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**Title**: 130.000 Rope pumps worldwide
25 years experiences from Nicaragua, Ethiopia, Tanzania and six other countries

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**Abstract/Summary**
In Subsaharan Africa rural water supply will depend for many more years on hand pumps. There are a range of hand piston pumps like Afridev, Indian Mark 2 and others which are in general imported. Piston pumps that are produced locally are Canzee, Mark 5 or EMAS pumps. Another type of hand pump is the Rope pump. It has a different pump principle than piston pumps and can be produced in any country with materials that are available in the local market like PVC and GI pipes, rope and used car tires. This ancient pump principle was 're-invented' in 1970 in the Netherlands and started to scale up in Nicaragua 25 years ago. There is much discussion wether a Rope pump is fit for communal rural water supply. In countries like Ghana, Mozambique and Uganda there indeed are negative experiences with this pump model. However in other countries like Nicaragua and Tanzania the Rope pump proves to be a sustainable solution for rural water supply for water levels till 35 meters deep. (ACRA. 2012). Rope pumps are also fit for Self-supply as proven in Tanzania. Of the 10.000 Rope pumps now installed there, over 50% is used for Self-supply and paid for by families. This paper describes both failures and successes of this hand pump in 9 countries. Studies and evaluations indicate that the Rope pump, if produced and maintained well, can reduce cost and drastically increase sustainability of communal rural water supply. (ACRA 2012, Maltha 2015). It can also increase the pump options for Self-supply, resulting in increased incomes and more food security for rural families.

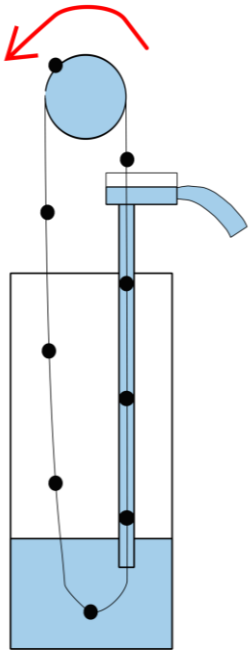
**Introduction**
Hand pumps are still the most used pump technology for rural water supply in Africa and models include Afridev, Indian mark 2, Nira, Tara, Vergnet, Volanta and Blue pump. In almost all African countries these pumps are imported from India, France or other countries. Cost for a pump at 30 meters deep range from 400 US$ for an Indian Mark 2 to 2000 US$ for a Blue pump. For water levels deeper than 30 meters only a few pump models are fit. Pumps like Mark 5 and Canzee pumps as produced in Malawi, have parts that are specially imported for this pump and are limited to depths of 10 to 20 metres. They are produced in a centralised workshop and in general not sold as a commercial product. Costs are 100 - 150 US$.
Hand pumps that are a commercial and free market product and do not require import of special parts are EMAS pumps and Rope pumps. Thousands of EMAS Pumps were produced in Bolivia and other countries in Latin America and is now starting in Sierra Leone. The Rope pump is produced in some 10 Countries in Africa and an estimated 40.000 are installed in Ethiopia, Tanzania and other countries. A model for 35 meters deep has a free market cost of 90-130US$

**The Rope pump history**
The Rope pump is an ancient technology that was improved in 1970 by Mr. Reinder van Thijen [Demotech] using PVC and car tire. This was published in the book "How to make a rope and washer pump" (Lamberts, ITDG, 1980). The pump was introduced in Africa but didn't took off, because of the 'string and bamboo' image. Around 1985 Jan Haemhouts introduced the

