CHAPTER 5
MODIFICATION AND INTRODUCTION OF TREADLE PUMPS AS TECHNOLOGY FOR OPTIMIZING LAND USE IN DAMBOS

5.1 Introduction

One of the strategies to rapidly increase food production in a drought prone country like Zambia is the introduction of technologies that would make it possible to produce food all year round by utilizing the available water resources. Many constraints abound in food production and these have been established and elucidated in this study. Dambos, which are scattered throughout the country and are accessible to a large number of Zambian farmers, are an option that this study has identified as a potential attribute that could increase food production, provided that production constraints are eliminated or mitigated. The major on the constraint is water and how this can be lifted for use in irrigated fields. Apart from mobilizing and utilizing the water, there is a need to conserve it since it is limited despite its abundance in the country. Paradoxical situations occur with water being poorly distributed and sometimes being over used.

The study has identified a very simple and inexpensive water lifting device (the treadle pump) as a low profile technological miracle, which without fanfare, has made millions of the world's poorest farmers from developing countries such as Bangladesh, India, Vietnam, Nepal and Cambodia double their incomes and step beyond bare subsistence. By using this device, farmers in these countries are able to harvest a second or third crop in the dry season and plant new varieties of vegetables and in some cases crops are being grown where nothing grew before.

5.2 What Is a Treadle Pump?

The treadle pump is an elegant foot operated human powered water lifting device which by using suction force, lifts water from rivers, swamps, reservoirs and shallow wells (hand dug) over a depth ranging from 0-8 meters to the ground surface where it is intended to be used by farmers for irrigation, livestock, domestic and other purposes.

To realize the potential use of this device into **"a dream come true"** for Zambia, this study embarked on the transfer of this technology and adapting it to the local prevailing conditions. Using the hydrological knowledge of some Zambian rivers and Dambo land, the study has established Dambos as a major niche for use of this technological device because of the existing shallow water tables throughout their places of occurrence.

These are similar conditions as those prevailing in the countries mentioned where this type of pump has been used successfully. The merit underlying the transfer of this technology lies in the fact that the treadle pump is made of locally available materials (i.e. scrap yard metal, wood and animal skin) which make it inexpensive and affordable by the small-scale poor farmer with a meagre financial resource base. Unlike the innumerable manual irrigation techniques that have been tried before and proved expensive, with lots of technical short-comings and out of reach of the poor farmer, the treadle pump is a farmers' friend whose return to capital is more than 100% even with the first crop.

The study has proven beyond doubt that designs of modern water lifting devices, which include motorized pumps, are expensive and sometimes inappropriate for Zambian conditions. The treadle pump is affordable and appropriate for the small-scale farmer (see Section 5.10). Some so called "appropriate low-cost technologies" involve costs as high as motorized devices and thus become unaffordable by the small-scale poor farmers whose large numbers would exert the kind of impact necessary to accelerate the rate of increase in agricultural food production to levels that would match or exceed the population growth rate currently prevailing. This is possible if and once appropriate and sustainable technologies are made available at low costs.

5.3 Treadle Pump Technology Development

The initial steps in transferring and developing the technology involved acquisition and testing of prototypes for the treadle pumps. The prototypes and blueprint designs were obtained from Bangladesh under a Special Programme for Food Security ran by FAO. This study identified that it was necessary to pilot the operation of the technology in the three Dambo study sites where hydrological research under this study had proven it was possible to grow crops provided water lifting and drainage were addressed.

Working with the FAO and IDE, an NGO spearheading the development of small-scale irrigation in Zambia, the author embarked on on-farm testing and later modifying the treadle pump prototypes according to field results/feedback from farmers to suit the existing conditions so that the pumps would be adopted by them. Piloting started in 1997 at three Dambo sites, i.e. Chipala Dambo, Noole Dambo and Mugabi Dambo in the Copperbelt, Southern and Eastern provinces of Zambia respectively.

Three types of treadle pumps were tested and modified according to farmers' suggestions in the field. The three prototypes included the tube well treadle pump, the river treadle pump and a pressure treadle pump. A tube well is referred to as a borehole in Zambia. Under Zambian hydrological conditions, boreholes have water tables that are too deep below the surface to use the tube well treadle pump, whose suction limit is 8 m below the ground surface. The pumps were piloted in the field for a period of one year. Although piloting continued in the following season, an appreciation level for the modifications made to the pumps had been reached to such a level that adoption started at a very rapid rate.

5.3.1 Operating Principles of Treadle Pumps

Treadle pumps are essentially manual pumps operated by human feet (Figure 14). Pumping is achieved by standing on the two treadles connected to pistons in the cylinder. By shifting the human body weight side to side the pistons in the pump cylinders are activated up and down to create suction pressure. The suction pressure creates a vacuum in the cylinders and by help of atmospheric pressure and force of gravity acting on the free water surface, water is forced to enter the pump cylinders through the inlet pipe connected to the junction box.

Except for the pressure pump, each upward movement of the pistons on the suction type pumps (original tubewell, modified and river pumps) lifts water by means of rubber cups fitted onto the pistons and discharges it through the spout. The pressure pump, though operating exactly on the same principles, on the other hand discharges water on the downward movement of the pistons by pressurizing it through the junction box to the outlet pipe connected to it.

Figure 14: The Treadle pump in Operation Activated By Human Feet.

