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Swiss Centre for Development Cooperation in Technology and Management

Choice of Technology

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I. Introduction

If rural water supply and sanitation facilities are to become sustainable it is essential that the users have a voice in the decision-making processes of their projects. Top-down planning needs to be replaced by bottom-up planning. The village communities are to be involved the in the planning of their facilities, they have to participate in the choice of technology and they need to be given both the capability and the responsibility for the operation and maintenance of their water points. In a demand driven programme, individual communities decide whether they want to participate in the water and sanitation programme or not. They then decide the type of water supply and sanitation system that they want, *can afford*, and *can maintain*. Easily understood information materials on the different options (point sources or piped systems) must be available. The information has to include typical drawings and the cost (capital and recurrent).

This all might not be of such importance in the case of emergency situations, where the fast and efficient provision of services is a more important consideration than sustainability. However, where and when ever possible, it should be encouraged to apply the principles of joint decision making with the communities.

In theory the final choice of technology would rest with the communities themselves, since they are responsible for the management of their water supply system. The community's choice of technology is normally guided by their own sense of need and by the affordability of their share of the cost for the implementation. Furthermore they have to take into consideration the cost for operation, maintenance and major repairs or replacements that they have to be able to afford, and the reliability of the system. The communities depend on reliable advice and assistance given to them to arrive at a sensible choice.

Even though theoretically a great variety of systems can be put together with the various system components, the options a community may have are usually limited in number due to the hydrogeological conditions, project execution policies and governments decisions to standardise on one or a few technologies only. The effects and benefits of standardisation (familiarity, availability of spare parts, back-up through

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trained mechanics) by far outweigh other considerations. The project planners and decision-makers should always be aware that their selection of technology should be fitting into the prevailing circumstances. A familiar, known technology that is supported by the relevant after sales services might be the better choice than an optimal technology.

Whenever the geological conditions allow it, professionally constructed hand dug wells or hand drilled borehole that remain operational in the dry season are in many instances the lowest cost option for the small rural communities. However, in many areas the hydrogeological conditions would not allow digging of wells at acceptable cost, and the more expensive borehole drilling will be necessary. The hand dug wells and machine drilled boreholes can be fitted with a variety of water lifting devices, some of which are mentioned below. *The linkage between the water source (borehole/well) and the pumping device* is often a determining factor for the success of an installation.

There are also other water sources, such as spring catchment or in some cases rainwater harvesting.

2. *Technology components*

For the sake of simplicity the small rural water supply systems briefly described in this booklet were limited to the major technologies available. The major options are described in form of packages consisting of system components. For instance, a simple hand dug well fitted with a handpump would consist of two components, the dug well with either in situ lining or cement block lining and a shallow well handpump. A pipeborne system is more sophisticated and may consist of the following main components: drilled borehole with 150 mm diameter, an electric submersible pump with associated switchgear, a diesel generator unit, a small power house for the diesel generator unit, an elevated storage tank and the pipe transmission and distribution system.

Beside the standard systems there may also be hybrid systems, as for instance diesel/solarpump systems or mechanised wells, supplemented by handpump equipped hand dug or machine drilled wells. In some instances hybrid systems may develop during the implementation of a facility, as the yield expectations may not be fulfilled.

Each typical component is shown on a component sheet in Annex 2.

There are two major groundwater sources:

- hand dug wells with an approximate diameter of 1.2 meters
- machine drilled boreholes with internal diameters of 100 mm, 126 mm and 150 mm. The internal diameter of the boreholes will depend upon the well yield and the technology option.

Handpumps to choose from are:

- Suction Pumps for very shallow installations of less than 7 metres (No 6 pump)
- Direct action pump for shallow installations of up to 15 meters (Malda, Nira)
- Deep well pumps for installations between 10 and 45 meters (India MkII, Afridev, Vergnet, etc.)

As for mechanised wells, there are basically three options, all of them powering small submersible electric centrifugal pumps. They may be driven by electricity from either:

- the national grid,
- a small diesel generator or
- a photovoltaic system.

3. *Typical Cost for Small Water Supply Systems*

The estimated cost for the above technologies were calculated to serve as general guidelines. It should, however, be stressed that these calculations are based on the situation in West Africa. They are averages only and may change substantially from country to country and region to region. Price levels are lower in East Africa and much lower in Asia. However the relations still remain valid.

When pricing the system components and analysing the costs, one arrives at a typical range of cost per capita or cost per unit water for standard assumptions. Some of the major parameters are mentioned below. Since the number of parameters is quite substantial, even with small pipeborne plants, the least cost option may differ from community to community. An exact analysis can only then be made, when the actual data from a community are known.

Important parameters are:

- Cost of boreholes;
- settlement pattern of the community;
- location of the well site;
- well yield;
- cost of labour, fuel and electricity;
- cost of major machinery, especially solar panels, etc.

For each standardised system the typical investment cost and the annual cost has been calculated, based on average population figures, population densities and a daily demand listed below.

The main default parameters are as follows:

Contingencies on capita investment		10%
Overhead on capita investment		50%
Rate of interest for capital amortisation		10%
Water demand:		
❖ for bucket with rope and handpumps	lpcd	15
❖ for pipeborne systems	lpcd	20
Population density in core area	cap/ha	60-70
Population density in total area	cap/ha	15-18
Distance of pump site to village	m	500
Distance of pump site to the grid	m	500
Pumping head for deep well handpumps	m	15-20
Pumping head for mechanised systems	m	35
Solar system sizes	Wp	900 and 1,600
Factor panel size/energy	Wp/m^4/day	1.7-1.8
Cost for diesel fuel	($/litre	0.50
Cost for electricity	($/kWh	0.10

The assumptions include several simplifications, which do, however, not have a great impact on the overall outcome of this estimation.

The below table shows the estimated cost of various options:

Type of Technology	Design Criteria (Persons)	Investment Cost (US$)	Cost per Capita (US$)	Annual Cost (US$)	Running Cost (US$)	Cost /m3 (US$)	Running Cost/m3 (US$)
Dug Well	150	1,650	11	286	50	0.35	0.06
Dug well with Direct Action Pump	200	2,700	14	536	125	0.49	0.11
Borehole with Handpump	300	13,500	45	2,112	224	1.29	0.14
Borehole with Electric Pump	2,400	84,000	35	11,120	1,960	0.63	0.11
Borehole with Dieselpump	2,400	68,000	28	13,760	3,900	0.79	0.22
Borehole with Solarpump	2,400	72,000	30	11,040	1,435	0.76	0.1

The options can be summarised as follows:

3.1 Hand Dug Wells,

If equipped with bucket and rope as lifting device, this technology offers the lowest investment per capita ($11/cap) and also the lowest annual unit cost for the community size from 100 to 5000 inhabitants. However, this technology provides only basic service and the wells may easily get polluted. The annual cost would be about $0.35 per m^3 of water and $1.89 per capita (including depreciation cost). If fitted with a reliable and easily maintainable direct action handpump the danger of polluting the well would be reduced. This technology is also very low in capital investment ($14/cap) and in annual unit cost ($0.49 per m^3 water and $2.66/cap, including depreciation cost). High yielding dug wells of sufficient depth to prevent drying up during the dry season could even further reduce the above estimated cost, as they could be equipped with floating solarpumps (as used for irrigation) or above ground centrifugal pumps, if the water table allows it.

3.2 Boreholes Ø100 mm and Ø126 mm with Handpump,

If the test during the drilling works indicate that the well yield will just be enough for a handpump, say about 1 m^3/h, then the well may be fitted with only Ø 100 filters and well casings. Shallow conditions requiring handpump installation depths of not more than 16.5 meters would be equipped with a reliable direct action handpump which is lower in cost and easier to maintain than deep well handpumps. Higher pump lifts require deep well handpumps. Typical investment cost is $40-$50 for this technology. The annual cost per m^3 water would be in the range of $1.20-$1.40, and the cost per capita would be $6.65-$8.00 (including depreciation cost). Depending upon the well yield, the necessary drilling depth, the dynamic water table, the handpump efficiency and the size of the community, the cost could vary substantially. Generally, the cost is about 3 times higher than the ones for hand dug wells. Machine drilling should consequently only employed when there is no chance to construct a reliable hand dug well. The Ø126 mm boreholes are only about 5% more expensive than Ø 100 mm boreholes. The somewhat larger internal well diameter offers

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several technical advantages, such as possibility of future mechanisation, ease of handpump installation, less operating problems if the borehole is not perfectly straight as well as use of more effective well rehabilitation methods, if required and ease of well testing with a standard 4 inch submersible electric pump. Also, two Vergnet pumps may be fitted to such a well. Whenever possible the wells should be cased with Ø 126 mm pipes rather than Ø 100 mm pipes.

3.3 *Mechanised Boreholes Ø 126 mm and Ø 150 mm,*

The costs in the above table indicate that under the standard assumptions this technology would be attractive, if the communities are exceeding about 1,000-1,200 inhabitants. With few exceptions, the major technologies are systems employing a submersible electric pump powered by either the national grid, a diesel-generating unit or by photovoltaic panels.

3.3.1 Submersible Pump Powered by Grid

If there is a reliable power supply from the grid to the community, and the community has a population of about 2,400 an investment of $35 per capita and annual cost of $0.63 per m³ of water respectively $8.30 per capita (including depreciation cost) can be expected. This is basically in the same range as the boreholes equipped with handpumps. For larger communities the cost will decrease, being about 70%for communities with 4,800 inhabitants. Long distances from grid to the pump site and the village to the pump site, in conjunction with a low population density can double these costs. Under such unfavourable conditions handpumps would even be lower in costs for the larger communities, respectively a diesel generator or solarpump systems may better be chosen. Higher pumping heads would, however, hardly effect the costs, as the additional energy cost is reasonable. Such a system would, therefore, have its advantages when high lifts have to be pumped. If two wells had to drilled because the first well did not yield enough water for a large community of 4,800 would result in additional investment and annual cost of about 10%.

3.3.2 Submersible Pump Powered by a Diesel Generating Unit

The investment cost for the community with 1,200 inhabitants would be almost identical with the cost for the systems with mains supply ($30 per capita), the extra cost for the diesel generator being greatly offset by the cost for the power line. However, the annual cost would be about 20%-25% higher for the system with the diesel generator, as the power from the grid is lower in cost than the one from the diesel generator. This applies for the population range up to 5,000 inhabitants. Naturally the diesel generator requires increased servicing and maintenance and may require a full-time operator. There would be a slight decrease in annual cost if pumping time could be shortened with a high yield well and pump, provided no extra costs would arise from a larger diameter transmission main. Diesel generator systems have the advantage that they are independent from a grid, which may be far away from the well site, or may supply a low quality of electricity respectively no power.

3.3.3 Submersible Pump Powered by a Photovoltaic Solarpump System

Small solarpump systems for communities with only 600 inhabitants may be only cost-effective at a low head and when pumping directly into small ground level reservoir. The results confirm former calculations that solarpumps have a high potential for communities between about 1000 and 2000 inhabitants, especially in the lower pumping head range. At present the standardised small solar systems with up to about 1,600 Wp panel size are of interest, because of their acceptable cost and proven reliability. Photovoltaic solar panels are still quite expensive, which results in high energy costs. In addition, the standardised systems are still rather small in capacity so that larger communities would need more than one solarpump with extra wells/boreholes. Once larger units are available (this refers mainly to the availability of reliable and low-cost inverters) and the panels have become cheaper, the cost will also go down.

