanized steel roof;
semi-permanent: walls: poles with mud/cement plastering, galvanized steel roof;
non-permanent; mud and wattle walls and roof
shown to be (-) absent or nearly absent, (+) present as a substantial percentage of total, (++) predominant.

5.2.2 Infrastructure

Infrastructure in the district is poorly developed. The total length of classified roads is only 336.8 km, i.e 1.6 km per 100 km² of area. Electricity is available only in Maralal and Sukuta Marmar.

The majority of facilities in the District are located within 10 km distance from the main roads. This is probably related to the inaccessibility of many areas for trucks and other vehicles. Dams, pans and boreholes are also near these roads, generally because in most cases the thick bush in association with steeply undulating terrain hinder the access for building machines or drilling rigs.

5.2.3 Organization and Attitude

The Samburu people had a very unique form of organisation before independence. They had no chiefs and all power was contained in the institution of elders. Normally they used to settle conflicts through extensive discussions. Every man would be given a chance to air his views until an acceptable solution would be reached. They believed so much in the power of the curse and this was especially used to control the behaviour of the Morans. A curse it was believed would never fail.

The Samburu people appear to have rejected development plans and programmes because they feel that such changes appear to them as a move to the unknown and hazardous destination. This they claim has no basis whatsoever in their culture. A case in point is their attitude towards formal education. They argue that formal education does not adequately cover the Samburu cultural background. Evidence of their poor attitude towards education is shown by the very low school enrolment and especially in secondary schools. Between 1983 and 1987 secondary school enrolment increased by only 4%. In general the Samburu people feel that they should be allowed to participate in planning and decision making. Assuming the above statements to be true, then it is the form rather than the content of development which has proved unacceptable to the people.

In the past, the Samburu ideology of work emphasised on individualism. There was very poor attitude towards harambee (self-help) projects. However recent changes from field data show contributions to harambee projects as being considerable. Cases of close co-operation have also been noted in the digging of water-holes which sometimes involves several households.

Recently committees have been formed by the rural Samburu which organise some of the activities of the community. An example is the grazing of animals, for which areas are indicated each season outside which grazing is not allowed. These committees may play an important role in the implementation of the future development plans for the District.

Pastoralism is regarded as a noble profession amongst the Samburu people. In fact livestock related activities account for about 57% of employment. Agriculture is not so highly regarded and in fact it is considered as an occupation of the poor. Currently it accounts for about 4% of the employment. Self-employment in small-scale and informal business accounts for about 7.3% of the employment and this is expected to rise by about 11.6% annually for the next five (5) years. It must however be emphasized here that employment as a source of income is still very insignificant for the Samburu people. Only a handful of people go out to look for employment in urban areas or leave the district seeking jobs. Nevertheless there are quite a number of Samburu men enlisted in the armed forces.

The average earnings for people working in the major towns (Maralal, Wamba and Baragoi) for the year 1988 were Shs. 822 per capita per month. Earnings in the rural areas can therefore be expected to be quite low.

5.3 Considerations for Technology Choice

The definition of technical options for the extension of water supply coverage should be placed within the context of the Samburu 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. Poorly developed physical infrastructure, resulting in poor accessibility and serviceability of water supply systems (e.g in terms of fuel and spare parts supply and repairs);

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

3. The small size of the rural centres, and the extremely low density of the rural population.

4. Limited chances of effective cost recovery

The above considerations can be interpreted for the various supply areas as shown in the table below:

Table 5.4 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
Maralal	18,000	good	good	fair
Other Urban Areas	3,500	good	fair	fair
Rural Centres	500	fair to poor	fair to poor	low
Rural Institutions	<500	fair to poor	fair to poor	fair
Dispersed population	<100	poor	poor	low

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.

5.4 Technology Choice

The sources for water supply development in Samburu have been recommended in Part 1.

The proposed development of the water resources was determined according the following assumptions:

1. The development of groundwater (and springs) is preferred to the development of surfacewater for reasons of water quality and of supply reliability during drought situations. The increase of the domestic demand until 2003 is therefore expected to be supplied from groundwater resources.

2. Rural domestic demand is supplied from springs (if present), groundwater (boreholes or wells) or rainwater (roof catchments). The use of these sources ensures the best possible water quality, with no or little treatment required.

3. Urban domestic demand is supplied from springs (e.g Wamba, Archer's Post, Sukuta Marmar, South Horr, Tuum), surface water (Maralal) or groundwater (e.g Baragoi, almost all other small centres). Water supply is required in greater quantities than for rural domestic supplies, therefore surface water is also an option. Treatment is required for surface water sources.

Table 5.5 Proposed Source Development for 2003 Demand (Scenario 2)

	Domestic Supply			Non-Domestic Supply				
	Gw	Rw/Sw	Sp	Gw	Rw/Sw	Sp	No. Res.	No. Dev.
Baragoi Division								
- Quantity (m^3/d)	917	87	18	158	122	0	21	-
- Nr. of sub-locations	18	2	2	11	7	0	2	7
Lorroki Division								
- Quantity (m^3/d)	3,575	1,349	70	214	181	0	531	-
- Nr. of sub-locations	29	9	2	12	9	0	17	12
Wamba Division								
- Quantity (m^3/d)	722	0	70	52	21	0	0	-
- Nr. of sub-locations	12	0	3	3	1	0	0	9
Waso Division								
- Quantity (m^3/d)	138	0	107	68	52	0	67	-
- Nr. of sub-locations	8	0	1	5	3	0	4	1
Total Quantity (m^3/d)	5,351	1,436	265	492	376	0	619	-

Note: 1) Gw = Groundwater, Rw = Rainwater, Sw = Surface Water, Sp = Spring,
No Dev. = No development due to rangeland condition,
Nat. Res= Natural Resources (no development required)

2) Total number of sub-locations may be bigger than the total in the Division, because some sub-locations have more than one water source

Total sub-locations: Baragoi Division: 20
Lorroki Division: 29
Wamba Division: 12
Waso Division: 8

4. Rural non-domestic demand is supplied from springs, surface water or groundwater. If possible surfacewater and groundwater are used in combination on a 50-50% basis. In some areas sources are naturally available from rivers, streams, springs, lakes or depressions. These will supply part of the water demand, for which therefore no development is required. The methodology for the determination of the non-domestic (livestock) water supply development is described in detail in Appendix 8 and the results for each sub-location is presented in Table A8.4.

5. Urban non-domestic demand is not catered for, separately. Livestock demand in urban areas is assumed to use sources allocated to the non-domestic demand in nearby rural areas. Industrial demand only exists at Maralal, which supply was included with the domestic demand.The technical options recommended for the provision of water supply based on the above consideration are shown in table 5.6 and 5.7 for the various supply categories:

Table 5.6 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
Ground-water	Drilled/Dug Well	Single outlet 3)	Hand pump	-	++	++	+
			Windmill & Storage	-	++	++	-
			Motor pump (fossil fuel) + Storage	-	+	+	-
		Multiple outlet	Windmill + Storage + Distribution System	-	-	-	-
			Motor pump + Storage + Distribution System	++	-	-	-
	Spring Protection	Single outlet	Storage	-	++	++	++
		Multiple outlet	Storage + Distribution System	++	-	-	-
Rain water	Roof Catch-ments	Single outlet	Gutters + Storage	+	++	++	-
	Rock Catch-ments	Single outlet	Storage	-	++	+	+
		Multiple outlet	Storage + gravity distrib.	-	-	-	-
Surface water	Sub-surface dam + dug wells	SEE ABOVE FOR DRILLED/DUG WELL					
	Direct intake	Multiple Outlet	Motorized pumps, treatment, storage, distribution	+	-	-	-

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

2) Supply category:
1. Urban Centre
2. Rural Centre
3. Rural institution
4. Dispersed Rural Population

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

Table 5.7 Suitability of Technologies for Livestock Water Supply

Livestock Water Supply Development			
Source Development		Water Supply Development	Suitability
Source	Technology		
Groundwater	Dug/Drilled well	Hand pump Windmill + storage + trough Motorpump + storage + trough	+ ++ -
Rainwater	Deepening Depressions	-	++
	Dam Construction	Fencing + troughs	+

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 below:

Table 5.8 Recommended Technologies for Various Types of Users

Supply Area	Source Development	Water Supply Development 1)	Feasi-bility 2)
Urban Areas	Dug/Drilled wells Spring protection Surface Water Intake Roof Catchment	Motorized pump, Storage, Distr. Storage, distribution Treatment, storage, distrib. Gutters, storage (individual)	++ + + +
Rural Centres	Dug/Drilled Well 3) Dug/Drilled Well Sub-surface Dam Spring Protection Roof Catchment Rock Catchment	Windmill, storage Hand pumps Dug Well + Hand pump Storage Gutters, storage (individual) Storage	++ ++ ++ + + +
Rural Institution	Dug/Drilled wells 3) Dug/Drilled well 3) Sub-surface Dam Spring protection Roof Catchment Rock Catchment	Hand pumps (small units) Windmill + storage (large units) Dug Well + Hand pump Storage Gutters, storage (individual) Storage	++ ++ ++ + + +
Dispersed Rural Population	Spring protection Rock Catchment Dug/Drilled Well 3) Sub-surface Dam	Storage Storage Hand pump Dug Well + Hand pump	++ + + +
Rural Livestock	Deepening Depressions Dug/Drilled well 4) Dam construction 4)	- Windmill, storage, trough Fencing, trough	++ ++ +

1) Development shown in decreasing order of suitability for each type of supply area
2) Feasibility with regards to availability of water resources
3) Dug wells in aquifer, or in storage provide by sub-surface dam
4) May be used also for supply of rural population, provided adequate measures are taken

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 Samburu District. Both costs are used for a cost effectiveness analysis and for the determination of unit costs per m^3 produced and per beneficiary.

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.

- 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.

Further complication of the unit costs analysis is caused, because of differences between the designs adopted for Samburu District and the designs used in other parts of Kenya. The DWDS has tried to overcome these complications, by determining the typical properties and components of the water supply technologies specific for Samburu District, and to obtain separate cost estimates for these components.

The construction costs of each component was analysed and finally cost estimates were determined of the complete water supply options, which are applicable to the conditions in Samburu 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.

Table 6.1 Production Capacity and Capital Cost of Water Supply Development

Source Development	Supply Development	Production (m^3/day)	Capital Cost (Shs)	Cost/m^3/day (Shs)
Borehole	Pump, storage, chlorination, distribution,	50/100 [1])	1,437,500/ 1,625,000	28,750/ 16,250
	Windmill, storage, small distribution	35	1,425,000	40,700
	Handpump	10	375,000	37,500
Dug well	Windmill, storage, small distribution	40	1,175,000	29,400
	Hand pump	10	112,500	11,250
Surfacewater Intake	Weir, treatment, storage, distribution	200	6,250,000	31,250
	Weir, storage, chlorination, small distribution	70	1,150,000	16,500
Spring Protection	Storage, chlorination, distribution	200	4,800,000	24,000
	Storage, small distribution	70	1,281,250	18,300
	Storage, cwp, trough	35	293,750	8,400
	Storage, one outlet	10	25,000	2,500
Dam or Pan	2,500 m^3	(50) [2])	156,250	(3,100)
	5,000 m^3	(50) [2])	312,500	(6,250)
	10,000 m^3	(50) [2])	625,000	(12,500)
	25,000 m^3	40	1,562,500	39,000
	50,000 m^3	40	3,125,000	78,000

Notes: 1) Production Basement Rock: 50 m^3/day
Volcanic Rock: 100 m^3/day

2) Contains and supplies water part of the year only

The typical properties and components of the water supply options for Samburu 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 Samburu District (see also chapter 6 of Part 1).

6.1.1 Source Development

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 Samburu District are gravity springs. Spring discharges range from 10 m^3/day (Oromodei) to >300 m^3/day (South Horr).

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 Samburu 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 recommended in certain areas, mainly near laggas. 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. The required depth of the dug wells in Samburu District is expected to be 5-10 m.

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 Samburu District is 560 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 Samburu 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 Samburu District are summarized in table 6.2.

Table 6.2 Average Properties of Boreholes in Samburu District

	Basement Area	Volcanic Area
Drilled Depth	100 m	200 m
Drilled Diameter	200 mm	200 mm
Casing Diameter	150 mm	150 mm
Type of Casing	steel	steel
Length of Filters	21 m	21 m
Borehole Yield	2-4 m^3/hr	2-12 m^3/hr

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 Samburu District was determined at 375,000 Shs (Appendix 5). This 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.

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.

Surface water intakes are feasible at a few sites only in Samburu District (South Horr, Amaiya, Kichich). A water supply project is currently under construction at South Horr (MoWD, SIDA and KWAHO), including a weir costing 120,000 Shs. The cost estimate for an average weir adopted for the Samburu District Water Development is 200,000 Shs (Appendix 5).

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 it can be stated that in general, conditions are favourable, especially in the Basement area where dykes cross the numerous laggas.

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 Samburu 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.

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 in many areas of Samburu does not exceed 250 mm.

Table 6.3 Required Area and Storage of Rainwater Catchments

Continuous Demand (m^3/day)	Storage Tank (m^3)	Roof Area (m^2)	Rock Area (m^2)
1	120	2,250	3,600
5	600	11,250	18,000
10	1,200	22,500	36,000
20	2,400	45,000	72,000

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 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 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 Samburu District. A small one was constructed recently at Raraita, but information is not yet available. 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, therefore unit costs were not included at this stage of the Samburu District Water Development Study.

Pans and Dams: 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 by DCU5 in Samburu 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 of total costs based on rates provided by DCU5 was made. 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

Investigations to locate sites for dams/pans were not executed by WRAP. However areas with potential for the construction of dams and pans can be determined from the surveys executed for the Range Management Handbook. These areas will be presented in Part 1 of the Samburu District Water Development Study.

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.

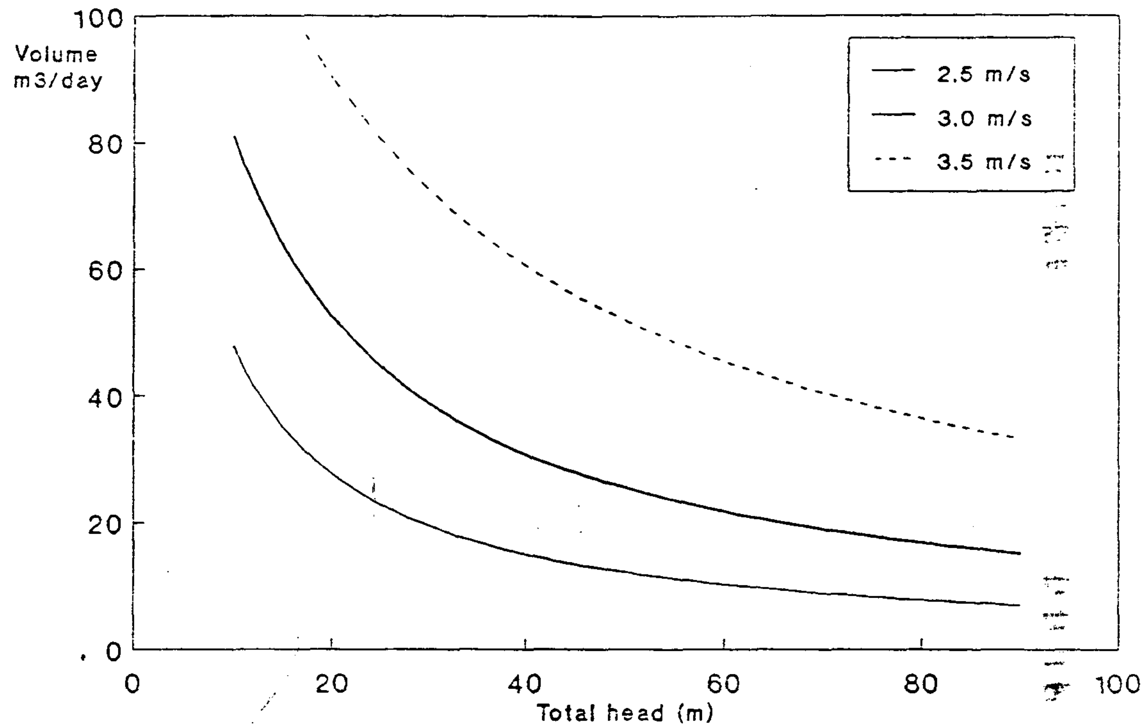


Fig. 6.1 **The Economics of Wind Pumps Versus Diesel Pumps for Village and Livestock Water Supplies in Kenya (from: IT-Power, 1989)**

Wind speed data are not available for Samburu District. The nearest station with data is at Rumuruti. Average wind speed at this station is >2.5 m/s during 11 months per year. If conditions are similar in Samburu then wind pumps are feasible. At Lerata a windmill was installed a few years ago. The people of Lerata complain that the wind pump does not provide sufficient water, but a clear conclusion cannot be drawn from their experience, because the storage tank is not connected.

Hydraulic Rams and Solar Pumps: Both use natural sources of energy. 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 Samburu such sites are few. At Amaiya the mission is currently using a ram pump.

Solar pumps may be suitable for arid areas. 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) which at this stage of development is considered too expensive to be included as a feasible option. However some donors currently include solar units in their projects, therefore it will be interesting to monitor the performance of these units.

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 treatment may be estimated at 300,000 Shs.

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 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: The planned water supplies in Samburu District are of a small scale, therefore treatment is not always feasible, due to in proportion high costs. 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.

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

	Rural Centre (20 m^3/day)	Urban Area (200 m^3/day)
Individual Connections	5	200
Communal Water Points	2	20
Cattle Troughs	1	-

It is difficult to establish a unit cost for distribution systems, because it is not possible to generalize diameters 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/m³ 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.

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

Windmill: 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. Maintenance costs therefore 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 embarkment(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

The water supplies in Samburu District will mainly supply water for domestic use and livestock watering. The overview of the cost of water supply development for different supply areas therefore distinguishes three types of supply: domestic supply only, livestock supply only and combined domestic - livestock supply (Table 6.5 and 6.6). Indicated in the tables are estimates of the initial capital (investment) costs, the annual O & M costs and the costs per capita. These costs were used to carry out an economic analysis of the supply technologies.

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 Section 5.2 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". Tables 6.5 and 6.6 set 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.

6.3.2 Results of Analysis

The cost effectiveness exercise was conducted for 21 different types of domestic supply systems, representing supplies to rural areas, rural centres and urban centres (Appendix 7). The analysis was carried out over a 20 year period, and the systems were ranked according to the 10% discount rate.

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.

