SMARTech Catalogue

Water and Sanitation Technologies for Rural Communal Supply & Self-supply

Training the local private sector in
Simple
Market based
Affordable and
Repairable
Technologies

The
SMART Centre
Group

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Background

The Sustainable Development Goal (SDG) for water promises *Safe and affordable water for all*. Of the 660 million people without an improved water source, 80 % live in rural areas (UNICEF, 2015), often in small communities where machine drilled boreholes and imported hand pumps are too expensive. Some 35 % of the hand pumps in sub-Saharan countries are not functioning. How do we reach the yet unserved? How can we assure that existing and new communal water systems will be maintained and repaired? How do we get more water for productive uses?

One option is to apply, where possible, SMARTechs, (Simple, Market based, Affordable, Repairable Technologies). In general SMARTechs can be produced with local skills and materials and its application can both reduce the cost of communal water supply and scale up the options for Self-supply at family level. In this catalogue an overvieuw of SMARTechs, a range innovative and affordable technologies that are proven in several countries.

Rope pumps

An example of a SMARTech is the rope pump, an innovative and inexpensive hand pump that can be produced by the local private sector. It fits on boreholes or hand dug wells as deep as 35 meters. Worldwide some three million people now use rope pumps, of which 1.4 million reside in Africa where it is probably the fastest growing hand pump model. It is fit for family wells but, if management is organised, it can serve communities of up to 150 people. Its high pumping capacity makes it popular for productive uses as car washing, life stock and small scale irrigation. For the same depth, the rope pump is three to five times cheaper than (imported) piston pumps.

Some rope pump experiences:

Nicaragua. Of the 70,000 rope pumps installed since 1990, 80 % are used for Self-supply at family level. Families with a rope pump earn USD 220/year more than families without a pump.

Ghana. Experiences with the first 200 rope pumps have been discouraging. 80 % did not function after one year because of lack of user involvement and errors in production and installation. The “wrong” introduction of the rope pump hampered the acceptance by the government for a long time and it took great efforts from organisations such as WaterAid and Victoria pumps to improve the “image” with better pumps and more user involvement.

Ethiopia. After the introduction of the rope pump in 2005, local governments and NGOs distributed free pumps. Some workshops started to copy high quality pumps with low quality production and improper installation, such that sales went down. In 2013 a training program was started to improve the rope pump quality and in 2014, 10,000 pumps were ordered by a local government. The rope pump is now part of the National policy to scale up water access with Self-supply.

Tanzania. After the SHIPO SMART Centre introduced the rope pump in 2005, there now are 20 workshops producing pumps. Of the 10,000 pumps installed, 40 % are purchased by families.

Other SMARTechs

Besides rope pumps, examples of other SMARTechs are:

Manual drilling (Rota sludge, SHIPO drill, EMAS drilling): For drilling in semi hard ground layers of up to 40 meters or deeper. There are 20,000 EMAS small diameter wells in Bolivia costing USD 150 - 400 for both drilling and EMAS pump.

Wire cement tanks: Costs are 30 - 40 % lower than ferro cement tanks.

Groundwater recharge: Systems that store water underground, costing USD 10 for materials.

Siphon and table top filters: Effective water filters that produce 30 - 60 litres of safe drinking water per day and costs ca USD 20.

Reducing cost of rural water points

Many rural water points in Africa consist of machine drilled boreholes and imported piston hand pumps like the Afridev or India Mark 2 pump and cost USD 5,000 to 10,000. These water points deliver water to an average of 250 people such that the cost per capita is USD 20 - 40. In areas with softer soils and water levels less than 40 meters the cost of water points could be reduced drastically by manual drilling. For example in Tanzania the shift from machine to manual drilled boreholes reduced the cost of the borehole by 70 % and over 2,000 manual drilled tube wells (boreholes) have been installed. If these wells are combined with a locally produced rope pump instead of an imported hand pump, cost per capita can reduce to USD 10 - 20.

Self-supply Water ladder

In many parts of the world rural families use a “Water ladder” (incremental improvements). For example, a hundred years ago many farmers in Europe had a hand dug well with a rope and a bucket (step1). Step 2 on the Water ladder was the installation of a hand pump. Step 3 was a borehole with an electric or engine pump. Step 4 was a connection to piped water supply. So there were three steps on the Self-supply Water ladder before families had water supply with piped systems that were run on a commercial base. Initial investment of piped systems were (partly) subsidised and with the increased incomes, among others as a result of the Self-supply water source, farmers could afford the cost of operation and maintenance of the piped system. With increased incomes they could also afford improvements of their Self-supply source; for instance replacing the hand pump by a borehole and an electric pump. Now European farmers use water from the (communal) piped system for drinking and domestic use and use Self-supply wells for productive uses like livestock and irrigation. Circumstances in Africa are different but the same “Self-supply water ladder” logic can be applied there also.

Self-supply results in ‘profit-based sustainability’. The local entrepreneurs generate income with selling wells and pumps. Families like the convenience of water near the house and water increases

income so pumps are maintained. The training of local entrepreneurs in these technologies creates a sustainable supply chain of new products and spare parts. Technologies fit for Self-supply include wellhead protection for USD 50, hand drilled wells of USD 200, hand pumps of USD 80, household water filters at USD 20 and low pressure drip irrigation. Improved Self-supply in general results in improved health, increased incomes and more food security.