When pumping against a head of 35 meters the 1,600 Wp plant would give an output of about 25 m^3/day, supplying 1,200 people, and when pumping against only 20 meters total head about 45 m^3/day, supplying 2,000 people, can be expected at a daily irradiation of 4.5-5.0 kwh/m^2/day. The lower pumping head would decrease the investment cost from $60-75 to $30 per capita and the annual cost from $8.50 to $6.00 (including depreciation cost). per capita. While small pipeborne systems that get power from the mains supply or from a small diesel-generating unit are hardly effected by the higher power consumption, solarpump systems are rather sensitive to the power requirements. For the default community with 1,200 inhabitants the solarpump option would be lower in annual cost than the diesel generator system and the handpumps; it would even compete heavily with the grid system.

There are some solarpump systems running with little or no problems.

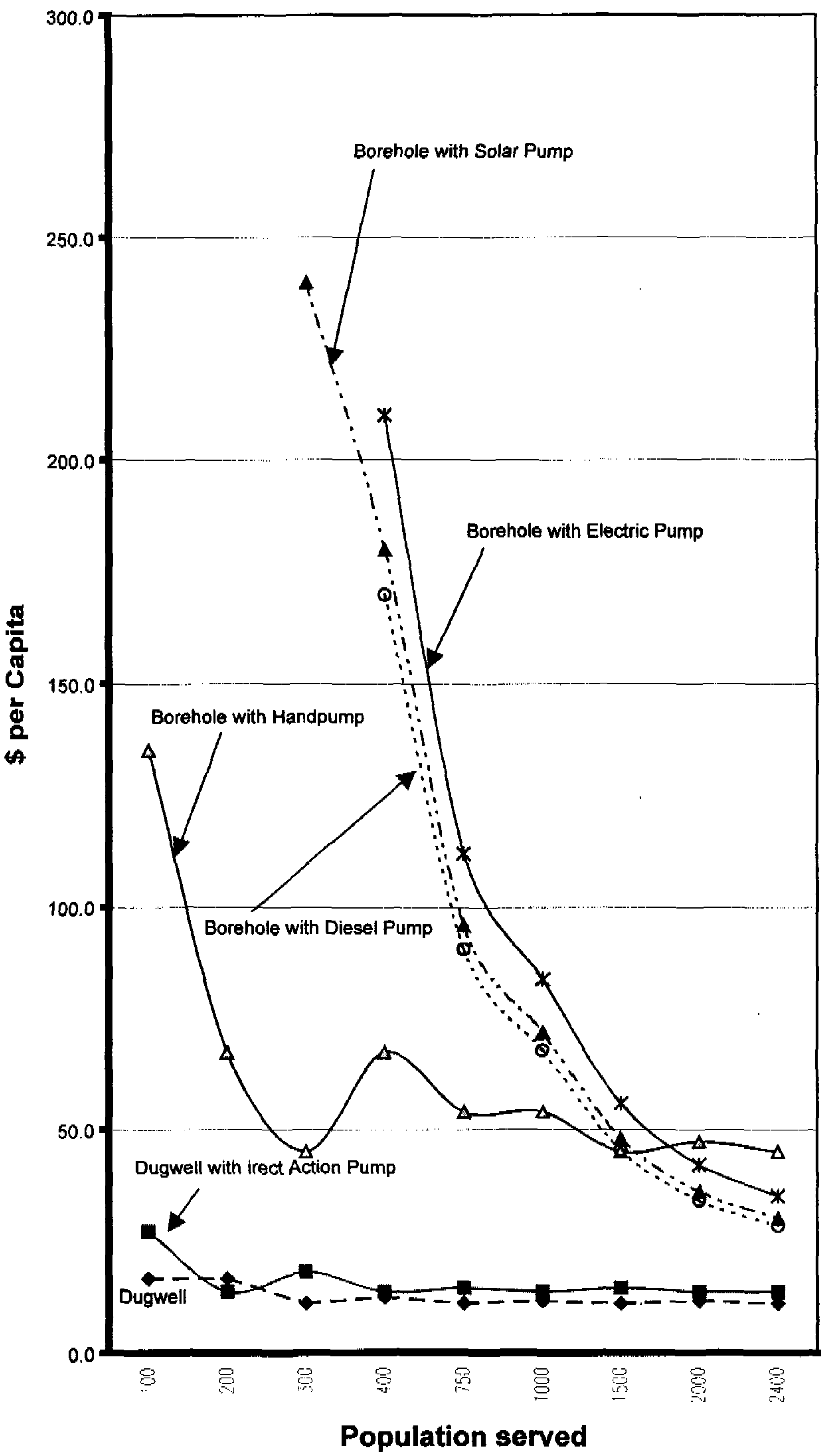
3.3.4 Recapitulation

The main cost indicators, investment per capita, and the annual running cost per capita have been compiled in the graphs in figures 1, 2. They are based on the above default data. Professionally constructed hand dug wells with hand pumps which do provide a safe water supply all year round, equipped with simple but reliable and easily maintainable direct action handpumps present the lowest cost option in investment cost and annual unit cost. They overcome the drawback of bucket and rope lifting devices, which provide a constant danger of pollution. If the wells provide safe high yields also in the dry season, they could be mechanised in the larger communities.

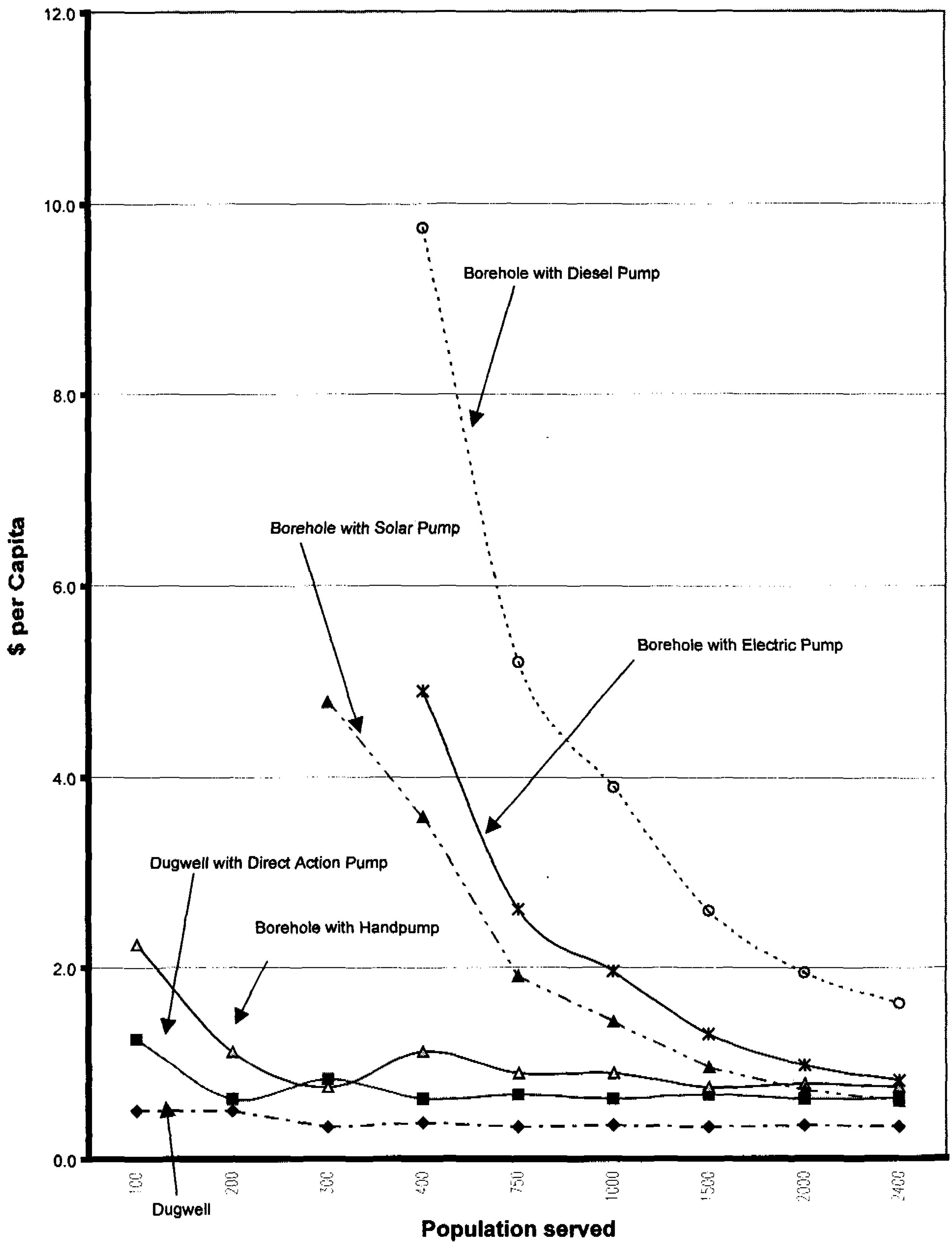
If wells cannot be dug by hand because of adverse hydrogeological conditions, boreholes have to be drilled with a drill rig. Generally, for small communities up to about 1,000 inhabitants good quality boreholes with preferably internal Ø 126 mm casings, and equipped with reliable and robust handpumps which can be easily maintained by the users or a village mechanic, present the most cost effective choice.

For larger communities between 2000 and 5000 inhabitants small pipeborne systems with submersible pumps powered by electricity from the grid or a diesel generator will be lower in cost than handpumps, since only one or two high yield wells will be required. Naturally, this holds only if borehole yields are sufficient. In the size range of 1000-2000 inhabitants there are basically all standard configurations possible. In this range pipeborne systems with solarpumps are attractive, especially if the pumping lifts are low. Contrary to grid or diesel generator powered systems, solarpump systems are sensitive to energy consumption, as long as the photovoltaic panels are not getting cheaper and the standard solarpump sizes are limited in number.

Investment Cost per Capita



Running Cost per Capita



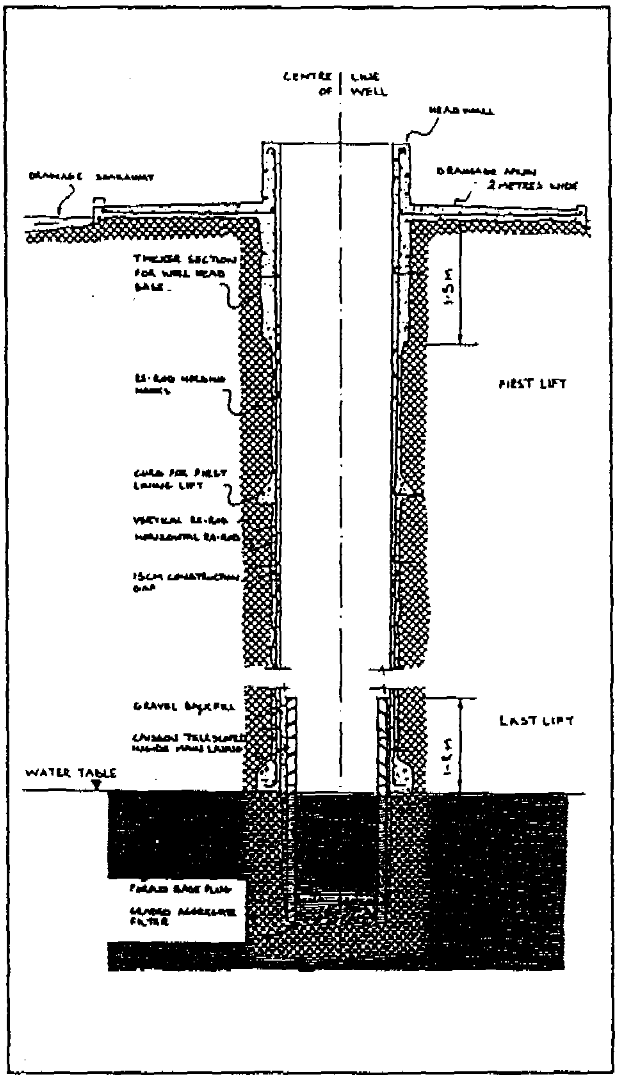
TECHNOLOGY OPTIONS COMPONENT

Hand Dug Well, in situ lining

Description: Hand dug wells are constructed with simple tools in weathered rock, overburden or sedimentary formations. The well is lined down to the aquifer with in situ cast concrete. The penetration in the water bearing zone is done with caisson rings. This allows further deepening in case the water table falls. Production is done with community participation for the digging and the construction work. An alternative design employs cement block lining instead of in situ cast concrete. The latter design is, however, unsuitable for loose soil conditions.