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.
springs							
1	Spring	76,650	25,000	10,500	8.7	8.2	7.8
3	Spring, 35 m3 Storage	268,275	293,750	627,375	54.5	45.2	40.0
5	Spring, Gravity Distribution, 70 m3	536,550	1,281,250	2,050,125	101.6	86.5	77.9
8	Spring, Gravity Distribution, 200 m3	1,533,000	4,800,000	6,216,000	120.3	104.3	95.2
groundwater							
2	Dug Well with Handpump	76,650	187,500	10,500	44.4	39.4	36.6
4	Dug Well with Handpump	38,325	187,500	10,500	88.9	78.8	73.2
9	Borehole with Handpump	76,650	450,000	73,500	127.4	119.1	114.5
10	Borehole with Motorpump, Distribution	536,550	1,925,000	3,176,250	149.1	123.1	108.4
11	Dug well with Windmill	220,500	1,175,000	283,500	129.2	124.1	121.2
13	3 Boreholes with Motorpump, Distrib	1,533,000	6,218,750	10,976,427	178.4	148.6	131.8
14	Borehole with Motorpump, Distribution	268,275	1,275,000	1,811,250	180.8	149.7	132.3
15	Borehole with Windmill	220,500	1,425,000	336,000	156.2	150.2	146.8
18	Borehole with Windmill	126,000	1,131,250	336,000	224.4	213.9	207.9
19	Borehole with Motorpump, Limited Distr.	153,300	1,093,750	1,563,240	269.8	221.7	194.9
20	Borehole with handpump	38,325	450,000	73,500	254.8	238.3	229.0
surface water							
6	Surface Water, Weir, Gravity Distr.	268,275	487,500	1,572,375	117.1	93.9	80.7
7	Surface Water, Weir, Gravity Distr.	536,550	1,150,000	3,181,500	124.8	101.4	88.1
12	Pan (5000 m3, 6 months with water)	94,500	312,500	580,125	152.1	127.8	114.0
16	Dam (25000 m3) with Handpump and Trough	383,250	2,137,500	2,669,625	209.1	180.7	164.5
17	Surface Water, Weir, Distribution	1,533,000	7,250,000	16,012,500	233.0	188.6	163.6
21	Surface Water, Dam, Distribution	1,533,000	13,250,000	17,272,500	326.3	278.7	251.7

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 includes investment + replacement costs.

6.3.3 Conclusions

The total costs in Shs/m³ 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 in a limited number of areas. Other cost effective systems are dug wells with handpumps, followed by surface water weirs with small gravity distribution systems. Boreholes with handpumps are expensive due to the costs of the borehole and the ranking of this system may be low if the total yield is small.

The outcome of the comparison of boreholes and dug wells equipped with windmills or motorpumps depends on the total yield of the system. Systems with a windmill benefit from a low discount rate, because of the relatively low O & M costs. Supplies from boreholes are generally expensive, due to the high construction costs of boreholes in Samburu and will therefore have a low ranking in case of a low total yield.

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 m³ 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 Samburu 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 in Samburu District mainly supply water for domestic use and livestock watering. Therefore only population and livestock are considered as beneficiaries.

The supplies have been distinguished in domestic supply only, livestock supply only and combined domestic-livestock supply. The cost per beneficiary is estimated per head of population. Cost per head of livestock has not been calculated. The costs are based on the initial capital costs and are presented in table 6.5 and 6.6.

The cost per capita for the combined domestic-livestock supplies is higher than for the domestic supply only. This is because the cost of water development for livestock supply is also included. As the livestock is owned by the population, the benefits of livestock water supply will come to them and therefore higher per capita costs are acceptable.

The supply to urban areas has been costed for three options: boreholes, springs or surface water intake. The capital costs per capita of the three do not differ much at around 1,000 Shs, but the surface water option using an intake weir is the most expensive. This option is only feasible at a few locations in Samburu. Intake from a dam with sufficient storage to last the dry season is feasible at more locations (e.g Wamba), but this option is even more expensive, due to the high costs of the dam.

The supply to rural centres (500 population) is relatively expensive due to the cost of distribution. Per capita costs for supply from boreholes or surface water intake are around 2,000 Shs and if including livestock supply 2,500-3,500 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 a dug well with a hand pump, which is about 675 Shs/capita. Boreholes are more expensive, because of the required large drilling depths in Samburu District.

The non-domestic supply is cheapest in case a small dam or pan is feasible. The cost per LU is about 600 Shs.

The supply of the dispersed population is relatively expensive, because of the small number of users per facility. Options where domestic and non-domestic supply can be combined should be preferred in the rural areas. The cost of a filter structure with a hand pump as domestic water supply off-take from a dam or pan can be estimated at the same cost as a dug well with hand pump. This option was included under livestock supply from a dam in table 6.6.

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 6.5 and 6.6 and the results are presented in the last columns.

The unit cost gives an indication of the financial contribution which may be required from the rural population. The least expensive options using handpumps on dug wells show a cost price of about 4-8 Shs/m^3 or 8-16 cts/debe (20 litres). The annual O & M cost is 2.5-5 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 a spring or from dug wells may be cheaper.

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%):

Springs: This technology generally has the lowest capital costs and unit costs: 2-4 Shs/m^3 for rural supplies, 7-11 Shs/m^3 for urban supplies. But springs are not present in many areas, therefore springs are often not an option.

Dug Wells: Dug wells are usually selected in combination with a handpump, in which case costs remain low: 4-9 Shs/m^3. The combination dug well - windmill has higher capital costs, but O & M costs are also low. The unit costs are about 13 Shs/m^3. Dug wells can be made at locations where shallow groundwater is present, eg. near laggas. Therefore dug wells are not an option, in case the groundwater table is deep. Dug wells may be used in combination with sub-surface dams or with dams or pans.

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 between 12 and 25 Shs/m^3, depending on the daily yield. Fitted with a windmill the unit costs are between 11 and 22 Shs/m^3. Fitted with an electrical submersible pump the unit costs are between 13 and 23 Shs/m^3. Windmills and pumps are not much different in terms of unit costs, but windmills are less expensive to operate.

Surface Water Intakes: The use of surface water from streams is usually attractive in case a gravity supply is possible: unit costs are about 11 Shs/m^3. But it is expensive when pumping is needed: about 20 Shs/m^3 or more. The O & M of surface water supplies includes treatment, which is not needed (except chlorination) for groundwater or spring supplies.

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.

Dams and Pans: The unit costs of dams and pans are high; 13-19 Shs/m^3. This is due to the high maintenance rate of 5%. The siltation of dams and pans may lead to lifetimes shorter than 20 years, in which case the unit costs will even be higher.

The unit costs analysis shows that a combined domestic-livestock supply is cheaper per m^3 than domestic supply alone. Considering that livestock is the main livelihood for the rural population, where possible combined supplies should be encouraged (In many areas it may be that participation of the community can only be expected if the water supply for the livestock is implemented before the domestic supply).

Table 6.5 Cost of Water Supply Development: Overview of Domestic Water Supply

Supply Area	Source Development	Water Supply Development	Initial Capital Cost (Shs) Source Develop.	Initial Capital Cost (Shs) Supply Develop.	Initial Capital Cost (Shs) Total Cost	Annual O&M Cost (Shs)	Capital Cost/ Capita (Shs)	Annual Cost/ Capita (Shs)	Yield (m^3/d)	Unit Costs (Shs/m^3) Discount rate 5%	10%	15%
Domestic Supply												
Urban Area 5,000 pop. (200 m^3/d)	Boreholes (Volcanic:3) (Basement:5)	Borehole pump, storage, chlorination, distribution	1,406,250	4,362,500	5,768,750	522,687	1,150	105	200	13.3	15.6	18.2
	Spring protection	Storage, chlorination, distribution	625,000	4,175,000	4,800,000	296,000	960	60	200	8.9	11.0	13.1
	Surface Water Intake (weir)	Transmission, treatment, storage, distribution	250,000	6,000,000	6,250,000	762,500	1,250	155	200	17.3	19.8	22.5
	Surface Water Intake (Dam)	Transmission, treatment, storage, distribution	6,250,000	6,000,000	12,250,000	822,500	2,450	165	200	24.2	29.3	34.7
Rural Centre 500 pop. (20 m^3/d)	Borehole	Windmill, storage, limited distribution	312,500	818,750	1,131,250	16,000	2,265	32	20	16.7	22.5	28.6
	Borehole	Pump, storage, limited distribution	312,500	531,250	843,750	74,440	1,690	150	20	20.0	23.3	26.8
	Dug wells (3 no)	Handpumps (3 no)	112,500	225,000	337,500	25,500	675	51	20	7.8	9.1	10.5
	Spring protection	Storage, limited distrib.	25,000	185,000	210,000	28,200	420	56	20	6.0	6.9	7.8
	Surface Water Intake (weir)	Storage, Chlorination, limited distribution	125,000	275,000	400,000	38,000	1,865	76	20	9.3	11.0	12.8
	Individual Roof Catchment	Gutters, storage	-	-	-	-	-	-	-	-	-	-
	Rock Catchment	Storage, limited distrib.	-	-	-	-	-	-	-	-	-	-
Rural Institution 200 pop. (10 m^3/d)	Dug Well	Handpump	37,500	75,000	112,500	500	565	2.5	10	3.3	4.1	5.0
	Borehole	Handpump	312,500	62,500	375,000	3,500	1,875	17.5	10	9.5	12.5	15.8
	Spring protection	Storage, one outlet	25,000	-	25,000	500	125	2.5	10	0.6	0.9	1.1
	Roof Catchment	Gutters, storage	-	-	-	-	-	-	-	-	-	-
	Rock Catchment	Storage	-	-	-	-	-	-	-	-	-	-
Dispersed Rural Pop. 100 pop. (5 m^3/d)	Spring protection	One outlet	25,000	-	25,000	500	250	5	5	1.3	1.7	2.2
	Dug well	Hand pump	37,500	75,000	112,500	500	1,125	5	5	6.6	8.3	10.1
	Borehole	Hand pump	312,500	62,500	375,000	3,500	3,750	35	5	18.9	25.0	31.5

Table 6.6 Cost of Water Supply Development: Overview of Combined Domestic - Livestock and Livestock Water Supply

100 pop. (5 m³/d)	Dug well	Hand pump	37,500	75,000	112,500	500	1,125	5	5	6.6	8.3	10.1
	Borehole	Hand pump	312,500	62,500	375,000	3,500	3,750	35	5	18.9	25.0	31.5

Table 6.6 Cost of Water Supply Development: Overview of Combined Domestic - Livestock and Livestock Water Supply

Supply Area	Source Development	Water Supply Development	Initial Capital Cost (Shs)			Annual O&M Cost (Shs)	Capital Cost/ Capita (Shs)	Annual Cost/ Capita (Shs)	Yield (m^3/d)	Unit Costs (Shs/m^3)		
			Source Develop.	Supply Develop.	Total Cost					Discount rate 5%	10%	15%
Combined Domestic - Livestock Supply												
Rural Centre 500 pop. 1000 L.U (70 m^3/d)	Spring Protection	Storage, limited distrib.	62,500	1,218,750	1,281,250	97,625	2,560	195	70	7.5	9.1	10.7
	Surface Water Intake (Weir)	Storage, chlorination, Limited distribution	150,000	1,000,000	1,150,000	151,500	2,300	303	70	9.3	10.7	12.1
	Borehole	Pump, storage, limited distribution	468,750	1,156,250	1,625,000	151,250	3,250	300	70	11.1	12.9	14.9
Rural Centre 200 pop. 500 L.U (35 m^3/d)	Spring Protection	Storage, cwp, trough	25,000	268,750	293,750	29,875	1,470	150	35	4.0	4.8	5.5
	Dug Wells (5 no)	Handpumps (5 no.)	187,500	375,000	562,500	26,500	2,815	135	35	6.1	7.4	8.7
	Surface Water Intake (Weir)	Storage, chlorination, Limited distribution	150,000	327,500	487,500	74,875	2,440	375	35	8.7	9.9	11.1
	Dug well	Windmill, storage, cwp, trough	37,500	1,137,500	1,175,000	13,500	5,875	65	35	9.6	13.0	16.7
	Borehole	Pump, storage, cwp, trough	312,500	712,500	1,025,000	110,250	5,125	550	35	15.3	17.6	20.1
	Borehole	Windmill, Storage, cwp, trough	312,500	1,112,500	1,425,000	16,000	7,125	80	35	11.6	15.8	20.2
Livestock Supply												
Rural Livestock 500 L.U (25 m^3/d)	Pan (5000 m^3)	-	312,500	-	312,500	27,625	-	-	25[1]	11.3	13.4	15.7
	Borehole	Windmill, storage, trough	312,500	793,750	1,106,250	16,000	-	-	25	13.1	17.6	22.5
Rural Livestock 1000 L.U (50 m^3/d)	Borehole	Windmill, storage, trough	312,500	1,075,000	1,387,500	16,000	-	-	50	7.9	10.8	13.8
	Dam (25,000 m^3)	Fencing, trough, handpump	1,562,500	500,000	2,062,500	127,125	-	-	50	15.5	19.0	22.7

1) Pan contains water on average 6 months/year.

Price level:1988

Note: For detailed estimates of capital costs, see Appendix 5.

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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	**Required rehabilitation:**
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	. . . .

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

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

Required rehabilitation:

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

WATER RESOURCES ASSESSMENT AND PLANNING PROJECT
Ministry of Water Development

WATER SUPPLY INSPECTION FORM **SHEET 2.2**
for groundwater sources

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
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

2.3

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 ....

....

....

....

....

side

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.	Weight (Grams)	ALUM SULPHATE Dosage P.P.M.	Weight Killogram	LIME AND/OR SODA-ASH PRETREATMENT Dosage P.P.M.	Weight Killogram	CONDITIONING Dosage P.P.M.	Weight Killogram	RESIDUAL CHLORINE Morning 8.0 A.M 10 Min.	60 Min.	Afternoon 4.0 P.M. 10 Min.	60 Min.	TURBIDITY P.P.M. Raw Water	Treated Water	P.H. VALUES Raw Water	Treated Water Sample Point	CALCIUM STABILITY (WEEKLY) Raw Water Original PH	Total Alk	Raw Water Final PH	Total Alk	Treated Water Original PH	Total Alk	Treated Water Final PH	Total Alk	ALKALINITY (PPM) (WEEKLY) Raw Water Phen Phth	Total	Treated Water Sample Point Phen Phth	Total
25	0.8	7.500	48	52			8	12	0.6	0.4	0.5	0.3	50	7	6.8	7.0												
26	0.8	7.500	48	52			8	12	0.5	0.3	0.4	0.2	50	7	6.8	7.0									NIL	8	NIL	10
27	0.8	7.500	48	52			8	12	0.4	0.2	0.4	0.2	60	7	6.8	7.0												
28	0.8	7.500	48	52			8	12	0.5	0.3	0.5	0.3	50	7	6.8	7.0	6.8	6			7.0	8						
29	0.8	7.500	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
30	0.8	7.500	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	7.500	48	52			8	12	0.6	0.4	0.5	0.3	40	7	6.8	7.0												
2	0.8	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
3	0.8	7.500	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	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
5	0.8	7.500	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	7.500	48	52			8	12	0.6	0.5	0.5	0.3	40	7	6.8	7.0												
7	0.8	7.500	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	7.500	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
9	0.8	7.500	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
10	0.8	7.500	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	7.500	48	52			8	12	0.4	0.2	0.5	0.3	40	7	6.8	7.0												
12	0.8	7.500	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	7.500	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
14	0.8	7.500	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	7.500	48	52			8	12	0.5	0.3	0.5	0.3	40	7	6.8	7.0												
16	0.8	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
17	0.8	7.500	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	7.500	48	52			8	12	0.5	0.3	0.4	0.2	40	7	6.8	7.0												
19	0.8	7.500	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	7.500	48	52			8	12	0.6	0.3	0.5	0.3	40	7	6.8	7.0												
21	0.8	7.500	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	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
23	0.8	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0												
24	0.8	7.500	48	52			8	12	0.4	0.2	0.4	0.2	40	7	6.8	7.0									NIL	6	NIL	8
TOTAL	Kgr. 22	Gr. 5000	Kgr. 15	Gr. 6000	Kgm	Gr.	Kgr. 3	Gr. 60000																				

WATER SUPPLY OPERATION CHART – SECTION 2

EMBU URBAN WATER SUPPLY — JULY MONTH — 1989 YEAR

PUMPING PLANT

PRIME MOVERS: ENGINES, ELEC. MOTORS, GENERATING SETS, TURBINES,

PUMPS: SURFACE:- INCLUDING HYDRAMS, BOREHOLE:- INCLUDING AIRLIFT COMPRESSORS, AND GRAVITY SUPPLIES.

DAY	No. 1 DRIVING PUMP No/S MAKE:- SIZE:-			No. 2 DRIVING PUMP No/S MAKE:- SIZE:-			No. 3 DRIVING PUMP No/S MAKE:- SIZE:-			No. 4 DRIVING PUMP No/S MAKE:- SIZE:-			No KAPINGAZI RAW WATER/~~PURE WATER~~ (DELETE DUTY NOT APPLICABLE) MAKE:- GRAVITY SIZE:- 150mm						No. NGANDOR ~~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	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 LITRES	HRS RUN	VOLUMETRIC TEST M^3/hr	B/H WATER LEVEL B.S. FT.	AMPS	VOLTS	K.W. HRS OR LUB OIL LITRE	HRS RUN	VOLUMETRIC TEST M^3/hr	B/H WATER LEVEL B.S. FT.	AMPS	VOLTS	K.W. HRS OR LUB OIL LITRE	HRS RUN	VOLUMETRIC TEST M^3/hr	B/H WATER LEVEL B.S. METRE	AMPS	VOLTS	K.W. HRS OR LUB OIL LITRE	HRS RUN	VOLUMETRIC TEST M^3/hr	B/H WATER LEVEL B.S. LITRE	AMPS	VOLTS	K.W. HRS OR LUB OIL LITRE
25													24						24																	
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

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.

DAY	A: FILTERS. (WASH WATER)	B: RESERVOIR.	C: COAG. BASIN.	MASTER METERS — METER NO. IV: INDEX READING. 8.0. A.M.	METER NO. IV: QUANTITY PASSED M³.	METER NO. V: INDEX READING. 8.0. A.M.	METER NO. V: QUANTITY PASSED M³	METER NO. VI: INDEX READING 8.0. A.M.	METER NO. VI: QUANTITY PASSED M³
MASTER METER READING - LAST DAY PRECEEDING MONTH.				483614		116850		433	
25				483635	21	116850	–	433	–
26				483647	12	116850	–	433	–
27				483678	31	116850	–	433	–
28				483689	11	116850	–	433	–
29				483898	209	116850	–	433	–
30				484044	146	116850	–	433	–
31	–			–	–	–	–	–	–
1				484184	140	116850	–	433	–
2				484328	144	116850	–	433	–
3				484407	79	116850	–	433	–
4				484511	104	116850	–	433	–
5				484639	128	116850	–	433	–
6				484773	134	116850	–	433	–
7				484848	75	116850	–	433	–
8				484968	120	116850	–	433	–
9				485101	133	116850	–	433	–
10				485174	73	116850	–	433	–
11				485240	66	116850	–	433	–
12				485284	44	116850	–	433	–
13				485423	139	116850	–	433	–
14				485578	155	116850	–	433	–
15				485733	155	116850	–	433	–
16				485880	147	116850	–	433	–
17				486037	157	116850	–	433	–
18				486190	153	116850	–	433	–
19				486338	148	116850	–	433	–
20				486480	142	116850	–	433	–
21				486615	135	116850	–	433	–
22				486750	135	116850	–	433	–
23				486889	139	116850	–	433	–
24				487020	131	117538	688	433	–
TOTAL					3406		6881		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 METERED 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.	RATE.	TOTAL.	
	kg.	Per.kg.	Shgs.	Cts.
PURCHASE OF WATER .... m³ @.....				
CHEMICALS: Alum.	1560.000	4.75	7320	00
Soda Ash.	360.000	2.12	763	20
Hydrated Lime				
Chlorine Gas or Trop. Chloride of Lime.	225.000	10.25	2,306	25
other chemicals.				
	Litre	Per 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 FOR [illegible]	" " " "		3560	00
TRANSPORT: Funding. P.O.L. (Lump Sum.)	" " " "		900	00
[illegible]	" " " "		[illegible]	[illegible]
OVERHEADS: Provincial Engineer ....%. (See Notes)	" " " "			
Water Supt.........%. (See Notes)	" " " "			

BALANCE OF STORES.		
BALANCE B/F.	QUANTITY RECEIVED.	BALANCE C/F.
kg	kg.	kg.
116.000	1500.000	56.000
—	400.000	40.000
15.000	250.000	40.000
Litre	Litre	Litre

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

NAME.	DUTY.	Shgs.	Cts.
1 ZAKARIA M'REMBURIA	CHATTANDANTS	1190	00
2. CHARLES KABIRU	"	970	00
3 MOSES K. MUGANE	"	940	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 KANGICHO	"	1120	00
10. SAMSON M'RACHI	PIPE FITTER	1570	00
Divisional costs: (see Notes.)			
TOTAL COSTS CHARGED TO O. & M. S. E.		36,744	65
METERS - COST OF REPAIRS CHARGED TO METER REPAIR S. E. FOR MONTH.			