SMART Centres

Although options like rope pumps are simple, the experience indicates “Simple is not easy”. Even for a simple hand pump good quality is essential. For instance too much clearance in a rope pump bushing can cause the handle to break within two months and if it is right, the very same bushing can last for 15 years. Good quality requires professional training both on technical and non technical aspects. Technical aspects include quality control in production, installation maintenance and repairs. Non technical aspects include business skills, marketing and financial management/ assistance. One option to train in these aspects are so called ”SMART Centres” which are innovation centres where SMARTechs are demonstrated and with capacity to train the local private sector and others in the technical and non-technical topics mentioned above.

This catalogue includes technologies that are demonstrated in the SMART Centres in Tanzania, Malawi and Mozambique. Results of the SMART Centres in these countries are that there are some 35 local entrepreneurs trained and functioning, over 10,000 rope pumps installed. The use of manual drilling and rope pumps reduced the cost of rural water points from USD 40 - 15. Of all the pumps some 40 % were purchased by families (Self-supply).

Information of the product or technologies in this catalogue include pictures,a short description, advantages, disadvantages, and information/features.

No.	Topic	Action /method	Technology / model product
1	Access to groundwater	Hand dug well	1.1 Unlined well
			1.2 Lining with blocks, bricks
			1.3 Lining with cement rings
			1.4 Well head, Apron, Soak away
			1.5 Well reducer ring - bricks
			1.6 Well reducer ring - blocks
			1.7 Well cover, prefabricated
		Deepening hand dug well	1.8 Underlining
			1.9 Well pipe
		Hand drilled tube well	1.10 SHIPO drill
			1.11 Mzuzu drill, Tube bailer
2	Water lifting devices	Rope	2.1 Rope, bucket, pulley
		Windlass	2.2 Windlass
		Hand pumps	2.3 Rope pump Model 1
			2.4 Rope pump Model 2
			2.5 Rope pump Model 3
			2.6 Canzee pump
			2.7 EMAS pump
		Treadle pumps	2.8 Treadle pump
		Renewable energy (in development)	2.9 Solar and Wind pumps
		Electric and Engine pumps	2.10 Electric and Engine pumps
3	Storage/ Rainwater harvesting	Cement tanks	3.1 Wire-brick cement tank
		Ground water recharge	3.2 Tube recharge
4	Irrigation	Drip systems	4.1 Drip irrigation with rope pump
5	Household Water Treatment & Safe storage	Water treatment	5.1 Chlorine, boiling
		Water filtering	5.2 Types of filters
6	Sanitation	Latrines	6.1 Zero cement latrine
			6.2 Flapper

1 Access to groundwater - Hand dug well

1.1 Unlined well

Description:

Wells can be dug in almost any kind of soils with simple tools.

Advantages compared to drilled wells:

- In most cases much cheaper;
- Can be made with tools like a hoe, pick axe, hammer
- Skills are locally available;
- Large storage capacity so good in areas with poor aquifers (Water flows in at night and taken out in the day);
- If completed with a well cover, apron seal and pump, hand dug wells can deliver safe water.

Disadvantages compared to drilling:

- Can only go in the first shallow aquifers so limited to suitable areas;
- Digging often limited to dry season, waiting for the lowest water level;
- Shallow water layers are more often contaminated than deeper layers;
- More difficult to make a good seal.

Information:

- Depth in range of 1 to 30 meters deep and well diameters of 0.8 to 3 meters.
- In soft layers lining is important to avoid collapsing.
- Water lifted by a rope and bucket, windlass, pumps like Mark 5, Canzee, rope pump.
- Cost depends on soil type, well depth and diameter of the well.
- Cost indication: **USD 50 - 500** (excl. lining, cover, apron, pump).
- Producers: Local well diggers. Info at SMART Centres Tanzania and Malawi.

Top photo: Digging of a well with a small diameter of 0.9 meter diameter.

Middle photo: Well fan, used to bring fresh air in the well especially good when wells are deeper than 10 meters.

Bottom photo: Rope pump used to pump out water so the well can be dug deeper.

1 Access to groundwater - Hand dug well

1.2 Lining with bricks, blocks

Description:

When soil is unstable (sandy), a well needs a lining. In other cases often only the top of the well and the lower 1 or 2 meters need lining.

Advantages of lining:
- No collapsing of the well;
- Safer to go down in the well for cleaning or deepening;
- Functions as a sanitary seal against contamination from around the top;
- Gives a firm base for a well cover.

Disadvantages of lining:
- More expensive than no lining;
- Requires materials which may not be readily available.

Information:
- Lining can consist of bricks or cement blocks.
- Bricks need to be of good quality (high temperature firing).
- Cost depends on material, well depth and diameter of well.
- Cost indication complete lining: **USD 100 - 500** for a 10 m deep well.
- Cost indication of partial lining: **USD 50 - 200**
- Producers: Local well diggers.

Top photo: Lining a well from the bottom up with bricks.

Midle photo: A well in sandy soil completely lined with cement blocks. In Malawi mostly bricks are used.

Bottom photo: A well lined at the top and bottom with cement and stones.

1 Access to groundwater - Hand dug well

1.3 Lining with concrete rings

Top photo: A well completely lined with cement rings.
Middle photo: Lowering a well ring with ropes.
Bottom photo: Concrete ring at the bottom of a well.

Description:

A common way for lining is with concrete rings. Wells can be made deeper by digging inside the rings so the rings go down.

Another option is to use telescoped rings (smaller rings which fit inside the larger rings.)