Technical data:

Well diameter (mm):	1300
Outside diameter (mm):	1500
Caisson outside dia. (mm):	1100
Caisson inside dia. (mm):	900
Average depth of well (m):	10-15
Average SWL (m):	7
Average caisson in aquifer (m):	2.5
Height of well head (m):	0.6
Apron diameter (m):	4.5
Assumed yield (m^3/h):	0.5
Service population (nos.):	150
Households (nos.):	15



Water lifting devices: Bucket and rope
Windlass
Direct action pump

Remarks:

- Hand dug wells provide a minimum service level with bucket and rope
- The well head provides a protection but water can get polluted
- Risk of drying up during dry season
- Construction is difficult in loose soil condition or in hard rock
- Maximum depth is approx. 20 m

Maintenance:

If the well is properly constructed and is not damaged by overpumping or by scraping away the gravel with the bucket, only occasional cleaning with disinfection will be required. The pad needs cleaning and may need repairs.

Estimated well construction cost ($):

- 8 m deep:	820
- 12 m deep:	1,160
- 16 m deep:	1,510
Annual well and pad maintenance:	30

TECHNOLOGY OPTIONS COMPONENT

Machine Drilled Borehole 100/126/150 mm

Description: Borehole depths vary from about 25 meters in basement formations to about 80 meters, in exceptional cases up to 200 meters, in sedimentary formations. Well siting might require geophysics. Most drilling is done in the overburden and in weathered, fractured rock. Rotary rigs are used for drilling. Slotted screens are installed at the level of the aquifer. The wells are lined with uPVC pipes. A concrete well pad is constructed for the hand pump. Production gives little opportunity for community participation.

Technical data:

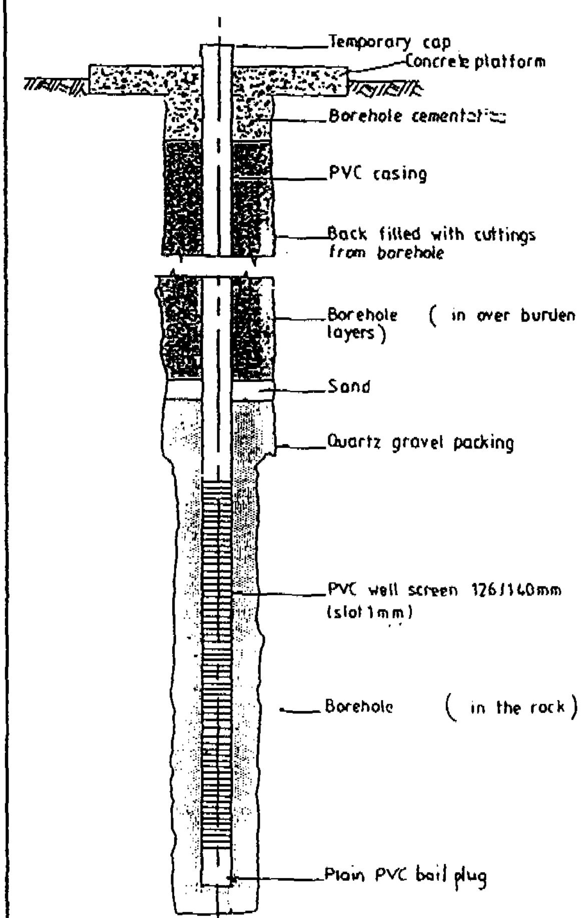
Borehole ID (mm):	100
	126
	150
Average depth of well (m):	45
Average SWL (m):	10
Average DWL (m):	15*)
Yield range (m^3/h):	1-20
Service population (nos.):	300*)
Households (nos.):	30*)

Water lifting devices: Deep well handpump
Direct action pump
Submersible pump

*) for mechanized machine drilled wells the data will usually differ

Remarks:

- 100 mm borehole can only be fitted with handpumps.
- 126 mm borehole can be fitted with two Vergnet handpumps
- 126 and 150 mm boreholes ease well redevelopment and handpump installation
- High yielding 126 and 150 mm drilled wells allow mechanization with small submersible electric pumps
- The borehole provides a good protection against pollution
- Drilling is nearly everywhere possible in Ghana with a success rate of 70%-80% with yields of 1-2 m^3/h for handpumps



Maintenance:

Depending on the geological formations the borehole will require maintenance about once in ten years, when it will be cleaned and redeveloped, with subsequent well testing. The well pad has to be kept clean and may require occasional repairs.

Estimated borehole drilling costs ($):

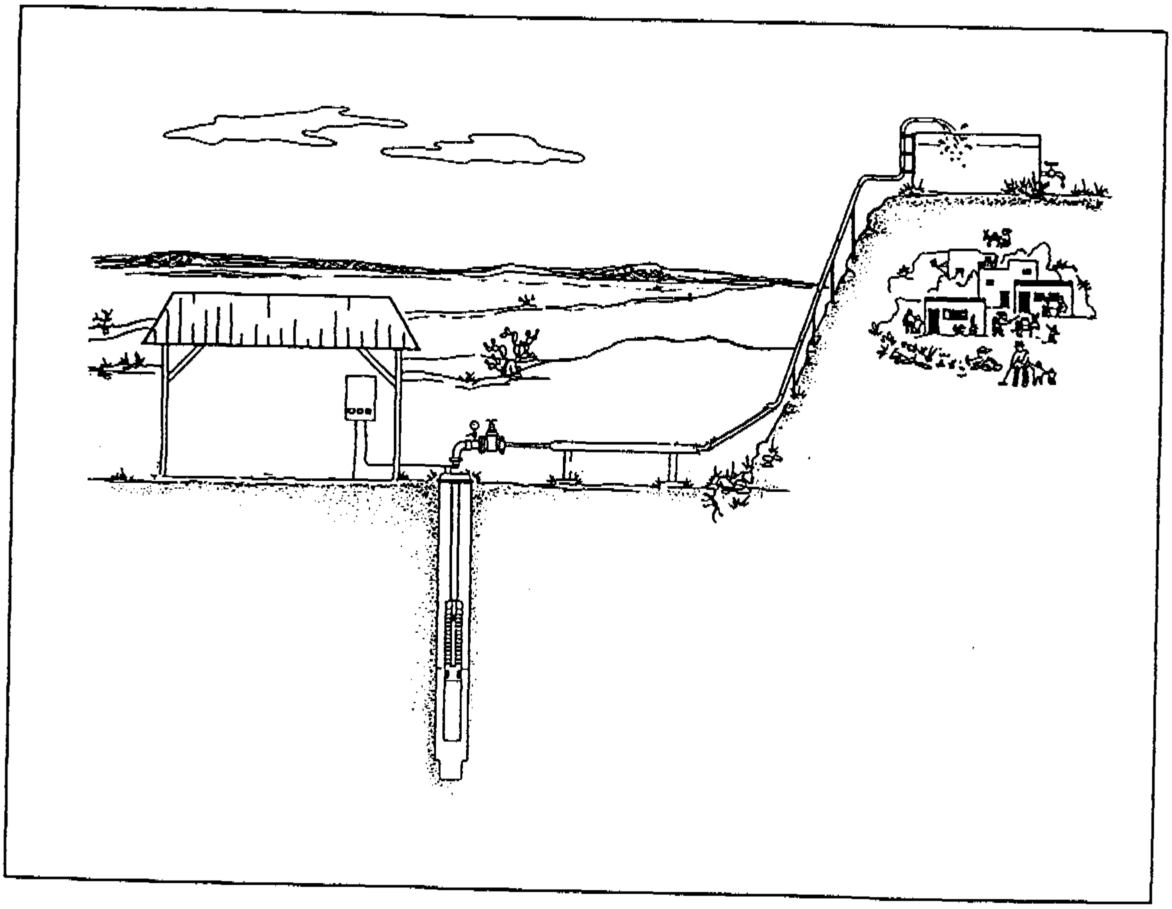
- ID 100 mm, 45 m deep: 10,400; each additional meter $ 90
- ID 126 mm, 45 m deep: 11,000; each additional meter $ 100
- ID 150 mm, 45 m deep: 12,600; each additional meter $ 120

Borehole rehabilitation: 750, including well testing (once in ten years)

TECHNOLOGY OPTIONS COMPONENT

Electric Submersible Pump - Mains

Description: Where extensions from the national power grid reach the villages this system is favorable for medium and large communities, provided no long extra power lines have to be laid to the pump site. This technology is well proven and there are no limitations in pump size for the small plants up to 5000 inhabitants; the pump flow is limited by the internal borehole diameter. The capital cost for submersible electric pumps are moderate. The present tariff system makes the use of electricity attractive. A water storage tank is required to balance the hourly fluctuations in demand.



