



**INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN
(INBAR)**

**TRANSFER OF TECHNOLOGY MODEL
(TOTEM)**

THE BAMBOO TREADLE PUMP

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Note: the technology presented in this report has been developed by International Development Enterprises, for use in India, Bangladesh and Nepal.

TRANSFER OF TECHNOLOGY MODELS (TOTEMS)

Transfer of Technology Models (TOTEMS) are focussed educational tools providing relevant information and distance training on one specific area of bamboo/rattan management, processing or utilization. They are a means of technology transfer between similar regions throughout the world, with the emphasis on South-South transfer for livelihood development. They enable those involved in the management and use of bamboo and rattan resources to more efficiently and effectively develop and use skills relating to these resources.

TOTEMS are primarily intended as practical information resources and teaching aids for those at the local extension level in their communities, who can utilize them to assist local community development. Each TOTEM consists of a detailed written report of the technology, a PowerPoint presentation, a video, and, where relevant, a set of technical photographs. They also include information on target users, financial analyses of sample set-ups from the partner country preparing the report and information on where to source particular technologies (such as equipment). The TOTEM thus provides all the information required for establishing similar technologies within interested countries and regions.

- The **report** contains all the technical details of the processes involved, as well as other relevant information for establishing the technology such as costs of business establishment, running costs and cash flows.
- The **PowerPoint** presentation contains details of the relevant technologies and their applications, and is intended to provide an overview of the potential of the technology for development.
- The **film** provides a visual guide to the processes involved and helps to bring them alive in the minds of the learners.

The different parts of the TOTEM are targeted at slightly different audiences, via the local extension workers. The report and film are intended to be the main means of extension to the individuals and communities who will implement the technology and who will directly benefit from it. The PowerPoint presentation is primarily intended as a tool for the extension worker to sell the technology and its role in development to those who provide the infrastructural, policy and financial support for its implementation, such as government departments, donors and NGOs. There is considerable flexibility, however. Local extension workers will be able to incorporate the TOTEMS in their own work as they wish and adapt and develop the TOTEM to suit their particular requirements and conditions.

This TOTEM on **bamboo treadle pump** has been produced by Dr. Parimal M. Sadaphal, who used to work for International Development Enterprise-India (IDE-India) where the pumps described here were originally designed and developed. It is intended to be used in conjunction with the illustrative video included in this TOTEM package. The first part of the report introduces the technology, discusses its history, its development attributes and its benefits and limitations. The second part of the report provides detailed information on the technical aspects of the manufacture of the pump. The third part of the report covers construction of the pump framework and its operation. Appendix I provide a financial analysis of the manufacture of the pump. Appendix II gives a list of contact addresses.

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THE BAMBOO TREADLE PUMP AT-A-GLANCE

What is a bamboo treadle pump?

A bamboo treadle pump is a lightweight, portable means of pumping water from shallow depths. The pump itself is usually made of steel and has two barrels and is able to produce an almost continuous flow of water. The pumping mechanism comprises a bamboo framework and is operated by alternately depressing the bamboo treadles with ones feet.

What is it used for?

The bamboo treadle pump is used to pump water from depths of up to 7-8 metres. It can pump from boreholes and from open bodies of water and is primarily intended for use by poor farmers for the irrigation of higher- value crops such as vegetables.

How is it produced?

Treadle pumps can be produced by large or small-scale manufacturers with standard metalworking skills. A supply of cold-rolled steel is required, along with a range of miscellaneous parts such as washers, nuts and bolts and split pins. The pumping framework may be installed by trained technicians or by the user themselves.

What is its role in development?

The bamboo treadle pump affords a supply of irrigation water to poor farmers on marginal lands. They have complete control over their supply of irrigation water and require no additional inputs to operate it. The pump permits all-year-round cropping and the cultivation of a wider range of crops, and hence increases the income generating opportunities and the food security of the farmers. Previous experience has shown that incomes in India and Bangladesh have at least doubled through the use of the pump and income increases have been in the range USD \$50 - 500 per annum. Due to the extra attention farmers pay to their pump-irrigated fields, they become more market aware and are able to manage their holdings more effectively. Production, distribution, retailing and installation of pumps also provides employment opportunities to a range of non-agricultural workers.

How do I obtain, install and use a bamboo treadle pump?

Presently bamboo treadle pumps are only available from IDE in India and Nepal and from private companies in Bangladesh. They are not presently available in other countries. Significant opportunities exist for establishing pump-manufacturing units in other countries to supply the expected demand. Full details of installation are included in part three of this TOTEM. Further details on applicability of the technology can be supplied by IDE who have used treadle pumps for rural development for many years.