Advantages compared to bricks:
- Faster;
- Can be stronger;
- Digging can be done inside the rings so the well rings go down by their own weight so the well can be made deeper without collapsing of the wall.

Disadvantages compared to bricks:
- Requires moulds for casting;
- More skills needed;
- Heavy to lower in well;
- More expensive than bricks;
- In sandy soils, rings can sink by own weight at the bottom of the well and become unstable;
- Often impermeable, water comes up from bottom.

Information:
- With rings of 0.8 meter diameters, the wells needs to be 1 meter or more.
- Can be prefabricated or made on site.
- Cost depends on length of lining and diameter of cement ring.
- Cost indication for a 10 m deep well: **USD 100 - 500** (excl. apron, well cover).
- Producers: Info at SMART Centre Malawi.

1 Access to groundwater - Hand dug well

1.4 Well head, apron, soak away

Description:

Open dug wells can be improved with a well head. Parts are a well cover (concrete slab), a parapet, an apron and a soak away.

In general it is essential that the bucket stays off the ground and that hands are clean before touching the bucket.

Advantages compared to an open well:

- A slab, metal cover avoids contamination from above, windblown dirt, small animals etc.;
- A parapet and cover prevents people, children from falling in the well, and (rain) splash water flowing into the well;
- An apron and soak away avoids dirty water from flowing back into the well.

Disadvantage compared to an open well

- More expensive.

Information:

- Well covers, concrete slabs can be in any size and thickness.
- Important to keep the bucket off the ground.
- Cost depends on well diameter and materials used.
- Cost indication for a 1.2 diameter concrete slab: **USD 50 - 200**
- Producers: Local masons, well diggers.

Top photo: A well cover mounted on a parapet (well rim). In this case the concrete slab has a metal cover which can be opened when water is needed.

Bottom photo: A well with a parapet, a concrete well slab plus apron and soak away. The apron and soak away are to avoid water around the well and infiltration of water in the well.

1 Access to groundwater - Hand dug well

1.5 Well reducer ring - bricks

Description:

An option to make the well top fit for a well cover is a well reducer ring. In this cases made of bricks.

Advantages compared to a concrete slab:
- Can be made for any diameter well;
- No need for steel reinforcement;
- Ring 1.5 meter made of 1 bag cement;
- Includes a seal, so less danger of contamination from outside;
- The diameter of the hole can be 70 cm so a prefabricated well cover will fit on;
- By making the ring tapered it becomes very strong, so no collapsing;
- A tapered ring avoids water flowing back into the well.

Disadvantages compared to concrete slab:
- For small diameter wells more expensive;
- Not a known technology yet, requires training.

Information:
- For wells with any diameter. Although the preferred diameter is 70 cm, it can be other sizes if necessary.
- Can be combined with a prefabricated well cover and mounted with a rope or other pump.
- Cost depends on diameter, available materials.
- Cost indication: **USD 50 - 100** (excl. cover for the pump).
- Producers: Info at all SMART Centres.

Top photo: A finished well reducer ring.

Middle and bottom photo: Making a well reducer ring on a well of 1.2 meter diameter.

1 Access to groundwater - Hand dug well

1.6 Well reducer ring - blocks

Description:

If burnt bricks are not available or more expensive than cement blocks, a reducer ring can also be made of tapered cement blocks.

Advantages compared to bricks:

- An option where bricks are expensive or low quality;
- Can be longer so a longer overlap is possible. For instance on a well of 1 meter only one ring of blocks is needed to reach an inside diameter of 70 cm.

Disadvantages compared to bricks:

- Requires moulds for blocks;
- Maybe more expensive;
- Not a known technology yet, requires training.

Information:

- Blocks can be made on site or be prefabricated.
- Blocks are 40 cm long and 5 cm thick.
- With each ring the diameter can be reduced with 30 cm.
- Cost depends on the diameter of the well (either 1 ring, 2 rings or 3 rings).
- Cost indication: **USD 60 - 120** for well diameter 1 meter (excl. cover).
- Producers: Still in development.

Top photo: Well reducer ring made with tapered cement blocks.

Middle photo: The blue items are moulds made of sheet metal used to make the cement blocks.

Bottom photo:The white parts are the cements blocks with a length of 40 cm.

1 Access to groundwater - Hand dug well

1.7 Well cover, prefabricated

Top photo; Prefabricated well cover with bolts for mounting a rope pump.

Bottom photo: A well cover mounted on a hand dug well with a well reducer ring. The pump is mounted with bolts on the prefabricated well cover. Partly ready. Requires apron and soak away.

Description:

If a rope pump will be installed and the well has a well reducer ring, the well cover can be small in diameter (0.8 meter) and can be prefabricated in the pump or other workshop.

Advantages compared to on site production well cover:

- In most cases cheaper;
- Better quality, easier to control;
- Fast installation. Pump and cover can be installed in one hour. No need to wait until the cement is dry and no need to come back for installation of the pump.

Disadvantage compared to on site production:

- Depending on way of transport, maybe heavy to transport.

Information:

- Well cover diameter is 0.80 meter. Well cover weight 25 - 40 kg.
- Cover has a 4 inch pipe for both pump pipe and return pipe so all maintenance and repair can be done via this 4 inch pipe.
- Well cover and well reducer ring sealed with cement so no water flows back into the well.
- Cost indication: **USD 30 - 60** (excl. pump).
- Producers: Info at all SMART Centres.