The operation to lift water follows some ingenuity of connecting the pump to a water source by a pipe called **"inlet"** which is fitted with a non-return valve that allows water to enter this pipe one way and does not allow it to flow back to the water source.

Essentially the piston and the cylinder have a very close or tight fit so that when the piston is raised, it creates a vacuum in the cylinder and water is sucked into the pump. When the piston is pushed down (see Figure 15a), the water is pushed through a small valve in the piston to fill up the space above it. When the piston is raised again, it lifts this water until it pours over the rim of the cylinder and into an irrigation channel or tank. At the same time more water is drawn into the space below the piston. The downward stroke of the piston once again pushes water through the small valve into the space above the piston and the process is repeated (Figure 15a).

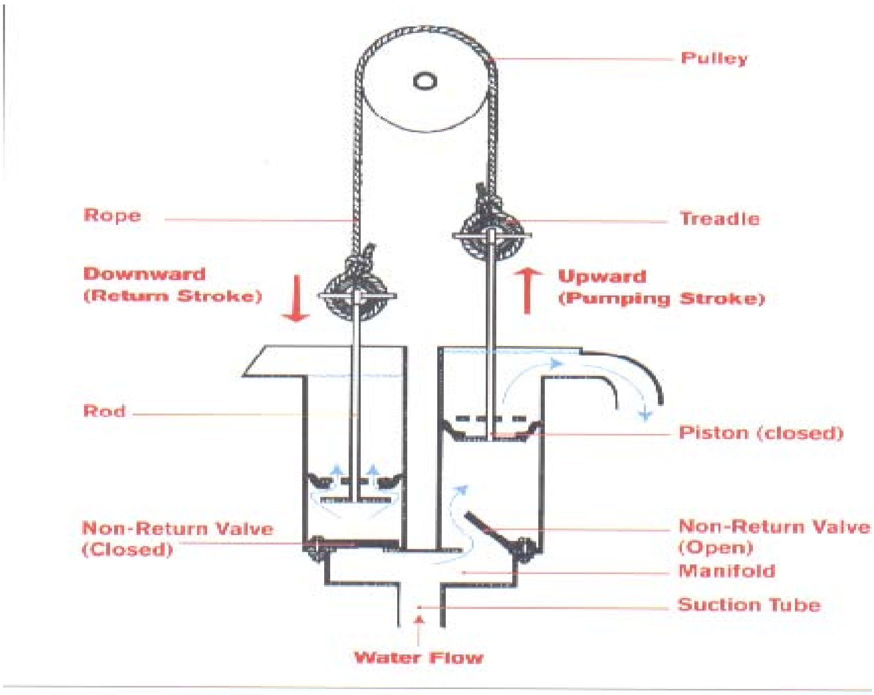

Figure 15a: The treadle pump operating principles.

5.3.2 *Structural and Operational Characteristics Of Different Prototype Modifications of Treadle Pumps Tested*

The treadle pump essentially consists of twin cylinders whose internal diameter is 89 mm except the pressure pump, which has an internal diameter of 100 mm. The optimal discharge at a suction lift of 7 m below ground surface is between 1.5 and 2.0 l/s. To operate the pump, internal parts such as foot valves, which allow water to flow in one way and stop it from flowing back to the source, the rubber/leather cups acting as seals with the cylinders and which lift water in a nearly continuous flow in these cylinders when fitted to the pistons that get connected to the treadles with a metal rod, are required to be assembled.

In case of the river and pressure pumps, a pulley wheel and rope connect the two treadles to the piston rods and enable the operator to work the treadles up and down in reciprocating movements. These are the complete mechanical parts of the pump. The pump discharges water on the upward stroke through a spout attached to the lips of the cylinders.

On the other hand, the pressure pump has an internal diameter of 100 mm and discharges between 2.0 l/s and 2.5 l/s at a suction lift of 0-4 m below ground surface. The internal parts consist of rubber flaps as foot valves and leather cups which perform the same functions as those described for the rubber valves and cups above. The leather cups fit water tight in the cylinders and as such pressurize water out of the cylinders through the discharge pipe on the downward stroke. The pressure with which the water is discharged depends on the operator's energy. As a result of the pressure created by the pressure pump, it can deliver water at elevations up to 7 m above ground level (or actually above pump level), whereas the tubewell, modified and river treadle pumps which are basically suction pumps can only lift water from the source and bring it to ground (or pump) level. The basic components which act as ancillary parts to these pumps are shown in Figure 15b whereas Table 18 gives a comparison of the characteristics of the different types of pumps tested in the field.

