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Household pumps from the informal sector

Robert A. Lambert and Richard D. Faulkner

Abstract The development of two pumps, the rope-washer and the treadle pump, is described. The pumps can be made by the informal artisan sector and are suitable for household use in domestic supply and irrigation. The rope-washer pump is cheap, easy to operate and maintain, can lift water from depths in excess of 20m and up to 5m overhead. The treadle pump can raise water from depths of up to 6m and up to 20m above itself. Dissemination of the technology has already started in Zimbabwe and initial results are encouraging. A strategy for further dissemination is outlined.

INTRODUCTION

The need for water

An adequate supply of domestic water is vital for human health and hygiene. Despite the great progess made in the recent decade the achievement of the goal of clean water for all is still a long way off. An adequate water supply is also vital for the production of food. In many parts of Africa, rainfall is a very unreliable provider of such water. For example, in Zimbabwe, Mupawose (ref 1) states that unreliable rainfall and the incidence of mid-season drought represent the single most critical uncertainty facing the Zimbabwean farmer today. While staple foods such as maize and rice produced during the rainy season can be stored for consumption in the dry season, the same is not true of vegetables and fruit which are essential for good nutrition. Since the early part of this century, the answer to the problem of inadequate rainfall has been through the provision of modern irrigation schemes. The failure of such schemes in many parts of Africa is well documented (ref 2) and there is little hope of significant expansion in this sector.

The water resource

Most of these irrigation schemes depend on the utilization of surface water resources, principally through the construction of dams. There is growing concern over the use of such dams because of their adverse impact on health, their inundation of large areas of often fertile soils, their displacement of successful farmers and the severe limitations on their useful life due to siltation (ref 3). Groundwater resources offer significant potential for both irrigation and domestic supplies (refs 4, 5 & 6).

In order to develop groundwater resources a suitable waterlifting technology must be employed. While much work has been done on the development of power sources for water pumping (e.g. ref 7), for many people in rural Africa the use of human energy remains the only practical option (ref 8). In recent years there have been significant improvements in the design of handpumps for community use. However community water points still suffer breakdowns and attempts to remedy this, through community managed pump maintenance schemes, are still far from universally successful.

The problems of community management could be avoided through the promotion of household supplies, where these are feasible. An example of such a strategy in Zimbabwe is the programme of upgrading family wells (ref 9). However, most of the pumps developed for community use are either not available to individual households or are too expensive.

In recognition of the need for simple water lifting technology, the Overseas Development Administration of the UK funded a 3 year research project, based at Loughborough University and the University of Zimbabwe, to develop simple and affordable pumps suitable for micro-scale irrigation. This project is now nearing completion. Two designs were selected as the most suitable, the rope-washer and the treadle (ref 10).

PUMP DESIGN AND DEVELOPMENT

The rope washer pump

The principle of the rope-washer pump is very old, dating back to ancient Rome and China. A pipe extends from the surface down to below the water level. A loop of rope with washers attached is pulled by a pulley up through the pipe, and returns down to the water outside the pipe. Attached to the rope at intervals are washers whose diameter is slightly less than that of the pipe. As the rope and washers travel up inside the pipe, they draw water with them which discharges at the top of the pipe (Fig 1). Historically the pulley was fashioned from wood or steel with teeth to grip the washers on the rope. Considerable skill was needed to make a pulley capable of pulling a wet and slippery rope which was under tension from the weight of water in the pipe.

A great simplification was made with the introduction of the split car tyre pulley which seems to have been invented in the 1970s by a Dutch organisation (ref 11). This pulley can be made in about an hour using some steel bar and an old car tyre (ref 12). It gives an excellent grip on wet nylon rope and is very robust. Similarly the washers can be cut from old car tyre, using skills and equipment found in most parts of less developed countries. For the pipe, PVC tube is ideal, although virtually any type of pipe can be used provided there is a smooth bore for the bottom few metres. Square wooden pipes have been used with success, although the time taken to make them is only justified where plastic pipe is not available. Pipe sizes from 20mm (internal bore) to over 80mm have been used, giving a 16 fold variation in flow rate and lift.