1 Access to groundwater - Deepening hand dug well

1.8 Underlining

Description:

When a well dries up in the dry season it can be made deeper with the so called Underlining method. With bricks or blocks one ring is made. A next ring is made underneath so the first ring stays in place. Does not go down like cement rings. In this way the well can be made deeper without collapsing.

Advantages compared to cement rings:

- No need for transport of moulds or cement rings;
- Can be made with local bricks or cement blocks;
- Can be made in any diameter well;
- In most cases cheaper.

Disadvantages compared to well rings:

- If rings are available it takes more time;
- Only possible until the water layer (can go on when water is pumped out or taken out with buckets);
- Need high quality bricks, so bricks do not crumble in water over time.

Information:

- Underlining need to be made with good quality (high temperature burnt) bricks.
- No need to put cement between the brick layers, just a bit in the corners.
- Can be installed in any size of well.
- Cost indication **USD 20 - 40** per meter.
- Producers: Info at all SMART Centres.

Top photo: Underlining using bricks.

Middle photo: Underlining using cement blocks. Starting with the first block.

Bottom photo: After the first ring is ready, a second ring is mounted underneath.

1 Access to groundwater - Deepening and dug well

1.9 Well pipe

Description:

An option to make wells deeper is the so called Well pipe. A PVC pipe with a filter screen is put at the well bottom. With a bailer on a tube, sand is pumped out and the PVC pipe (screen) goes down. In this way the well can made deeper 1 to 3 meter without collapsing.

Advantages compared to underlining:

- Is faster;
- Is cheaper;
- Can be done with water in the well, no need to wait for the dry season;
- Safer in wells that may collapse.

Disadvantages compared to underlining:

- Requires tools like a tube bailer;
- Does not work in case of rock or boulders or gravel larger than 4 cm;
- Requires skilled technicians;
- Less storage capacity.

Information:

- When the screen is deep enough it is cut off 0.8 meters above the bottom and a “trumpet” is mounted to facilitate the mounting of a pump.
- For wells over 6 meters deep, use a short tube bailer and work at the bottom of the well.
- PVC pipe (filter screen) can be 3 to 6 inch, depending on pump type.
- Cost depends on soil type, length of screen and diameter of casing.
- Cost indication for a 2 m long screen, 4 inch: **USD 40 - 200** (incl. filter screen).
- Producers: Information at Mzuzu SMART Centre.

Top photo: Using the well pipe system to pump out sand, gravel.

Middle photo: Sand is pumped out inside the PVC pipe by moving the tube bailer up and down.

Bottom photo: Sand and gravel removed by the tube bailer.

1 Access to groundwater - Hand drilled tube well

1.10 SHIPO drill

Description:

An option to make manual drilled tube wells is the so called SHIPO drill.

Advantages compared to hand dug wells:

- Is faster;
- Can be cheaper in soils where a well needs to be completely lined;
- More water guarantee in dry season since it can drill deep into the aquifer;
- Can be done at any time no need to wait for the dry season;
- Is safer. Hand dug wells may collapse.

Disadvantages compared to hand digging:

- Requires specific tools;
- Does not work in case of boulders or gravel larger than 2 cm;
- Requires skilled technicians;
- Less storage capacity;
- A disadvantage of a borehole (compared to a hand dug well) is that there is no access to the water if the pump is broken.

Information:

- SHIPO drill method is used much in Tanzania and trained via/promoted by SHIPO.
- It is a combination of sludging and percussion and can be combined with jetting.
- It has a heavy lower drill pipe and other drill pipes are of PVC so light weight.
- It makes tube wells with casings of 2 to 6 inch diameter and drill to 50 meters deep.
- Cost depends on soil type, length of screen and diameter of casing.
- Cost indication: **USD 100 - 1000**, depending on depth, soil, diameter casing (excl. pump).
- Cost of a drill set: **USD 500 - 700.**
- Producers: Information at all SMART Centres.

Top photo: Drilling a well with the SHIPO drill.

Middle photo: Testing a tube well after drilling.

Bottom photo: A rope pump installed on a hand drilled tube well of 28 meters deep.

1 Access to groundwater - Hand dug well

1.11 Mzuzu drill, Tube bailer

Description:

In softer soils with water levels of 8 meter or less a tube well can also be made with a the Mzuzu drill using a soil punch and bailer.

Advantages compared to SHIPO drilling:
- Is much cheaper;
- Less tools and skills needed;
- Easier to see the soil coming out.

Disadvantages compared to SHIPO drill:
- Can not go as deep;
- More difficult in hard soils less percussion force.

Information:
- With a soil punch and tube bailer, tube well can be made in areas with soft, sandy soils.
- With a bailer on a tube, sand is pumped out and the PVC pipe (screen) goes down.
- Cost depends on soil type, length of screen and diameter of casing.
- Cost indication for a 6 m deep tube well, 3 inch casing: **USD 50 - 200** (excl.pump).
- Cost indication complete system (6 m deep well, 3 inch casing, concrete cover, rope pump Model 2): **USD 150 - 350**.
- Producers: Information SMART Centre Malawi.

Top photo: Using a soil punch to make a hole until the water level. The pipe of the punch can be made longer with smaller (light weight) pipes so total length can be 8 meters.

Middle photo: Emptying the soil punch. The soil punch consist of a 2 inch pipe with a slot in the length and hard steel teeth. A hole can be made until the water level. When reaching the water layer, the punch does not lift the wet sand anymore. Than a PVC casing is put into the hole and tube bailer is used to make the hole deeper and lower the PVC pipe/filter screen.