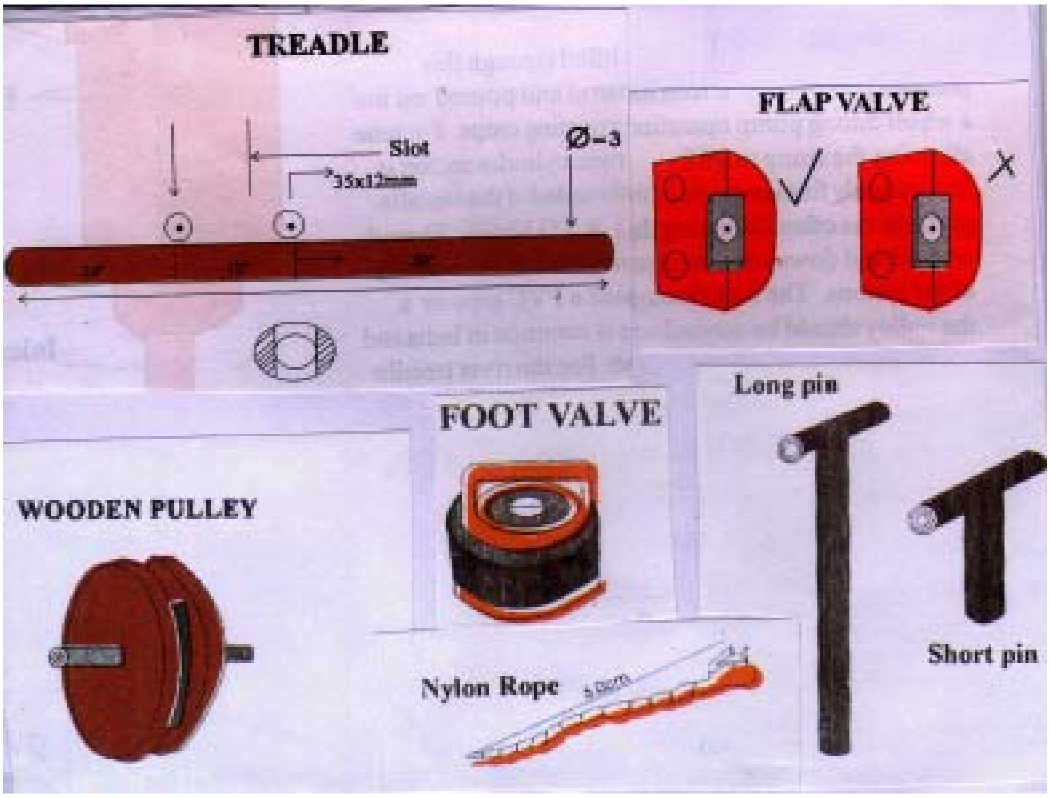

Figure 15b: Basic Ancillary Components Of The Treadle Pump.

Table 18: Characteristics of the prototype pumps and their components.

Characteristic	Tube well pump	Modified pump	River pump	Pressure pump
Suction lift(m)	0-8	0-8	0-8	0-4
Discaharge(l/s)	1.5-2.5	1.5-2.0	1.5-2.0	2.0-2.5
Delivery head(m)	0	0	0	7
Foot valve durability	5 years	5 years	5 years	3 years
Rubber cup durability	9-18 months	9-18 months	9-18 months	N/A
Leather cup durability	N/A	N/A	N/A	6-12 months
Pulley durability	N/A	N/A	1-3 years	1-3 years
Treadles durability	1 year	1 year	1 year	1-2 years
Pump head durability	5-7 years	5-7 years	5-7 years	5-7 years
Pulley string/rope durability	N/A	N/A	1-3 months	1-3 months

5.3.3 Super-structural Assembly

Three pump models as prototypes were tested and these looked different in terms of the structural appearance at final assembly and installation. Descriptions of each prototype tested, including the modified tube well treadle pump, are given in the following sub-sections.

5.3.3.1 Original prototype of the Tube Well Treadle Pump

The tube well pump comprises a pumphead with twin cylinders attached to a junction box where an adapter is fixed at the bottom to suit installation onto a shallow water borehole or a tube well. Alternatively a hosepipe is attached to this adapter and directed to a suitable surface water source. The pump has a rectangular shaped spout welded onto the twin cylinder head. This acts as a trough into which the pumped water is discharged under free-flow onto the ground in an irrigation channel or into any container when used for domestic purposes, as the case may be.

This pump requires a wooden or metallic stand post or a tree stump of 1-2 m height to anchor it on. The stand posts are installed into holes dug into the ground to a depth of 50 cm. Thus 0.5 m - 1.5 m of the stand post remains above ground. Disused rubber bands from either a vehicle or motorcycle/bicycle tube are used to tie the pump head.

Treadles, which have holes drilled in them, are fixed to the pistons and the stand posts, which are also drilled with holes, by connecting an iron rod through the stand posts, treadles and piston rod holes. The rod has punch holes through which wire pins are fixed to avoid the anchorage coming out unduly during operation. Figure 16 shows the complete assembly of this prototype.