The traditional design of the rope-washer pump involved a set up over a vertical well (Fig 1i). This arrangement is suitable for many domestic wells and allows the wells to be adequately protected against contamination. However, in many parts of Africa, farmers use shallow unlined ponds or streams for irrigation and such a vertical arrangement would be both unwieldy and expensive. Working in Tanzania in 1981, the vertical arrangement was modified by Lambert for use in unlined ponds or streams (Fig 1ii).

Other modifications have been introduced by farmers and artisans, showing that they are capable not only of maintaining the pump but of adapting it to their needs. For example, in cases where the well head or stream bank is lower than the plot to be irrigated or the water tank to be filled, the designs shown in Fig 1i &1ii are inadequate. Confronted with this problem, an artisan trained in Zimbabwe devised a twin axle pulley system to lift water into overhead tanks (Fig 1iii). The present design of the rope-washer pump means that it can be made from locally available materials and using very basic carpentry tools. A trained pump maker can make and instal one pump in a day, provided all materials are on site.

The treadle pump

The treadle pump was developed in Bangladesh and is now in widespread use there (ref 13). Its principle advantage is that it can be operated by leg muscles - these muscles are capable of higher power outputs than the arms used in hand operated pumps. However the Bangladesh design is limited to a suction lift of 6 metres, with no positive head possible. Manufacture of the treadle pump requires, at the very minimum, welding facilities and skills and the pump is more expensive than the rope-washer. For these reasons the Bangladesh version is not a serious competitor to the rope-washer pump in many situations.

However, in parts of Zimbabwe, sandy river beds offer significant potential for micro-scale irrigation of vegetables in the dry season (ref 14). In such cases a pump must be capable of raising water over the bank of the river - a difficult job with the rope-washer pump. Furthermore, the pump must be portable for removal when the river is flowing. It must also be capable of dealing efficiently with pumping heads ranging from 5 - 20m. The treadle pump was redesigned to allow pressurised discharge through an outlet pipe (Lambert & Faulkner 1989). A capacity to deal with variable heads was achieved by allowing for a variable stroke length and interchangeable small and large cylinders. The treadle pump design is illustrated in Fig 2.

PUMP PERFORMANCE

Technical evaluation

The technical performance of both pumps has been evaluated in a series of laboratory tests (ref 8 & 15). The performance of a pump in terms of flow rate of water at a known lift is described by the hydraulic output. A hydraulic output of $10m^3m/h$ means that $5m^3/h$ can be lifted over 2m or $2m^3/h$ over 5 metres. As Table 1 shows, the hand-operated rope-washer pump gives a comparable output of water to the foot operated treadle. Changing from hand to foot operation could allow an extra 75-80% of human energy to be used (ref 8) giving an increased output of water. The only way in which the treadle pump outperforms the rope-washer is in its ability to lift water overhead. Delivery heads of over 20 metres have been achieved with the treadle compared to about 5 metres for the rope-washer, this being the height of the poles needed to support the upper axle (Fig1iii). The rope-washer pump has been able to cope with all deep wells encountered - the deepest to date being 22m.

Farmer evaluation

Early on in the research a number of pumps were installed with farmers in the Chihota area of Zimbabwe. The response was very positive and most of the farmers, when given the opportunity to buy the pumps after the test period, did so.

Particular attention was paid to the ability of the farmers to maintain the pumps in operation. Continuous monitoring showed that, with the rope-washer pump, farmers had no problems in coping with the minor breakages inevitable with such a design. In fact the farmers, when questioned, insisted that the pump suffered no breakdowns - presumably because a breakdown is only serious if it can't be fixed due to lack of spare parts or necessary skills. Even in conditions of heavy usage in a peri-urban area, where one pump was installed on a