Bottom photo: Sand and gravel removed by the tube bailer.

2 Water lifting devices - Rope

2.1 Rope, bucket, pulley

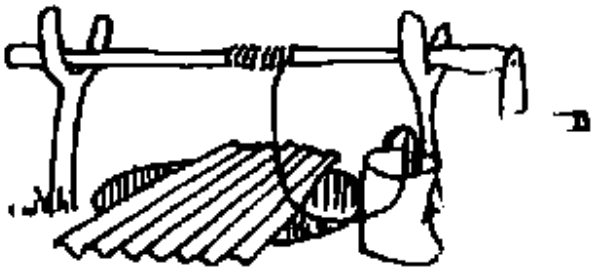


Photo: Water taken out of a hand dug well with a rope and rubber bucket.

Drawing: The well covered with a sheet.

Description:

The most simple way of lifting water from a well is a rope and a bucket or other container like a tyre.

Advantages compared to a pump:

- Much cheaper;
- Simple to use;
- Easy maintenance, bucket and rope need frequent replacement;
- Can adjust with water level changes.

Disadvantages compared to a pump:

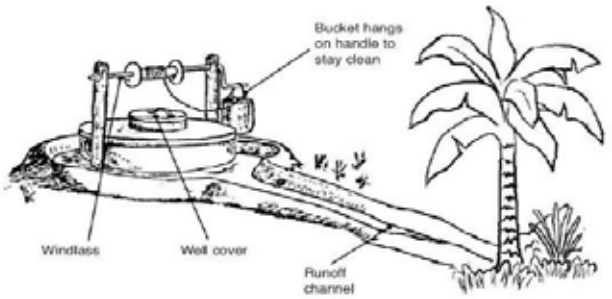
- To use a bucket the well has to be open so dirt, or even children, can fall into the well;
- A bucket and rope can contaminate the water in the well, because of dirty hands, mud on the bucket etc.;
- The movement of a bucket may cause turbidity in the well water;
- Speed of extracting water in general is less than with a pump;
- More heavy work (women, children).

Information:

- Rope and bucket can be used in any well depth.
- Cost depends on type of rope, well depth and type of bucket.
- Cost indication for a 10 m deep well: **USD 10 - 30.**
- Producers: Can be produced in workshops and in households.

2 Water lifting devices - Windlass

2.2 Windlass



Description:

A windlass is simple way of lifting water and can be made with many different materials.

Advantages compared to a rope and bucket:

- Lifting water is easier because a handle is used;
- If managed well, it is more hygienic. The bucket can hang upside down on poles and be disinfected by the sun;
- Bucket and rope are in the centre of the well so less contact with the well top and or wall.

Disadvantages compared to rope and bucket:

- More expensive;
- More maintenance.

Information:

- Can be installed on any depth of well.
- Important to keep the bucket of the ground.
- Make sure hands are clean before touching the bucket.
- Cost depends on well depth and materials used.
- Cost indication for a 15 m deep well: **USD 20 - 50**.
- Producers: Local welders, masons, well diggers.

Top photo: A windlass made with a wood pole and metal handles.

Middle drawing: The principle of a windlass. Note the bucket hanging on the handle. Also note the apron around the well and the run of channel, soak away. This to avoid any water around the well.

Bottom photo: A windlass as used in Zimbabwe with well cover and small opening (Photos: S. Sutton).

2 Water lifting devices - Hand pumps

2.3 Rope pump Model 1

Top photo: Rope pump on the hand drilled tube well of 25 meters deep, including an apron and soak away.

Bottom photo: Rope pump Model 1 on a hand dug well. Note the 4 inch pipe is high to avoid water entering the well in case of flooding. All maintenance can be done via this pipe.

Description:

Rope pumps have a wheel, a rope and washers to lift the water.

Advantages rope pumps compared to Afridev pumps:

- 3 to 5 times cheaper;
- Simpler in construction;
- Easier to install and repair;
- Local production so low cost spares are available;
- Fit for small communities;
- Can be an option where Afridev pumps are too expensive.

Disadvantages rope pumps compared to Afridev pumps:

- Is not fit for large communities, max. number of users 150;
- Requires more frequent maintenance;
- Has less “hi-tech” look;
- Is a semi open pump so water in the well could be contaminated by the rope.

Studies indicate that in similar wells and good quality pump and installation, the water quality from a rope pump is hardly less than water quality from piston pumps like an Afridev pump.

Information:

- Rope pumps can pump from wells of 1 to 35 meters deep.
- Fits on any size hand dug well and tube wells with casings of 2 to 6 inch.
- Pump capacity; 0 - 10 m deep-35 l/min, 10 - 20 m deep-18 l/min, 20- 35 m deep-9 l/min.
- Cost: U**SD 100 - 130** (off workshop. Well cover ca. USD 40).
- Producers: Info at all SMART Centres.

2 Water lifting devices - Hand pumps

2.4 Rope pump Model 2

Description:

Rope pump Model 2 is an economic version of Model 1.

Advantages Model 2 compared to Model 1:

- 30 % cheaper;
- The pump can be bought in steps. The wheel cover is optional and can be bought lateron when the family has funds;
- All parts are galvanised pipes;
- All parts are welded, no bolts;
- Is easier, faster to produce.

Disadvantages Model 2 compared to Model 1:

- When bushings are worn out the whole pump has to be taken to the workshop;
- If handle is ½"pipe, it is less sturdy than a handle of ¾".