Technical data:

Pump/motor diameter (m):	140
Pumping head (m):	5-300
Discharge (m^3/h):	1-25
Power input (kw):	0.55-18.5
Water tank (% of Qd):	30-40
Water consumption (lpcd):	20-25
Population served (nos.):	1000-5000
Households (nos.):	100-500

Maintenance and remarks:

- Submersible electric pumps can operate with little maintenance
- The distribution network to the standpipes allows for community participation during construction
- Voltage fluctuation in the grid can cause operating problems, or may even make operation impossible

Typical cost for system components, excluding contingencies and overheads:

WATER SOURCES	Unit	$/Unit
Hand dug well, 1.2 m diameter, 16 m deep	LS	1,500.00
Drilled well, 150 mm diameter, 45 m deep	LS	12,600.00
DISTRIBUTION SYSTEMS		
Siting and Design	LS	4,000.00
Elevated (5 m) tank complete - 18 cu.m	LS	11,000.00
Elevated (5 m) tank complete - 25 cu.m	LS	12,000.00
Elevated (5 m) tank complete - 35 cu.m	LS	14,500.00
Groundlevel tank 18 cu.m	LS	7,500.00
Groundlevel tank 25 cu.m	LS	8,500.00
Groundlevel tank 35 cu.m	LS	10,000.00
Distribution pipes and fittings		
50mm PVC class C	m	4.50
80mm PVC class C	m	6.00
100mm PVC class C	m	8.00
Standpipes	unit	450.00
WATER LIFTING SYSTEMS		0.00
Submersible pump set	LS	2,300.00
LT extension of power grid '	m	20.00

Default values for the below estimated cost:

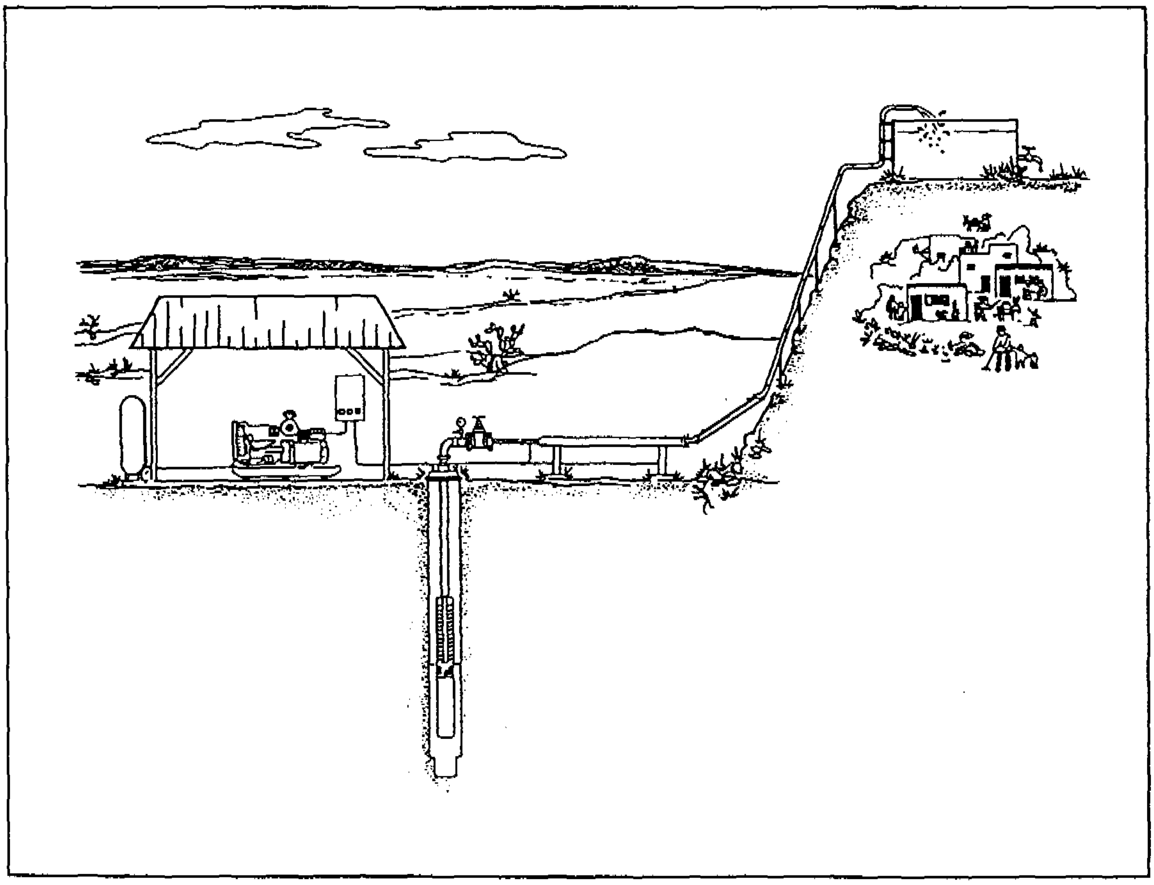
Daily water consumption (lpcd):	20
Distance of pump site to the village (m):	500
Distance of the pump site to the grid (m):	500
Unit cost for electricity ($/kwh):	0.10
Total pumping head (m):	35
Reservoir type:	Elevated
Minimum well yield/pump capacity (m^3/h):	6
Population density in core area/total area (n/ha):	60/15

Typical system cost, including 10% contingencies and 50% overheads:

Size of community (nos.)	Total investment in $	Annual cost in $/CAP
1,200	85,200	10.30
2,400	94,100	5.8
3,600	110,600	4.6
4,800	138,000	4.3

TECHNOLOGY OPTIONS COMPONENT
Diesel Generator Driven Submersible Pump

Description: Small diesel engines coupled to a generator are driving a submersible pump. Capital cost for diesel engine, generator and electric pumps are acceptable. The present fuel price makes this option less attractive. The diesel engine requires intensive maintenance and spare parts. A water storage tank is required to ensure water supply during the period when the engine is not operating.



Technical data:

Pump/motor diameter (mm):	140
Pumping head (m):	5-300
Discharge (m^3/h):	1-25
Power input (kw):	0.55-18.5
Water tank (% of Qd):	30-40
Water consumption (lpcd):	20-25
Population served (nos.):	1000-5000
Households (nos.):	100-500

Maintenance and remarks:

- Diesel-generator driven submersible pumps require an operator to be on attendance when in use
- They need constant maintenance and the spare part supply needs to be ensured
- Fuel supplies need to be organized
- The systems are independent of any voltage fluctuations from the grid
- The distribution network to the standpipes allows for community participation during construction

Typical cost for system components, excluding contingencies and overheads:

WATER SOURCES	Unit	$/Unit
Hand dug well, 1.2 m diameter, 16 m deep	LS	1,500.00
Drilled well, 150 mm diameter, 45 m deep	LS	12,600.00
DISTRIBUTION SYSTEMS		
Siting and Design	LS	4,000.00
Elevated (5 m) tank complete - 18 cu.m	LS	11,000.00
Elevated (5 m) tank complete - 25 cu.m	LS	12,000.00
Elevated (5 m) tank complete - 35 cu.m	LS	14,500.00
Groundlevel tank 18 cu.m	LS	7,500.00
Groundlevel tank 25 cu.m	LS	8,500.00
Groundlevel tank 35 cu.m	LS	10,000.00
Distribution pipes and fittings		
50mm PVC class C	m	4.50
80mm PVC class C	m	6.00
100mm PVC class C	m	8.00
Standpipes	unit	450.00
WATER LIFTING SYSTEMS		0.00
Diesel generator	LS	6,800.00
Generator house	LS	2,400.00
Submersible pump set	LS	2,300.00
Fencing	LS	1,000.00

Default values for the below estimated cost:

Daily water consumption (lpcd):	20
Distance of pump site to the village (m):	500
Unit cost for diesel fuel ($/liter):	0.50
Total pumping head (m):	35
Reservoir type:	Elevated
Minimum well yield/pump capacity (m^3/h):	6
Population density in core area/total area (n/ha):	60/15

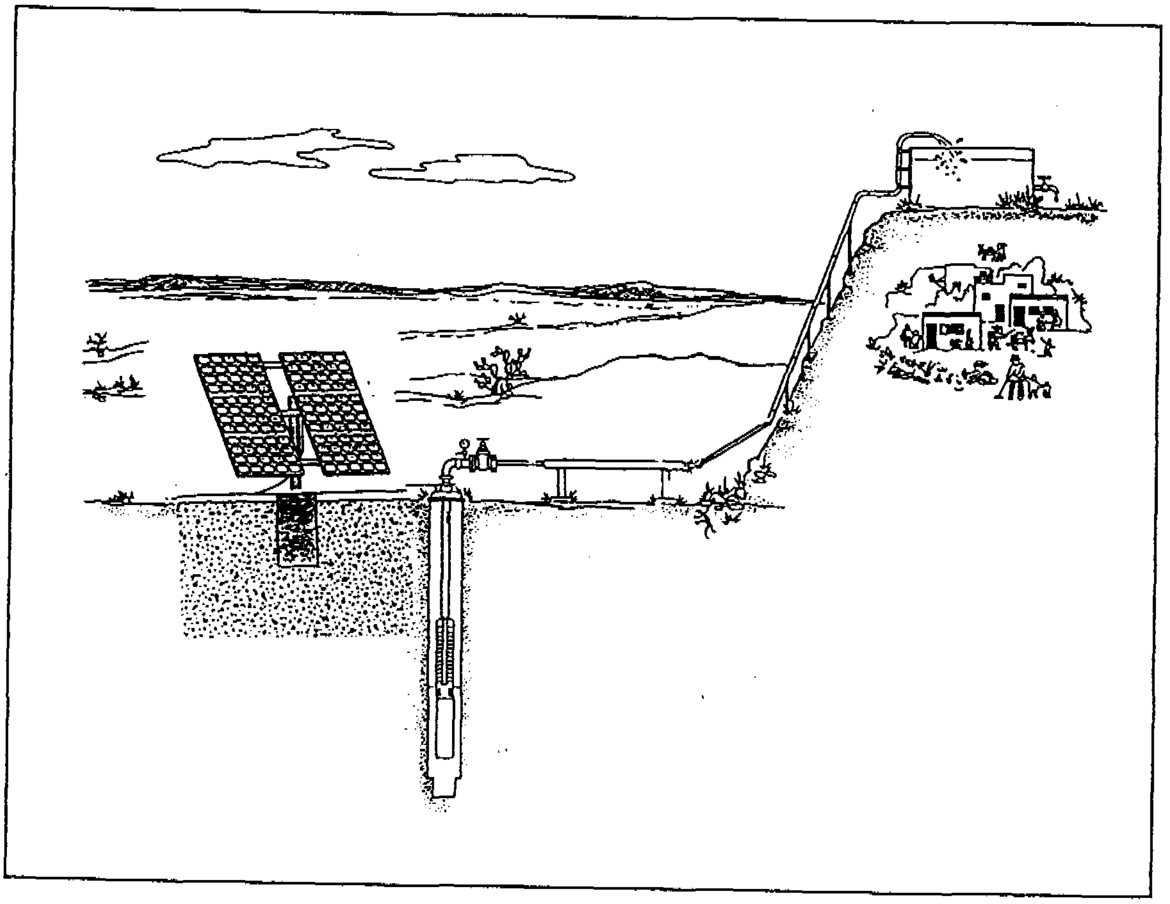
Typical system cost, including 10% contingencies and 50% overheads:

Size of community (nos.)	Total investment in $	Annual cost in $/CAP
1,200	85,500	12.70
2,400	94,400	7.20
3,600	110,900	5.60
4,800	138,300	5.20

TECHNOLOGY OPTIONS COMPONENT

Solar Submersible Pump

Description: Presently there are two major types of solarpumps; both are photovoltaic (PV) pumping systems converting directly sunlight into a DC current. One of them converts the DC current of the PV array into a conditioned AC current by means of an inverter, which drives a speed-regulated three-phase submersible centrifugal pump. The other type of solarpump employs a submersible pump with a DC submersible electric motor and does not require an inverter. The arrays are mounted on frames. The pumps operate automatically when the solar radiation supplies enough energy to run the electric motor. The systems run virtually maintenance free. The solarpumps normally fit into a 126 mm borehole. A water storage tank is required to ensure water supply when the pump is not running and to balance the hourly fluctuations in demand.