‘Demotech design’ in Nicaragua as a ‘do it yourself’ pump and indeed some families did this. Lateron Bernard van Hemert (SNV), started to use a steel frame and made other improvements so it would fit in a tube well. He trained local welders in Juigalpa and with others wrote the book ’The Rope pump’ (Hemert 1989 ). 200 Pumps were installed in Blue fields after hurricane Mitch 1998. When an evaluation was done after 2 years, surprisingly over 80% of the pumps were still working even though there had hardly been training in maintenance. The pump was also installed in Las Mercedes near Managua in a hygiene program. Just replacing the rope and bucket by a Rope pump reduced cases of diarrhoea drastically (Gorter 1995). Around 1990 Henk Alberts assisted in starting the local company Bombas de Mecate and invested much in marketing. Initially sales were to rich cattle farmers and slowly also NGOs started to buy the pump. Years later, after much lobbying by Henk Alberts and support of the Swiss organization Cosude, the Rope pump became a national standard pump and the import of piston pumps like the Afridev reduced drastically. In 1992 the company AMEC in Managua was started by Luis Roman with support of Henk Holtslag and the hand pump was further improved. AMEC also developed Rope pumps powered by Pedals, Electric motor, Engine, Horse and Wind. Later on other companies copied these and an estimated 3000 pedal, motor and wind rope pumps were sold. More local companies were trained or just started copying the pump. By 2005 there were an estimated 70.000 Rope pumps in Nicaragua. After 2005 sales reduced because of the rural electrification. Villages like San Benito where some 30% of the families had a Rope pump, people now have piped system or an electric pump. Some still use the Rope pump for the garden or as a backup.
There are many reasons for the rather success of the Rope pump in Nicaragua like changing from a ‘NGO product’ to a ‘private sector product’. Because local metal workshops made money there was a profit based sustainability and production went on after projects stopped. The shift from imported pumps to locally produced pumps resulted in a cost reduction of 60%. The technology spread out and there are now (2016) about 130,000 Rope pumps in more than 25 countries serving an estimated 4 million people.

**How the Rope pump works**

The basic design has a wheel with a continuous loop of rope with pistons that fit in the PVC pump pipe. At the bottom of the well/borehole is a block that guides the rope into the pipe. By turning the wheel, the rope is lifted and each piston pushes water up. At the top end the pump pipe diameter increases and the water comes out via a Tee piece. Women and children can power it (50 Watts). One person can draw water from 35 m deep, two persons can pump from 60m deep. With engines 80 meters or more are reached. It fits on boreholes of 6 cm diameter or bigger. It delivers 35 litres/min from 10 meter water level and halve of that for water levels of 20m. If maintained they can last for 20 years or more as is proven in Nicaragua where some of the pumps that were installed in 1992, are still working. The Rope pump is fit for families but also for small communities with a recommended maximum of 25 families (150 people). In Nicaragua and Tanzania there are examples of Rope pumps used in schools of 500 children and still working after 10 years. Like any pump the key for functionality of a Rope pump is ownership (money for maintenance).



**Comparison of Rope pumps and Piston pumps**

| Advantages | Disadvantages |
|---|---|
| - Easy to maintain.<br>- Simple, no "black box".<br>- Easy to train on production, maintenance.<br>- Can be made by local workshops.<br>- 2 to 5 times cheaper than imported pumps for the same depth.<br>- Ergonomic continuous rotating movement.<br>- Pump parts in the wells are PVC and concrete, so no or less corrosion.<br>- Rotating shaft, easy to power by hand, pedal, motors or engines, wind or solar energy.<br>- Ideal to be used by one or two families.<br>- Fit for irrigation (income).<br>- If made and maintained well, one pump can supply up to 250 people. However, suggested maximum 150 people. | - It is too simple which is good but also leads to bad copying resulting in early breakdown and bad image.<br>- It cannot pump higher than the pump outlet.<br>- Requires frequent maintenance like oiling the bushings.<br>- After use, the blocking system must be used to avoid spinning of the handle.<br>- The Rope pump is semi open at the top which in theory, can cause contamination of the well. If well made this is hardly a problem (ACRA2012).<br>- The Rope pump splashes more than piston pumps.<br>- Not suitable for large depths and large number of users per pump. |

**Maintenance & functionality**

A main strength of the Rope pump is its "Repairability". It is not a better pump than piston pumps but is it much easier and cheaper to repair. The pump principle is simple people understand how it works so can do simple repairs. The pump is produced locally (decentralised) so spares are available nearby as well as technicians for larger repairs.

Maintenance consist of oiling the bushings weekly or monthly depending on use. The most frequent repair is replacing the rope. The installation and repair of the pump can be done with one spanner and pump pipes are very light (no lifting equipment).

The Communal pump (also rope pumps) often fail due to lack of ownership and problems raising money for repairs. However, if produced installed and maintained properly, over 95% remain operational, even after many years as is proven by pumps in Nicaragua, (IRC. 2000), in Ghana (Drouin 2005), Tanzania (ACRA 2012, Maltha 2015) and Malawi (Roosedahl 2015).