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 MURIMIA	II		1740	00
EPHANIUS K. GITHINJI	II	X/D	1520	00
PETER K. NJUGUNA	I		1520	00
STEPHEN MATHEKA	II		1340	00
MERCY K. MWARANIA	II		1340	00

EXPENDITURE & REVENUE	Shgs.	Cts.	£.
TOTAL EXPENDITURE, EX-LEDGER: (Incl. Liabilities) SINCE 1st JULY.	[illegible]	[illegible]	[illegible]
REVENUE EARNED DURING MONTH:	[illegible]	90	5022.40
REVENUE EARNED SINCE 1st JULY:	[illegible]	[illegible]	[illegible]

OPERATOR - STATE ANY PLANT MAINTENANCE REQUIRED

for W.S.O. i/c

SIGN.

REMARKS. S.I.W.S.

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

SIGN

Provincial Water Engineer/Officer Remarks

for PROVINCIAL WATER ENGINEER
P.O. Box [illegible]
15/9/89

SIGN.

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 1/12 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.)

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

APPENDIX 2

INVENTORY OF INFRASTRUCTURE (BY MPND)

APPENDIX 2

INVENTORY OF INFRASTRUCTURE

(by Ministry of Planning and National Development)

Water Facilities:

1. Responsibility and Capacity
2. Users, Utilization Rate and Condition
3. Supply and Costs

INVENTORY OF INFRASTRUCTURE: FORMAT NO.5A
DISTRICT: SAMBURU
Water Facilities: Responsibility and Capacity

Date: 29/03/88
Page: 1

Division	Location/Sublocation	Name of Facility	Local Partcp. Y/N	Establishing Agency	Maintenance Agency	Source L/R/D/B/E	Size of area served Km2	Storage Capacity M3	Delivery Tech-nology	Distrib. Capacity M3/day	Quality H/M/L	Number of days w/o water p/year
BARAGOI	ELBARTA/NGILAI/	BARAGOI WATER SUPPLY	N	MOWD	MOWD	B	3.00	45.00	P	24.00	M	32
BARAGOI	MARTI/LOKORKOR/	MARTI WATER SUPPLY	N	RDF/MOWD	MOWD	B	2.00	45.00	P	24.00	M	189
BARAGOI	NOOTO/LESERKAN/	LESERKAN WATER PROJECT	N	RDF	MOWD/RDF	B	2.60	0.00	G	0.00	M	218
BARAGOI	NYIRO/S.HORR/	SOUTH HORR WATER PROJECT	N	SIDA/MOWD	SIDA/MOWD	R	0.00	0.00	G	0.00	M	0
BARAGOI	NYIRO/TUUM/	TUUM WATER PROJECT	N	RDF	MOWD	B	2.00	22.50	G	16.00	M	560
LORROKI	BAAWA/LKILORIT/	BAAWA WATER SUPPLY	N	RDF/MOWD	MOWD	B	3.00	22.50	P	16.80	M	280
LORROKI	KISIMA/NAUNERI/	KISIMA WATER PROJECT	N	MOWD	MOWD	D	2.50	50.00	CW	20.00	L	0
LORROKI	MARALAL URBAN/	MARALAL WATER SUPPLY	N	MOWD	MOWD	D	50.00	850.00	P	600.00	H	0
LORROKI	PORO/SIAMBU/	PORO WATER PROJECT	N	NGO/MOWD	MOWD	D	2.10	45.00	CW	14.20	L	92
LORROKI	FORO/SIRATAOIRO/	SIRATA OIROBI WATER SUPPLY	N	MOWD	MOWD	B	2.30	45.00	P	15.20	M	166
LORROKI	SUGUTA/LOLMOG/	SUGUTA MARMAR WATER SUPPLY	N	LA/MOWD	LA/MOWD	B	4.20	45.00	P	33.60	M	29
WAMBA	LODUNGOKWE/SESI/	LODUNGOKWE	N	MOWD	MOWD	B	2.40	45.00	P	20.00	M	70
WAMBA	WAASA/LERATA/	LOIJOK WATER SUPPLY	N	MOWD	MOWD	B	1.00	45.00	CW	24.00	M	660
WAMBA	WAASA/NGUTUK/	ARCHERS POST	N	MOWD	MOWD	R	6.00	50.00	P	60.00	H	0
WAMBA	WAASA/NGUTUK/	WEST GATE	N	MOWD	MOWD	R	0.00	0.00	P	0.00	L	0
WAMBA	WAMBA/SEPASHE/	LERATA WATER SUPPLY	N	MOWD	MOWD	B	2.20	45.00	CW	14.60	M	140
WAMBA	WAMBA/SEPASHE/	WAMBA WATER SUPPLY	N	MOWD	MOWD	B	0.00	0.00	P	116.00	M	46

INVENTORY OF INFRASTRUCTURE: FORMAT NO.5B
DISTRICT: SAMBURU
Water Facilities: Users, Utilization Rate and Condition

Date: 29/03/88
Page: 1

Name of Facility	Type of Use	Utilization: House-Holds	Utilization: Live/stock	Utilization: Hectares	Average Walking Distance	Util. Estm. H/M/L	Utilization Remarks	Cond. G/F/P	Condition Remarks	Proposals for Addressing Problems
BARAGOI WATER SUPPLY	H/L/	260	0	360	2.00	M	INADEQUATE WATER	F	DRAW PIPES & WELL RODS CORRODED	REHABILILATE EXISTING SYSTEM & DRILL ANOTHER BOREHOLE
MARTI WATER SUPPLY	H/L/	80	0	400	44.00	H	FACILITY IS OVERUTILIZED	P	DRAW PIPES & WELL RODS CORRODED.TANK LEA	COMPLETE REHABILITATION PROGRAM ON THE SYSTEM NEEDED
LESERKAN WATER PROJECT	H/L/	30	0	100	2.00	L	CULTURAL PATTERNS AFFECT UTILIZATION	P	PIPES & STORAGE TANK NOT CONSTUCTED	FACILITY INCOMPLETE
SOUTH HORR WATER PROJECT	L/ /	0	0	0	0.00	M	FACILITY UNDER CONSTRUCTION	F	PROVIDE MORE COMMUNAL WATER POINTS	FACILITY UNDER CONSTRUCTION
TUUM WATER PROJECT	H/ /	40	0	80	3.50	L	WATER SHORTAGE DUE TO POOR MAINTENANCE	P	PIPES BROKEN. REHABILATATION IN PROGRESS	COMPLETE REHABILITION PRORGRAM ON THIS SYSTEM NEEDED
BAAWA WATER SUPPLY	L/ /	35	0	120	1.50	L	CULTURAL PATTERNS AFFECT UTILIZATION	F	THERE ARE NO C W P	C W P TO BE PROVIDED
KISIMA WATER PROJECT	H/L/	200	0	300	1.00	L	FACILITY UNDER CONSTRUCTION	P	EXTEND LINE TO CATHOLIC MISSION	FACILITY TO BE COMPLETED
MARALAL WATER SUPPLY	H/L/	400	0	5,000	0.50	H	LOCAL WATER USE CONSTRAINS UTILIZATION	G	THERE IS ONLY ONE KIOSK	BUID MORE WATER KIOSKS
PORO WATER PROJECT	L/ /	25	0	250	1.50	L	FACILITY IS INCOMPLETE	P	WATER NOT TREATED	COMPOSITE FILTER TO BE CONSTRUCTED
SIRATA OIROBI WATER SUPPLY	H/ /	120	0	450	2.50	M	CULTURAL PATTERNS AFFECT UTILIZATION	F	BOREHOLE NEED REHABILITATION	MORE I.C & CATTLE TROUGHS TO BE PROVIDED
SUGUTA MARMAR WATER SUPPLY	L/ /	100	0	300	1.20	L	FACILITY IS INCOMPLETE	P	MORE I.C TO BE PROVIDED	I.C. AND C.W.P. TO BE CONSTRUCTED
LODUNGOKWE	H/ /	120	0	80	3.00	L	QUALITY OF THE IS SALINE	P	PIPES CORRODED DUE TO SALINITY OF WATER	ANOTHER BOREHOLE SHOULD BE SUNK
LOIJOK WATER SUPPLY	H/L/	60	0	200	3.00	L	CULTURAL PATTERN AFFECT UTILIZATION	P	PUMBING PLANT DAMAGED	REHABILITATION WORKS TO BE UNDERTAKEN
ARCHERS POST	H/ /	100	0	100	1.50	M	FAIR	G	NO PROBLEM	EXTENSION LINE TO BE PROVIDED
WEST GATE	L/ /	0	0	0	0.00	M	FACILITY UNDER CONSTRUCTION		FACILITY UNDER CONSTRUCTION	FACILITY TO BE CONSTRUCTED

WEST GATE	L/ /	0	0	0	0.00	M	FACILITY UNDER CONSTRUCTION		FACILITY UNDER CONSTRUCTION	FACILITY TO BE CONSTRUCTED

INVENTORY OF INFRASTRUCTURE: FORMAT NO.5B
DISTRICT: SAMBURU
Water Facilities: Users, Utilization Rate and Condition

Page: 2

Name of Facility	Type of Use	Utilization: House-Holds	Utilization: Live/stock	Utilization: Hectares	Average Walking Distance	Util. Estm. H/M/L	Utilization Remarks	Cond. G/F/H	Condition Remarks	Proposals for Addressing Problems
LERATA WATER SUPPLY	H/L/	80	0	300	3.50	L	WATER SHORTAGE DUE TO POOR MAINTENANCE	P	WINDMILL DEPENDS ON THE SPEED OF WIND	REPLACE PUMPING EQUIPMENT WITH A SOLAR O R DIESEL POWE
WAMBA WATER SUPPLY	H/L/	300	0	600	2.50	H	WATER SHORTAGE DUE TO POOR MAINTENANCE	P	STORAGE TANK DOES NOT EXIST	STORAGE TANK & REHABILITATION OF LINES T O BE STARTED

INVENTORY OF INFRASTRUCTURE: FORMAT NO.5C
DISTRICT: SAMBURU
Water Facilities: Supply and Costs

Date: 29/03/88
Page: 1

Name of Facility	Construction Cost	Rates F/M	Water M3 Produced	Water M3 Sold	Revenue Billed KShs.	Revenue Collected KShs.	Operation and Maintenance KShs.
BARAGOI WATER SUPPLY	320,000.00	M	12,600.00	8,000.00	16,000.00	14,700.00	17,000.00
MARTI WATER SUPPLY	220,000.00	F	0.00	0.00	0.00	0.00	18,700.00
LESERKAN WATER PROJECT	0.00	M	0.00	0.00	0.00	0.00	0.00
SOUTH HORR WATER PROJECT	0.00	M	0.00	0.00	0.00	0.00	0.00
TUUM WATER PROJECT	0.00	M	0.00	0.00	0.00	0.00	0.00
BAAWA WATER SUPPLY	550,000.00	F	7,160.00	0.00	0.00	0.00	18,200.00
KISIMA WATER PROJECT	1,000,000.00	M	0.00	0.00	0.00	0.00	0.00
MARALAL WATER SUPPLY	33,000,000.00	M	221,612.00	192,000.00	48,000.00	46,750.00	120,000.00
PORO WATER PROJECT	450,000.00	F	9,200.00	0.00	0.00	0.00	16,000.00
SIRATA OIROBI WATER SUPPLY	200,000.00	M	11,000.00	0.00	0.00	0.00	38,000.00
SUSUTA MARMAR WATER SUPPLY	400,000.00	F	8,064.00	0.00	0.00	0.00	17,000.00
LODUNSOKWE	250,000.00	M	8,700.00	0.00	0.00	0.00	20,500.00
LOIJOK WATER SUPPLY	350,200.00	F	9,900.00	0.00	0.00	0.00	26,000.00
ARCHERS POST	3,000,000.00	M	12,600.00	0.00	0.00	0.00	72,000.00
WEST GATE	0.00		0.00	0.00	0.00	0.00	0.00

INVENTORY OF INFRASTRUCTURE: FORMAT NO.5C
DISTRICT: SAMBURU
Water Facilities: Supply and Costs

Date: 29/03/88
Page: 2

Name of Facility	Construction Cost	Rates F/M	Water M3 Produced	Water M3 Sold	Revenue Billed KShs.	Revenue Collected KShs.	Operation and Maintenance KShs.
LERATA WATER SUPPLY	290,000.00	F	18,200.00	0.00	0.00	0.00	10,700.00
WAMBA WATER SUPPLY	300,000.00	F	9,160.00	0.00	0.00	0.00	70,000.00

APPENDIX 3

INVENTORY OF EXISTING WATER SUPPLIES IN SAMBURU DISTRICT

APPENDIX 3

INVENTORY OF EXISTING WATER SUPPLIES IN SAMBURU DISTRICT

Appendix 3. INVENTORY OF EXISTING WATER SUPPLIES IN SAMBURU DISTRICT

3.1 Introduction

This Appendix describes the existing water supplies in Samburu District by Division. The Appendix describes the water supplies in Baragoi Division, Lorroki Division and Wamba Division in that order. 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

The water supplies are summarized in tables 4.11 and 4.12 at the end of chapter 4. Table 4.11 contains technical data and Table 4.12 contains operational data.

3.2 Baragoi Division

3.2.1 Baragoi Water Supply

Technical Description: This is a water supply which serves Baragoi Rural Centre and its environs. The source of water is a borehole whose yield is 0.9 m^3/hr. The borehole is located about 2 km from supply area. The total supply storage is 45 m^3.

Potential and Actually Served Beneficiaries: Currently the supply serves Baragoi Rural centre. The 1979 census gives the population of Baragoi centre as 2,592. The population projection for 1988 is 3365. The population that is served by the water supply is estimated as 3000. There are 17 individual connections, one communal water point and there are 63 institutions served from the system. The supply covers an area of about 8 km^2.

Livestock Use: Due to the nomadic lifestyle of the people in the District, estimation of livestock actually using the supply cannot be very accurate but an average figure of 130 is estimated to be using the existing supply.

Functional Analysis: The supply is reliable most times of the year. As long as there is a regular supply of diesel operational reliability is good. The major cause of malfunction in this system is that sometimes the fuel supply is unreliable. Minor pipe breakages also causes the supply to malfunction. Seventy five percent of the meters are not functional. The water quality is good in terms of colour and turbidity. The amount of TDS is less than the maximum allowed by WHO.

Financial Analysis: The project was constructed at a cost of Ksh. 320,000.00 in 1973.
The average revenue collected per month is about Ksh. 600 - 800. The diesel consumption used for pumping is about 33.6 litres per day. The cost of diesel at Maralal is about Ksh.7 per litre. The cost then is Ksh. 7,056 per month. The staff and labour costs amount to Ksh. 3095 per month. This gives Ksh. 10,151 as total operating cost per month, which is much higher than the revenue collected per month (data collected at the supply, 1988). This project is handled by the Ministry of Water Development and hence all operation costs are met by the Ministry of Water Development.

Institutional Analysis: As in all the water supplies operated by the Ministry of Water Development, there are two categories of staff who are involved in operation and maintenance of water supplies. There are members of staff who are resident at the works site, and the District Headquarters staff, who once a month travel to the water supplies to check the general performance and to supply fuel. In this case, a Divisional Water Officer is stationed at Baragoi Centre and he is overall in charge of the water supply. This one has qualified from the Ministry's Training Institute. There are two pump attendants and one watchman whose education levels are primary school and not educated respectively.

3.2.2 Baragoi Secondary School Water Supply

Technical Description: This water supply serves Baragoi Secondary School, which is a Boarding Institution located about 2 km from Baragoi Rural Centre. Water is pumped from a borehole which is situated about 1 km from the school, using a Kijito windmill. The borehole water whose tested yield is 1.73 m^3/hr is stored in a 12 m^3 elevated steel tank and then gravitates to consumers. The total length of the distribution mains is about 0.5 km, mainly to staff houses where there are 5 individual unmetered connections. There are two other unmetered connections which serve the kitchen and wash rooms.

Potential and Actually Served Beneficiaries: This water supply is an institutional water supply and hence serves only the students, teachers and other members of staff who are resident in the school compound. The total population served is 400.

Livestock Use: This is an institutional water supply and there is no livestock kept in the school compound.

Functional Analysis: The tested yield of the Borehole is as indicated earlier 1.73 m^3/hr. The conveyance reliability is good because as long as there is wind, the windmill will always function. The major constraint of this water supply is that the water is very hard and the consumers use detergents for bathing and washing. The water was also said to be saline, but this is not confirmed from samples taken some years ago. The valves and pipes in the distribution network get blocked. After some consultation with the headmaster, he stated that the water quantity is not always enough.

Financial Analysis: The existing borehole was drilled by the Ministry of Water Development in 1977 and the total amount spent in equipping the borehole was Ksh. 85,000. The distribution pipelines which were constructed in 1981 cost Ksh. 77,000. The storage cost of Ksh. 115,000 included the elevated storage tank (Ksh. 80,000) and the 8 m^3 roof catchment storage (Ksh. 35,000).

Operation & Maintenance: The greasing expenditure is minimal because this is done once in two months. Amount used is about 2 kg of grease per year. 3 washers are also changed once after every 6 months and hence the monthly expenditure is negligible. The total revenue collected from the system is Ksh. 75 per month and the total operating cost is about 2,150 Ksh per month.

Institutional Analysis: The school employs one artisan who has a Government Trade Test Grade III for the maintenance of water supply at a salary of Ksh. 2,000 per month.
The school is wholly responsible for operation and maintenance of the water supply.

3.2.3 Lesirikan Water Supply

Technical Description: This water supply is located in Lesirikan sub-location of Ndoto location. The source of the water is a borehole whose yield is estimated as 5.5 m^3/hr. It uses solar energy as the source of power. The borehole is only 600 m from the storage tank (50 m^3), which is under construction. The water is not treated.

Potential and Actually Served Beneficiaries: The supply covers an area of about 2.68 km^2 and serves about 38 households through 1 communal water point situated about 600 m from the borehole intake.

Livestock use: Livestock in this area which utilise the facility are estimated as 50 LU.

Functional Analysis: The supply uses solar energy for pumping and as long as there is sun, the pump always works. Currently the supply is not fully functional because construction of the tank is going on, but a communal water point is giving service meanwhile.

Financial Analysis: Information available for the construction cost of this water supply indicate that the borehole was drilled at a cost of Ksh. 170,000. But the solar equipment was donated freely. Since pumping is undertaken using solar energy operation, maintenance cost are negligible for this water supply. No revenue is collected here.