Technical data:

Pump/motor dia. (mm):*)	101/125
Pumping head (m):	12-120
Discharge (m^3/h):	1-15
Max. panel size (Wp):	1,600
Water tank (% of Qd):	50-60
Water consumption (lpcd):	20-25
Population served (nos.)	1000-2000
Households (nos.):	100-200

*) depending on pump model

Maintenance and remarks:

- Estimated average solar irradiation in Ghana is 4.5-5.5 kwh/m^2/day
- Solarpumps can operate with a minimum maintenance and do not require any consumables
- At present the price of the solar panels is still rather high, which increases the cost for systems requiring more energy

Typical cost for system components, excluding contingencies and overheads:

WATER SOURCES	Unit	$/Unit
Hand dug well, 1.2 m diameter, 16 m deep	LS	1,500.00
Drilled well, 150 mm diameter, 45 m deep	LS	12,600.00
DISTRIBUTION SYSTEMS		
Siting and Design	LS	4,000.00
Elevated (5 m) tank complete - 18 cu.m	LS	11,000.00
Elevated (5 m) tank complete - 25 cu.m	LS	12,000.00
Elevated (5 m) tank complete - 35 cu.m	LS	14,500.00
Groundlevel tank 18 cu.m	LS	7,500.00
Groundlevel tank 25 cu.m	LS	8,500.00
Groundlevel tank 35 cu.m	LS	10,000.00
Distribution pipes and fittings		
50mm PVC class C	m	4.50
80mm PVC class C	m	6.00
100mm PVC class C	m	8.00
Standpipes	unit	450.00
WATER LIFTING SYSTEMS		0.00
Solar generator (900 Wp) and foundation (DC systems)	LS	7,500.00
Solar generator (1600 Wp) and foundation (AC system)	LS	9,400.00
Solar pump set	LS	3,500.00
Fencing	LS	1,000.00

Default values for the below estimated cost:

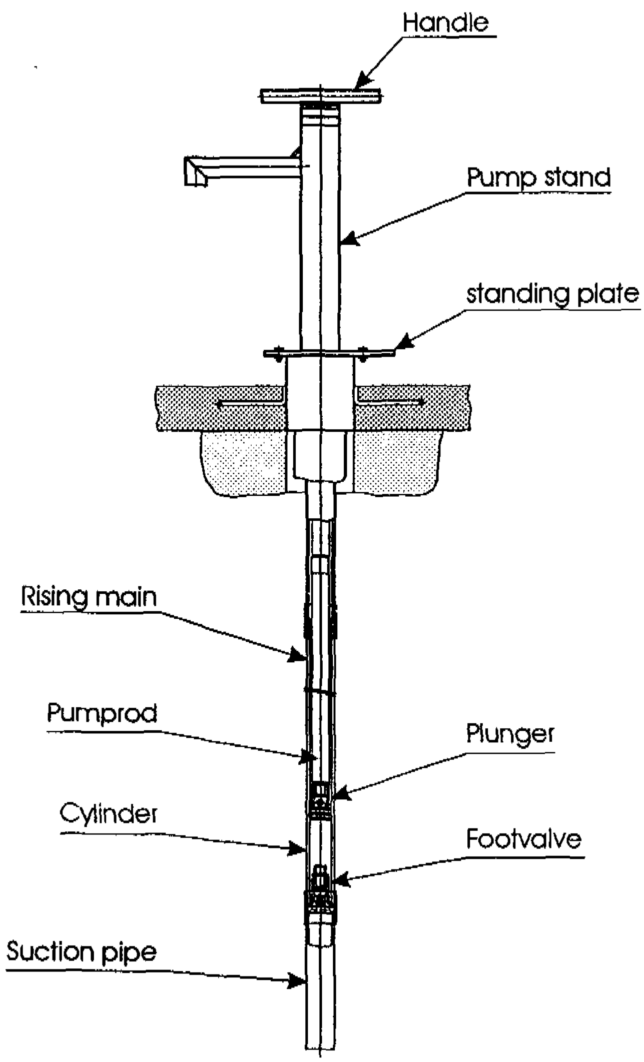
Daily water consumption (lpcd):	20
Distance of pump site to the village (m):	500
Total pumping head (m):	35
Reservoir type:	Elevated
Minimum well yield/pump capacity (m^3/h):	6
Population density in core area/total area (n/ha):	60/15

Typical system cost, including 10% contingencies and 50% overheads:

Size of community (nos.)	Total investment ($)	Annual cost ($/CAP)
1,200 (20 m pumping head)	86,600	10.40
1,200 (35 m pumping head)	90,000	10.80
2,000 (20 m pumping head)	96,400	6.90
2,400 (35 m pumping head)	125,600	7.40

Technology Choice **MALDA** Pump

Description: The MALDA Pump as a Direct Action Handpump is based on a buoyant pump rod that is directly articulated by the user, discharging water at the up- and down stroke. The pump head, standing plate and the handle are made of galvanised steel. The sleeve who protects the handle bar against wear is made of stainless steel. Pumprod and rising main are of HDPE pipes and the rest of the down hole components are made of plastics. This makes this pump completely corrosion resistant.



Technical data:

Cylinder diameter (mm):		50.0
Maximum Stroke (mm):		410
*) Approx.discharge m^3/ h:	at 5 m head	3.5
(depending on	at 10m head	1.8
installation and well)	at 15 m head	1.2
Pumping lift (m):		2-15
Population served (nos.):		300
Households (nos.):		30
Water consumption (lpcd):		15-20
Type of well:	borehole or dugwell	

*) at about 75 watt input.

Material:

- Pump head — galvanised steel
- Handle — galvanised steel
- Handle sleeve — stainless steel
- Pump rods — HDPE pipe
- Rising main — HDPE pipe
- Cylinder — HDPE pipe
- Plunger/footvalve — HDPE

Local manufacturing:
The MALDA Pump is specially designed to be produced in various developing countries.

Installation:
The installation of the MALDA Pump is very easy and does not need any lifting equipment or special tools. The rising main with footvalve and pumphead as well as the pumprod with handle and plunger can be assembled on the ground. When laid next to each other the correct length can be checked. For the installation both, the rising main and the pumprod do not need to be dismantled again.

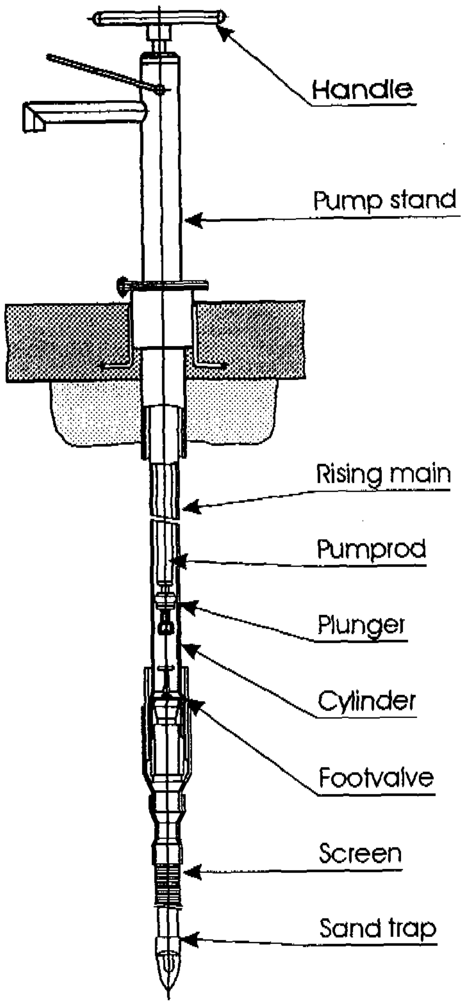
Maintenance:
This pump has an excellent "Community Management Potential". Only simple tools are needed to pull out the entire pumping element as well as the footvalve and rising main.

Remarks:
This pump is like most of the "Direct Action Pumps" (DAP) limited to pumping lifts of a maximum of 15 m. It is recommended not to go deeper than 12 m.

Suppliers:
The MALDA Pump is a **public domain handpump**. Technical information and a list of recommended manufacturers is available from HTN SKAT, Vadianstrasse 42, CH-9000 St.Gallen, Switzerland.
Phone: +41 71 228 54 54 /Fax: +41 71 228 54 55 / e-mail: 100270.2647 @ COMPUSERVE.COM

Technology Choice **TARA** Pump

Description: The TARA Pump as a Direct Action Handpump is based on a buoyant pump rod that is directly articulated by the user, discharging water at the up- and down stroke. Typically TARA's are installed in collapsible tubewells with the screen extending to the coarse sand aquifer. The pump head and the handle are made of galvanised steel. Pumprod and rising main are of PVC pipes and the rest of the down hole components are made of rubber, plastic, stainless steel and brass. This makes this pump corrosion resistant. The TARA Pump is subject to Indian Standard IS 14106.



Technical data:

Cylinder diameter (mm):	54.2	
Maximum Stroke (mm):	600	
*) Approx.discharge m^3 / h:	at 5 m head	3.5
(depending on	at 10m head	1.8
installation and well)	at 15 m head	1.2
Pumping lift (m):	2-15	
Population served (nos.):	100	
Households (nos.):	10	
Water consumption (lpcd):	20-25	
Type of well:	borehole (or dugwell)	

*) at about 75 watt input.

Material:

• Pump head	galvanised steel
• Handle	galvanised steel
• Pump rods	PVC pipe
• Rising main	PVC pipe
• Cylinder	PVC pipe
• Plunger/footvalve	different materials

Local manufacturing:
The TARA Pump has an excellent potential for local manufacturing.

Installation:
The installation of the TARA Pump is easy and does not need any lifting equipment or special tools. The drillers who sink the tubewell with the "sludger method" also install the pump.

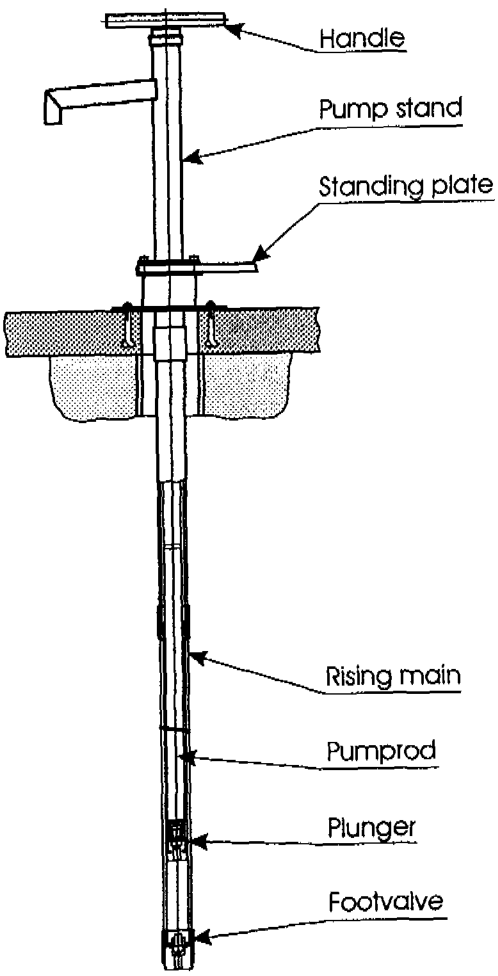
Maintenance:
This pump has an excellent "Community Management Potential". Only simple tools are needed to pull out the entire pumping element and the footvalve. All maintenance operations can be performed by a village caretaker.

Remarks:
This pump is like most of the "Direct Action Pumps" (DAP) limited to pumping lifts of a maximum of 15 m. It is recommended not to go deeper than 12 m. The TARA Pump is not designed for a high daily output, but rather a family or small community pump.