**Self supply & Income generation**

Because of its low cost and high pump volume, the Rope pump is popular for Self-supply. A survey among 5,025 rural families in Nicaragua indicated that a Rope pump at household level increases family income. Families with a pump on their well earn an average 220 US$ more per year than families who use a rope and a bucket on their well (Alberts, vd Zee. 1998). The total accumulated income by families in Nicaragua is over 100 million US$ in a period of 10 years

**If Rope pumps are so good, why aren't they used much more?**

Some reasons are:

**Lack of awareness.**

- Organizations, governments often do not know the Rope pump or do not have information on updated models or examples where the pump is successful so do not include them in development plans.
- For some the Rope pump still has a "stone age" image.
- Some do not consider Rope pumps as an improved water source since it is "open" and the well can be contaminated. Studies indicate that these assumptions are not correct. (Drouin

2005, ACRA 2013)

- A lack of "critical mass" of functioning pumps. To create demand, especially for Self-supply, a certain number of good looking and functioning pumps in one area is needed.
- A lack of long term follow up. To get good quality pumps, long term and repeated training is needed. An example of this long term follow up is Nicaragua where Bombas de Mecate and AMEC were guided during 10 years. The same now (2016) is happening in Africa via the so called SMART Centres in Tanzania, Malawi, Mozambique and Zambia.
- A lack of policy, national acceptance and training. Governments should include it curricula of vocational training like in Tanzania.

**Simple is not easy.**

- Conditions for sustainability are **repairability.** (ownership, availability of spares and knowledge, affordability etc)**.** Whatever communal system is installed, the users or an external party like government, need to be able and willing to invest in maintenance, repairs and replacement.
- The Rope pump seems and is simple but many errors can be made in the construction and installation. In technology "the devil is in the (de)tail" (Naugle, 2000).
- For scaling up a good strategy is essential. Ethiopia is an example. After first introduction and training of private sector, many metal workshops copied the pump, made "improvements" or reduced cost by using thin walled pipes for the pump structure. This caused pumps to break. Wrong installation of pumps resulted in water leaking back into the well causing recontamination. These problems gave a bad image of the Rope pump and it will takes many good pumps to "repair" a bad image.

**Context, aims and activities undertaken**

There now are some 130,000 Rope pumps world wide used for communal supply and Self-supply, irrigation, chicken, cattle, water vending and even car washing.

**Latin America**

**Nicaragua**

About 70,000 Rope pumps have been installed. The shift from imported piston pumps to Rope pumps has increased rural water supply by 23 % in ten years, much faster than countries that applied imported hand pumps (Alberts 2005). Users do the maintenance and over 90% of the Rope pumps remain in operation (IRC 2000). The Rope pump has been adopted as the standard water pump by the government. About 80% of the Rope pumps in Nicaragua are used by one or a few families and donated by NGOs. Families with a pump earn an average of 220 US$ more than families without a pump. Generating over 100 million US$ in 10 years. (CESADE/ICCO surveyed 5015 families). The extra income is explained by the fact that a pump provides water for gardening, animals, time saving for women, more water is used, more hygiene etc. The result is reduced health related cost and generation of extra income

**Honduras, El Salvador, Guatamala, Mexico, Peru, Bolivia , Argentina**

In these countries the Rope pump was introduced. For instance the Mennonites installed hundreds of Rope pumps in Bolivia. Organisations like FIDER installed them in Mexico. Bombas de mecate had a second company in Honduras.

*Hand Rope pump Nicaragua*

*Motor Rope pump Nicaragua*

**Experiences in Africa**

The Rope pump was introduced in several African countries but has often not been successful.

**Zimbabwe** A Rope pump model called Elephant pump was introduced by Pump Aid in 1990 and later on in Malawi. The wheel and guidebox are different from other Rope pump models and there is a round concrete structure to protect the well and pump. Because of this structure the cost of one pump ranges from 200 to 400 US$ (excl. cost of the well). This pump model is hardly sold to private families. Over 10.000 pumps have been installed in Zimbabwe and Malawi. In general they are donated if people help to dig the wells. Pumps are produced and installed by technicians of Pump Aid which has the risk that activities stop when funds stop.