Institutional Analysis: There is currently no person who is engaged full time to work at the supply. If any sort of advice is required, some personnel travel from Maralal. The supply is under the Ministry of Water Development.

3.2.4 Marti Water Supply

Technical Description: This water supply is located in Kalele sub-location of Marti Location. The source of water is a borehole whose yield is 0.68 m^3/h. Pumping is done 8 hours per day. The borehole is located about 500 m from Marti centre. From the borehole the water is pumped to a 24 m^3 tank in a pipe about 25 m long. From the tank the water is conveyed to a cattle trough. Just close to the storage tank, there is a communal water point. Pump and diesel engine are in a pumphouse.

Potential and Actually Served Beneficiaries: Currently the supply serves a population of about 500 including 13 commercial plots at Marti centre from the communal water point. The area covered is about 11 km^2

Livestock Use: The number of livestock actually using the supply can not be stated accurately but we estimate that currently about 1200 in the supply area use the facility.

Functional Analysis: As in most water supplies in this area which utilise diesel for pumping, this water supply is reliable as far as conveyance to the cattle trough and communal water point is concerned. Sometimes there is shortage of diesel and the engine has to be serviced now and then, therefore there are many days without water at this supply.

Financial Analysis: The supply was constructed at a cost of Ksh. 220,000. There is no revenue collected from this supply since there are no kiosks and no metered connections. The diesel consumption per month amounts to Ksh.2700 if diesel is supplied regularly. Staff and labour costs amount to Ksh. 2,330. The owner of this supply is Ministry of Water Development and hence the Ministry is the one which finances all the operation and maintenance.

Institutional Analysis: There are two full time pump attendants at the pumping station. One is educated up to standard seven and the other one has not attended any formal schooling. Personnel from the head office make occasional visits.

3.2.5 South Horr Catholic Mission

Technical Description: This water supply is an institutional water supply belonging to the Catholic Mission of the Diocese of Marsabit. It is located in South Horr sub-location of Nyiro location. The source of the supply is a stream. The water gravitates to the mission and is stored in storage tanks. The surrounding communities are served through two communal water points at the mission compound. All other houses in the mission compound are served via individual connections.

Potential and Actually Served Beneficiaries: As stated above, the water supply serves the mission and surrounding communities through two communal water points. The actual population served could not be obtained.

Livestock Use: This is an institutional water supply and so no livestock utilise the supply.

Functional Analysis: The South Horr stream data taken between 1973 and 1988 show a maximum discharge of 3292 m^3/day and a minimum of 346 m^3/day. Comprehensive chemical analysis has been done and the raw water quality is good. This supply is very reliable as far as operational reliability is concerned because it is a gravity supply.

Financial Analysis: The operation and maintenance cost per month is negligible considering that no pumping is required and no treatment is undertaken. There are no personnel employed specifically to operate the scheme. If a breakdown occurs the workers from the mission are dispatched to repair the breakage.

Institutional Analysis: Since this supply is just operated by the mission and no serious operation is undertaken, there is no institutional set up for operation and maintenance of the supply.

3.2.6 South Horr Water Supply

Technical Description: This water supply is under construction by a joint venture involving Ministry of Water Development and self-help. The Ministry of Water Development is supplying technical know-how, materials and construction supervision. The beneficiaries are supplying unskilled labour.

The source of supply is the South-Horr stream, where a weir 1.5 m. wide has been constructed. The raw water gravitates through a raw water main whose length is 1.35 km to a plain sedimentation chamber whose dimensions are 0.9 x 0.9 x 1.8 m. From here the water gravitates to a clear water storage tank whose capacity is 100 m^3. The water then gravitates to consumers through 11.5 km of distribution mains.

Potential and Actually Served Beneficiaries: The population to be served initially is expected to be 5,410, rising to 7,200 in 1997 and ultimately to 9,583 in the year 2,007. The proposed consumer supply points is expected to be 20 individual connection, 100 metered connections, 10 non-metered connections and 10 communal water points. The total supply area is 75 km^2.

The population served by individual connections is expected to be 50 initially, rising to 199 in 1997 and ultimately 443 in 2007. Those benefiting from communal water points are expected to be 4,483 initially, rising to 5,967 in 1997 and ultimately to 7,941 in 2007. Two institutions will be served. A nursery school will have an initial population of 97 consumers rising to 129 ultimately in 2007. A primary school will have an initial population of 370 consumers rising to 492 ultimately in 2007.

Livestock Use: It is expected that ultimately 4,400 livestock units will benefit from the supply through construction of 3 cattle troughs in the supply area.

Functional Analysis: The South Horr stream data taken between 1973 and 1988 show a maximum discharge of 3,292 m^3/day and a minimum of 346 m^3/day. The design discharge for the scheme is 746 m^3/day. It can be seen that during the very dry seasons when the river flow is minimum there is a shortfall of 400 m^3/day. During rainy seasons the water carries a lot of silt and suspended materials this will obviously affect the quality of water.

The conveyance system is expected to be reliable because this is a gravity scheme and so the frequent fuel shortages and engine breakdowns that limit the functional reliably of other pumped schemes in the district will not be applicable here.

Financial Analysis: The estimated construction cost when the scheme is commissioned is expected to be Ksh. 1,340,000.

The initial operation cost per year is expected to be Ksh. 120,000 rising to Ksh. 132,000 in future and ultimately Ksh. 145,000. The maintenance cost is expected to be initially Ksh. 11,310 rising to Ksh. 45,720 in future and ultimately to Ksh. 118,590.

The total operation and maintenance cost is then expected to be Ksh. 131,310, rising to Ksh. 177,320 in future and ultimately Ksh. 263,590. The tariff rate is expected to be the current system used by the Ministry of Water Development at a rate of Ksh. 2/m^3 for all metered connections.

Institutional Analysis: It is expected that when the supply is functional, a full time meter reader will be stationed here. He will be reporting to the Divisional Water Officer who is based in Baragoi Centre. The Divisional Water Officer reports to the District water office headquarters in Maralal.

Since this will require filling the operation and maintenance charts it is expected that the person stationed here will have an education background of up to form four and have some technical training preferably in possession of Government Trade test Grade III.

3.2.7 Tuum Water Supply

Technical Description: This water supply is located in Tuum sub-location of Nyiro location. The source is a mountain stream which does not dry up even in very dry seasons. Discharges taken for the Tuum spring in late 1987 and early 1988 show a minimum discharge of 43 m^3/day and a maximum of 432 m^3/day. The water is abstracted from a stream about 7 km upstream into a storage tank whose capacity is 45 m^3. The discharge is about 16 m^3/day. From this storage tank, the water gravities to consumers at distance of about 5 km. There are 12 non-metered individual connections. There is no treatment undertaken.

Potential and Actually Served Beneficiaries: Currently the supply serves a population of about 250 and 12 institutions through unmetered individual connections.

Livestock Use: The livestock served from this supply could not be established accurately but an estimate of about 50 livestock units is approximated, the majority being donkeys used for transportation.

Functional Analysis: The estimated water production to consumers for this supply is about 16.0 m^3/day. The water is not treated so its bacteriological quality is not reliable. Since the source is a mountain stream, the water is not saline. It is slightly turbid. Lack of treatment of water may be considered as a draw back. However, the water is of good quality. The operation reliability of this supply is very good, because the whole system is gravity. Apart from leaves from forest trees blocking the intake pipe occasionally, and which are removed manually, the system is trouble free as far as conveyance of water to consumers is concerned.

Financial Analysis: This project was commissioned in 1988 and the value of historical investment cost is estimated at Ksh. 3,000,000. The operation and maintenance costs per month are negligible because no personnel is employed to run the system on full time basis. No treatment is undertaken so the cost of chemicals is zero. The occasional breakage of pipe which happens very irregularly can be taken as negligible cost per month. No revenue is collected from consumers.

Institutional Analysis: There is no staff resident here to operate and run the scheme. If any maintenance or operation problem arises, then personnel from Division Headquarters in Baragoi are dispatched to rectify the situation.

3.3 Lorroki Division

3.3.1 Amaiya (Agriculture) Water Supply

Technical Description: This water supply is located in Amaiya sub-location, Sukuta Marmar Location. The water supply was initially meant for irrigation, but it is now used for domestic consumption. The intake is Amaiya stream. A concrete weir was erected across the stream about 6 km downstream of the source. Water then gravitates to consumers at a distance of about 5 km from the intake. No treatment is undertaken here and the consumers are served through 2 communal water points.

Potential and Actually Served Beneficiaries: Currently about 175 people benefit from this supply. Two institutions are served from this supply.

Livestock Use: Any livestock present in the area use the water from Amaiya stream.

Functional Analysis: From visual observation, it was seen that the water was slightly turbid, and small particles of leaves were present. It was also found that the scheme is very reliable in terms of conveyance to consumers, because it is a gravity system.
The system works very reliably and there are no causes of malfunction. Amaiya stream discharge measurements between late 1987 and mid 1988 indicate a minimum discharge of 933 m^3/day and maximum of 6273 m^3/day.

Financial Analysis: Direct operational costs are negligible per month as the water is not treated and it gravitates to consumers. No revenue is collected from consumers.

Institutional Analysis: This water supply was commissioned by Ministry of Agriculture in 1978 and therefore they are the owners of the scheme. No institutional set up is in existence.

3.3.2 Amaiya (Inland Church) Water Supply

Technical Description: This water supply is administratively in Baringo District but due to the close proximity to Samburu, it was included in Samburu inventory. The intake is also in Amaiya stream where a small concrete dam was constructed in 1978. The water gravitates to an hydram which pumps the water to the mission, a distance of about 6 km. No treatment is undertaken and the supply just serves the mission through unmetered individual connections to a Dispensary and the Residential House in the mission compound.

Potential and Actually Served Beneficiaries: As explained briefly above, the supply serves the mission and the Dispensary whose resident population is about 10.

Livestock Use: No livestock is served from this supply as it is an institutional supply.

Functional Analysis: The water quality is also from visual observation slightly turbid. From the information obtained from site the operational reliability of the scheme was good. No serious cases of malfunction were reported in the system as it was working very reliably.

Financial Analysis: Operational costs are also minimal due to the nature of the system.

Institutional Analysis: The African Inland Church is solely responsible for operation and maintenance of the supply. The system requires very little maintenance.

3.3.3 Bauwa Water Supply

Technical Information: The supply is located in Lkilorit sub-location of Poro location. The source of the supply is a borehole which uses diesel for pumping. The tested yield of the borehole is 4 m^3/hr and the distance to storage is only 50 m from borehole. The storage capacity is 22.5 m^3. No treatment is undertaken here and consumers get their water from individual un-metered connections. The total distribution network is 4 km.

Potential and Actually Served Beneficiaries: It is estimated that about 500 people use this supply, all served from un-metered individual connections. The scheme covers an area of about 16 km^2.

Livestock Use: The number of livestock currently using the supply could not be accurately determined.

Functional Analysis: According to information obtained from Ministry of Planning the distribution capacity of the scheme is 0.7 m^3/hr. The water is not treated but from visual inspection, the water is of good quality. The system operates very reliably and there are no serious cases of malfunction.

Financial Analysis: The project was constructed in 1984 at a cost of Ksh. 550,000. The current operation and maintenance cost amount to Ksh. 18,200 per year. No revenue is collected from consumers. No treatment is undertaken here and hence no chemical related costs are incurred.

Institutional Analysis: The Ministry of Water Development is responsible for operation and maintenance of scheme. Normally the District head office staff make regular visits to site to check the working conditions of the scheme.

3.3.4 Kirimun Water Supply

Technical Description: This water supply is located in Kirimun sub-location of Lodokojek location. The source is a spring which is located at the boundary between Laikipia and Samburu District. A concrete canal leads the spring water to a pump sump where using a diesel engine, water is pumped to the trading centre and another pipe takes water to a high level tank and from here of gravitates to Livestock Marketing Division consumers. The total length of pipe to the storage tank is about 1 km. The storage is about 200 m^3 capacity. The water is not treated and it is fed to consumers using 6 non-metered individual connections and 2 cattle dips. The pumping equipment is housed in a pump house.

Potential and Actually Served Beneficiaries: Currently it is estimated that the total population served is about 400 including 6 institutions all served through individual un metered connections.

Livestock Use: The number of livestock actually using the supply could not be accurately determined, but a figure of 1300 livestock units is estimated.

Functional Analysis: The amount of water produced from the spring was estimated to be about 20 m^3/hour. The spring is perennial. The water quality from visual observation looked good, but protection *is required against surface pollution.*
The system works very reliably in terms of the conveyance to consumers but in terms of bacteriological quality of water this could not be ascertained because it looked as if the system is prone to surface pollution especially during the rainy seasons.

Financial Analysis: The historical investment cost was estimated as Ksh. 1.6 m as for 1986 prices. Two pump operators are employed at the pumping station and their total remuneration is Ksh. 4000 per month. Diesel consumption is about Ksh. 700 per month. No revenue is collected from the consumers and operation and maintenance is undertaken by Ministry of Livestock Development. The total operation and maintenance cost per month then amount to about Ksh. 5000.

Institutional Analysis: Ministry of Livestock Development is wholly responsible for operation and maintenance of the supply. The operators who are resident at the pumping station report to the Livestock Marketing Office who is stationed at a distance of about 3 km in Laikipia District. The personnel employed to run the system have not had any formal schooling.

3.3.5 Kisima Water Supply

Technical Description: This supply is currently under construction and it is expected to supply the Kisima Centre in Mbaringon sub-location of Kisima location. The source is Ngare-Narok Dam which is located in Nauneri sub-location, a distance of about 4.8 km. The raw water undergoes full treatment before being conveyed to a 100 m^3 storage tank and then distributed to consumers through 60 non-metered connections and 2 communal water points. The distribution system which also serves 7 institutions is 6.6 km long. The following facilities are located at treatment works site; workshop, double grade 9 staff housing, laboratory and office.

Potential and Actually Served Beneficiaries: This supply will be serving about 60 shops in Kisima centre plus 7 institutions and population to be served in future will be 850.

Livestock Use: The livestock use in supply could not be established, but it is believed that any livestock in this area would utilize the Lake Kisima which is nearby or Ngare -Narok Dam also nearby.

Functional Analysis: The raw water pipeline discharge is 0.5 m^3/hr and the treated water pipeline discharge is 0.4 m^3/hr. The water quality is expected to be good, because full treatment will be undertaken here.

Financial Analysis: The project is not complete yet so the investment costs can not be ascertained. The cost of chemicals can not be ascertained yet, but the value of labour cost would amount to about Ksh. 7000 per month.

Institutional Analysis: This is a Ministry of Water Development Project and so when the project is fully operational the Ministry will deploy its personnel to manage the system. These personnel will be reporting to District Water Office.

3.3.6 Lodokojek Water Supply

Technical Description: This water supply belongs to the Catholic Diocese of Marsabit. The source of water is a borehole No. C7191. It is expected that a 50 mm from the borehole to a new tank will be laid. From the tank, 30 mm pipeline will convey the water to a rest house and another to a new building which will be erected.

Potential and actually served Beneficiaries: This is a new mission post water supply and it is currently expected to serve about 200 people.

Livestock Use: No livestock is expected to use this supply.

Functional Analysis: The project is under construction and is expected to be reliable in terms of conveyance to consumers. The water analysis from the borehole indicate that the fluoride content is very high.
Financial Analysis: Quotation from bore-hole contractor gave a figure of Ksh. 128,750 for equipping of the borehole. The borehole drilling is expected to cost about Ksh. 195,000.

Institutional Analysis: The supply will be operated by the diocese, when fully operational. The water matters in the diocese are handled by the Diocese Water Project.

3.3.7 Longewan Water Supply

Technical Description: The project is located in Longewan sub-location of Suguta Marmar Location.

The source of the supply is a borehole which was drilled in 1952 and whose tested yield was 2.50 m^3/hour. The borehole is housed in a pump house, and using a Lister engine, which uses diesel water is pumped to a 50 m^3 tank through a 75 mm pipe, about 150 m long. The water then gravitates to 2 cattle troughs, 20 m and 220 m away respectively. At the storage tank the outlet from the pumping main serves as a communal water point.

Potential and Actually Served Beneficiaries: The population served here is estimated at about 500. Including a school, and 2 shops.

Livestock Use: It is estimated that about 2000 livestock units use the supply every day.

Functional Analysis: The water quality as per visual observation was not turbid. The TDS is 546 mg/l. No bacteriological examination was done, but it was noted that there was diesel ingress into the borehole. The major problem with this supply was the unreliability of diesel. They rely on any donor to supply them with diesel. The engine belt also breaks down.

Financial Analysis: The historical investment cost could not be obtained due to the age of the supply. The diesel availability is so irregular that the fuel running cost per month can not be ascertained. When some diesel is donated, any one of the residents of the area volunteers to switch on the engine. So the labour cost is also negligible. But considering 1986 prices the investment cost would amount to Ksh. 424,000.

Institutional Analysis: The supply is operated by the beneficiaries themselves on self help basis. Talks have been going on between the representative of the beneficiaries and the District Water Office on the possibility of Ministry of Water Development taking over the running of the supply, but so far nothing has taken place.

3.3.8 Maralal Water Supply

Technical Description: This water supply is a major supply which serves Maralal Township. The supply area is in Township and Ledero sub-location, of Maralal location. The source is Nundoto dam. Water is pumped from the dam using electrical driven pumps over a distance of about 3 km to the treatment works where the raw water is given full conventional treatment. The water then gravitates to consumers who are served through 347 individual metered connections, 4 kiosks and 1 communal water point.

Potential and Actually Served Beneficiaries: The current population served is about 20,000 through individual connections, kiosks, and communal water point.

Livestock Use: It appears that since this supply was meant to serve township population no facilities for cattle troughs were built. It can be safely said that livestock use here is negligible.

Functional Analysis: The average daily consumption is 450 m^3. The water is given full treatment and so the water quality is good. Conveyance to consumers is also very reliable. The operational reliability is good as there are no water shortages in town.

Financial Analysis: The project was commissioned in 1986 at a cost of Ksh. 33 million. Total revenue collected per month is about Ksh. 8,456. The total operation costs per month is about Ksh. 36,000. This includes electrical power consumption cost of about Ksh. 18,000 per month and chemicals cost of about Ksh. 9,000 and staff / labour costs of about Ksh. 8,900 per month.

Institutional Analysis: The day to day running of the system is supervised by Water Supply operator grade II, who has attended the Ministry's Training School. His deputy is a water supply operator grade III. His training level is equivalent to that of the water supply operator. There is then the chemical attendant, pump attendant and subordinate staff whose level of education is primary class seven. The staff from the District Head Office makes frequent checks.

3.3.9 Poro Water Supply

Technical Description: This water supply whose some components are still under construction is located in Siambu sub-location, Poro location. The source of the supply is a dam. The water is pumped using a diesel engine to a 45 m^3 storage tank and the water then gravitates to consumers through individual connections. A composite filter is under construction.

Potential and Actually Served Beneficiaries: The supply is intended to supply water to a population of about 500 including a Primary School.

Livestock Use: The total number of livestock units in Siambu location is currently estimated as 1231. The actual number using this supply is estimated at 900.

Functional Analysis: The water consumption from this supply is estimated as 12 m^3/day. The quality from the surface dam is bound to be low, but since treatment will be undertaken, it is expected that the quality to consumers will be good and of acceptable quality. It is also expected that when construction of the project is complete, the operational reliability will be good.