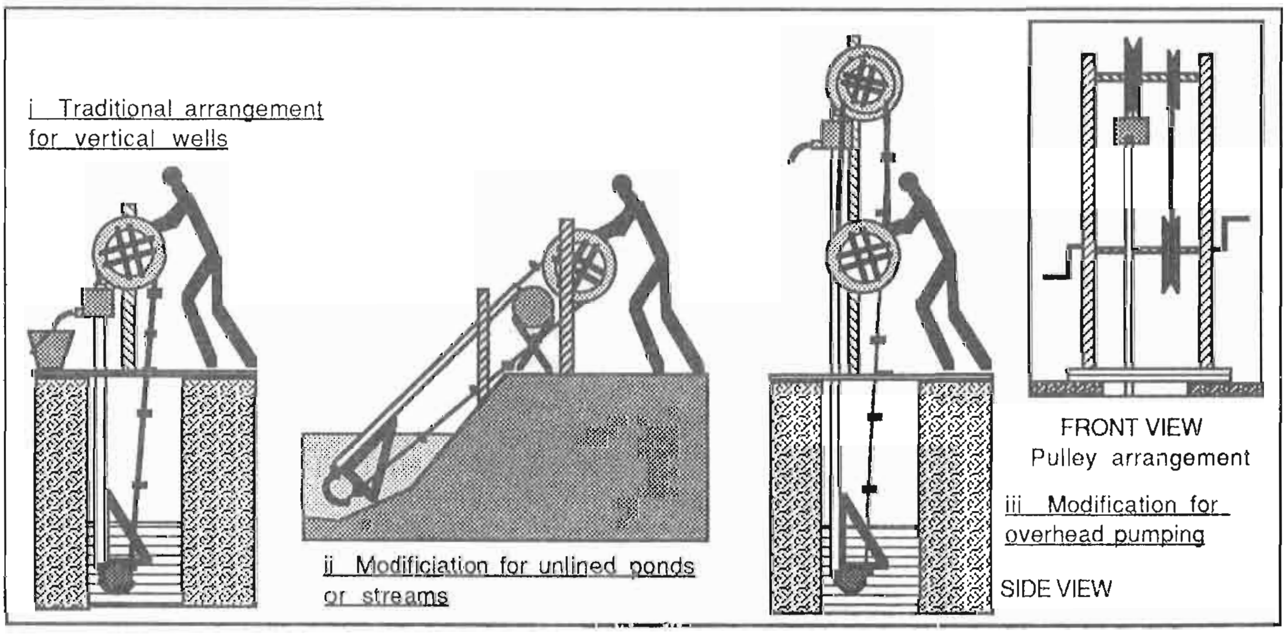

Figure 1 Three arrangements of the rope-washer pump

private well but used by many nearby families, it was noted that users took considerable care to operate the pump properly. This experience is similar to that reported by in Indonesia (ref 11), where 5 years after the installation of 128 pumps, more than two-thirds were still working. Many of the pumps that were not working had been donated free of charge.

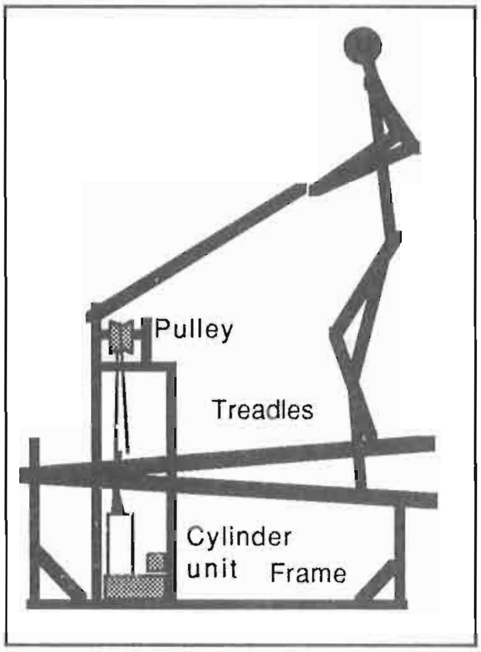

Figure 2 The treadle pump

The treadle pump caused more problems, with some farmers finding it difficult to understand how it worked. In some cases, wear of the cylinders was reported due to sand ingress. However in many cases farmers were reported to be using the pump successfully. In the longer term, repair and maintenance will require welding facilities.