**Ghana** The first experiences with Rope pumps in Ghana were discouraging. In the year 2000 some 200 pumps were installed. After 1 year 80% of these pumps were defect. Major reasons were errors in construction and installation, lack of follow up and no ownership. These problems caused a bad image and the government did not approve of this pump type. In other parts of Ghana other Rope pump models were installed like the Victoria model produced in Bolgotanga for hand dug wells and the 'Pumping is Life' model on boreholes. Better quality and good community involvement resulted in much better results and most of the new model Rope pumps are working and about 3000 Pumps are now installed. The Rope pumps in northern Ghana were among others supported by Water Aid and the good results of the new pumps slowly improves the image of the Rope pump in Ghana again.


*The Elephant Model Rope pump in Malawi*

*The Victory model, Ghana Bolgatanga*

**Burkina Faso** In 2013 WaterAid 'developed' a Rope pump model suitable to local conditions. This project has resulted in a renewed understanding across WaterAid of the need to ensure that Rope pumps destined for community water supplies require high quality manufacturing and installation techniques in order to improve their sustainability. WaterAid now (2016) intends to renew its efforts across the organization to improving the quality of Rope pumps in countries where this is supported. A training course for manufacturers from Burkina Faso, Ghana, Mali, Zambia and Malawi was held in early 2010 as part of this process. This is currently being piloted on a few pumps. Another organisation, Winrock, started training other local workshops and install Rope pumps of the SHIPO model in communities up to 150 people. About 100 were installed at the end of 2013 and 98% are functioning (Winrock 2014).

**Ethiopia.** Rope pumps were introduced here around 2006 by the Practica foundation and supported by organizations like IDE, JICA and Water Aid. During several years local metal workshops have been trained in production. However the pump became so popular that untrained workshops also started to produce and sell the pumps. By 2012 there were an estimated 10.000 Rope pumps installed but often the pump and or installation was of a poor quality resulting water to leak back in the well and causing recontamination. In 2013 the government of Ethiopia decided to improve and standardize the Rope pumps and is doing this with support from JICA and MetaMeta. A national policy now is to reach the goal of water for all by a large upscaling of Self-supply. The Rope pump is seen as an important tool to reach this goal and in 2014 local governments ordered 10.000 Rope pumps. However most of these pumps are still in stores since the demand for Self-supply was never created. Before this almost all of the first 10.000 pumps were given away (Mekonta 2014).

*Rope pump Burkina Faso, Winrock in 2012*

*Rope pump model Ethiopia*

**Malawi** Several Rope pumps were introduced around the year 2000 in order to provide an alternative for the Afridev Community hand pump, which is the standard hand pump in Malawi. The Afridev was less popular due to many breakdowns (although this was mainly due to lack of maintenance) and not available spare parts, especially in the more remote areas. However, the Rope pumps also broke down, sometimes several times per month, due obsolete pump designs low quality, the high number of users and lack of maintenance and repair capacity. It was not considered by the users as a good community pump, although repairs were possible. Another disadvantage mentioned was that children found it difficult to pump (caused by too large pump pipe diameter) and sometimes got hurt when the handle blocking system was not functioning (due to lack of quality control). In 2008 over 2000 simple Pole model Rope pumps for irrigation were installed near Blantyre made by the organization DAPP. In 2012 the CCAP SMART

Centre in Mzuzu introduced the SHIPO model Rope pump. This centre, supported by MetaMeta, is now (2016) training local companies in manual well drilling and Rope pumps. A focus is on quality control via certification. After initial problems now good quality pumps are produced and about 250 are installed. www.malawismartcentre.com

**Mozambique** As in Malawi, the Rope pump was seen as a viable alternative to the Afridev which is generally the official pump of choice. WaterAid had first introduced a bucket and windlass system in the Niassa province as an alternative due to the high failure rate of Afridev pumps, but the Mozambican government refused to accept these as official community water supplies. WaterAid with SDC, UNICEF, CARE and the Government of Mozambique, therefore began a lengthy process of piloting a robust community Rope pump, first relying on support from Bombas de Mecate in Nicaragua, but later adapting the design from Madagascar which is a pump model with a closed wheel cover and meet government criteria. Three manufacturers were trained using drawings made by SKAT and there was a final approval of the Rope pump in 2011 as well as the licensing of the manufacturers by the Governments standards laboratory. About 300 Rope pumps were installed across in Niassa, Cabo Delgado and Zambezia with funds from WaterAid and others. In 2013 the manufacturers stopped producing and most, if not all pumps are defect and not being repaired. Reasons seem the complicated design so maintenance and repairs is relatively difficult. Also a lack of ownership/ payment and the large number of people per pump.
In 2012 the organization ADPP in Itoculo (near Nampula ) trained workshops in the production of the so called SHIPO model. In 2014 the GSB SMART Centre in Bilibiza (north of Pemba) was trained in this model and manual drilling of Tube wells. Now about 100 Rope pumps of this model are in operation and in the Bilibiza are over 90% are functioning.