Financial Analysis: After the construction of the project is over, it is expected to cost Ksh. 450,000. The components which are complete, have operational costs which amount to about Ksh. 1,400 per month. No revenue is collected. The Ministry of Water Development is responsible for operation and maintenance of the supply.

Institutional Analysis: Currently a pump attendant is employed to operate the pump. He is educated to the level of primary class seven.

3.3.10 Sirata Oirobi Water Supply

Technical Description: This supply is located in Sirata Oirobi sub-location of Poro Location. The source which is a borehole whose drilling was completed in 1972 has a tested yield of 2.20 m^3/hour. Pumping is undertaken using a diesel driven engine. The consumers are served through 1 kiosk whose construction was finished in 1988. No treatment is undertaken but the water quality from visual observation indicate that the water quality is good. There exists staff housing at the site.

Potential and Actually Served Beneficiaries: The water supply serves an estimated population of 500 including 1 primary school and 1 dispensary. The consumers obtain their water from a kiosk.

Livestock Use: The estimated population of livestock units in Sirata-Oirobi is about 750. The actual number using the supply could not be estimated accurately, but it is estimated that about 80 utilize the facility.

Functional Analysis: The borehole yield is 2.2 m^3/hour. The water quality is good, although it is expected to be slightly saline and probably hard. The consumption rate is estimated as 1.9 m^3/hour. The operational reliability of the supply is fair.

Financial Analysis: The supply was constructed in 1973 at a cost of Ksh. 288,000. The diesel consumed per month is Ksh. 1,702, staff and labour cost about Ksh. 2,760 per month. The total operation and maintenance cost per month is then Ksh. 4,462.The total revenue collected per month is Ksh. 560.

Institutional Analysis: The supply is operated by the staff from the Ministry of Water Development. A water supply inspector who graduated from the Ministry's Training Institute is in charge. He is assisted by 1 subordinate staff who has not had any formal schooling and a watchman.

3.3.11 Suguta Marmar Water Supply

Technical Description: Water is pumped using a diesel driven engine from a spring into 45 m^3 storage tanks and then is distributed to consumers through 10 metered and 35 non-metered connections. The pumphouse is at the vicinity of the intake.

Potential and Actually Served Beneficiaries: The supply serves a population of about 2,500.

Livestock Use: It is estimated that the number of livestock units in the supply area is about 2,000. The animals drink directly from the springs.

Functional Analysis: The water consumption for this supply is estimated at about 20 m^3/day. The water quality from visual observation was found to be good in terms of colour. The supply was not found to be saline. The conveyance to consumers is reliable there are no major breakages. It was however indicated that the current production was not enough for the current population. There are no major causes of malfunction.

Financial Analysis: The project was constructed at a cost of Ksh. 400,000. The average operation and maintenance costs for the supply is Ksh. 3,200 per month. There is no revenue collected from the system, and Ministry of Water Development pays for operation and maintenance of the supply.

Institutional Analysis: The Ministry of Water Development operates and maintains the system. At the site, there resides a water supply operator who has had training from the Ministry's Training Institute. He reports to the Head Office in Maralal.

3.4 Wamba Division

3.4.1 Archer's Post Water Supply

Technical Description: The project is located in Archer's Post sub-location of Waso location. The supply has its source in Buffalo springs in Isiolo District at a distance of 3.7 km from the treatment works site. The intake is fenced and has meshed screens to trap large objects from entering the raw water main. From the intake, the raw water gravitates to the treatment works located close to the bridge over Ewaso Nyiro River.
The quality of raw water is quite good and only chlorination is undertaken at the treatment works. The water is then pumped to various elevated storage tanks from where it is supplied to consumers via gravity, through 10 metered connections, 3 non-metered connections, 3 kiosks and 1 cattle dip. At the treatment works site, there exists a store, a laboratory, a pumphouse and a staff house.

Potential and Actually Served Beneficiaries: Currently the population served is 3,180. This includes 1 school, 1 hospital, 2 nursery schools, School of Combat Engineering and Chokaa Gate of Samburu Game Reserve. The total population served in Samburu District is estimated at 900.

Livestock Use: No livestock use the supply, except for the cattle dip.

Functional Analysis: The average water production per day is 60 m^3. This figure could be taken as the consumption figure as during the site visit no leakage was detected. As indicated earlier, the water quality is good although it is slightly saline due to the fact that the source is a spring, which is underground in origin. Since the water is chlorinated, its bacteriological quality can be assumed to be good. At the time of visit the system had no operational problems as far as conveyance was concerned. The only matter which needed to be looked into was repair of the standby pump.

Financial Analysis: At the time of completion, the project (which was contracted) had a revised contract value of Ksh. 7,636,493.15. The personnel employed to actually run the scheme have a total remuneration of Ksh. 6,000 per month. Tropical chloride of lime is dosed at a rate of 500 grams per day. The total dosing cost is about Ksh. 200 per month. The diesel cost is about Ksh. 5,600 per month. The total operation cost is then about Ksh. 12,000 per month. The total revenue collected per month is on average currently Ksh. 3,800 per month which is much lower than operation and maintenance costs. It was also noted that due to increased consumption due to recent connection to the School of Combat Engineering, the revenue collected for the month of October 1988 amounted to Ksh. 7,000. This means that the full potential of the system has not been realized yet to be able to pay off the operation costs from revenue collected. This is a supply that is run and managed by Ministry of Water Development and the cost of operation and maintenance is met by the Ministry.

Institutional Analysis: The personnel responsible for actual day to day operation of the system are headed by an operator in charge who qualified from a technical institute. Working under him are two assistants who are pump operators and also help in dosing the water. A watchman is also employed at the treatment works compound. All the personnel here report to the District Water Office, Samburu.

3.4.2 Lerata Water Supply

Technical Description: The project is located in Lerata sub-location of Waso location. The source which is a borehole is located about 30 metres from the road to Wamba from the Archer's Post-Serolipi junction. A windmill is used for pumping. Water is then pumped to a 50 m^3 storage tank located about 60 m from the borehole. From this tank, the water gravitates to a cattle trough and a communal water point located about 50 m from the tank. From visual observation the water quality seems good. The yield from the borehole is estimated at 2.27 m^3/hr. Chemical analysis indicates that the water is saline and very hard. At the site exists a staff house.

Potential and Actually Served Beneficiaries: Currently the supply serves an estimated population of 350 and a primary school nearby.

Livestock Use: Information obtained from the operator at the site indicated that approximately 1000 cattle come to use the water here every day.

Functional Analysis: The system depends on wind energy to pump water. As long as there is wind, the pump will work. So operational reliability for this system is good. There is no treatment undertaken here but from visual observation, the water is not turbid, but it is slightly saline. When there is continuous high wind, the tank, which does not have an overflow arrangement overflows from the inspection hole. The water then undermines the masonry wall and the foundation.

Financial Analysis: The Kijito windmill used for pumping was purchased at a cost of Ksh.375,000. The operator (pump) attendant earns about Ksh. 1,500 p.m. The grease for the gear system of the supply is supplied by the Catholic Diocese of Marsabit. The water is provided free to consumers and so there is no revenue collected. Apart from the salary of the operator, there is no other operational expenditure incurred in this supply.

Institution Analysis: The water supply is under the Ministry of Water Development and so the salary of the operator is paid by the ministry. The supply of grease is done by the Catholic Diocese. The operator who runs the supply has had no formal schooling. He reports directly to the District Water office.

3.4.3 Lodungokwe Water Supply

Technical Description: The water supply is located in Lpus sub-location of Wamba location. The source is a borehole which is located at a distance of about 3.5 km from the storage tank whose capacity is 45 m^3 capacity. The water is pumped using a Lister engine, which uses diesel to pump the water. From the storage tank water gravitates to consumers. Two pumps are used. One low lift and the other high lift. The yield of the borehole is 3.05 m^3/hr. Total length of distribution to consumers is about 1 km. The water is not treated and there are 17 metered connections and 1 kiosk. At the pumping station there exists 1 pump house, 1 store and staff housing for the operators.

Potential and Actually Served Beneficiaries: Currently it is estimated that 800 people are served by the supply which covers an area of about 4 km^2. Also served are 12 commercial plots.

Livestock Use: The number of livestock served by the supply can not be accurately assessed but it is approximated that about 100 livestock units use the supply.

Functional Analysis: The water quality as far as turbidity is concerned is good, but like most ground waters in this area, it is saline. The chemical analysis done indicate that the supply is fit for domestic use.
At the time of site visit, the supply was good in terms of conveyance to consumers. The fuel supply was also reliable. Apart from minor repairs to distribution network and the rising main, which is subject to vandalism, the supply is functionally good.

Financial Analysis: The supply was commissioned in 1978 at a cost of Ksh. 250,000. In terms of direct labour cost, two casual workers are employed on full time basis, at a total cost of Ksh. 3,215 per month. The diesel supply which is regular, costs about Ksh. 2,800 per month. The water is not treated and so chemical cost is zero per month. The total operation and maintenance costs are Ksh. 6,015 per month. Average revenue collected per month is about Ksh. 800, which is much lower than the expenditure.

Institutional Analysis: The supply is under a Divisional Water Officer who resides at Wamba centre but makes regular visits to site. He in turn reports to District Water Officer at Maralal. At the water supply, 1 operator, 2 casual workers and a watchman reside there on full time basis.

3.4.4 Loijok Water Supply

Technical Description: The water supply is located in Lerata sub-location.
Originally two boreholes existed, but due to vandalism one was filled up with stones. The supply is located far away in a swamp. Water is pumped from borehole to a 50 m^3 tank, 100 m away, and from this a tap is drawn which acts as a communal water point. There is no treatment undertaken here and the consumers have to come and draw the water from the CWP at the storage. At the site there is one staff house.

Potential and Actually Served Beneficiaries: It is estimated that currently about 450 people are served from this supply through the communal water point adjacent to the tank.

Livestock Use: No accurate figures could be obtained for livestock actually using the supply, but a figure of 1100 is estimated.

Functional Analysis: Due to the remoteness of the supply, fuel delivery is very unreliable. It is estimated that the production from the source is 9.6 m^3/day.
During the rains, due to the fact that the supply is located at a swamp and drainage is poor, the area around the borehole gets flooded and renders the system non-functional. The supply is currently out of order and it is reported that it has not been operated for the last two years.

Financial Analysis: The borehole was drilled and equipped in 1974 but the cost in 1986 is estimated at Ksh. 400,000. The water is not treated so no cost of chemicals is incurred. Normally the Ministry headquarters visits the supply once to supply the system with a drum of diesel with a capacity of 200 litres. The cost per month for fuel is about Ksh. 1,400. The consumers are not charged any revenue for the water and hence no revenue is collected from this supply.

Institutional Analysis: There is no personnel who is involved full time for the maintenance of the supply. The personnel who make a site visit now and then from District Headquarters come once a month to bring fuel.

3.4.5 Samburu Lodge Water Supply

Technical Description: This is a private water supply which is located in Archer's Post sub-location of Waso location. The supply serves the lodge. The source of water is a borehole which was drilled in the vicinity of lodge about 1 km from treatment works. The water is pumped by an electrical submersible pump into a treatment works which include coagulation, flocculation and filtration using a pressure filter supplied by Davis and Shirtliff. The water is then pumped into an elevated pressed steel tank whose capacity is 40 m^3. The supply normally serves the lodges and the other amenities in the lodge including the swimming pool. There are hence 75 individual connections which are not metered. There exists workshop, store and staff house.

Potential and Actually Served Beneficiaries: This supply serves the entire lodge population which, together with the staff is at an average of 1500. All cottages have their own individual connections and the junior staff houses have a communal water point.

Livestock Use: This is a private water supply and so there is no livestock in the supply area.

Functional Analysis: The total amount of water produced here could not be estimated because there is no necessity for meters as the water is not sold. The quality of water is good. It is given full treatment. The system operates very reliably all the year round. There are no serious causes of malfunction of this supply.

Financial Analysis: The cost of construction of the project could not be estimated because it was built in phases. The person employed to run the system earns a salary of about Ksh. 4000 of p.m. The cost of chemicals used amounts to about Ksh. 400 per month. The electricity generated from the lodge's generator is used for the whole lodge and hence the amount spent on water supply could not be estimated.

3.4.6 Serolipi Water Supply

Technical Description: This water supply is located in Serolipi sub-location of Serolipi location. The source is a borehole which is located about 1.5 km from the supply area across a dry river bed (Lagga). The yield of the borehole is approximated to be about 3.57 m^3/hour. The supply uses a diesel engine to pump and the water is conveyed to a 50 m^3 storage tank to a distance of about 1.5 km from the source. There is no treatment undertaken here and water is supplied to consumers through a communal water point located at the police compound. At the borehole site, the engine is housed in a pumphouse.

Potential and Actually Served Beneficiaries: This water supply serves the police post and the surrounding population including 2 shops, 1 school, 1 church, 1 game department and a clinic. The total population served is estimated at about 500.

Livestock Use: There is a pan located near the supply point and so it can be assumed that the livestock in this area do not use this supply.

Functional Analysis: Water is not treated, is hard and saline. The fuel supply is adequate and there are no serious causes of malfunction. It was noted that the supply is adequate in terms of quantity.

Financial Analysis: There is no person employed to specifically run the supply and so there are no labour related costs. No chemicals are used because there is no treatment and no chemical related costs. *The water is provided free to consumers and so there is no revenue collected.*

The diesel consumed per month for pumping is about 1,000 litres and this would cost about Ksh. 7,000 per month. The investment cost is estimated at Ksh. 450,000.

Institutional Analysis: The overall responsibility of running the supply is under the officer in charge of the station who reports to the District Office in Maralal.

3.4.7 Wamba Borehole Water Supply

Technical Description: This supply is located in Wamba Town. The source is a borehole located about 3 km from the Game Camp tank and about 2 km to Health centre storage. The borehole has a tested yield of 6.825 m^3/hour, and the average consumption is 3 m^3/hour. There is no treatment undertaken here. Currently the consumers are served by a communal water point. There is a pumphouse at the pumping station. The total storage is currently 48 m^3.

Potential and Actually Served Beneficiaries: It is estimated that currently about 3000 people are served by the supply which covers an area of about 15 km^2. This includes 2 schools (1 primary and 1 secondary).

Livestock Use: A pan is located nearby and it can be assumed that the livestock use water from the pan.

Functional Analysis: At the time of the visit the supply was in good operational state. The water quality in terms of turbidity is good but it is saline. Currently the major problem with the system is that the distribution network is completely out of order.

The estimated 1993 total demand for Wamba town is 273 m^3/d. The borehole tested yield is 6.825 m^3/hour. Assuming an 8 hour pumping period the total amount available from borehole falls short of demand. So clearly an alternative scheme has to be designed to cater for this short fall.

Financial Analysis: The borehole was drilled in 1978 and records concerning the historical investment costs indicate a construction cost of Ksh. 300,000. There are two pump attendants employed full time at the pumping station whose total salaries amount to about 3,000. The supply consumes about 500 litres of diesel per month whose cost amounts to Ksh. 3500 per month. The total revenue collected per month is about Ksh. 300. The total operation and maintenance cost is thus 6,500 per month which is *met by the Ministry of Water Development, who own and maintain the supply.*

Institutional Analysis: The two pump attendants who run the supply are employees of Ministry of Water Development and they report to the Divisional Water Officer who is based in Wamba.

3.4.8 Wamba Gravity Water Supply

Technical Description: This water supply which is currently under construction is meant to augment the existing Wamba borehole. The source is a rock catchment. The water then gravitates to Game camp tank. No treatment is undertaken and it is expected that the supply will be connected to the centre's distribution network. The description give her is not up to date.

Potential and Actually Served Beneficiaries: Currently the supply is not operational as the project is under construction. It is estimated that after construction is complete about 3000 people will benefit.

Livestock Use: This supply as that one of Wamba Borehole is meant for human population and hence no livestock is anticipated to use the supply.

Functional Analysis: The water quality is of good quality and it is expected that when the construction is complete, operational reliability will be good.

The data available indicate that 70% of the time, the average yield from the source is about 75 m^3/d and that 30% of the time, the average yield is 35 m^3/d. The lowest discharge was recorded in 1987 as 23 m^3/d. The 1993 total demand for Wamba town is estimated as 273 m^3/d. Clearly this demand can not be met by this supply alone, and an alternative scheme has to be designed to augment this.

Financial Analysis: When the scheme is fully operation and the distribution network is complete, it is expected that the total costs will be about Ksh. 900,000. The supply will be run and maintained by the Ministry of Water Development.

Institutional Analysis: The Divisional Water Officer who is currently based in Wamba is the overall in charge. He reports to Maralal water office.

3.4.9 West Gate Water Supply

Technical Description: This is a water supply located at the West Gate of Samburu Game Reserve in Archer's Post sub-location, Waso location.
The source is river Ewaso Nyiro, where a petrol driven portable pump, pumps water to treatment works just 50 m from the bank of the river. The water undergoes full treatment and filtration is undertaken by a pressure filter supplied by Davis and Shirtliff. The water is then pumped to a storage tank from where it gravitates to consumers. The consumers are connected using unmetered individual connections. There are 13 individual connections.

Potential and Actually Served Beneficiaries: This supply serves the Game staff who man the West Gate. Currently there are 111 people including 1 school and teachers.

Livestock Use: The livestock at the vicinity of the supply use River Ewaso Nyiro and so no livestock uses this supply.

Functional Analysis: At the time of visit, the system was completely out of order. River Ewaso-Nyiro had overflowed its banks and the flood waters had knocked down elements of the system. Plans had also been mooted to have a major supply which would incorporate the West Gate and the surrounding areas including livestock. In this respect the distribution network was removed. Discussion are now underway to have the distribution network reinstated and the treatment works rehabilitated.

Financial Analysis: The historical investment cost estimate the supply was estimated at Ksh. 900,000. The labour costs amount to Ksh. 1,500 per month and petrol used for pumping amounted to Ksh. 320 per month. There is no revenue collected from consumers and all operational and maintenance costs are met by Samburu County Council who own the Game Reserve.

Institutional Analysis: A full time employee of Samburu County Council is employed to run the system when it is operational. He reports to the warden in charge.