PART ONE

INTRODUCTION

**DEVELOPMENT ATTRIBUTES, TARGET GROUPS and
BENEFITS of**

BAMBOO TREADLE PUMPS

1. The Bamboo Treadle Pump

The bamboo treadle pump is a simple and economical pumping device. It permits the lifting of ground water from shallow depths such as borings and tube-wells, as well as from open bodies of water such as open wells, ponds, lakes, streams and rivers. The pump is simple to construct and made of cheap and light materials. It is composed of two parts; the pump itself and the operating mechanism. The pump is made mostly of metal and consists of two cylinders (or barrels) usually 3.5” (8.9 cm) in diameter, connected to a suction pipe at the base, and with an outlet spout at the top. The operating mechanism consists of bamboo foot pedals fitted to a bamboo superstructure, and includes a framework that the operator can hold onto for support.

The pump is operated manually and is easy to use. Operation relies solely on the operator shifting his/her own body weight on the pedals. Plungers inside the pump barrels are connected to the bamboo foot pedals and made to reciprocate by the operator alternately depressing the bamboo pedals with his/her feet. Water is drawn alternately into each barrel, and non-return valves protecting the inlet and those on the lower plate of the plunger itself allow the plunger to move down through the water in the barrel on the downward stroke without forcing it back down the suction pipe. Subsequent upward movement of the plunger then lifts the water in the barrel out of the spout at the top and simultaneously draws another volume of water into the barrel from the suction pipe.

The pump is usually produced with 3.5” diameter barrels but note that the main promoters of the technology, International Development Enterprises (IDE India), also produce pumps with 5” (12.7 cm) diameter barrels and with treadles made of metal or wood instead of bamboo. However, the 3.5” diameter pump with bamboo treadles described in this TOTEM is the most broadly applicable of all the pumps.

The pump gives small and marginal farmers access to an independent source of irrigation water. It thus affords them considerable freedom to choose the crops they grow, permits year-round cropping and significantly increases income and food security for the farmers. Due to its low production costs, in India the bamboo treadle pump can be made available to the farmer at a cost of only INR. 390/- (approximately US \$ 9.50). This investment normally pays for itself within one cropping season.

2. History of the development of bamboo treadle pumps

The concept of the bamboo treadle pump originated in Bangladesh in the early nineteen-eighties. The forerunner of the concept was apparently developed by a Bangladeshi farmer. The design was further refined by a Norwegian engineer, Mr. Gunnar Barnes, who worked at the Rangpur – Dinajpur Rural Service, a local NGO. Initial versions had a wooden pulley with a coir rope over it connecting the two pedals to help keep the pedals out of phase. In later versions the pulley was eliminated and the counterbalancing effect was achieved by extending the length of the bamboo pedal. This version was more

acceptable to farmers who started using it in large numbers when it was promoted by IDE. Since then IDE has been promoting it vigorously in Bangladesh, India, Nepal and a number of other countries. Almost one million have been purchased over the last decade and a half.

The popularity of the pumps has varied considerably. In Bangladesh, where the pumps in their various forms have been available for over a decade, over 1.3 million have been sold, with a sales boom in the mid 1990s. In Bangladesh production of treadle pumps is decentralised and subject to market forces. Over eighty private manufacturers produce pumps, and prices are fixed and profit margins determined by them. Evidence has shown that price is the most important factor in whether a farmer purchases a pump and with this system farmers prices are set at a market level for the quality of product produced. In India IDE has established a network of manufacturers, distributors and dealers which are subject to tight quality and pricing controls. Sales of pumps in India fall far short of the potential though there are many different factors involved, although these are not yet properly understood.

3. General development attributes and advantages

The technology is suitable for socio-economic and agricultural development projects in backward areas that currently have little or no access to basic infrastructural facilities such as grid electricity and canal irrigation. The most important need met by the bamboo treadle pump is that it gives the farmers water independence by providing access to an affordable and reliable irrigation source over which they have complete control. As a consequence of this the farmer is able to grow vegetables and similar crops that give him quick returns.

The main development attributes of bamboo treadle pumps are as follows:

- They provide an independent source of irrigation water to small farmers.
- They enhance the subsistence and income generation capabilities of the user.
- They lighten the workload of both male and female farmers.
- They generate employment and promote enterprise development.

The pump is a cheap, easy to operate and durable device which easily fits the budgets of the main target group of users, being small-scale and marginal farmers owning very small patches of land. Moreover, it is a robust and tough device with few moving parts, which makes maintenance economical.

The main advantages of this product are as follows:

- It is **cheap and affordable**. It is several times cheaper than the cheapest mechanized diesel or electric irrigation pump on the market, does not require fuel to operate and hence has no running costs. Furthermore, it is usually possible for the purchaser to cover the cost of his investment in one cropping season.