*Malawi. Rope pump model no 3 ( Pole model) A family pump used for irrigation*

*Mozambique. Model with complete cover, (Madagaskar model) 300 installed around 2005. Many problems with maintenance.*

**Tanzania** Here the local organization SHIPO in Njombe introduced the Rope pump in 2006. With support of the Dutch organization Connect International and funds of the Dutch government and Aqua for all, a so called SMART Centre started. This centre demonstrates a range of low cost water technologies like manual drilling hand pumps, water tanks, household filters etc. and trains organizations and local private sector in production, maintenance, business skills etc. The centre organizes trainings for organizations like Winrock/USAID, MSABI, World Vision, Dorcas and others. The result after 10 years is about 35 local companies trained, over 10,000 SHIPO model Rope pumps installed, over 3,000 manual drilled tube wells. Cost

reduction for rural water points from 40 to 15US$ per person. More than half of the 10,000 pumps is for Self-supply, sold to families in peri urban areas and increasingly to rural families.

*Tanzania. SHIPO Model for communities*

*Bad quality well covers result in Corrosion*

**Study on Rope pump and other hand pumps**

The following part is based on a study done in 2012 by the Italian organisation ACRA, comparing several types of hand pumps on functionality and water quality in rural Africa. This study was conducted in a fully participatory manner, in order to select and weight the most meaningful and relevant parameters of comparison. The study utilises interviews with water users, sanitary surveys, water quality analysis and the application of a Comparative Performance Analysis technique to obtain quantitative results. This analysis follows a previous analogous study conducted in Ghana (Harvey & Drouin, 2006), with a view to provide a partial comparison of the two cases in order to validate conclusions.

1) The first level of comparison considered is bacteriological contamination risk.
2) The second part evaluates the performance.
   a) Functionality/ Reliability/Sustainability
   b) Reparation cost

**1.** Water contamination of Rope pumps compared to Piston pumps

| | Traditional piston pumps | rope pumps |
|---|---|---|
| **General Results** | 37% | 49% |
| **Dry Season** | 24% | 32% |
| **Rain Season** | 53% | 65% |

**Water Quality Test results, percentage of contaminated samples**

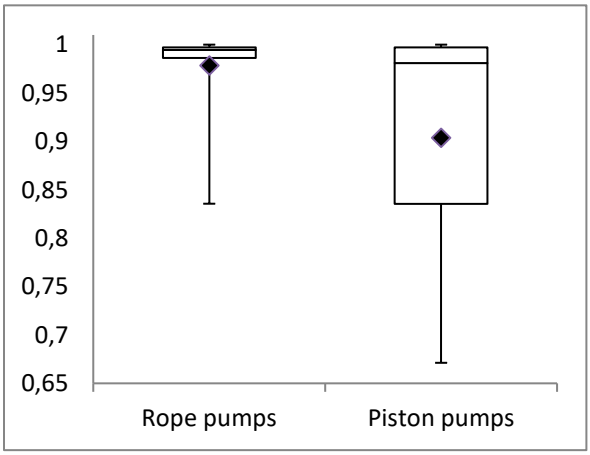
Water samples from wells equipped with both technologies show quite high contamination rates. ***This implies that technological choice is not sufficient to assure safety of water supply and more effort is required to improve hygienic conditions and proper maintenance of water sources.***

At first sight, water quality analysis seem to confirm a ±10% higher contamination risk in wells

equipped with rope pumps compared to the ones equipped with hermetically sealed traditional piston pumps.
This does not necessarily mean that the Rope pump is not suitable to protect the well, but that it is generally installed with less attention to hygienic standards. This consideration raises some questions concerning mechanisms to assure sufficient quality standards in case of rope pumps diffusion at larger scale. In fact, the technology's simplicity and the local availability of all constituent, favour the establishment of a strong supply chain, with a larger number of producers and supplier, but hinder any possibility to effectively monitor the respect of minimum quality standards in production, installation and maintenance of rope pumps.