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)

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 KWDP	1988 `85-`87	 ?	120,000 68,228	260 200	460 341	 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	

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 1984	360,000 470,000	125 125	2,880 3,760	150 mm diameter 200 mm diameter
Diocese	Baragoi Lodokojek	 1986	- 159,550		2,500 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 m³ ferro cement tank & gutters
SIDA	Marimanti-Health Centre		77,000			90 m³ tank, 138 m gutters
	Primary Sch.		95,000			112 m³ tank, 160 m
	Marimanti				525/m³	Tank
	Marimanti				215/m³	Gutters

Supply: Roof Catchment Tanks

Source of Data	Project Name	Year	Type	Volume (m³)	Costs/ m³	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/m³			Stone masonry
			41/m³			Stone gutters
			100,000	200	500	Complete 10 m³/day
McPherson	Mutomo	1984	150,000	1,500	100	Storage 3,500 m³, 15m³/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 m³/day
GSK	KIDP	1989	900/m³			Stone masonry wall
			150,000	100	1,500	Sand Dam 5 m³/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 m³ storage
	Embu District	1984	125,000	300-400	300-400	Sand weirs, donor:ODA

Supply: Pans

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
PENCOL	CBWDP	1984	2,923,000	1250	2340	50 m³/day perennial
			950,000	(1250)	760	50 m³/day seasonal
			1,500,000	450	3333	18 m³/day domestic
DCU5	-	1989	Rates	60	Shs/m³	Desilting
			Only	85	Shs/m³	Embankment (excavation, transport, compaction)
				65	Shs/m³	Excavation
GSK	KIDP	1989	10,000	200	50	Small earth dam, 10 m³/day
			250,000	1,200	208	Medium earth dam, 60 m³/day

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

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

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

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			

Supply Component: Surfacewater Intake (weir)

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	-	-	-

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

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		Horizontal roughing filters incl. 50m^3 tank

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: 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
SIDA	Marimanti	1988			525	Roof tank

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: Hydram

Including: Hydram, pumphouse

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

Supply Component: Motor Pump

Including: Diesel Generator - Pump

Source of Data	Project Name	Year	Total Costs	Popu.	Costs/ Capita	Remarks
ODA	Kijito Wind-pump Evaluation	1989	123,255			Excluding installation
			150,975			Including installation
GSK	Kitui/Danida	1989	150,000			50 m^3/day
Diocese	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	176,650 209,850 273,600 325,600 383,600			1 m^3/hr, 75 m head 3 m^3/hr, 75 m head 5 m^3/hr, 75 m head 8 m^3/hr, 75 m head 12 m^3/hr, 75 m head

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

UNIT COSTS OF WATER SUPPLIES: SOURCE DATA

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

APPENDIX 5

DETAILS AND COSTS OF A TYPICAL WATER SUPPLY

Using:
- A Borehole
- Dug Wells
- A Surface Water Intake
- A Spring

DETAILS AND COSTS OF A LIVESTOCK WATER SUPPLY

Details and Costs of a Typical Water Supply using a Borehole

Supply Area	Urban Area	Rural Centre	Rural Centre	Rural Centre	Rural Centre	Rural Institution
Population	5000 people	500 people	200 people	200 people	500 people	200 people
Livestock	-	1000 L.U.	500 L.U.	500 L.U.	-	
Daily Supply	200 m^3/d	70 m^3/d	35 m^3/d	35 m^3/d	20 m^3/day	5-10 m^3/d
Boreholes	3 nr. (1 stand-by)	1 nr. (Volcanic Area)	1 nr.	1 nr.	1 nr.	1 nr.
Borehole Depth	150 m.	150 m.	100 m.	100 m.	100 m.	100 m.
Borehole Yield	>5 m^3/hr	5 m^3/hr	<5 m^3/hr	5 m^3/hr	3 m^3/hr	2 m^3/hr
Pump Plant	Electrical subm.	Electrical subm.	Electrical Subm.	Windmill (6 m. rotor)	Windmill	Handpump
Main Lines	0.5 km	200 m	200 m	200 m	200 m.	-
Treatment	Chlorination only	-	-	-	-	-
Storage	200 m^3	70 m^3	35 m^3	105 m^3	60 m^3	-
Distribution	.... km	.... km	.... km	.... km	-	
Communal Water points	20 nr.	2 nr.	1 nr.	1 nr.	1 nr.	-
Individual Connections	200 nr.	5 nr.	-	-	-	-
Cattle Troughs	-	1 nr.	1 nr.	1 nr.	-	-
Boreholes	1,125,000 Shs	375,000 Shs	250,000 Shs	250,000 Shs	250,000 Shs	250,000 Shs
Pump Plant	450,000 Shs	150,000 Shs	125,000 Shs	235,000 Shs	235,000 Shs	20,000 Shs
Superstructure	-	-	-	-	-	10,000 Shs
Main Lines	200,000 Shs	50,000 Shs	50,000 Shs	50,000 Shs	50,000 Shs	-
Treatment	40,000 Shs	-	-	-	-	-
Storage	600,000 Shs	210,000 Shs	105,000 Shs	315,000 Shs	180,000 Shs	-
Distribution	1,000,000 Shs	200,000 Shs	-	-	-	-
Communal Water Points	300,000 Shs	30,000 Shs	15,000 Shs	15,000 Shs	15,000 Shs	-
Individual Connections	400,000 Shs	10,000 Shs	-		-	-
Cattle Troughs	-	25,000 Shs	25,000 Shs	25,000 Shs	-	-
Buildings	400,000 Shs	200,000 Shs	200,000 Shs	200,000 Shs	150,000 Shs	-
Fencing	100,000 Shs	50,000 Shs	50,000 Shs	50,000 Shs	25,000 Shs	20,000 Shs
Contingencies (25%)	1,153,750 Shs	325,000 Shs	205,000 Shs	285,000 Shs	226,250 Shs	75,000 Shs
Total construction Costs	5,768,750 Shs	1,625,000 Shs	1,025,000 Shs	1,425,000 Shs	1,131,250 Shs	375,000 Shs
Costs per Capita	1,150 Shs	3,250 Shs	5,125 Shs	7,130 Shs	2,260 Shs	1,875 Shs

Note: Urban supply in Basement Area requires 5 boreholes of 100 m depth. Total cost is similar as above.

Details and Costs of a Typical Water Supply using Dug Wells

Supply Area	Rural Centre	Rural Institution
Population	200 people	200 people
Livestock	500 L.U.	-
Daily Supply	35 m^3/d	5-10 m^3/d
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	105 m^3	-
Distribution	-	-
Communal Water points	1 nr.	-
Individual Connections	-	-
Cattle Troughs	1 nr.	-
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	315,000 Shs	-
Distribution	-	-
Communal Water points	15,000 Shs	-
Individual Connections	-	-
Cattle Troughs	25,000 Shs	-
Buildings	200,000 Shs	-
Fencing	50,000 Shs	20,000 Shs
Contingencies (25%)	235,000 Shs	22,500 Shs
Total construction Cost	1,175,000 Shs	112,500 Shs
Costs per Capita	5,880 Shs	560 Shs

Note: It is not certain whether the combination dug well-windmill will yield enough water

The daily production 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

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

Supply Area	Urban Area	Urban Area	Rural Centre	Rural Centre
Population	5000 people	5000 people	500 people	200 people
Livestock	-	-	1000 L.U.	500 L.U
Daily Supply	200 m³/d	200 m³/d	70 m³/d	35 m³/d
Intake Structure	Dam: 100,000 m³	Weir	Weir	Weir
Treatment	Full	Full	Chlorination	Chlorination
Pump Plant	Diesel / Electric	Diesel / Electric		-
Pump Capacity	10 m³/hr	10 m³/hr	Gravity	Gravity
Main Lines	2 km	2 km	200 m	200 m
Storage	200 m³	200 m³	70 m³	35 m³
Distribution	... km	... km	... km	... km
Communal Water points	20 nr.	20 nr.	2 nr.	1 nr.
Individual Connections	200 nr.	200 nr.	5 nr.	-
Cattle Troughs	-	-	1 nr.	1 nr.
Intake Structure	5,000,000 Shs	200,000 Shs	120,000 Shs	100,000 Shs
Treatment	1,000,000 Shs	1,000,000 Shs	25,000 Shs	25,000 Shs
Pump Plant	500,000 Shs	500,000 Shs	-	-
Main Lines	500,000 Shs	500,000 Shs	50,000 Shs	50,000 Shs
Storage	600,000 Shs	600,000 Shs	210,000 Shs	105,000 Shs
Distribution	1,000,000 Shs	1,000,000 Shs	200,000 Shs	-
Communal Water points	300,000 Shs	300,000 Shs	30,000 Shs	15,000 Shs
Individual Connections	400,000 Shs	400,000 Shs	10,000 Shs	-
Cattle Troughs	-	-	25,000 Shs	25,000 Shs
Buildings	400,000 Shs	400,000 Shs	200,000 Shs	50,000 Shs
Fencing	100,000 Shs	100,000 Shs	50,000 Shs	20,000 Shs
Contingencies (25%)	2,450,000 Shs	1,250,000 Shs	230,000 Shs	97,500 Shs
Total construction Cost	12,250,000 Shs	6,250,000 Shs	1,150,000 Shs	487,500 Shs
Costs per Capita	2,450 Shs	1,250 Shs	2,300 Shs	2,440 Shs

Details and Costs of a Typical Water Supply using a Spring

Supply Area	Urban Area	Rural Centre	Rural Centre	Rural Institution
Population	5000 people	500 people	200 people	200 people
Livestock	-	1000 L.U.	500 L.U.	-
Daily Supply	200 m³/d	70 m³/d	35 m³/d	10 m³/d
Spring Protection				
Treatment	Chlorination only		-	-
Pump Plant	Gravity	Gravity	Gravity	Gravity
Pump Capacity	-	-	-	-
Main Lines	2 km	1 km	200 m	-
Storage	200 m³	70 m³	35 m³	-
Distribution	.... km	.... km	-	-
Comm. Water points	20 nr.	2 nr.	1	1
Indiv. Connections	200 nr.	5 nr.	-	-
Cattle Troughs	-	1 nr.	1	-
Spring Protection	500,000 Shs	50,000 Shs	20,000 Shs	20,000 Shs
Main Lines	500,000 Shs	250,000 Shs	50,000 Shs	-
Treatment	40,000 Shs	-	-	-
Pump Plant	-	-	-	-
Storage	600,000 Shs	210,000 Shs	105,000 Shs	-
Distribution	1,000,000 Shs	200,000 Shs	-	-
Comm. Water points	300,000 Shs	30,000 Shs	15,000 Shs	-
Indiv. Connections	400,000 Shs	10,000 Shs	-	-
Cattle Troughs	-	25,000 Shs	25,000 Shs	-
Buildings	400,000 Shs	200,000 Shs	-	-
Fencing	100,000 Shs	50,000 Shs	20,000 Shs	-
Contingencies (25%)	960,000 Shs	256,250 Shs	58,750 Shs	5,000 Shs
Total construction Costs	4,800,000 Shs	1,281,250 Shs	293,750 Shs	25,000 Shs
Costs per Capita	960 Shs	2,560 Shs	1,470 Shs	125 Shs

Details and Costs of a Typical Livestock Water Supply

Supply Area	Rural Area	Rural Area
Population	-	-
Livestock	1000 L.U.	500 L.U
Daily Supply	50 m^3/d	25 m^3/d [1])
Dam Capacity	25,000 m^3	5,000 m^3
Pump Plant	Handpump	-
Main Lines	200 m	-
Storage	-	-
Distribution	-	-
Communal Water points	-	-
Cattle Troughs	2	-
Dam	1,250,000	250,000
Structures	30,000	-
Pump Plant	20,000	-
Main Lines	50,000	-
Storage	-	-
Distribution	-	-
Communal Water Points	-	-
Cattle Troughs	50,000	-
Buildings	150,000	-
Fencing	100,000	
Contingencies (25%)	412,500	62,500
Total construction Cost	2,062,500 Shs	312,500 Shs

Note: [1]) Supply from pan only 6 months/year

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/m³)
	Surface Water Source:		
SIDA - South-Horr	Gravity, 20 cwp, 8 troughs	5,400	4 *
Chepalunga	Gravity (7% pumping), 4330 km²	135,850	1.6 *
	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

* O & M costs include depreciation

APPENDIX 7

COST EFFECTIVENESS ANALYSIS

APPENDIX 7

COST EFFECTIVENESS ANALYSIS

Urban Supply from Boreholes with Pumps
Rural Supply from a Borehole with a Pump
Rural Supply from a Borehole with a Pump
Rural Supply from a Borehole with a Pump
Rural Supply from a Borehole with a Windmill
Rural Supply from a Borehole with a Windmill
Rural Supply from a Borehole with a Handpump
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
Rural Supply from a Dug Well with a Handpump

Urban Supply from a Spring
Rural 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
Rural Supply from a Surface Water Weir
Rural Supply from a Surface Water Weir

Livestock Supply from a Dam
Livestock Supply from a Pan

Cost Effectiveness Analysis of Urban Supply from Boreholes with Pumps

Technology: 3 Boreholes with Motorpump, Distribution, 200 m3 Storage, Chlorination

Capital cost: 5,768,750 Shs
Annual Costs: 522,687 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 450,000 for motorpumps + generators every 15 years (incl. stand-by pump)

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	5,768,750	522,687	6,291,437	86.2	6,291,437	86.2	6,291,437	86.2
1	73000		522,687	497,797	6.8	475,170	6.5	454,510	6.2
2	73000		522,687	474,093	6.5	431,973	5.9	395,226	5.4
3	73000		522,687	451,517	6.2	392,702	5.4	343,675	4.7
4	73000		522,687	430,016	5.9	357,002	4.9	298,848	4.1
5	73000		522,687	409,539	5.6	324,548	4.4	259,868	3.6
6	73000		522,687	390,037	5.3	295,043	4.0	225,972	3.1
7	73000		522,687	371,464	5.1	268,221	3.7	196,497	2.7
8	73000		522,687	353,775	4.8	243,837	3.3	170,867	2.3
9	73000		522,687	336,929	4.6	221,670	3.0	148,580	2.0
10	73000		522,687	320,884	4.4	201,518	2.8	129,200	1.8
11	73000		522,687	305,604	4.2	183,199	2.5	112,348	1.5
12	73000		522,687	291,052	4.0	166,544	2.3	97,694	1.3
13	73000		522,687	277,192	3.8	151,404	2.1	84,951	1.2
14	73000		522,687	263,992	3.6	137,640	1.9	73,871	1.0
15	73000	450,000	522,687	467,879	6.4	232,854	3.2	119,538	1.6
16	73000		522,687	239,449	3.3	113,752	1.6	55,857	0.8
17	73000		522,687	228,047	3.1	103,411	1.4	48,571	0.7
18	73000		522,687	217,187	3.0	94,010	1.3	42,236	0.6
19	73000		522,687	206,845	2.8	85,464	1.2	36,727	0.5
20	73000		522,687	196,995	2.7	77,694	1.1	31,936	0.4
Total	1,533,000	6,218,750	10,976,427	13,021,730	178.4	10,849,093	148.6	9,618,411	131.8

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	178.4	148.6	131.8

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Pump

Technology: Borehole with Motorpump, Distribution, 70 m3 Storage

Capital cost: 1,625,000 Shs
Annual Costs: 151,250 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 150,000 for motorpump + generator every 10 years

Annual Yield: 70 m3/day * 365 = 25550 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	25550	1,625,000	151,250	1,776,250	69.5	1,776,250	69.5	1,776,250	69.5
1	25550		151,250	144,048	5.6	137,500	5.4	131,522	5.1
2	25550		151,250	137,188	5.4	125,000	4.9	114,367	4.5
3	25550		151,250	130,655	5.1	113,636	4.4	99,449	3.9
4	25550		151,250	124,434	4.9	103,306	4.0	86,478	3.4
5	25550		151,250	118,508	4.6	93,914	3.7	75,198	2.9
6	25550		151,250	112,865	4.4	85,377	3.3	65,390	2.6
7	25550		151,250	107,491	4.2	77,615	3.0	56,860	2.2
8	25550		151,250	102,372	4.0	70,559	2.8	49,444	1.9
9	25550		151,250	97,497	3.8	64,145	2.5	42,995	1.7
10	25550	150,000	151,250	184,941	7.2	116,145	4.5	74,464	2.9
11	25550		151,250	88,433	3.5	53,012	2.1	32,510	1.3
12	25550		151,250	84,222	3.3	48,193	1.9	28,270	1.1
13	25550		151,250	80,211	3.1	43,812	1.7	24,582	1.0
14	25550		151,250	76,392	3.0	39,829	1.6	21,376	0.8
15	25550		151,250	72,754	2.8	36,208	1.4	18,588	0.7
16	25550		151,250	69,289	2.7	32,916	1.3	16,163	0.6
17	25550		151,250	65,990	2.6	29,924	1.2	14,055	0.6
18	25550		151,250	62,847	2.5	27,204	1.1	12,222	0.5
19	25550		151,250	59,855	2.3	24,731	1.0	10,628	0.4
20	25550	150,000	151,250	113,538	4.4	44,779	1.8	18,406	0.7
Total	536,550	1,925,000	3,176,250	3,809,780	149.1	3,144,055	123.1	2,769,217	108.4

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	149.1	123.1	108.4

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Pump

Technology: Borehole with Motorpump, Distribution, 35 m3 Storage

Capital cost: 1,025,000 Shs
Annual Costs: 86,250 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 125,000 for motorpump + generator every 10 years

Annual Yield: 35 m3/day * 365 = 12775 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	12775	1,025,000	86,250	1,111,250	87.0	1,111,250	87.0	1,111,250	87.0
1	12775		86,250	82,143	6.4	78,409	6.1	75,000	5.9
2	12775		86,250	78,231	6.1	71,281	5.6	65,217	5.1
3	12775		86,250	74,506	5.8	64,801	5.1	56,711	4.4
4	12775		86,250	70,958	5.6	58,910	4.6	49,314	3.9
5	12775		86,250	67,579	5.3	53,554	4.2	42,881	3.4
6	12775		86,250	64,361	5.0	48,686	3.8	37,288	2.9
7	12775		86,250	61,296	4.8	44,260	3.5	32,425	2.5
8	12775		86,250	58,377	4.6	40,236	3.1	28,195	2.2
9	12775		86,250	55,598	4.4	36,578	2.9	24,518	1.9
10	12775	125,000	86,250	129,689	10.2	81,446	6.4	52,218	4.1
11	12775		86,250	50,429	3.9	30,230	2.4	18,539	1.5
12	12775		86,250	48,027	3.8	27,482	2.2	16,121	1.3
13	12775		86,250	45,740	3.6	24,984	2.0	14,018	1.1
14	12775		86,250	43,562	3.4	22,712	1.8	12,190	1.0
15	12775		86,250	41,488	3.2	20,648	1.6	10,600	0.8
16	12775		86,250	39,512	3.1	18,771	1.5	9,217	0.7
17	12775		86,250	37,631	2.9	17,064	1.3	8,015	0.6
18	12775		86,250	35,839	2.8	15,513	1.2	6,969	0.5
19	12775		86,250	34,132	2.7	14,103	1.1	6,060	0.5
20	12775	125,000	86,250	79,618	6.2	31,401	2.5	12,907	1.0
Total	268,275	1,275,000	1,811,250	2,309,966	180.8	1,912,318	149.7	1,689,653	132.3

	DISCOUNT RATE		
	5 %	10 %	15 %
total cost per m3	180.8	149.7	132.3

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Pump

Technology: Borehole with Motorpump, Limited Distribution, 20 m3 Storage

Capital cost: 843,750 Shs
Annual Costs: 74,440 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 125,000 for motorpump + generator every 10 years

Annual Yield: 20 m3/day * 365 = 7300 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	7300	843,750	74,440	918,190	125.8	918,190	125.8	918,190	125.8
1	7300		74,440	70,895	9.7	67,673	9.3	64,730	8.9
2	7300		74,440	67,519	9.2	61,521	8.4	56,287	7.7
3	7300		74,440	64,304	8.8	55,928	7.7	48,946	6.7
4	7300		74,440	61,242	8.4	50,844	7.0	42,561	5.8
5	7300		74,440	58,326	8.0	46,221	6.3	37,010	5.1
6	7300		74,440	55,548	7.6	42,019	5.8	32,182	4.4
7	7300		74,440	52,903	7.2	38,199	5.2	27,985	3.8
8	7300		74,440	50,384	6.9	34,727	4.8	24,335	3.3
9	7300		74,440	47,985	6.6	31,570	4.3	21,160	2.9
10	7300	125,000	74,440	122,439	16.8	76,893	10.5	49,299	6.8
11	7300		74,440	43,524	6.0	26,091	3.6	16,000	2.2
12	7300		74,440	41,451	5.7	23,719	3.2	13,913	1.9
13	7300		74,440	39,477	5.4	21,563	3.0	12,099	1.7
14	7300		74,440	37,597	5.2	19,602	2.7	10,521	1.4
15	7300		74,440	35,807	4.9	17,820	2.4	9,148	1.3
16	7300		74,440	34,102	4.7	16,200	2.2	7,955	1.1
17	7300		74,440	32,478	4.4	14,728	2.0	6,917	0.9
18	7300		74,440	30,931	4.2	13,389	1.8	6,015	0.8
19	7300		74,440	29,458	4.0	12,172	1.7	5,231	0.7
20	7300	125,000	74,440	75,167	10.3	29,645	4.1	12,186	1.7
Total	153,300	1,093,750	1,563,240	1,969,727	269.8	1,618,713	221.7	1,422,670	194.9