Suppliers:
The TARA Pump is a **public domain handpump.** Technical information and a list of recommended manufacturers is available from HTN SKAT, Vadianstrasse 42, CH-9000 St.Gallen, Switzerland.
Phone: +41 71 228 54 54 /Fax: +41 71 228 54 55 / e-mail: 100270.2647 @ COMPUSERVE.COM

NIRA AF85 Pump

Description: The NIRA AF85 Direct Action Handpump is based on a buoyant pump rod that is directly articulated by the user, discharging water at the up- and down stroke. The pump head and the standing plate are made of galvanised steel and the handle of stainless steel. Pumprod and rising main are of HDPE pipes and the rest of the down hole components are made of plastics. This makes this pump completely corrosion resistant.



Technical data:

Cylinder diameter (mm):	53.4	
Maximum Stroke (mm):	400	
*) Approx.discharge m^3 / h:	at 5 m head	3.5
(depending on	at 10m head	1.8
installation and well)	at 15 m head	1.2
Pumping lift (m):	2-15	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole or dugwell	

*) at about 75 watt input.

Material:

- Pump head — galvanised steel
- Handle — stainless steel
- Pump rods — HDPE pipe
- Rising main — HDPE pipe
- Plunger/footvalve — HDPE

Local manufacturing:
The NIRA AF85 Pump is a protected product and is not intended for local production. Although besides the main company in Finland, there is one branch in Ghana (Ghanira) and one in Tanzania (Tanira) producing this pump.

Installation:
The installation of the NIRA AF 85 Pump is easy and does not need any lifting equipment or special tools.

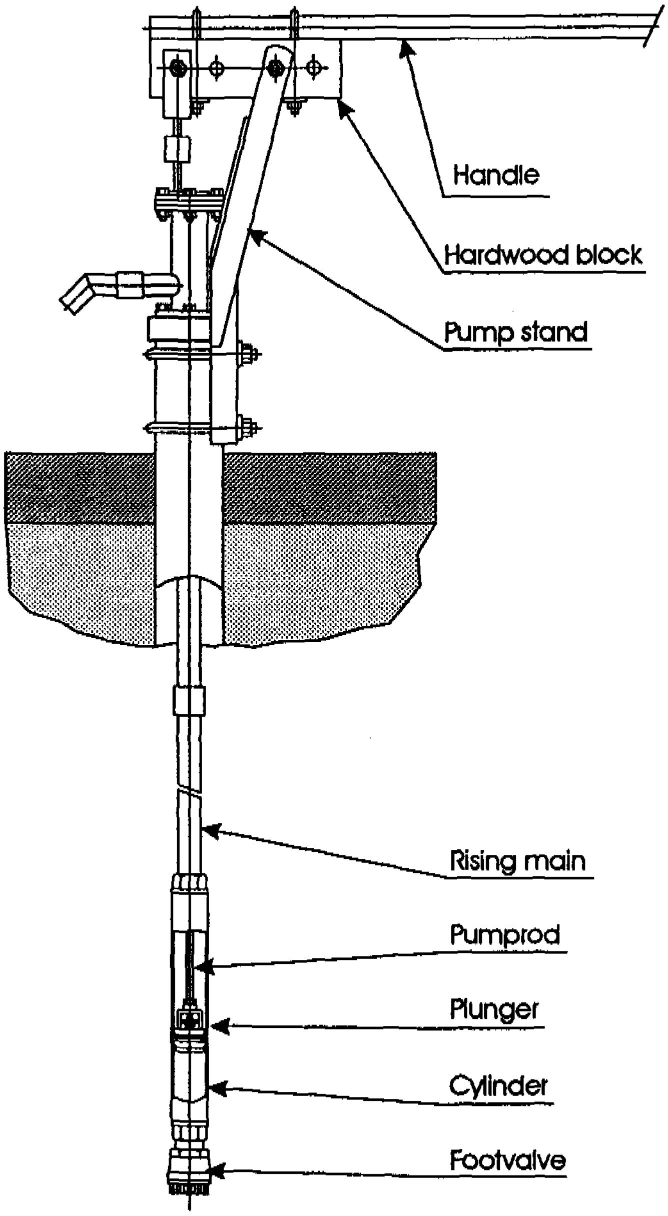
Maintenance:
This pump has an excellent "Community Management Potential". Only simple tools are needed to pull out the entire pumping element as well as the footvalve and rising main. This pump is reliable and popular with the communities.

Remarks:
This pump is like most of the "Direct Action Pumps" (DAP) limited to pumping lifts of a maximum of 15 m. It is recommended not to go deeper than 12 m.

Suppliers:
Technical information on the NIRA AF85 is available from Vammalan Konepaya Inc. P.O.Box 54, SF-38201, Vammala, Finland. Tel: +358 351126 67 / Fax: +358 351 431 34.

Technology Choice **BUSH** Pump

Description: The Bush Pump is a conventional lever action handpump. The typical feature of this pump is the "Hardwood block" that acts as both a bearing and lever mechanism. The pump stand is of painted mild steel and the handle is a galvanised G.I. pipe. The "down hole components" consist of Ø50 mm (NB) G.I. pipe for the rising main, pumprods of Ø16mm galvanised mild steel, brass footvalve and cylinder (Ø75mm), bronze plunger with leather seals. This pump is not corrosion resistant and should not be used in areas with aggressive water (pH value < 6.5).



Technical data:

Cylinder diameter (mm):	75	
Maximum Stroke (mm):	200 - 250	
*) Approx.discharge m^3 / h:	at 10 m head	1.4
(depending on	at 15 m head	1.1
installation and well)	at 20 m head	0.9
	at 25 m head	0.8
	at 30 m head	0.7
Pumping lift (m):	5-50	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole or dugwell	

*) at about 75 watt input.

Material:

- Pump stand — painted steel
- Handle — galvanised steel pipe
- Bearing block — Hardwood
- Pump rods — galvanised steel
- Riser pipes — galvanised G.I. pipe
- Pump cylinder — brass
- Plunger/footvalve — bronze/brass

Local manufacturing:
The Bush Pump has an excellent potential for local manufacturing and is produced by different companies in Zimbabwe.

Installation:
The installation of the Bush Pump needs well trained area mechanics. Lifting tackle is only used for deep applications and for large size "open top cylinders". No special tools are needed.

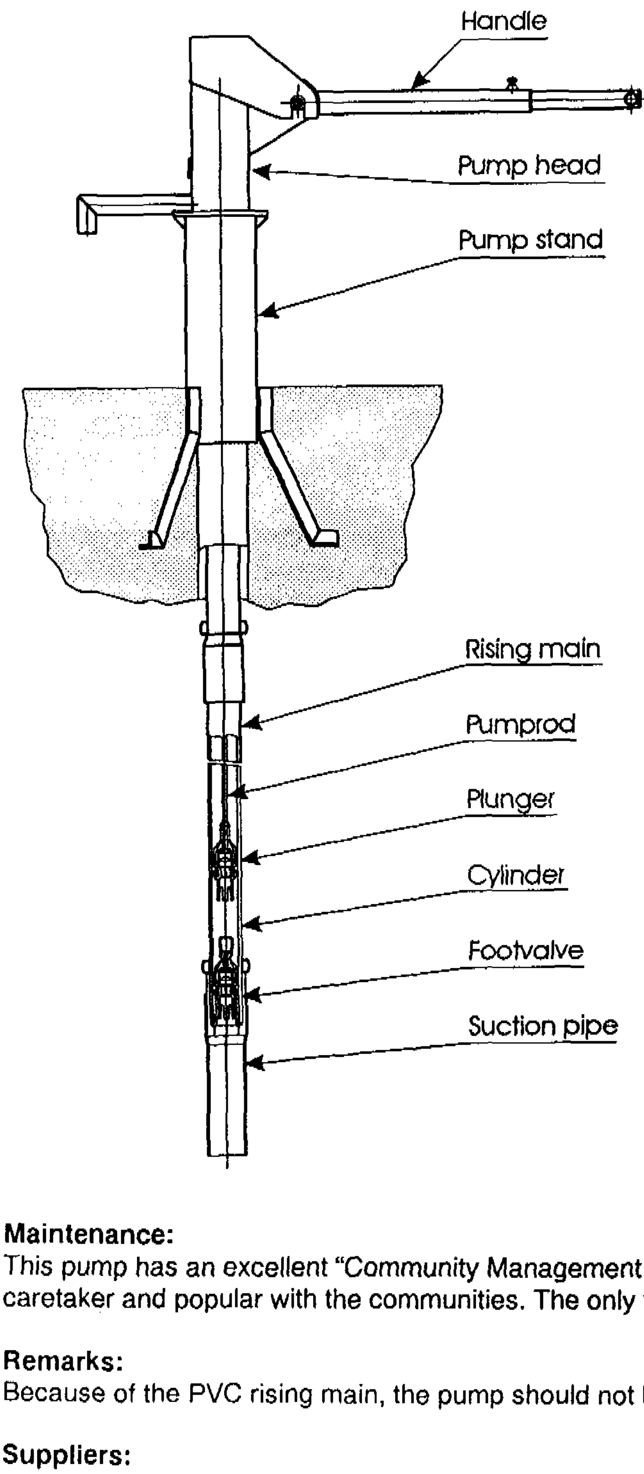
Maintenance:
The pump with the Standard configuration has a limited Community Management Potential", but it is reliable and popular with the community. The "open top cylinder version" gives the possibility of a simpler maintenance (see remarks).

Remarks:
Besides the "Standard" configuration there exists an "Open Top Cylinder" version with different cylinder sizes (Ø50mm/Ø63.5mm/Ø75mm). To make maintenance easy, pumprods with casehardened hook and eye connectors are also available.

Suppliers:
Technical information on the Bush Pump is available from The National Action Committee for Water Supplies and Sanitation, Government of Zimbabwe.

AFRIDEV Pump

Description: The AFRIDEV Pump is a conventional lever action handpump. The configuration includes an open top cylinder, i.e. the piston can be removed from the cylinder without dismantling the rising main. The footvalve is retractable with a fishing tool. The riser pipes are made of u-PVC. The pumprods are of stainless- or mild steel with hook and eye connectors, allowing removal without tools. Engineering plastics like POM and PA66 are used for the pumping elements, plunger/footvalve and for the bearings. This pump is corrosion resistant in the stainless steel rod configuration.



Technical data:

Cylinder diameter (mm):	50	
Maximum Stroke (mm):	225	
*) Approx.discharge m^3 / h:	at 10 m head	1.4
(depending on	at 15 m head	1.1
installation and well)	at 20 m head	0.9
	at 25 m head	0.8
	at 30 m head	0.7
Pumping lift (m):	10-45	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole	

*) at about 75 watt input.

Material:

- Pump head — galvanised steel
- Handle — galvanised steel
- Pump stand — galvanised steel
- Pump rods — stainless or galvanised steel
- Rising main — u-PVC pipe 63 mm
- Pump cylinder — u-PVC pipe 2 inch
- Plunger/footvalve — Polyacetal POM

Local manufacturing:
All steel parts of this pump have a potential for local manifacturing.
Local companies who manufacture u-PVC pipes and have the knowledge of processing engineering plastics are able to produce the "down hole components".
The cost of the tooling requirement is substantial and therefore the number of manufacturer will be limited.

Installation:
The installation of the AFRIDEV Pump is not difficult and does not need any lifting equipement.