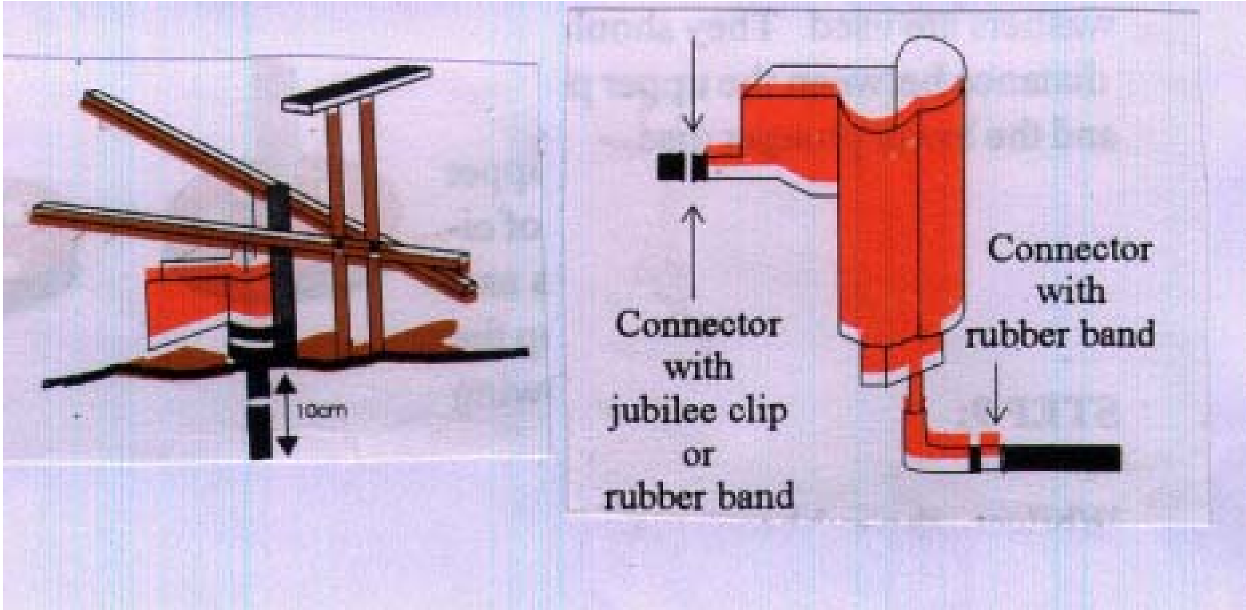

Figure 16: **The Well treadle pump assembly.**

5.3.3.2 Modified Well Treadle Pump

The modified pump is, as the name implies, a modification of the original tube well pump, which farmers found cumbersome and difficult to install in the field. It was not appreciated because one had to look for a stand post and dig holes in the ground for installing the stand posts onto which the pump was to be anchored. Farmers found that it was tedious to do this and it also took some time to do it properly. To make it a **"plug and play"** pump as farmers required of it, the pump was anchored with metallic stands **(legs)** in a tripod stand arrangement welded to the pump head. The pump is also provided with a fulcrum whose top is welded with a short metal rod (on the opposite side of the pistons) onto which the treadles would fit when connected to the pistons. In this way the pump legs are simply driven into the ground and a pipe connected to the suction side composed of a short pipe connected to the junction box and then it is ready to operate. In this way the pump has been made easy to install within a very short time and the assembly becomes firmer compared to when the pump head is anchored by use of rubber bands. The spout has also been fitted with a 50 mm round pipe to make it suitable for fitting a hosepipe when required. This can be done because the metallic legs elevates the pump head to a metre height, from which water can easily flow by gravity in a hose pipe to the ground surface in the field (Figure 17).

Figure 17: The modified well treadle pump superstructure.

Because of the ease of installation and operation of this modified pump, FAO requested modification of all the 350 original well treadle pumps which were originally brought in for piloting, but were not preferred by farmers. After modifications, all the modified pumps became appealing and were bought by farmers. This model has become so popular the original well treadle pump has been phased out due to farmer preference for the modified version. Users can, however, request manufacturing of the original well treadle pump if needed or preferred under varying circumstances.

5.3.3.3 The River Treadle Pump

The river treadle pump has exactly the same arrangement of twin cylinders with a rectangular shaped spout attached to them as the tube well pump. The major differences are that the junction box is connected with a 40 mm inlet manifold pipe to which a suction hose pipe is attached and connected to a water source.

The junction box has two metallic bolts welded on both sides, where wooden platform pieces are fixed and tightened with nuts. This makes the pump head stand in a vertical position to the ground. Two metallic rods with grooved heads are welded to where the twin cylinders meet. These grooved rods stand vertically above the cylinders and enable the installation of a wooden pulley, which has a metal rod passing through the centre hole. When the two ends of the rod are in the grooves, the pulley is located exacly in the centre where the twin cylinders meet. Treadles are attached to the cylinders by means of a rope which passes over the pulley and connects the two pistons in the cylinders. This assembly makes the pump stable, as the wooden platform can be shallowly placed into the ground to make it firm during operation. Figure 18 shows how the river pump is installed in the field.

Figure 18: The river pump superstructure after installation.

5.3.3.4 The Pressure Treadle Pump

The pressure pump superstructure is one that can be described as robust and the easiest to install since one only requires to take the pump close to the water source and place it on a horizontal surface. With a pipe connected to the inlet manifold and taken to the water source, the pump is ready for operation. Unlike the three models described above, the entire assembly is well connected together without any need to install the superstructure in any special way.

The twin cylinders and an adjustable metal frame onto which the pulley and a T-bar, which the operator uses to hold his hands on, are welded together. The junction box which has provision for inspecting the internal flap valves has a base with a flanger fitted with a rubber gasket around. The junction box and the base are bolted together by using nuts. The base frame is welded together with the bottom base of the junction box. Attached to the base frame are the inlet and outlet (discharge) pipes. The inlet pipe is longer than the discharge pipe so that it provides a fulcrum or pivot centre attached to it in a special way for the treadles to get connected with this point and the pistons directly vertically into the cylinders. Figure 19 shows the pressure pump superstructure.

Figure 19: The pressure pump superstructural assembly.