**2.** Comparative Performance Analysis
The method utilised in this study was adapted from the basic principles adopted in multi-attribute utility-measurement for social decision making (Edwards, 1976).
The overall evaluation score for rope pumps, on a scale 1 to 100 is equal to 41.2, while for piston pumps is 29.9. The parameter showing the biggest discrepancy between the two pumps types, as well as the one with the highest assigned weight, is initial investment cost. This is predictable, being one the best known advantage recognized to rope pumps. Rope pump seem to show highest scores for all parameters, with the exception of contamination rate. Apparently, this confirms the main argument constraining rope pumps from spreading at larger scale in Tanzania and other countries. Nevertheless, these results are widely discussed in a section about sanitary conditions and other influencing factors are taken into account for deeper insight into the issue of water contamination risks.

**2a.** Functionality/ Reliability/Sustainability of Rope pumps compared to Piston pumps
The percentage of pumps experiencing some kind of failure during the past 12 months is 86% of Rope pumps, against the slightly lower 80% for conventional piston pumps. Nevertheless, looking at the duration of the failures, Rope pumps show much higher reliability figures (see below).




**Box plots representing reliability figures for rope pumps and piston pumps**

Non-functioning rope pumps were out of service for an average of 5 days, with a maximum of 60 days in a row. For piston pumps the average non-functioning time is 28 days, with a maximum of 120 days. This data is interesting in terms of technical sustainability and in addition to the reliability of the technology itself; it takes into account other sustainability factors such as availability of spare parts and technical assistance, as well as reparation costs.

| | Rope pump | Piston pump |
|---|---|---|
| **Average out-of-service days** | 5 | 28 |
| **Maximum out-of-service days** | 60 | 120 |

Another factor to be considered in this analysis is certainly the age of pumps considered. No relevant correlation was found, for both technologies, between their age and reliability figures.

**2b.** Reparation cost of Rope pumps compared to Piston pumps

| | Rope pump | Piston pump |
|---|---|---|
| **Annual Reparation Costs (users)** | 12.5 USD | 17.8 USD |
| **Annual Reparation Costs (suppliers)** | 13.3 USD | 136.3 USD |
| **Most frequent intervention needed** | Rope replacement | Rubber seals |
| **Cost of spare parts** | 10.1 USD | 9.5 USD |
| **Cost for technical assistance** | 3.2 USD | 126.8 USD |

Reparation costs

Cost for transport and labour costs depend heavily on distance. Rope pump producers are close to rural areas while conventional piston pump experts are mostly found in provincial capital cities.

Conclusion of the Acra study

Following a Comparative Performance Analysis, we can demonstrate that Rope pumps reached a higher score for all parameters included in the study, with the exception of contamination rate (which is slightly better for conventional pumps compared to old type of rope pumps).
The study shows that the rope pump is actually a valid low cost alternative to assure sustainable water supply in rural areas.

**Conclusions**

1. If people have a choice in hand pumps and they know the Rope pump they often prefer Rope pumps. (ACRA 2012).
2. If Rope pumps are well installed with an apron, good hygienic seal etc, there is hardly any difference between the water quality of Rope pumps and Piston pumps (Drouin 2006, ACRA 2012)
3. The ±10% higher contamination rates for water from Rope pumps, is mainly related to poor hygienic conditions of the pumps surroundings and to the adopted excavation technique, rather than to the type of pump installed. ( ACRA 2012)
4. As with every option, Rope pumps have advantages and drawbacks. (ACRA 2012)
5. Compared to traditional piston pumps, Rope pumps seem to show better performances for most of the parameters considered. (ACRA 2012)
6. In many countries the dissemination of the Rope pump failed for both technical and non technical reasons. For both a hard lesson learned was “Simple is not easy”.
7. The success of the Rope pump in Nicaragua was due to technical improvements and the approach of changing from a ‘NGO product’ to a ‘private sector product’.
8. Also in Africa the Rope pump can be successfully disseminated as proven in Tanzania
9. This or other simple hand pumps can improve the 3 to 5 million in open hand dug wells in Africa and be installed on new wells or boreholes.
10. In summary, the Rope pump has high potential to scale up ‘access to an improved water source’ (SDG 6), reduce rural poverty and increase food security.
11. A condition in all cases is… …quality. Good quality requires demonstration and long term follow up on training of local entrepreneurs, certification, marketing, facilitating payment options etc.

**Recommendation**

Let's do it. Learn from the failures and copy the successes.

*A Rope pump in Tanzania, the SHIPO model*

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