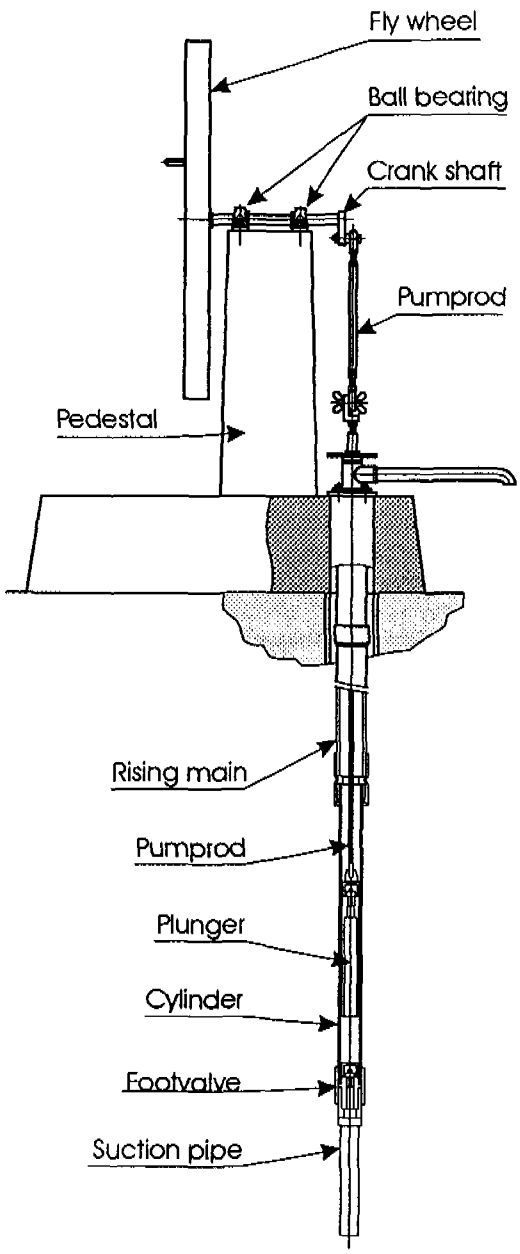
Maintenance:
This pump has an excellent "Community Management Potential", it is reliable, easy to repair by a village caretaker and popular with the communities. The only tools needed are one spanner and the fishing tool.

Remarks:
Because of the PVC rising main, the pump should not be used in unlined boreholes.

Suppliers:
The Afridev is a **public domain handpump**. Technical information and a list of recommended manufacturers are available from HTN SKAT, Vadianstrasse 42, CH-9000 St.Gallen, Switzerland.
Phone: +41 71 228 54 54 /Fax: +41 71 228 54 55 / e-mail: 100270.2647 @ COMPUSERVE.COM

VOLANTA Pump

Description: The VOLANTA Pump is a reciprocating pump driven by a large flywheel. A crank and a connecting rod convert the rotary motion in a reciprocating action which is transmitted to the plunger via stainless steel pumprods. The crank shaft and the flywheel run on ball bearings mounted on a plate which can be fixed to a steel or concrete pedestal. The cylinder is of glass fibre reinforced epoxy resin with a close-fitting seal-less stainless steel plunger. The complete cylinder can be lifted from the well by the threaded pumprods, without removing the PVC rising main. This pump is corrosion resistant.



Technical data:

Cylinder diameter (mm):	50	
Maximum Stroke (mm):	400	
*) Approx discharge m^3 / h:	at 20 m head	1.0
(depending on	at 30 m head	0.7
installation and well)	at 40 m head	0.5
	at 50 m head	0.37
	at 60 m head	0.25
	(at 80 m head	0.15)
Pumping lift (m):	10-80	
Population served (nos.):	450	
Households (nos.):	45	
Water consumption (lpcd):	15-20	
Type of well:	borehole	

*) at a speed of about 50 rpm, with flying start and about 75 watt input.

Material:

- Pump stand — mild steel painted
- Flywheel — mild steel painted
- Rising main — PVC
- Pump cylinder — reinforced epoxy resin
- Plunger / Pumprods — stainless steel
- Valves — rubber

Local manufacturing:
The VOLANTA Pump is a protected product and is not intended for local manufacturing, but there are countries where assembling and installation of this pump are made locally.

Installation:
The installation of the VOLANTA Pump is not difficult and does not need any lifting equipment. However extensive masonry work is required.

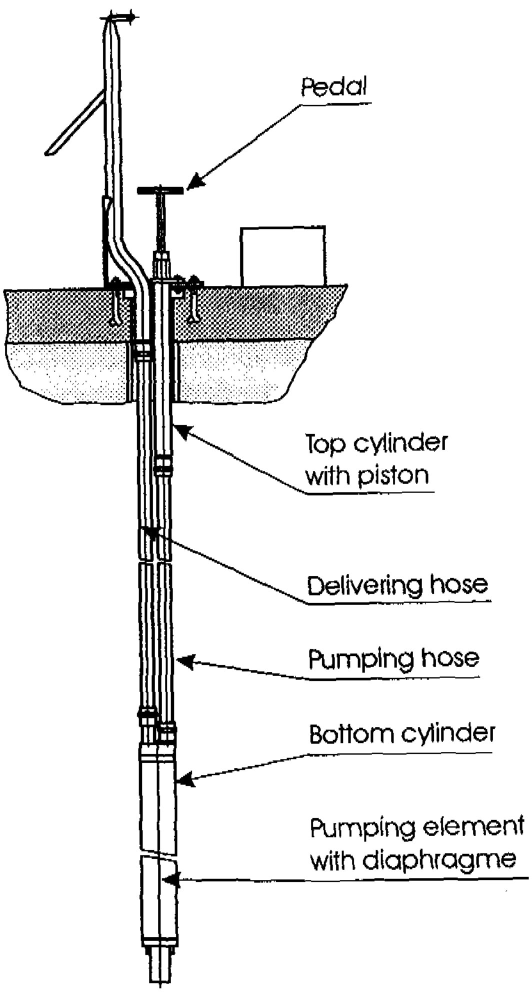
Maintenance:
This pump has an excellent "Community Management Potential". Only simple tools are needed to pull out the entire pumping element, including pumprod and footvalve.

Remarks:
Some users find it difficult to start the pump. Small children have to stay away from this pump, especially the area of the rotating flywheel is a dangerous playground. Because of the PVC rising main, the pump should not be used in unlined boreholes.

Suppliers:
Technical information on the VOLANTA Pump is available from Jensen Venneboer b.v., P.O.Box 12, NL-8130 AA Wijhe, the Netherlands. Tel: + 31 57052 2525 / Fax: + 31 57052 3618.

VERGNET Pump

Description: The VERGNET Pump has unconventional design features. It is operated by foot with a pedal. The displacement of the piston located at ground level is hydraulically transmitted to a rubber diaphragm down in a stainless steel cylinder. The expansion and the contraction of the diaphragm delivers the water to the surface. The top cylinder is connected to the pumping element on the bottom, via a flexible hose. The pumping element is made of rubber and stainless steel, that makes this pump corrosion resistant.



Technical data:

Cylinder diameter (mm):	na	
Maximum Stroke (mm):	200	
*) Approx.discharge m^3 / h:	at 10 m head	1.0
(depending on	at 15 m head	0.9
installation and well)	at 20 m head	0.75
	at 25 m head	0.7
	at 30 m head	0.65
Pumping lift (m):	10-45	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole or dugwell	

*) at about 75 watt input.

Material:

- Pump stand — galvanised steel
- Foot pedal — mild steel
- Pipes (flexible hose) — HDPE
- Top cylinder — stainless steel
- Bottom cylinder — stainless steel
- Pumping element — rubber diaphragm
- Valves — brass

Local manufacturing:
The VERGNET Pump is a protected product and is not intended for local manufacturing.
Only the steel parts of the pump stand would have a potential for local manufacturing.

Installation:
The installation of the VERGNET Pump is very simple and does not need any lifting equipement.

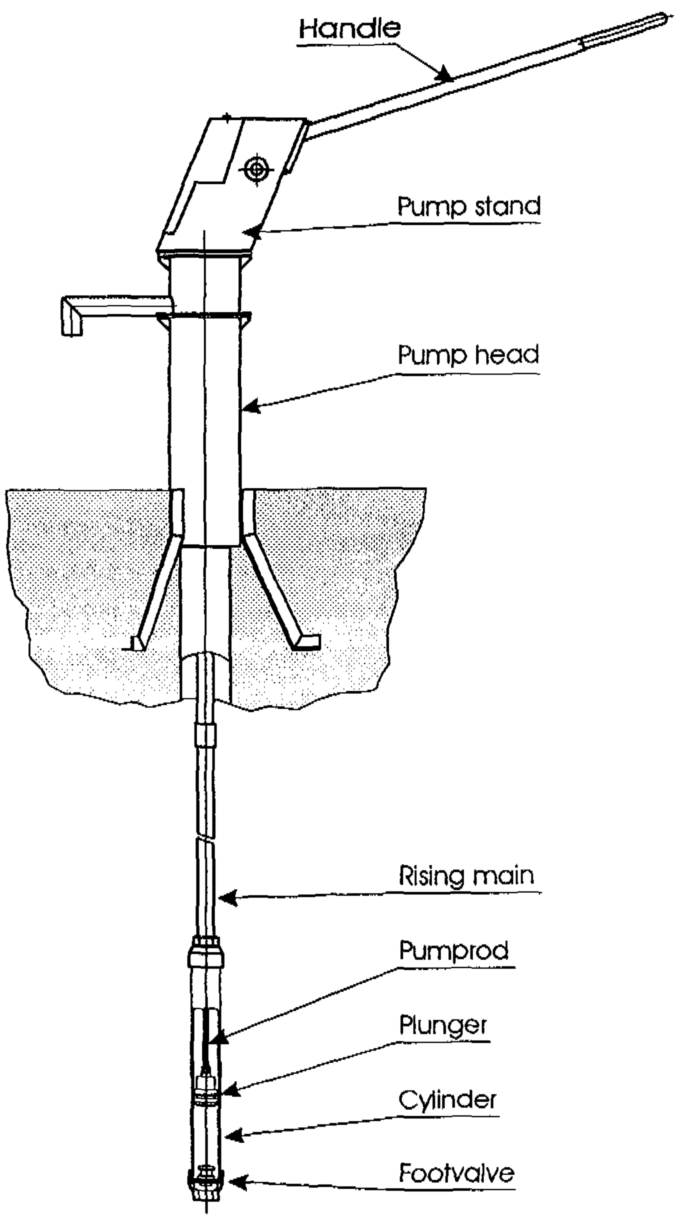
Maintenance:
This pump has a good "Community Management Potential". The above ground components allow interventions by the village caretaker, but below ground components are difficult to repair.
The diaphragm requires frequent cleaning.

Remarks:
The replacement of a diaphragm is expensive. The pump requires a considerable effort to operate. Although full body weight can be applied to the pedal, children and small users find it sometimes hard to operate the pump. If the yield of the borehole allows and the water demand is high, it is possible to install 2 pumps in one borehole.

Suppliers:
Technical information on the VERGNET Pump is available from Vergnet S.A. 6, rue Henry Dunant, F- 45140 INGRE, France. Tel: + 33 1 38 43 36 52 / Fax: + 33 1 38 88 30 50

INDIA Mark II Pump

Description: The INDIA Mark II Pump is a conventional lever action handpump and is subject to Indian Standard IS 9301. This pump has a pump head, pump stand and a handle of galvanised steel. The down hole components exist of a brass lined cast iron cylinder with a footvalve and a plunger of brass. The plunger has a double nitrile rubber cup seal, the rising main is a Ø32 mm G.I. pipe and the pumprods are of galvanised steel with threaded connectors. This pump is not corrosion resistant and should not be used in areas with aggressive water (pH value < 6.5).