5.4 Suitability of Treadle Pumps for Use in Dambos

Despite the limitation of suction lift, particularly in areas with deep water tables, these pumps can easily be operated in Dambos as water tables are normally shallow, i.e. within a depth of 0-3 m even during extreme dry periods as found in this study (see Chapter 3).

The ***well treadle pump*** is highly suitable for use on hand dug protected shallow wells usually used for drawing domestic water. In this case the well is capped with a concrete cover to protect dirt from falling into it. Thus, sanitation is assured as the well treadle pump is installed onto the opening of the cover to also seal the well. Instead of using a windlass, a rope and a bucket tied to it, users just operate the pump and fill their containers with water in a very short time (see Figure 20). Some farmers are using this pump installed onto the well located in the middle of garden to pump water into a drum whose bottom is fitted with two pipe outlets onto which hosepipes are connected to reticulate water to vegetable garden plots. The pipes are shifted as required after a plot is adequately irrigated. All the operator does is to continue filling up the drum when water depletes. When the drum is full, the pressure head is good enough to deliver water over some distance up to 50m within the garden. As the water depletes so does the pressure head reduce. This makes irrigation very easy as compared to drawing water from streams, filling up drums placed in a garden or indeed drawing the water from the wells using ropes and buckets and walking to vegetable plots to irrigate. The engineus use of this pump has reduced the labour for irrigation by women who mostly do the watering in gardens.

Using the pump even reduces the number of wells that needs to be dug. In Dambos, a single garden may have one to three hand dug shallow wells located strategically so that different parts are irrigated within short distances from the water source, using watering cans. The advent of treadle pumps has made this job easy since only a single well fitted with a well treadle pump is required per garden.

Similar situations also occur elsewhere. On the central plateau of Burkina Faso it was seen that women would use a rope and a bucket to draw water from a well situated strategically in the middle of the garden and tip it close to the well into furrows sloping away from it to irrigate vegetables (Laker, 2000; personal communication). The well treadle pump is certainly a more user-friendly alternative to this laborious technique.

Figure 20: **A tube well treadle pump installed onto a capped well for easy drawing of water.**

The ***river treadle pump*** is used for irrigating gardens that are on relatively flat ground with gradual slopes along small canals or streams. From the canal or stream water is delivered into furrows, the gradual slope allowing water to flow easily in them. Apart from furrow irrigation, micro-basins which may be rectangular or square in shape and bunded with earth

on all four sides are made by farmers to allow them irrigate the crop planted in them. It becomes easy to flood these basins with water and allow it to infiltrate into the soil. No skill for water control is required as water cannot flow out of the basins. For the river pump to effectively irrigate such gardens, it is installed on a relatively higher ground than the rest of the garden in order to let the water flow by gravity in an irrigation channel that leads the water into furrows or basins (see Figure 21). Some farmers use short flexible hose pipes, or pvc pipes fixed to an adaptor that is welded onto the pump to direct water to these infield structures. The pump is designed to pump water from surface sources such as rivers, swamps and dams. Although it can pump water from a shallow well or borehole as well, the way the inlet pipe enters the well/borehole from the pump is such that it bends. During pump operation, the bending point easily collapses and causes problems in operating the pump. It becomes hard to operate with water flow through the point where the pipe has collapsed being restricted.

Elsewhere where river treadle pumps may be very useful include the following: Firstly, in parts of South Africa the indigenous small-scale farmers have developed very efficient short furrow irrigation systems (De Lange, 1994). The main limitation of these systems presently is inefficient water delivery to the irrigated fields. The river pump could help to alleviate this limitation. Secondly, in Madagascar a case was observed where irrigation of a whole hectare potato field was done manually from a small canal diverted from a river. Men fill containers by scooping water from the canal and carrying the buckets or transporting small containers on wheelbarrows to different spots along the side of the field, where it is emptied into 200 litre drums from which the women draw it, using watering cans to irrigate the field (Laker, 2000; personal communication). The river treadle pump is certainly much better alternative to these laborious techniques. This specific situation would have been ideal for such pump: the canal is a little higher than the field and not too far from it. The field is flat, with a gentle slope in one direction. Since furrows are automatically formed during the ridging of the potatoes, combining the pump with a short furrow system could have been ideal.

Figure 21: Micro-basin And Furrow Irrigation Using a River pump.

The ***pressure pump*** is suitable for irrigating undulating ground because it has an ability to pressurize water from a source located on lower ground than the garden. Such situations occur where a farmer has to pump water from a river with steep banks and irrigate a crop that is higher up on an undulating surface. In this case the pump is located close to the water source, giving it an advantage of low suction lift, but allowing it to pressurize the water over the steep bank and indeed one can apply it in a fine spray like rainfall or direct the flow on the soil surface and flood the soil. Pressure pumps are also used to pressurize water to sprinklers, drippers and elevated head tanks.

On-farm field tests by farmers revealed that ***all the devices*** provided a better alternative for water application and distribution to their crop than using a rope and a bucket or scooping methods as shown in Figure 10 which they described as tedious and labour intensive to use.