Information:

- Rope pump Model 2 has the same features as Model 1.
- Cost : **USD 70 - 90** (off workshop. Metal wheel cover ca USD 15).
- Producers: Info at all SMART Centres.

Top photo: Rope pump Model 2 installed at a family farm in Mzuzu.

Middle photo: Rope pump Model 2.

Bottom photo: A wheel cover is optional.

2 Water lifting devices - Hand pumps

2.5 Rope pump Model 3

Description:

Rope pump Model 3 is mounted on poles and is the most economic version rope pump.

Advantages Model 3 compared to Model 2:

- 15 % cheaper;
- Does not have a wheel cover (the wheel cover is optional);
- Can be mounted on any size of well;
- Can be installed without a well cover;
- Is easier to produce, install;
- Handle can be mounted at 1 meter or higher to fill up a water tank.

Disadvantages Model 3 compared to Model 2:

- Requires wood poles;
- The wood poles need to be good quality and/or treated against termites or rotting;
- In loose soil, the poles start moving if not set in concrete;
- Looks less “hi-tech”.

Information:

- Rope pump Model 3 has the same features as other rope pump models.
- It is a first step model and can be installed without a well cover.
- If money is available a well and/or wheel cover can be bought.
- Fits on any hand dug well and tube well with casings of 2 to 6 inch.
- Cost: **USD 50 - 70** (off workshop, excl. well cover)
- Producers: Info at all SMART Centres.

Top photo: Rope pump Model 3 installed on a hand dug well.
Middle photo: Model 3 installed without a well cover.
Bottom photo: Model 3, handle mounted 1.3 meter high to fill up a water tank of 0.9 meter high. Note the platform.

2 Water lifting devices - Hand pumps

2.6 Canzee pump

Photo: Canzee pump.

Description:

The Canzee pump is a direct action and high quality hand pump.

Advantages compared to rope pumps:
- The metal parts like pump rod is stainless steel so no corrosion;
- Only one washer instead of many washers.

Disadvantages compared to rope pumps:
- A bit more expensive;
- Needs costly tools like a lathe for production;
- Needs some special parts like stainless steel;
- Needs a centralised production. Rope pumps can be produced decentralised with tools that are available in most blacksmith workshops.

Information:
- Can pump from wells of 10 - 20 meters deep.
- Can be installed on hand dug well or tube wells with diameters of 4 to 6 inch.
- Cost: 10 m deep well: **USD 120 - 150** (off workshop).
- Producers: Wells for Zoe. SMART Centre Malawi.

2 Water lifting devices - Hand pumps

2.7 EMAS pump

Top photo: EMAS pump installed at a family farm in Nicaragua.

Bottom photo: EMAS pump with a hose on the outlet. It can pump water to tanks up to 20 meters high.

Description:

EMAS pump is a small diameter piston pump with a pump rod of a PVC pipe. The water is lifted inside this pipe.

Advantages of the EMAS pump compared to rope pumps:

- 10 to 30 % cheaper than Model 1;
- Simpler in construction;
- Can lift water up to 20 meters high so can fill up elevated water tanks on a stand or a roof;
- Fits in a very small tube well so can be combined with low cost tube wells;
- Can be produced with local materials.

Disadvantages of the EMAS pump compared to rope pumps:

- It has an up and down movement which some people do not like;
- Has 20 - 30 % lower pump capacity;
- Plastic parts becomes brittle in sunlight over time, and needs regular replacement;
- Is not widely known in Malawi so needs training and a critical mass to scale up.

Information:

- EMAS pumps are used in Bolivia (30,000 installed).
- EMAS pumps can pump from wells of 1 to 35 meters deep.
- Fits on hand dug wells and tube wells with casings as small as 1.5 inch.
- Pump capacity: 0 - 10 m deep-25 l/min, 10 - 35m deep-5 l/min.
- Cost: **USD 50 - 70** (off workshop).
- Producers: Info SMART Centre Tanzania.

2 Water lifting devices - Treadle pumps

2.8 Treadle pump

Description:

A treadle pump is a pump with two cylinders and powered by pedals.

Advantages compared to rope pumps:

- 30 - 40 % more pump volume with the same lifting height (legs have more power than an arm);
- Easier to install and repair;
- The pressure model can lift water to an elevated tank or can be used for sprinkler irrigation.

Disadvantages compared to rope pumps:

- Is a suction pump so can only lift water from maximum 7 meters deep;
- Some people prefer a turning movement for pumping to an a up and down movement;
- Pedalling with legs is not fit for women in some cultures;
- More complicated to produce.

Information:

- Treadle pumps can pump from rivers, lakes or wells of 0 to 7 meters deep.
- Pump capacity: 0 - 10 m lift 50 l/min; 10 - 20 m lift 30 l/min.
- Cost: **USD 120 - 140** including suction hose.
- Producers: Sold in farm stores in Tanzania, Malawi.

Top photo: Treadle pump pressure model. There are also suction only models.

Bottom photo: Treadle pump suction model.

2 Water lifting devices - Renewable energy (in development)

2.9 Solar and Wind pumps

Top photo: A solar pump combined with a rope pump. In development at the SMART Centre.

Bottom photo: A wind rope pump. A wind mill combined with a rope pump. This is one of the most cost effective and simple water pumping wind mills.

Description:

Pumps can be powered by renewable energy like wind and sun.