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	269.8	221.7	194.9

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Windmill

Technology: Borehole with Windmill

Capital cost: 1,425,000 Shs
Annual Costs: 16,000 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 35 m3/day * 300 = 10500 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	10500	1,425,000	16,000	1,441,000	137.2	1,441,000	137.2	1,441,000	137.2
1	10500		16,000	15,238	1.5	14,545	1.4	13,913	1.3
2	10500		16,000	14,512	1.4	13,223	1.3	12,098	1.2
3	10500		16,000	13,821	1.3	12,021	1.1	10,520	1.0
4	10500		16,000	13,163	1.3	10,928	1.0	9,148	0.9
5	10500		16,000	12,536	1.2	9,935	0.9	7,955	0.8
6	10500		16,000	11,939	1.1	9,032	0.9	6,917	0.7
7	10500		16,000	11,371	1.1	8,211	0.8	6,015	0.6
8	10500		16,000	10,829	1.0	7,464	0.7	5,230	0.5
9	10500		16,000	10,314	1.0	6,786	0.6	4,548	0.4
10	10500		16,000	9,823	0.9	6,169	0.6	3,955	0.4
11	10500		16,000	9,355	0.9	5,608	0.5	3,439	0.3
12	10500		16,000	8,909	0.8	5,098	0.5	2,991	0.3
13	10500		16,000	8,485	0.8	4,635	0.4	2,600	0.2
14	10500		16,000	8,081	0.8	4,213	0.4	2,261	0.2
15	10500		16,000	7,696	0.7	3,830	0.4	1,966	0.2
16	10500		16,000	7,330	0.7	3,482	0.3	1,710	0.2
17	10500		16,000	6,981	0.7	3,166	0.3	1,487	0.1
18	10500		16,000	6,648	0.6	2,878	0.3	1,293	0.1
19	10500		16,000	6,332	0.6	2,616	0.2	1,124	0.1
20	10500		16,000	6,030	0.6	2,378	0.2	978	0.1
Total	220,500	1,425,000	336,000	1,640,395	156.2	1,577,217	150.2	1,541,149	146.8

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	156.2	150.2	146.8

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Windmill

Technology: Borehole with Windmill

Capital cost: 1,131,250 Shs
Annual Costs: 16,000 Shs (Maintenance + Salaries)
Replacement Costs: None

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

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	6000	1,131,250	16,000	1,147,250	191.2	1,147,250	191.2	1,147,250	191.2
1	6000		16,000	15,238	2.5	14,545	2.4	13,913	2.3
2	6000		16,000	14,512	2.4	13,223	2.2	12,098	2.0
3	6000		16,000	13,821	2.3	12,021	2.0	10,520	1.8
4	6000		16,000	13,163	2.2	10,928	1.8	9,148	1.5
5	6000		16,000	12,536	2.1	9,935	1.7	7,955	1.3
6	6000		16,000	11,939	2.0	9,032	1.5	6,917	1.2
7	6000		16,000	11,371	1.9	8,211	1.4	6,015	1.0
8	6000		16,000	10,829	1.8	7,464	1.2	5,230	0.9
9	6000		16,000	10,314	1.7	6,786	1.1	4,548	0.8
10	6000		16,000	9,823	1.6	6,169	1.0	3,955	0.7
11	6000		16,000	9,355	1.6	5,608	0.9	3,439	0.6
12	6000		16,000	8,909	1.5	5,098	0.8	2,991	0.5
13	6000		16,000	8,485	1.4	4,635	0.8	2,600	0.4
14	6000		16,000	8,081	1.3	4,213	0.7	2,261	0.4
15	6000		16,000	7,696	1.3	3,830	0.6	1,966	0.3
16	6000		16,000	7,330	1.2	3,482	0.6	1,710	0.3
17	6000		16,000	6,981	1.2	3,166	0.5	1,487	0.2
18	6000		16,000	6,648	1.1	2,878	0.5	1,293	0.2
19	6000		16,000	6,332	1.1	2,616	0.4	1,124	0.2
20	6000		16,000	6,030	1.0	2,378	0.4	978	0.2
Total	126,000	1,131,250	336,000	1,346,645	224.4	1,283,467	213.9	1,247,399	207.9

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	224.4	213.9	207.9

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Handpump

Technology: Borehole with Handpump

Capital cost: 375,000 Shs
Annual Costs: 3,500 Shs (Maintenance of Borehole and Handpump)
Replacement Costs: Handpump 25,000 Shs - every 6 years.

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	375,000	3,500	378,500	103.7	378,500	103.7	378,500	103.7
1	3650		3,500	3,333	0.9	3,182	0.9	3,043	0.8
2	3650		3,500	3,175	0.9	2,893	0.8	2,647	0.7
3	3650		3,500	3,023	0.8	2,630	0.7	2,301	0.6
4	3650		3,500	2,879	0.8	2,391	0.7	2,001	0.5
5	3650		3,500	2,742	0.8	2,173	0.6	1,740	0.5
6	3650	25,000	3,500	21,267	5.8	16,088	4.4	12,321	3.4
7	3650		3,500	2,487	0.7	1,796	0.5	1,316	0.4
8	3650		3,500	2,369	0.6	1,633	0.4	1,144	0.3
9	3650		3,500	2,256	0.6	1,484	0.4	995	0.3
10	3650		3,500	2,149	0.6	1,349	0.4	865	0.2
11	3650		3,500	2,046	0.6	1,227	0.3	752	0.2
12	3650	25,000	3,500	15,870	4.3	9,081	2.5	5,327	1.5
13	3650		3,500	1,856	0.5	1,014	0.3	569	0.2
14	3650		3,500	1,768	0.5	922	0.3	495	0.1
15	3650		3,500	1,684	0.5	838	0.2	430	0.1
16	3650		3,500	1,603	0.4	762	0.2	374	0.1
17	3650		3,500	1,527	0.4	692	0.2	325	0.1
18	3650	25,000	3,500	11,842	3.2	5,126	1.4	2,303	0.6
19	3650		3,500	1,385	0.4	572	0.2	246	0.1
20	3650		3,500	1,319	0.4	520	0.1	214	0.1
Total	76,650	450,000	73,500	465,082	127.4	434,872	119.1	417,909	114.5

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	127.4	119.1	114.5

Cost Effectiveness Analysis of Rural Supply from a Borehole with a Handpump

Technology: Borehole with handpump

Capital cost: 375,000 Shs
Annual Costs: 3,500 Shs (Maintenance of Borehole and Handpump)
Replacement Costs: Handpump 25,000 Shs - every 6 years.

Annual Yield: 5 m3/day * 365 = 1825 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	1825	375,000	3,500	378,500	207.4	378,500	207.4	378,500	207.4
1	1825		3,500	3,333	1.8	3,182	1.7	3,043	1.7
2	1825		3,500	3,175	1.7	2,893	1.6	2,647	1.5
3	1825		3,500	3,023	1.7	2,630	1.4	2,301	1.3
4	1825		3,500	2,879	1.6	2,391	1.3	2,001	1.1
5	1825		3,500	2,742	1.5	2,173	1.2	1,740	1.0
6	1825	25,000	3,500	21,267	11.7	16,088	8.8	12,321	6.8
7	1825		3,500	2,487	1.4	1,796	1.0	1,316	0.7
8	1825		3,500	2,369	1.3	1,633	0.9	1,144	0.6
9	1825		3,500	2,256	1.2	1,484	0.8	995	0.5
10	1825		3,500	2,149	1.2	1,349	0.7	865	0.5
11	1825		3,500	2,046	1.1	1,227	0.7	752	0.4
12	1825	25,000	3,500	15,870	8.7	9,081	5.0	5,327	2.9
13	1825		3,500	1,856	1.0	1,014	0.6	569	0.3
14	1825		3,500	1,768	1.0	922	0.5	495	0.3
15	1825		3,500	1,684	0.9	838	0.5	430	0.2
16	1825		3,500	1,603	0.9	762	0.4	374	0.2
17	1825		3,500	1,527	0.8	692	0.4	325	0.2
18	1825	25,000	3,500	11,842	6.5	5,126	2.8	2,303	1.3
19	1825		3,500	1,385	0.8	572	0.3	246	0.1
20	1825		3,500	1,319	0.7	520	0.3	214	0.1
Total	38,325	450,000	73,500	465,082	254.8	434,872	238.3	417,909	229.0

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	254.8	238.3	229.0

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Cost Effectiveness Analysis of Rural Supply from a Dug Well with a Windmill

Technology: Dug well with Windmill

Capital cost: 1,175,000 Shs
Annual Costs: 13,500 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 35 m3/day * 300 = 10500 m3/year (It is not certain whether this yield is possible)

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	10500	1,175,000	13,500	1,188,500	113.2	1,188,500	113.2	1,188,500	113.2
1	10500		13,500	12,857	1.2	12,273	1.2	11,739	1.1
2	10500		13,500	12,245	1.2	11,157	1.1	10,208	1.0
3	10500		13,500	11,662	1.1	10,143	1.0	8,876	0.8
4	10500		13,500	11,106	1.1	9,221	0.9	7,719	0.7
5	10500		13,500	10,578	1.0	8,382	0.8	6,712	0.6
6	10500		13,500	10,074	1.0	7,620	0.7	5,836	0.6
7	10500		13,500	9,594	0.9	6,928	0.7	5,075	0.5
8	10500		13,500	9,137	0.9	6,298	0.6	4,413	0.4
9	10500		13,500	8,702	0.8	5,725	0.5	3,838	0.4
10	10500		13,500	8,288	0.8	5,205	0.5	3,337	0.3
11	10500		13,500	7,893	0.8	4,732	0.5	2,902	0.3
12	10500		13,500	7,517	0.7	4,302	0.4	2,523	0.2
13	10500		13,500	7,159	0.7	3,910	0.4	2,194	0.2
14	10500		13,500	6,818	0.6	3,555	0.3	1,908	0.2
15	10500		13,500	6,494	0.6	3,232	0.3	1,659	0.2
16	10500		13,500	6,185	0.6	2,938	0.3	1,443	0.1
17	10500		13,500	5,890	0.6	2,671	0.3	1,254	0.1
18	10500		13,500	5,610	0.5	2,428	0.2	1,091	0.1
19	10500		13,500	5,342	0.5	2,207	0.2	949	0.1
20	10500		13,500	5,088	0.5	2,007	0.2	825	0.1
Total	220,500	1,175,000	283,500	1,356,740	129.2	1,303,433	124.1	1,273,001	121.2

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	129.2	124.1	121.2

Cost Effectiveness Analysis of Rural Supply from a Dug Well with a Handpump

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

Cost Effectiveness Analysis of Rural Supply from a Dug Well with a Handpump

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: 5 m3/day * 365 = 1825 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	1825	112,500	500	113,000	61.9	113,000	61.9	113,000	61.9
1	1825		500	476	0.3	455	0.2	435	0.2
2	1825		500	454	0.2	413	0.2	378	0.2
3	1825		500	432	0.2	376	0.2	329	0.2
4	1825		500	411	0.2	342	0.2	286	0.2
5	1825		500	392	0.2	310	0.2	249	0.1
6	1825	25,000	500	19,028	10.4	14,394	7.9	11,024	6.0
7	1825		500	355	0.2	257	0.1	188	0.1
8	1825		500	338	0.2	233	0.1	163	0.1
9	1825		500	322	0.2	212	0.1	142	0.1
10	1825		500	307	0.2	193	0.1	124	0.1
11	1825		500	292	0.2	175	0.1	107	0.1
12	1825	25,000	500	14,199	7.8	8,125	4.5	4,766	2.6
13	1825		500	265	0.1	145	0.1	81	0.0
14	1825		500	253	0.1	132	0.1	71	0.0
15	1825		500	241	0.1	120	0.1	61	0.0
16	1825		500	229	0.1	109	0.1	53	0.0
17	1825		500	218	0.1	99	0.1	46	0.0
18	1825	25,000	500	10,596	5.8	4,586	2.5	2,061	1.1
19	1825		500	198	0.1	82	0.0	35	0.0
20	1825		500	188	0.1	74	0.0	31	0.0
Total	38,325	187,500	10,500	162,195	88.9	143,831	78.8	133,631	73.2

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	88.9	78.8	73.2

Cost Effectiveness Analysis of Urban Supply from a Spring

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

Capital cost: 4,800,000 Shs
Annual Costs: 296,000 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

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	4,800,000	296,000	5,096,000	69.8	5,096,000	69.8	5,096,000	69.8
1	73000		296,000	281,905	3.9	269,091	3.7	257,391	3.5
2	73000		296,000	268,481	3.7	244,628	3.4	223,819	3.1
3	73000		296,000	255,696	3.5	222,389	3.0	194,625	2.7
4	73000		296,000	243,520	3.3	202,172	2.8	169,239	2.3
5	73000		296,000	231,924	3.2	183,793	2.5	147,164	2.0
6	73000		296,000	220,880	3.0	167,084	2.3	127,969	1.8
7	73000		296,000	210,362	2.9	151,895	2.1	111,277	1.5
8	73000		296,000	200,344	2.7	138,086	1.9	96,763	1.3
9	73000		296,000	190,804	2.6	125,533	1.7	84,142	1.2
10	73000		296,000	181,718	2.5	114,121	1.6	73,167	1.0
11	73000		296,000	173,065	2.4	103,746	1.4	63,623	0.9
12	73000		296,000	164,824	2.3	94,315	1.3	55,325	0.8
13	73000		296,000	156,975	2.2	85,741	1.2	48,108	0.7
14	73000		296,000	149,500	2.0	77,946	1.1	41,833	0.6
15	73000		296,000	142,381	2.0	70,860	1.0	36,377	0.5
16	73000		296,000	135,601	1.9	64,418	0.9	31,632	0.4
17	73000		296,000	129,144	1.8	58,562	0.8	27,506	0.4
18	73000		296,000	122,994	1.7	53,238	0.7	23,918	0.3
19	73000		296,000	117,137	1.6	48,398	0.7	20,799	0.3
20	73000		296,000	111,559	1.5	43,999	0.6	18,086	0.2
Total	1,533,000	4,800,000	6,216,000	8,784,814	120.3	7,616,015	104.3	6,948,762	95.2

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	120.3	104.3	95.2

Cost Effectiveness Analysis of Rural Supply from a Spring

Technology: Spring, Gravity Distribution, 70 m3 Storage

Capital cost: 1,281,250 Shs
Annual Costs: 97,625 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 70 m3/day * 365 = 25550 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	25550	1,281,250	97,625	1,378,875	54.0	1,378,875	54.0	1,378,875	54.0
1	25550		97,625	92,976	3.6	88,750	3.5	84,891	3.3
2	25550		97,625	88,549	3.5	80,682	3.2	73,819	2.9
3	25550		97,625	84,332	3.3	73,347	2.9	64,190	2.5
4	25550		97,625	80,316	3.1	66,679	2.6	55,817	2.2
5	25550		97,625	76,492	3.0	60,617	2.4	48,537	1.9
6	25550		97,625	72,849	2.9	55,107	2.2	42,206	1.7
7	25550		97,625	69,380	2.7	50,097	2.0	36,701	1.4
8	25550		97,625	66,076	2.6	45,543	1.8	31,914	1.2
9	25550		97,625	62,930	2.5	41,403	1.6	27,751	1.1
10	25550		97,625	59,933	2.3	37,639	1.5	24,131	0.9
11	25550		97,625	57,079	2.2	34,217	1.3	20,984	0.8
12	25550		97,625	54,361	2.1	31,106	1.2	18,247	0.7
13	25550		97,625	51,773	2.0	28,278	1.1	15,867	0.6
14	25550		97,625	49,307	1.9	25,708	1.0	13,797	0.5
15	25550		97,625	46,959	1.8	23,371	0.9	11,998	0.5
16	25550		97,625	44,723	1.8	21,246	0.8	10,433	0.4
17	25550		97,625	42,593	1.7	19,315	0.8	9,072	0.4
18	25550		97,625	40,565	1.6	17,559	0.7	7,889	0.3
19	25550		97,625	38,634	1.5	15,962	0.6	6,860	0.3
20	25550		97,625	36,794	1.4	14,511	0.6	5,965	0.2
Total	536,550	1,281,250	2,050,125	2,595,498	101.6	2,210,012	86.5	1,989,942	77.9

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	101.6	86.5	77.9

Cost Effectiveness Analysis of Rural Supply from a Spring

Technology: Spring, 35 m3 Storage

Capital cost: 293,750 Shs
Annual Costs: 29,875 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 35 m3/day * 365 = 12775 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	12775	293,750	29,875	323,625	25.3	323,625	25.3	323,625	25.3
1	12775		29,875	28,452	2.2	27,159	2.1	25,978	2.0
2	12775		29,875	27,098	2.1	24,690	1.9	22,590	1.8
3	12775		29,875	25,807	2.0	22,446	1.8	19,643	1.5
4	12775		29,875	24,578	1.9	20,405	1.6	17,081	1.3
5	12775		29,875	23,408	1.8	18,550	1.5	14,853	1.2
6	12775		29,875	22,293	1.7	16,864	1.3	12,916	1.0
7	12775		29,875	21,232	1.7	15,331	1.2	11,231	0.9
8	12775		29,875	20,221	1.6	13,937	1.1	9,766	0.8
9	12775		29,875	19,258	1.5	12,670	1.0	8,492	0.7
10	12775		29,875	18,341	1.4	11,518	0.9	7,385	0.6
11	12775		29,875	17,467	1.4	10,471	0.8	6,421	0.5
12	12775		29,875	16,636	1.3	9,519	0.7	5,584	0.4
13	12775		29,875	15,843	1.2	8,654	0.7	4,856	0.4
14	12775		29,875	15,089	1.2	7,867	0.6	4,222	0.3
15	12775		29,875	14,370	1.1	7,152	0.6	3,671	0.3
16	12775		29,875	13,686	1.1	6,502	0.5	3,193	0.2
17	12775		29,875	13,034	1.0	5,911	0.5	2,776	0.2
18	12775		29,875	12,414	1.0	5,373	0.4	2,414	0.2
19	12775		29,875	11,823	0.9	4,885	0.4	2,099	0.2
20	12775		29,875	11,260	0.9	4,441	0.3	1,825	0.1
Total	268,275	293,750	627,375	695,934	54.5	577,968	45.2	510,623	40.0

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	54.5	45.2	40.0

Cost Effectiveness Analysis of Rural Supply from a Spring

Technology: Spring

Capital cost: 25,000 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	25,000	500	25,500	7.0	25,500	7.0	25,500	7.0
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		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	25,000	10,500	31,731	8.7	29,757	8.2	28,630	7.8