Field tests revealed the following observations for the different pumps:

- The pressure pump appeared to operate smoothly and optimally at suction lifts of not more than 2 m as opposed to the range of 0-4 m described in Table 18. Moreover, the pump becomes hard to operate at a suction head of more than 4 m and in most cases fails between 7 and 8 m.
- The pressure pump exhibited an ability to deliver water up to a height of 7 m from the ground surface whilst the suction river and modified well pumps have no delivery head.
- The pressure pump, where required, would offer the advantage of delivering water from a water source to the field level over a height of the river bank or indeed can be used to take water into an elevated tank from which it can be gravitated to the field or be used for domestic purposes.
- The river pump, tube well pump and its modified version are easier to operate than the pressure pump at all suction ranges up to 8 m. Both women and children from the age of four years could easily operate the three pump types.
- The river, modified and pressure pumps are easier to install **(plug and play)** than the tube well pump whose installation farmers described as cumbersome and time consuming (see section 5.3.3.1).
- The tube well pump, which originally was adapted to boreholes, did not find much application in the field unless modified to suit abstraction of water by installing it onto a stand post in the field away from the well capping directly above the water source. Adapting it to quick installation as is obtained with its modified version was the farmers' desire in the field.
- Despite the ease of operation of the river pump, farmers called for an adaptation which would enable plugging in of a pipe at the discharge spout in order to allow reticulation of water through surface furrows as well as a hosepipe conduit.
- The lifespan of the foot valve and rubber cups greatly depend on the type of water being pumped.

- If muddy and sandy water is used, these components will wear out within a few weeks.
- It is important that the water sources are deep enough for the water not to run out. The wells should be lined with concrete rings so that water would be clean and recharge improved.

- It has been proven that the pump head, which is metallic, can last for as long as five to seven years when looked after well. In Zambia, water is often of good quality and this prolongs the lifespan of the pump to as much as ten (10) years with good maintenance.
- After four years of use in the field, it has been observed that the metallic components of the pumps
- Are the most difficult to wear out. However, it was found that most replacements had been done to the rubber cups and valves. About 10% of the pulleys had also been replaced on the 2500 pumps purchased over the three years.

5.5 Sustainability

To make the technology sustainable the study undertook to make available a manufacturing base, which would supply the pumps locally once demand was created as a result of piloting the technology. In Zambia there is a manufacturing potential from both big and small-scale manufacturers. A number of retired and retrenched artisans from the manufacturing industries have set up their own workshops for metal fabrication and foundry works.

In order to create competition, both small and big manufacturers were trained in the manufacturing of the treadle pumps. Some carpentry outlets were also trained in producing the wooden components, i.e. the pulleys, treadles and base stands for the river pump. These activities created employment at the manufacturing/assembly line. Six small-scale manufacturers who are geographically separated by distances and located in different provinces were trained in manufacturing the pump. Besides these, three big manufacturers were also trained. The big ones are characterized by a higher capacity to produce more pumps per day than the small ones. Often the big ones would produce about forty pumps per day as compared to six or ten per day for the small ones.

In Lusaka the small-scale manufacturers include Kasisi Agricultural Training Centre (KATC), DEN-MWA Engineering, Milo Investment and Chokwadi Investments. In Eastern and Copperbelt provinces they include Katopola Agricultural Engineering Services (KAESE) and DAVACA respectively. The big manufacturers are all Lusaka based and they include Knight Engineering, SARO Agricultural Engineering and SAMS (Small Agricultural Machines Services).

All these selected manufacturers were trained in manufacturing the pump on a demand-driven approach after they requested participation in disseminating the technology through manufacturing. This was manifest after they saw the demand for this humble device by farmers apparently increasing. To date there are nine treadle pump manufacturers.

All manufactured pumps are quality controlled by IDE marketing and quality control officers to ensure there are very few or no faults when in use in the field. A one-year warranty is given for any quality controlled pumps purchased by a farmer. It is the duty of manufacturers to ensure that high quality pumps are produced to minimize the frequency of breakdowns in the field, because these would erode consumers' confidence in the technology. The technology is sustainably available for as long as demand exists on a sustainable level.

5.6 Maintenance and Repair

The treadle pump pump has been designed and manufactured in such a way that it is easy to maintain and repair by an average user at village level. While the pump can last up to seven years, the internal movable parts (rubber cups) can last between 9-18 months, depending on the use and source of water. It has been established that sandy and muddy water will wear out the rubber cups in just few weeks time.

In order to increase the lifespan of the internal moveable parts, it is recommended to use a strainer at the intake in order to prevent debris coming into the pump. The foot valve can last as long as the pump itself, except the rubber flap which allows water one way into the pump by opening and closing. However, this moveable part can easily be replaced by making one from disused bicycle or motor vehicle tube.

The nylon rope, which moves over the pulley, may also break easily but animal skin hides, old bicycle chain and old fan belts easily replace this.

The wooden treadles can be made from any wood found in the village, provided a carpenter drills holes at correct intervals. When mukwa wood is used and treadles operated properly, the lifespan, which is normally one year, can extend to three years.

When leather cups are used, it is advisable to pre-soak them in water to allow them expand and create enough suction force when priming the pump. This applies to the pressure pump. Leather cups shrink when dry and this makes priming difficult until it has wetted enough.

When the pumps are not in use, they should be stored in a cool storage place and protected against corrosion by greasing the internal matallic parts of the cylinder.

Rubber cups, leather cups and foot valves should be kept away from rats, as they would damage them.