Table 1 Pump characteristics

Characteristic		Rope-washer	Treadle
Cost, £	Homemade	20	-
	Sold by artisan	50	150
Sustaniable power output, W	(1 person)	40	42
Hydraulic Output m^3m/h		15	16
Flow l/s	Maximum	3.0	3.0
	@ 3m lift	1.4	1.2
	@10m lift	0.4	0.4
Lift, m	below pump	20+	5
	above pump	5	20+
Manufacture time	days	1.0	6.0
Facilities needed		Carpentry	Welding

TRAINING AND DISSEMINATION

Rope-washer pump

Because of the positive results of the laboratory tests and the farmers in the field-trials, demonstrations and training workshops were organised and a construction manual and video were produced (ref 12). The initial dissemination strategy was to train artisans who could go into business making and selling the pumps to farmers. This was based on the assumption that it would be very difficult and time consuming to train farmers to make their own pumps and that they would prefer to buy them from artisans skilled in pump making. However, at the request of Agritex, Zimbabwe's agricultural extension service, staff at provincial level were trained and equipped with pumps in order to disseminate the technology directly to farmers. In addition, a number of NGOs became involved in the dissemination of the pump and are currently running farmer training courses in different parts of the country. Training courses have been organized in Kenya and it is hoped that dissemination to other countries will begin soon.

Successes Due largely to the enthusiasm of government staff who have been trained in the use of the pump it has now been widely exhibited at agricultural shows throughout Zimbabwe. In certain parts of the country, where farmers are receptive and the extension services well prepared, the pump is being adopted at an encouraging rate. It would seem that initial reservations about the capacity of the extension services to disseminate the technology directly to farmers were unfounded. The extension workers involved have performed very well, and the farmers have shown great skill and versatility in adapting the pump to their own requirements.

Firm data are not yet available on the number of pumps currently in operation but it is estimated to be in the order of several hundred.

Problems The rope-washer pump is not suited to centralized manufacture and distribution. Poor farmers have difficulty in raising even the small amounts of cash needed for the pump and artisans making the pump for them face the problem of obtaining payment. The problem is particularly severe for poorer farmers such as widows, who may not feel capable of making their own pump where government or NGO services are extending the technology. If credit were available then it has been demonstrated by numerous farmers using the pump that it is capable of paying for itself in just a few months.

Treadle pump

Following the initial laboratory tests and the production of several prototypes, a number of engineering companies in Harare were invited to manufacture the treadle pump. Although much interest was expressed and one company even made its own prototype model, there was an unwillingness to become involved in the redesign that was necessary. An artisan working in Mbare, a part of Harare with many informal sector workshops, expressed interest in making the pump. After considerable training and redesign of the pump to fit in with the limited facilities available, he has now begun making and selling the pump.

A strategy for further dissemination

In deciding on a dissemination strategy, a useful model could be that of the VIP latrine in Zimbabwe. Here, training is provided for local builders in the construction of the latrine. Some materials are provided by a donor and local materials and labour are provided by the beneficiary. The beneficiary family ends up with a useful household asset. A similar strategy could be employed with the rope-washer pump. Already there have been successes where training alone has been provided. These successes could be extended if materials, such as the rope and pipe, could be provided by a donor at nominal cost or on credit. Training could be given on installation, operation and maintenance.

CONCLUSION

Two pumps, the rope-washer and the treadle, have been developed to suit the water lifting needs of families for micro-scale irrigation and for domestic use. The rope-washer pump is cheap, easy to make, operate and repair. It performs as well or better than more expensive and sophisticated pumps and is suitable both for micro-scale irrigation and for domestic use. With training the rope-washer pump can be made by the pump user. Operation and maintenance can be done entirely on site. The treadle pump can be made by artisans in the informal sector and is particularly appropriate to pumping water from sandy river beds for micro-scale irrigation. Production of both pumps by the informal sector has started in Zimbabwe. The results to date indicate that the potential exists for giving families access to affordable and effective water lifting technology.

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