Advantages compared to engine pumps:

- No cost for fuel;
- If combined with a rope pump or if it is a submersible pump model, it can pump from wells deeper than 7 meters.

Disadvantages compared to engine pumps:

- Investment cost is higher;
- No pumping when there is no wind or no sun;
- A wind pumps needs a storage tank of at least 3 days of use;
- Wind pump is a new technology and skills for production and installation need to be further developed;
- More complicated in use.

Submersible Solar pumps

The SMART Centre is testing also a Singflo submersible solar pump. This can pump up to 60 meters high.

Information:

- Solar pumps exist in many sizes. This catalogue focus on models below USD 1,000.
- The solar and wind rope pump now tested at the SMART Centre, pump from 20 meters.
- Pump capacity of both models is 2 to 5 cubic meters per day.
- Cost indication: Still in development.
- Producers: Info at SMART Centre Tanzania and Malawi.

2 Water lifting devices - Electric and Engine pumps

2.10 Electric and Engine pumps

Description:

There is a wide range of electric or engine pumps. Engine pumps are mostly used for irrigation, electric pumps more for domestic use.

Advantages compared to hand pumps:
- Much more pump volume;
- Can pump up to elevated water tanks;
- Has a high pressure and can be used for sprinklers and elevated storage.

Disadvantages compared to hand pumps:
- Much more expensive;
- Needs daily investment gasoline or diesel;
- More complicated use, maintenance;
- Engine pumps are suction pumps so can only lift water from maximum 7 meters deep in tube wells.

In open hand dug wells pumps can be lowered, see lower photo.

Information:
- Electric or engine pumps can pump from rivers, lakes or wells of 0 to 7 meters deep.
- In hand dug open wells, pumps can be lowered so depths where suction pumps can be uses can be 10 meters or more.
- Pump capacity: 2 - 10 cubic meters/hour.
- Cost : **USD 150 - 350.**
- Sales: sold in farm stores in all countries.

Top photo: Engine pump, 2 inch outlet used for irrigation.

Middle photos: Engine pump pumping from a river and filling up a Wire-brick cement tank.

Bottom photo: A "walk in" well. When water levels are deeper than 5 to 7 meters the pump can be lowered. In this case the pump is installed in a dug canal of 4 meters deep.

3 Storage/rainwater harvesting - Cement tanks

3.1 Wire-brick cement tank

Description:

These tanks are made with wire, bricks and cement. No steel reinforcement is used.

Advances compared to ferro cement tanks:
- 20 - 40 % cheaper;
- Simpler in construction;
- Produced with local materials;
- Same strength.

Disadvantage compared to ferro cement tanks:
- Not yet widely known.

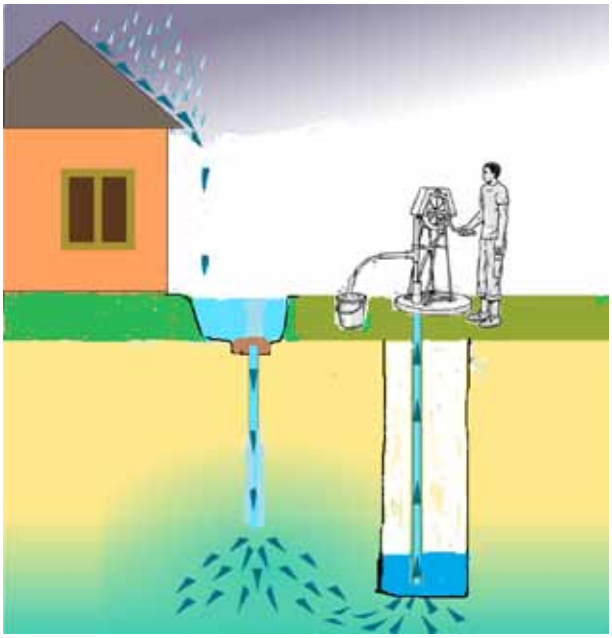
Information:
- Wire-brick cement tanks can have volumes of 0.5 to 50 cubic meters.
- Materials needed are 1 kg of 2 mm wire, bricks and 1 bag cement per cubic meter.
- Cost: **USD 40 - 60** (tank 2,000 litres).
- Producers: Info at all SMART Centres.

Top photo: Wire-brick cement tank of 2,000 litres.

Bottom photo: Training in the production of a Wire-brick cement tank at the SMART Centre Mzuzu.

3 Storage/rainwater harvesting - Groundwater recharge

3.2 Tube recharge



Description:

One option to store rainwater in the ground and avoid a well going dry is the so called tube recharge.

Advantages compared to water storage tanks:
- Per cubic meter, a system (pit, well, pump) is 5 times cheaper;
- No water lost by evaporation;
- Much larger storage capacity;
- Always "fresh" water.

Disadvantages compared to water storage tanks:
- Still unknown, needs specific training;
- Needs more field tests;
- Can not be combined with low cost wells and pump if aquifers are over 35 meters deep;
- Does not function in soils with very thick clays/ silty clays;
- Volume of infiltrated water that flows into the well cannot be predicted.

Information:
- Via a sand filter water is injected in the ground (not into the aquifer).
- Eventually water will seep into the aquifer.
- Cost: **USD 5 - 15** (cost of materials for a tube recharge; labour done by family).
- Producers: Info at all SMART Centres.

Top drawing: View of a tube recharge. Roof or surface water flows into a pit. In the pit there is a 3 - 5 meter deep (2 inch) hole filled up with sand and a PVC pipe. At the top a sand and cloth filter.