5.7 Training of Distributors and Users (Farmers)

The technology cannot be sustainable if those who distribute and use it in the field do not appreciate its use. Training in retailer/farmer relations, record keeping on sales, after sale service and quality control has been given to twenty-eight distributors throughout the country. They have also been trained in the installation, operation, maintenance and repair of the treadle pump. This ensures that they too explain the use of the pump to farmers (users) at the time of purchasing at retail outlets. Ministry of Agriculture Food and Fisheries (MAFF) technicians at camp level and key staff of collaborating agencies in the dissemination of the technology have also been given the same training. MAFF staff in turn train their camp officers who are in touch with farmers on a day to day basis and give the same training to them. This makes the supply chain sustainable.

5.8 Distribution Network of the Treadle Pump

A distribution network consisting of manufacturers, wholesalers, retailers, NGO/private partners and farmers as consumers (users) of the technology has been established. A network of twenty-eight retailers and forty active collaborating partners, including government departments that deal with the distribution and sale of treadle pumps, has been activated throughout the country. This replication of a marketing or dissemination chain is called "Rural mass-marketing". To accelerate and respond to the demand of the pumps, IDE makes available the technology to the retailers on consignment basis and they receive commission on each pump sold.

Due to an accelerated demand of the technology, retailers are slowly linking themselves straight to manufacturers for the supply of pumps. This is a positive aspect of sustainability since IDE as a supplier will not always be there.

5.9 Technology Dissemination and Promotion

Recognizing that technologies do not market themselves, the study embarked on carrying out promotional activities with IDE in the field. These included physical pump demonstrations at farmers' fields where hydrological conditions for suitable water sources exist. *In situ* demonstrations were also carried out at market places where farmers sell their produce and at

IDE field offices. Besides, live theatre troupes have been used to write a play that would have entertainment value while it stimulated pump sales. These demonstrations took place in Eastern, Lusaka, Central and Southern provinces.

Demonstration plots using treadle pumps were also established at strategic places where the pump visibility would offer a chance for a prospective treadle pump purchaser to try the pump at his own time. Pamphlets, leaflets and brochures explaining the use of the pump and where it can be bought from are distributed to clients during organized field days and agricultural shows/exhibitions. Other strategies to popularize the technology have included printing of calendars and T-shirts that depict the use and benefits of the technology. Other means include advertising the technology at retail outlets, in print media (Newspapers) and on radio programmes and interviews.

5.10 Pricing Structure of the Pump

The river and modified well pumps both cost ZK140,000 (US$40) from small-scale and ZK175,000 (US$50) from big manufacturers. The pressure pump is more expensive at ZK294,000 (US$84) and is produced by SARO Agricultural Engineering. Prices vary primarily due to higher overhead costs of big manufacturers compared with the small ones. On the whole, farmers feel these prices are affordable as they are within the range suggested by them during the Participatory Rural Appraisal (PRA). The farmers expressed their feelings as to what they could offer to buy the technology after demonstrations. Some felt they could give a cow or ten goats in exchange for the pump. These prices are pan-territorial (uniform regardless of the geographical distance from the point of manufacturing to the retail point) but it is increasingly becoming important for arbitrage to command. This means that unless transport costs continue to be subsidized by IDE as supplier to retailers, prices will increase away from the point of manufacturing. One counter-measure that can redress this situation is to establish manufacturers in areas where demand is rapidly increasing.

5.11 Brand Naming of the Technology

After modifications and successful piloting in the field, more and more pumps have been sold to potential users. The farmers have praised the treadle pump in many ways with respect to its uses and the role it has played in generating income and achieving household food security. As a result of this, the farmers have renamed the treadle pump as a **"Chova"** pump. **"Chova"** is an indigenous vernacular word which is understood countrywide and around the region in Malawi, Tanzania and Zimbabwe to mean the following:

(a) To boost

(b) To pedal

By connotation of the word Chova pump, the farmer quickly understands that this pump can boost or increase farmers' income and that it is operated by pedalling using feet. The Chova pump has recently gained popularity without much effort to advertise it. This is due to the spread of the message by users who have since purchased the pump. This pump has not only transformed the small-scale farmers' farming systems but also improved their livelihoods by generating income from growing crops throughout the year as opposed to once in an annual cycle. **"Chova pump"** has become a household name in Zambia because of the positive impact it has had on the resource poor small-scale farmers.

The impact of the pump has resulted in a demand for the technology in neighbouring Angola, Malawi, Tanzania and Zimbabwe also. This has compelled IDE to consider starting up a programme in Angola and Tanzania where Dambos (called **"Mbungas"**in Tanzania) will be utilized for food production. The Chova pump is certainly the poor farmers' friend as it transforms a poor hard working farmer's status to a level where he/she can afford basic essentials of life and have surplus for household food security.

5.12 Adoption Rates

Figure 22 shows adoption rates of the technology from inception of the study in pilot areas from December 1996 to December 1999 according to type of pump.

The large number of pumps installed in the first year (1997) are primarily demonstration pumps which were given to farmers on a loan basis to be paid for after making profit from their use to produce crops. Three hundred and fifty such pumps were installed in various Dambo sites where other farmers without pumps could see them. In some cases farmer groups owned the pumps in order to irrigate crops and generate enough income to buy more for each group member. The figure shows that many more tube well pumps were put in the field during this promotion/demonstration phase than the other models. However, farmers did not appreciate them and this resulted in their being modified by the end of 1997.