Technical data:

Cylinder diameter (mm):	63.5	
Maximum Stroke (mm):	125	
*) Approx.discharge m^3/ h:	at 10 m head	1.8
(depending on	at 15 m head	1.3
installation and well)	at 20 m head	1.0
	at 25 m head	0.9
	at 30 m head	0.8
Pumping lift (m):	10-50	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole	

*) at about 75 watt input.

Material:

- Pump head — galvanised steel
- Handle — galvanised steel
- Pump stand — galvanised steel
- Pump rods — galvanised steel
- Rising main — galvanised G.I. pipe
- Pump cylinder — cast iron / brass
- Plunger/footvalve — brass

Local manufacturing:
All "above ground components" have a potential for local manufacturing, all the other parts need a high degree of quality control to ensure a reliable operation. The cost of the tooling requirement is substantial and therefore the number of manufacturer will be limited.

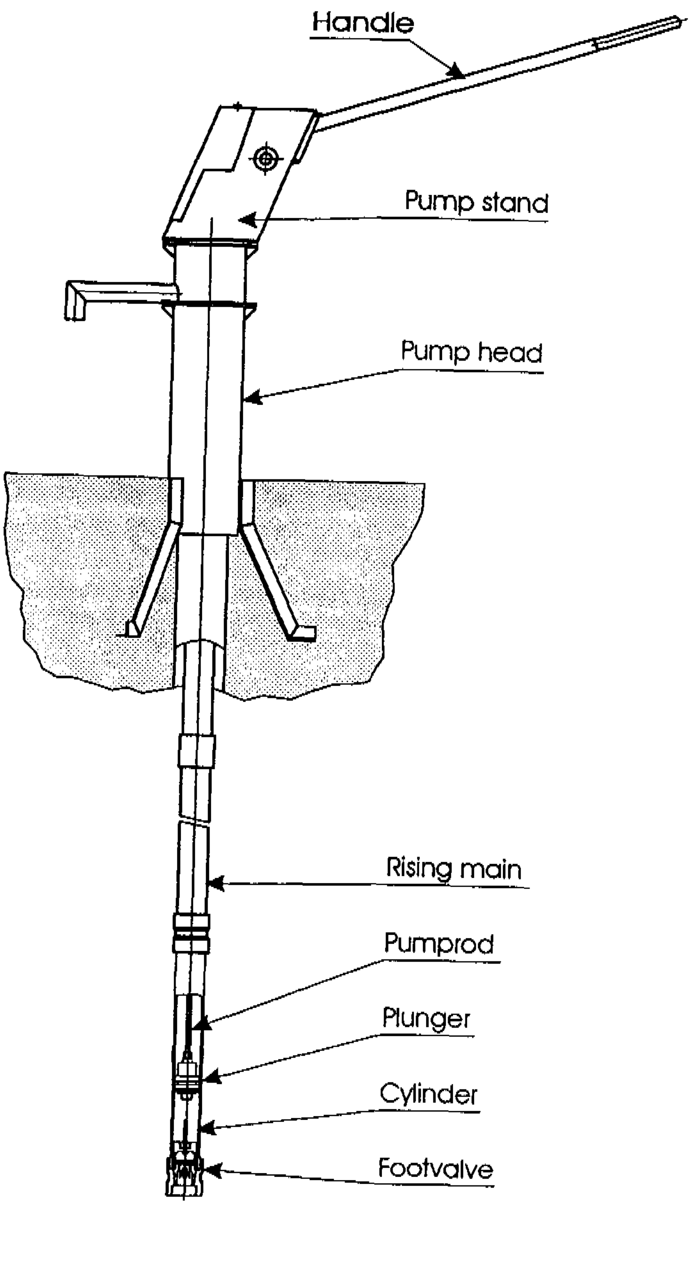
Installation:
The installation of the INDIA Mark II Pump need well trained area mechanics or a mobile team with lifting tackle and comprehensive tool kit.

Maintenance:
This pump has limited "Community Management Potential", but it is reliable and popular with the communities. To service the INDIA Mark II Pump skills and tools are needed which exeeds the ability of a village-level caretaker. However trained area mechanics can successfully maintain the pump.

Suppliers:
The INDIA Mark II is a **public domain handpump**. Technical information and a list of recommended manufacturers is available from HTN SKAT, Vadianstrasse 42, CH-9000 St.Gallen. Switzerland.
Phone: +41 71 228 54 54 /Fax: +41 71 228 54 55 / e-mail: 100270.2647 @ COMPUSERVE.COM

Technology Choice **INDIA Mark III** Pump

Description: The INDIA Mark III Pump is a conventional lever action handpump and is subject to Indian Standard IS 13056. This pump has simmilar configurations as the INDIA Mark II, only the "down hole components" were changed in order to improve the village level maintenance. The most important improvement is the "open top cylinder", which makes it possible to remove the plunger and also the footvalve without lifting the cylinder and the rising main (Ø65 G.I. pipe). This pump is not corrosion resistant and should not be used in areas with aggressive water (pH value < 6.5).



Technical data:

Cylinder diameter (mm):	63.5	
Maximum Stroke (mm):	127	
*) Approx.discharge m^3 / h: (depending on installation and well)	at 10 m head	1.8
	at 15 m head	1.3
	at 20 m head	1.0
	at 25 m head	0.9
	at 30 m head	0.8
Pumping lift (m):	10-30	
Population served (nos.):	300	
Households (nos.):	30	
Water consumption (lpcd):	15-20	
Type of well:	borehole	

*) at about 75 watt input.

Material:

- Pump head — galvanised steel
- Handle — galvanised steel
- Pump stand — galvanised steel
- Pump rods — galvanised steel
- Riser pipes — galvanised G.I. pipe
- Pump cylinder — cast iron / brass
- Plunger/footvalve — brass

Local manufacturing:
All "above ground components" have a potential for local manufacturing, the other parts need a high degree of quality control to ensure a reliable operation. The cost of the tooling requirement is substantial and therefore the number of manufacturer will be limited.

Installation:
The installation of the INDIA Mark III Pump needs well trained area mechanics or a mobile team with lifting tackle and comprehensive tool kit. Pump cylinder settings of more than 30m are difficult, because of weight of the rising main.

Maintenance:
This pump has an improved Community Management Potential" compared to the INDIA Mark II, because the "open top cylinder" gives the possibility of a simpler maintenance with less tools involved.

Suppliers:
The INDIA Mark III is a **public domain handpump**. Technical information and a list of recommended manufacturers is available from HTN SKAT, Vadianstrasse 42, CH-9000 St.Gallen, Switzerland.
Phone: +41 71 228 54 54 /Fax: +41 71 228 54 55 / e-mail: 100270.2647 @ COMPUSERVE.COM

Vadianstr. 42, CH-9000 St.Gallen, Switzerland
Phone: +41 (0)71 228 54 54 Fax: +41 (0)71 228 54 55
e-mail info@skat.ch
Swiss Centre for Development Cooperation in Technology and Management

Addresses of Handpump Manufacturers.

The following companies are manufacturers of whole Handpumps.

Meera and Ceiko Pumps Ltd.
Mr. Mahesh Desai
1-7-1054 / A, B,
Industrial Area
Azamabad
Hyderabad-500 020, India
Phone: +91 407 61 70 98
Fax: +91 407 61 43 76
(India MK II & MK III, Afridev, Malda, Metal Treadle)

Ajay Industrial Corporation
Mr. Devendra C. Jain
4561, Deputy Ganj
Sadar Bazar
Delhi-110 006, India
Phone: +91 11 684 96 72
Fax: +91 11 682 20 01

(India MK II & MK III, Afridev, Tara)

Karnataka Water Pumps Ltd.
Mr. Shankaranarayana Gupta
13-B, Attibele Industrial Area
Attibele-562 107
Anekal Taluk
Bangalore, India
Phone: +91 802 23 88 82
Fax: +91 802 22 57 74
(India MK II & MKIII, Afridev)

Politrusions (P) Ltd.
Mr. M.V. Madhavan
813, Poonamallee High Road
3-A Gleneden Place
Madras-600 010, India
Phone: +91 44 642 48 41
Fax: +91 44 642 83 11

(Tara)

M/S Engineering Concern Ltd.
Mr. M. Sarwat
39-C, Commercial Area
Nazimabad-4
Karachi-18, Pakistan
Phone: +92 21 61 86 27
Fax: +92 21 50 61 401
(Afridev)

Dacaar Handpumps Factory
Mr. M. Nugawela
Mardan Road
Swabi, Pakistan
Fax: +92 521 84 05 16

(Afridev)

The following companies are partly manufacturing Handpumps, the rest is procured from Indian suppliers. These companies represent the „Manufacturers of the South-east Region of Africa".

Stenaks Trading & Shipping Ltd.
Mr. Jan van Hoorn
Caixa Postal 1028
Maputo, Mozambique
Phone: +258 146 57 33
Fax: +258 146 57 37
(Afridev)

Afridev International Ltd.
Mr. Gilles Preat
P.O.Box 6431
Mbabane, Swaziland
Phone: +268 20 6 85
Fax: +268 20 6 84
(Afridev)

TWSSC Ltd.
Mr.Suraj Kakar
P.O.Box 7
Morogoro, Tanzania
Phone: +255 56 30 42
Fax: +255 56 44 26
(SWN, Afridev)

Kenya Water Handpumps Ltd.
Mr. Ravi Gandhi
P.O.Box 49745
Nairobi, Kenya
Phone: +254 254 26 87
Fax: +254 255 20 48
(SWN, Afridev)

Victoria Pumps Ltd.
Mr. Patrik Buhenga
P.O.Box 620
Kampala, Uganda
Phone: +256 41 34 24 83
Fax: +256 41 34 16 25
(India MK II & MK III)

It is strongly advised to have pumps inspected by a reputable inspection agency prior to shipping. Crown Agents and SGS have a long experience in **„Quality Assurance"** of handpumps.

Their adresses are:

Crown Agents
22 Richmond Road
Bangalore-560 025, India
Phone: +91 812 21 31 07
Fax: +91 812 21 21 41

SGS India Limited
Mr. G. Prakash
9-1-127/2, First Floor
43 Sarojoni Devi Road
Secunderabad-500 003, India
Phone: +91 842 82 57 51
Fax: +91 222 02 76 57

Both companies will be able to perform predelivery inspection of the pumps. Since these Quality Assurance Companies have representatives world-wide, it is also possible to call the local offices in order to get information.

Adresses of Manufacturers and their „private domain products“:

NIRA AF85	Vammalan Konepaya Inc. P.O.Box 54 SF-38201 Vammala, Finnland Phone: +35 835 11 26 67 Fax: +35 835 14 31 34
Vergnet	Vergnet S.A. 6, Rue Henry Dunant F-45140 Ingre, France Phone: +33 138 43 36 52 Fax: +33 138 88 30 50
Volanta	Jensen Venneboer b.v. P.O.Box 12 NL-8130 AA Wijhe, The Netherlands Phone: +31 570 52 25 25 Fax: +31 570 52 36 18
Kardia	Preussag Armaturen GmbH. D-31234 Edemissen, Germany Phone: +49 51 76 97 70