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	8.7	8.2	7.8

Cost Effectiveness Analysis of Urban Supply from a Surface Water Dam

Technology: Surface Water, Dam, Distribution, 200 m3 Storage, Full Treatment

Capital cost: 12,250,000 Shs
Annual Costs: 822,500 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 500,000 for motorpumps + generators 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	12,250,000	822,500	13,072,500	179.1	13,072,500	179.1	13,072,500	179.1
1	73000		822,500	783,333	10.7	747,727	10.2	715,217	9.8
2	73000		822,500	746,032	10.2	679,752	9.3	621,928	8.5
3	73000		822,500	710,506	9.7	617,956	8.5	540,807	7.4
4	73000		822,500	676,673	9.3	561,779	7.7	470,267	6.4
5	73000		822,500	644,450	8.8	510,708	7.0	408,928	5.6
6	73000		822,500	613,762	8.4	464,280	6.4	355,589	4.9
7	73000		822,500	584,535	8.0	422,073	5.8	309,208	4.2
8	73000		822,500	556,700	7.6	383,702	5.3	268,877	3.7
9	73000		822,500	530,191	7.3	348,820	4.8	233,806	3.2
10	73000	500,000	822,500	811,900	11.1	509,881	7.0	326,902	4.5
11	73000		822,500	480,899	6.6	288,281	3.9	176,791	2.4
12	73000		822,500	457,999	6.3	262,074	3.6	153,731	2.1
13	73000		822,500	436,189	6.0	238,249	3.3	133,679	1.8
14	73000		822,500	415,418	5.7	216,590	3.0	116,243	1.6
15	73000		822,500	395,637	5.4	196,900	2.7	101,081	1.4
16	73000		822,500	376,797	5.2	179,000	2.5	87,896	1.2
17	73000		822,500	358,854	4.9	162,727	2.2	76,432	1.0
18	73000		822,500	341,766	4.7	147,934	2.0	66,462	0.9
19	73000		822,500	325,491	4.5	134,485	1.8	57,793	0.8
20	73000	500,000	822,500	498,436	6.8	196,581	2.7	80,805	1.1
Total	1,533,000	13,250,000	17,272,500	23,818,069	326.3	20,342,000	278.7	18,374,943	251.7

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	326.3	278.7	251.7

Cost Effectiveness Analysis of Urban Supply from a Surface Water Weir

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

Capital cost: 6,250,000 Shs
Annual Costs: 762,500 Shs (Maintenance + Salaries + Energy Costs + Chemicals)
Replacement Costs: 500,000 for motorpumps + generators 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	6,250,000	762,500	7,012,500	96.1	7,012,500	96.1	7,012,500	96.1
1	73000		762,500	726,190	9.9	693,182	9.5	663,043	9.1
2	73000		762,500	691,610	9.5	630,165	8.6	576,560	7.9
3	73000		762,500	658,676	9.0	572,878	7.8	501,356	6.9
4	73000		762,500	627,311	8.6	520,798	7.1	435,962	6.0
5	73000		762,500	597,439	8.2	473,453	6.5	379,097	5.2
6	73000		762,500	568,989	7.8	430,411	5.9	329,650	4.5
7	73000		762,500	541,895	7.4	391,283	5.4	286,652	3.9
8	73000		762,500	516,090	7.1	355,712	4.9	249,263	3.4
9	73000		762,500	491,514	6.7	323,374	4.4	216,750	3.0
10	73000	500,000	762,500	775,065	10.6	486,748	6.7	312,071	4.3
11	73000		762,500	445,818	6.1	267,252	3.7	163,894	2.2
12	73000		762,500	424,589	5.8	242,956	3.3	142,517	2.0
13	73000		762,500	404,370	5.5	220,869	3.0	123,928	1.7
14	73000		762,500	385,114	5.3	200,790	2.8	107,763	1.5
15	73000		762,500	366,776	5.0	182,536	2.5	93,707	1.3
16	73000		762,500	349,310	4.8	165,942	2.3	81,484	1.1
17	73000		762,500	332,676	4.6	150,857	2.1	70,856	1.0
18	73000		762,500	316,834	4.3	137,142	1.9	61,614	0.8
19	73000		762,500	301,747	4.1	124,675	1.7	53,577	0.7
20	73000	500,000	762,500	475,823	6.5	187,663	2.6	77,139	1.1
Total	1,533,000	7,250,000	16,012,500	17,010,337	233.0	13,771,186	188.6	11,939,383	163.6

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	233.0	188.6	163.6

Cost Effectiveness Analysis of Rural Supply from a Surface Water Weir

Technology: Surface Water, Weir, Gravity Distribution, 70 m3 Storage, Chlorination

Capital cost: 1,150,000 Shs
Annual Costs: 151,500 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 70 m3/day * 365 = 25550 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	25550	1,150,000	151,500	1,301,500	50.9	1,301,500	50.9	1,301,500	50.9
1	25550		151,500	144,286	5.6	137,727	5.4	131,739	5.2
2	25550		151,500	137,415	5.4	125,207	4.9	114,556	4.5
3	25550		151,500	130,871	5.1	113,824	4.5	99,614	3.9
4	25550		151,500	124,639	4.9	103,477	4.0	86,621	3.4
5	25550		151,500	118,704	4.6	94,070	3.7	75,322	2.9
6	25550		151,500	113,052	4.4	85,518	3.3	65,498	2.6
7	25550		151,500	107,668	4.2	77,743	3.0	56,954	2.2
8	25550		151,500	102,541	4.0	70,676	2.8	49,526	1.9
9	25550		151,500	97,658	3.8	64,251	2.5	43,066	1.7
10	25550		151,500	93,008	3.6	58,410	2.3	37,448	1.5
11	25550		151,500	88,579	3.5	53,100	2.1	32,564	1.3
12	25550		151,500	84,361	3.3	48,273	1.9	28,316	1.1
13	25550		151,500	80,344	3.1	43,884	1.7	24,623	1.0
14	25550		151,500	76,518	3.0	39,895	1.6	21,411	0.8
15	25550		151,500	72,874	2.9	36,268	1.4	18,619	0.7
16	25550		151,500	69,404	2.7	32,971	1.3	16,190	0.6
17	25550		151,500	66,099	2.6	29,973	1.2	14,078	0.6
18	25550		151,500	62,951	2.5	27,249	1.1	12,242	0.5
19	25550		151,500	59,954	2.3	24,771	1.0	10,645	0.4
20	25550		151,500	57,099	2.2	22,520	0.9	9,257	0.4
Total	536,550	1,150,000	3,181,500	3,189,525	124.8	2,591,305	101.4	2,249,789	88.1

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	124.8	101.4	88.1

Cost Effectiveness Analysis of Rural Supply from a Surface Water Weir

Technology: Surface Water, Weir, Gravity Distribution, 35 m3 Storage, Chlorination

Capital cost: 487,500 Shs
Annual Costs: 74,875 Shs (Maintenance + Salaries + Chemicals)
Replacement Costs: None

Annual Yield: 35 m3/day * 365 = 12775 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	12775	487,500	74,875	562,375	44.0	562,375	44.0	562,375	44.0
1	12775		74,875	71,310	5.6	68,068	5.3	65,109	5.1
2	12775		74,875	67,914	5.3	61,880	4.8	56,616	4.4
3	12775		74,875	64,680	5.1	56,255	4.4	49,232	3.9
4	12775		74,875	61,600	4.8	51,141	4.0	42,810	3.4
5	12775		74,875	58,667	4.6	46,491	3.6	37,226	2.9
6	12775		74,875	55,873	4.4	42,265	3.3	32,371	2.5
7	12775		74,875	53,212	4.2	38,423	3.0	28,148	2.2
8	12775		74,875	50,678	4.0	34,930	2.7	24,477	1.9
9	12775		74,875	48,265	3.8	31,754	2.5	21,284	1.7
10	12775		74,875	45,967	3.6	28,868	2.3	18,508	1.4
11	12775		74,875	43,778	3.4	26,243	2.1	16,094	1.3
12	12775		74,875	41,693	3.3	23,857	1.9	13,995	1.1
13	12775		74,875	39,708	3.1	21,689	1.7	12,169	1.0
14	12775		74,875	37,817	3.0	19,717	1.5	10,582	0.8
15	12775		74,875	36,016	2.8	17,924	1.4	9,202	0.7
16	12775		74,875	34,301	2.7	16,295	1.3	8,001	0.6
17	12775		74,875	32,668	2.6	14,814	1.2	6,958	0.5
18	12775		74,875	31,112	2.4	13,467	1.1	6,050	0.5
19	12775		74,875	29,631	2.3	12,243	1.0	5,261	0.4
20	12775		74,875	28,220	2.2	11,130	0.9	4,575	0.4
Total	268,275	487,500	1,572,375	1,495,483	117.1	1,199,828	93.9	1,031,042	80.7

	DISCOUNT RATE 5 %	10 %	15 %
Total Cost (Shs/m3)	117.1	93.9	80.7

Cost Effectiveness Analysis of Livestock Supply from a Dam

Technology: Dam (25000 m3) with Handpump and Trough

Capital cost: 2,062,500 Shs
Annual Costs: 127,125 Shs (Maintenance + Salaries)
Replacement Costs: Handpump every 6 years

Annual Yield: 50 m3/day * 365 = 18250 m3/year

				Discount Rate					
	Annual	Capital	Annual	5 %		10 %		15 %	
Year	Yield (m3)	Costs (Shs)	Costs (Shs)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)	Costs (Shs)	Cost/yr (Shs/m3)
0	18250	2,062,500	127,125	2,189,625	120.0	2,189,625	120.0	2,189,625	120.0
1	18250		127,125	121,071	6.6	115,568	6.3	110,543	6.1
2	18250		127,125	115,306	6.3	105,062	5.8	96,125	5.3
3	18250		127,125	109,815	6.0	95,511	5.2	83,587	4.6
4	18250		127,125	104,586	5.7	86,828	4.8	72,684	4.0
5	18250		127,125	99,606	5.5	78,935	4.3	63,204	3.5
6	18250	25,000	127,125	113,518	6.2	85,871	4.7	65,768	3.6
7	18250		127,125	90,345	5.0	65,235	3.6	47,791	2.6
8	18250		127,125	86,043	4.7	59,305	3.2	41,557	2.3
9	18250		127,125	81,946	4.5	53,913	3.0	36,137	2.0
10	18250		127,125	78,044	4.3	49,012	2.7	31,423	1.7
11	18250		127,125	74,327	4.1	44,557	2.4	27,325	1.5
12	18250	25,000	127,125	84,709	4.6	48,472	2.7	28,433	1.6
13	18250		127,125	67,417	3.7	36,824	2.0	20,661	1.1
14	18250		127,125	64,207	3.5	33,476	1.8	17,966	1.0
15	18250		127,125	61,149	3.4	30,433	1.7	15,623	0.9
16	18250		127,125	58,237	3.2	27,666	1.5	13,585	0.7
17	18250		127,125	55,464	3.0	25,151	1.4	11,813	0.6
18	18250	25,000	127,125	63,211	3.5	27,361	1.5	12,292	0.7
19	18250		127,125	50,308	2.8	20,786	1.1	8,932	0.5
20	18250		127,125	47,912	2.6	18,896	1.0	7,767	0.4
Total	383,250	2,137,500	2,669,625	3,816,848	209.1	3,298,486	180.7	3,002,844	164.5

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	209.1	180.7	164.5

Cost Effectiveness Analysis of Livestock Supply from a Pan

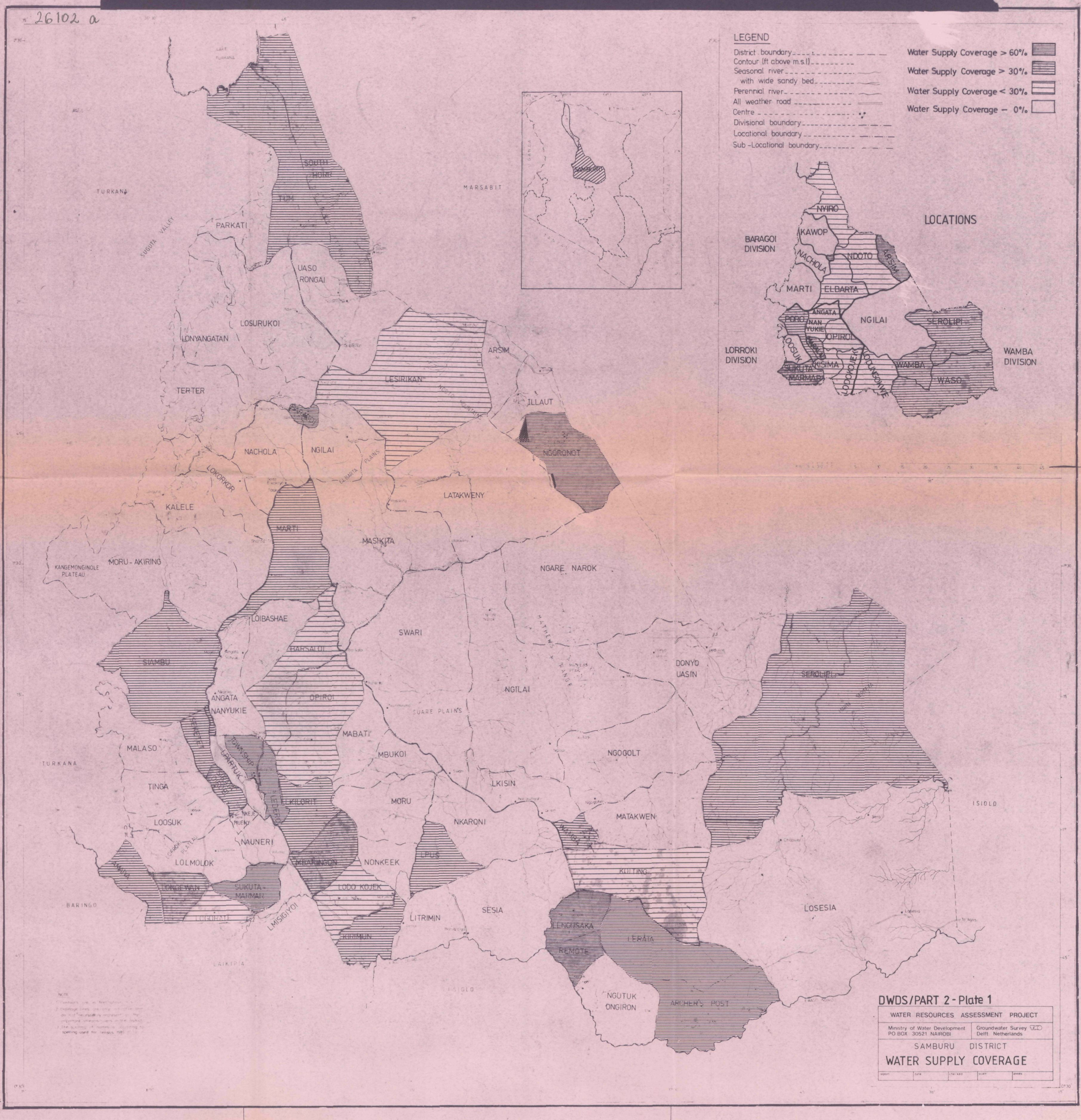
Technology: Pan (5000 m3, 6 months with water)

Capital cost: 312,500 Shs
Annual Costs: 27,625 Shs (Maintenance + Salaries)
Replacement Costs: None

Annual Yield: 25 m3/day * 180 = 4500 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	4500	312,500	27,625	340,125	75.6	340,125	75.6	340,125	75.6
1	4500		27,625	26,310	5.8	25,114	5.6	24,022	5.3
2	4500		27,625	25,057	5.6	22,831	5.1	20,888	4.6
3	4500		27,625	23,864	5.3	20,755	4.6	18,164	4.0
4	4500		27,625	22,727	5.1	18,868	4.2	15,795	3.5
5	4500		27,625	21,645	4.8	17,153	3.8	13,735	3.1
6	4500		27,625	20,614	4.6	15,594	3.5	11,943	2.7
7	4500		27,625	19,633	4.4	14,176	3.2	10,385	2.3
8	4500		27,625	18,698	4.2	12,887	2.9	9,031	2.0
9	4500		27,625	17,807	4.0	11,716	2.6	7,853	1.7
10	4500		27,625	16,959	3.8	10,651	2.4	6,828	1.5
11	4500		27,625	16,152	3.6	9,682	2.2	5,938	1.3
12	4500		27,625	15,383	3.4	8,802	2.0	5,163	1.1
13	4500		27,625	14,650	3.3	8,002	1.8	4,490	1.0
14	4500		27,625	13,953	3.1	7,275	1.6	3,904	0.9
15	4500		27,625	13,288	3.0	6,613	1.5	3,395	0.8
16	4500		27,625	12,655	2.8	6,012	1.3	2,952	0.7
17	4500		27,625	12,053	2.7	5,465	1.2	2,567	0.6
18	4500		27,625	11,479	2.6	4,969	1.1	2,232	0.5
19	4500		27,625	10,932	2.4	4,517	1.0	1,941	0.4
20	4500		27,625	10,412	2.3	4,106	0.9	1,688	0.4
Total	94,500	312,500	580,125	684,394	152.1	575,312	127.8	513,039	114.0

	DISCOUNT RATE		
	5 %	10 %	15 %
Total Cost (Shs/m3)	152.1	127.8	114.0


26102 a
LEGEND
District boundary
Contour (ft above m.s.l.)
Seasonal river
with wide sandy bed
Perennial river
All weather road
Centre
Divisional boundary
Locational boundary
Sub-Locational boundary
Water Supply Coverage > 60%
Water Supply Coverage > 30%
Water Supply Coverage < 30%
Water Supply Coverage – 0%
LOCATIONS
NYIRO
KAWOP
NACHOLA
NDOTO
ARSIM
MARTI
ELBARTA
ANGATA NANYUKIE
PORO
OPIROI
NGILAI
SEROLIPI
LOOSUK
KISIMA
SUKUTA MARMAR
LODOKEJEK
LODUNGOKWE
WAMBA
WASO
BARAGOI DIVISION
LORROKI DIVISION
WAMBA DIVISION
TURKANA
MARSABIT
SOUTH HORR
TUM
PARKATI
UASO RONGAI
LOSURUKOI
LONYANGATAN
ARSIM
LESIRIKAN
TERTER
ILLAUT
NGORONOT
NACHOLA
NGILAI
LOKORKOR
LATAKWENY
KALELE
MARTI
MASIKITA
KANGEMONGINOLE PLATEAU
MORU-AKIRING
NGARE NAROK
LOIBASHAE
SWARI
BARSALOI
SIAMBU
DONYO UASIN
SEROLIPI
OPIROI
NGILAI
ANGATA NANYUKIE
SUARE PLAINS
MABATI
MALASO
MBUKOI
NGOGOLT
TURKANA
TINGA
LKISIN
LKILORIT
MORU
ISIOLO
LOOSUK
NKARONI
MATAKWEN
NAUNERI
LOLMOLOK
NONKEEK
LPUS
KOITING
SUKUTA-MARMAR
LODO KOJEK
BARINGO
LMISIGIYOI
LITRIMIN
SESIA
LOSESIA
KIRIMUN
LERATA
REMOTE
NGUTUK ONGIRON
ARCHER'S POST
LAIKIPIA
ISIOLO
DWDS/PART 2 - Plate 1
WATER RESOURCES ASSESSMENT PROJECT
Ministry of Water Development
PO BOX 30521 NAIROBI
Groundwater Survey
Delft Netherlands
SAMBURU DISTRICT
WATER SUPPLY COVERAGE