Bottom photo: Construction of a tube recharge pit with a sand filter and a cloth filter.

4 Irritation - Drip systems

4.1 Drip irrigation with rope pump

Description:

Low pressure drip systems like the KB drip can be coupled directly to a treadle pump or rope pump.

Advantages compared to a bucket or hose:
- Less work to irrigate a certain area;
- Can irrigate 200 tomato plants in 10 minutes;
- More efficient water use, less water per plant.

Disadvantages compared to a bucket or hose:
- More expensive;
- More complicated to manage;
- Installation requires skilled people.

Treadle pumps and sprinkler irrigation

With the high pressure of a treadle pump a sprinkler system can be connected.

Information:
- Drip irrigation can irrigate surfaces of 10 to 10,000 square meters.
- Maximum area to be connected to a treadle pump or rope pump 1,000 square meters.
- Cost depend on surface and system used.
- Cost indication: **USD 15 - 25/100 square meters** (for KB drip directly connected to a rope pump).
- Producers: Info at SMART Centres Tanzania and Malawi.

Top photo: Rope pump directly connected to a drip irrigation system of 100 - 200 square meters.

Bottom photo: Drip irrigation with a pedal rope pump.

5 Household water treatment & safe storage - Water treatment

5.1 Chlorine, boiling

Top photo: PUR is used for turbid water. It is a flocculant disinfectant.

Middle photo: Klorin/Waterguard/Wa Ufa is a liquid just for disinfection.

Bottom photo: Lady using a liquid Chlorine.

Description:

With Self-supply water sources it is strongly advised to use some kind of household water treatment

Advantages compared to not using a treatment:

- Because it is difficult to assess whether water from a Self-supply source is safe to drink, using a treatment method is always preferable;
- With treatment of a good WHO recommended treatment product water is safe to drink;
- By treating no need to test the water quality;
- By treating the water Self-supply will be more acceptable, easier to support by governments and NGOs.

Disadvantages compared to not using a treatment:

- Although cheap, treatment cost money;
- Options like PUR, WaterGuard, Wa Ufa require discipline of treating every day. If there is no consistent use, a treatment does not have health effects.

Boiling: This is the simplest and most safe way of treatment but has its disadvantages like cost of fuel and indoor pollution.

Cloth: A low cost option is filtering through a double cloth which can reduce bacteria with 90%.

Information:

- Chlorine eliminates bacteria and viruses but does not kill Cryptosporidium.
- Cryptosporidium is a major cause for child mortality (SIE 2011).
- Cost: PUR ca. **USD 0.1/20 litres**; on yearly base this is **USD 10 - 20/family.**
- Cost: WaterGuard, Wa Ufa ca. **USD 0.3 for 600 litres;** yearly **USD 1.5 - 3/family.**
- Producers: Local stores, pharmacies.

5 Household water treatment & safe storage - Water filtering

5.2 Types of filters

Top photo: Table top filter, safi partly produced in Malawi.

Bottom photo left: Asian Table top filter including a mineral pot.

Bottom photo right: tulip siphon filter.

Description:

Another option for treatment are water filters. In the last years new lower cost filters entered the market in Malawi.

Advantage compared to Chlorine:

- Good quality filters do eliminate Cryptosporidium;
- Filters do not give a taste or smell like chlorine so people like it better;
- In general the consistence of use of filters is much higher than Chlorine. Once people are used to take waterfrom a filter they will do that daily.

Disadvantage compared to chlorine:

- High upfront cost;
- Not yet available everywhere, since it is still new, the supply chain needs to develop more;
- The Siphon model is more complicated than the table top model, so needs more training in maintenance.

Information:

- Filters remove germs in a mechanical way, no chemicals or additives are used.
- Filters like safi model and sulip siphon filters comply with the WHO standards for bacteria and protozoa (removal 99.995 %).
- Filter elements last for 1 to 1.5 years, after that they need replacement.
- Table top filters like the Asian model have a filter capacity of 25 - 30 litres. The safi filter is 50 litres per day. The siphon model is 100 litres per day.
- Cost: Safi filter ca **USD 18; filter elements ca USD 7.**
- Cost: Asian filters **USD 40 - 100.**
- Producers: Info at all SMART Centres.

6 Sanitation - Latrines

6.1 Zero cement latrine

Description:

A latrine build with bricks without using cement.

Advantage compared to other latrines:

- No need for cement so cheaper.

Disadvantage compared to other latrines:

- Only possible where bricks are easily available and low cost.

Information:

- Cost: Depending on number and cost of bricks ca **USD 20.**
- Producers: Info at SMART Centre Malawi.

Top photo: A zero cement latrine build in Malawi at the SMART Centre.

Middle and bottom photo: Finishing the latrine.

Sanitation - Latrines

6.2 Flapper

Description:

A nice looking and attractive latrine bowl made of plastic.

Advantages compared to concrete latrine slab:
- Looks attractive;
- Is smooth so easy to clean;
- Has an "outlet" valve so no or less smell;
- Can be cleaned with little water.

Disadvantage compared to Concrete latrine slab:
- Is a new technology no supply chains developed yet in.

Information:
- Cost: **Ca USD 5** for the plastic part.
- Producers: Info at SMART Centre Malawi.

Top photo: A flapper build into a concrete latrine slab (Malawi). Middle and bottom photo: Mounting a flapper into a slab.