This marketing effort resulted in twenty tube well pumps, fifty river pumps and fifty pressure pumps respectively being bought by individual farmers who appreciated the technology. The tube well pump was phased out as is indicative in the figure wherein only the river, modified and pressure pumps received continued demonstrations in the field and subsequent purchases show that these models are quite competitive. The river pump received more purchases than the modified and pressure pumps. This is particularly because it is user friendly in terms of easy of installation and operation. The river pump is also adaptable to a wide range of field conditions and is easy to carry back to the homestead after use to avoid theft in the field.

Coupled with *in situ* field demonstrations, the Chova pump technology began to catch on in many districts and provinces with farmers buying the pump on a cash basis. With more pumps being bought by individual farmers each year, the technology has spread to all provinces of Zambia with many other individual organizations involved in agriculture joining the dissemination effort.

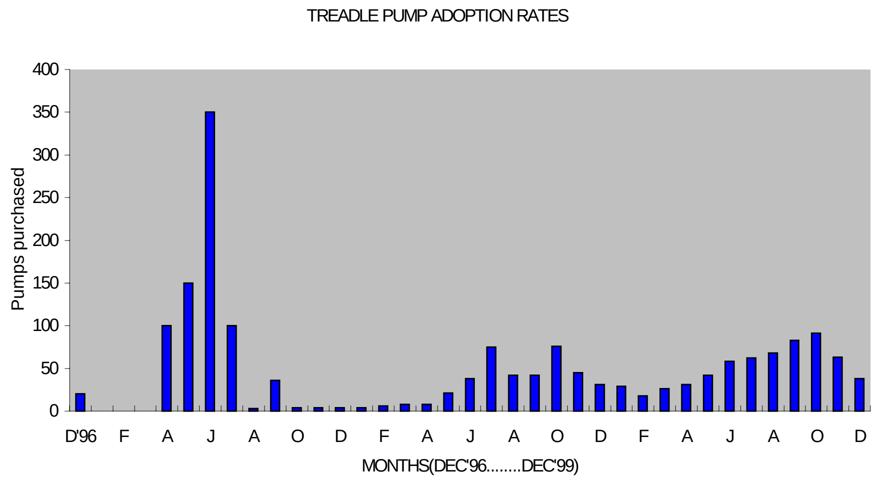

Figure 22: Adoption rates of treadle pump technology.

Figure 22 indicates a cyclic adoption with characteristic climaxes during the months of April to October and anticlimaxes during November to March for the years 1997, 1998 and 1999. The fact that more pumps are bought between April and October each year, is attributed to the coincidence with the dry season when irrigation becomes important and water lifting becomes critical for growing crops. The highest monthly sales were during October, which recorded eighty-six pumps bought, with more purchases coming from collaborating institutions. This may seem strange because October is the beginning of the rain season. It has relatively low rainfall, however, and the highest temperatures of the year. The latter leads to extremely high evaporative demands, giving October the biggest moisture deficit of the year. This month is often called the "death month" in Zambia (Kwaw-Mensah, 1996). This is illustrated in Figure 2. Sales of Dambo produce on local markets can fill the “hunger gap” (Figure 23).

Figure 23: Sale of Dambo vegetables during hunger periods in Zambia (photograph: Kwaw-Mensah, 19996).

The rain season is characterized by few pump purchases because farmers depend on rainwater for growing crops during this time of the year. It is anticipated that with irrigation using the Chova pump becoming popular and farmers appreciating the cost-benefit comparative advantage of the pump, purchases are expected to smoothen out throughout the year. This is expected along with the changing socio-cultural and farming system changes taking place. The Chova pump is a simple, inexpensive tool whose benefits can be achieved without the necessity of investing in dams, canals or other vast and environmentally unfriendly mega-structures.

5.13 Conclusions and Recommendations

1. The development of the treadle pump followed a participatory approach in which farmers
   were involved to field test the technology and give feedback for any shortcomings or appreciation on the performance. This had two unique advantages: Firstly the technology is adapted to field conditions and according to the operator's appreciation based on real life experiences and secondly the resulting models are easily adopted as they most likely meet farmers' requirements.
2. Any appropriate technology, no matter how good, cannot sell itself. What is required, is to market it and make it available by activating a local manufacturing capacity. This study has achieved this through promotions and training of small-scale producers of the pump.
3. The understanding of the Dambo hydrology and the existence of Dambos and surface water from rivers in Zambia has provided a potential niche for the technology. This would provide a source of livelihood option if adopted by over 800,000 small-scale farmers in the country.
4. The current adoption rate of 2,500 pumps in less than three years is a manifestation of an appropriate technology, which small-scale farmers can use to revolutionalize their lives and defeat the current droughts. It is imperative that with a single pump being used by a household of six members, there are about 15,000 beneficiaries of this technology.
5. Labour savings on irrigation by some 75% has resulted in an increase of vegetable garden sizes from a meagre 0.1 ha to between 0.25 ha and 0.50 ha.
6. The treadle pump is a gender friendly technological package which women easily operate.
7. The technology does not use fuel (kerosene, petrol or diesel) but depends on the operator's energy. The ease of operation allows an average farmer working with it for eight hours per day, being able to irrigate up to 1ha at that rate.
8. The treadle pump has been brand named as **"Chova pump"** by the Zambian small-scale farmer in appreciation of its performance and contribution to household food security.