- It is **easy to operate**. It works by alternately depressing the bamboo pedals a few inches at a time, while leaning on a bamboo cross bar support. The overall posture is very comfortable and therefore, less tiring.
- It is **easy to install**. It can be installed to pump from a bamboo boring, a PVC / metal boring or even an open body of water such as a pond, stream or lake.
- It is **light and portable**. The pump can be transferred easily for use in different locations. It weighs only about 7 to 9 kg excluding bamboo pedals and can be carried in one hand or on a bicycle.
- It is **sturdy and durable**. It is constructed of sheet metal and is unlikely to be damaged during the course of routine handling.
- It is **easy to repair**. Hardly any parts are susceptible to wear and tear except the rubber flap valves or the PVC bucket washers. Spares can easily be made available.
- Finally, the technology puts **little pressure on the natural environment**. As the pump is manually operated and its discharge is fairly small, it does not pose any threat to the ground water. In addition the pump does not require polluting fuels, and as such does not cause environmentally harmful emissions.
- Fields irrigated by the treadle pump become “**priority fields**” and receive more input and attention than non-treadle pump irrigated fields. The farmers pay particular attention to maximising yields and quality and increasing their financial benefits.

4. Suitable agro-ecological regions

In India the bamboo treadle pump is popular in areas where the ground water is close to the surface and certainly not more than 25 feet deep. The soil in these areas is predominantly clayey with very few stones or boulders. Manual boring is possible in such soils and is cheap and affordable. The climate is sub-tropical with reasonably high rainfall during the rainy season. The pump is particularly suited to areas that have pronounced wet and dry seasons and is thus able to permit efficient year round cropping. As already noted, it is also possible to use this pump in areas where there is an abundance of surface water, such as ponds and streams.

Indications exist that the bamboo treadle pump is useful in most Southeast Asian countries where the topographical, hydro-geological, climatic and socio-economic factors are similar to those of Bangladesh, India and Nepal. These could include Myanmar, Laos, Malaysia, Vietnam, Cambodia, China, Philippines and Indonesia. There is also potential for this technology in a number of African countries, such as Malawi, Zambia and Zimbabwe. Recently IDE has been attempting to introduce this technology into Haiti.

5. Target groups

The bamboo treadle pump has been adopted predominantly by small and marginal farmers in India, Bangladesh and Nepal. The adopters of this pump belong to several communities or social groups, such as traditional vegetable growers, lower castes and tribal people. Typically these farmers possess less than one acre of land, which is often

heavily fragmented. Several of them may possess fragments as small as one tenth of an acre. Typical annual income levels of these farmers are of the order of about INR. 2000/- to 3,000/- (about US \$ 50/- to 70/-).

In normal circumstances, these farmers have no access to any independent source of irrigation, except for traditional manual water lifting devices such as a swing basket and a *tenda / dhekuli* (rope and bucket counterweight lift) which are grossly inefficient and labour intensive, as well as being inconvenient to operate. The only other alternative is to purchase water from the pump sets of large farms nearby, but this is possible only on their terms and if and when they consent to sell water.

In most households women play a predominant role in the use and operation of the bamboo treadle pump. The percentage share of the operation time of this pump by women varies from household to household and from region to region; but women share a considerable portion of this work. There are households where almost the entire operation and maintenance of the bamboo treadle pump is assumed by women.

Previous experience has shown that the initial adopters of treadle pumps are not the very poorest landowners, nor those with the most land in need of irrigation, but most importantly those that are willing and able to take an initial risk and have the funds to do so. As time passes and the technology blends into the social fabric, the poorest farmers adopt it and the pioneering adopters acquire diesel pumps or return to purchasing water from diesel pump operators. The poorer farmers stick with the technology and, if sufficiently innovative, are able to grow crops to suit market requirements and maximise their returns on their investments. With suitable provision of information and support, there is no reason, however, why bamboo treadle pumps should not be adopted by the poorest farmers in the community from the outset. The treadle pump is not purchased by the landless poor.

Traditional vegetable growing communities are often more keen to adopt the technology than those that practice solely cereals agriculture, probably because the financial benefits accrued from increased vegetable production outweigh those of increased cereals production. In some instances, high yielding cereal varieties can be grown with pump irrigation, and thus provide similar levels of increased income to farmers.

Although the primary target of this technology is the small and marginal farmer, introduction of this technology also impacts a number of other constituents of the prevailing socio-economic matrix, such as small / medium entrepreneurs, traders / dealers, rural mechanics (*mistris*), and NGOs and they are all involved in the activity. Sometimes, government departments may also become involved in disseminating the technology.

6. Benefits

Benefits of Use

The primary benefit of the bamboo treadle pump is that it accords water independence to the user by providing a cheap, affordable and reliable source of water for irrigation. In the absence of assured irrigation facilities, the small patch of land owned by the farmer is unlikely to be able to yield profitably. Most marginal farmers are forced to lease land (or engage in a produce-sharing arrangement), work as casual labor or seek other means of earning a living.

With the bamboo treadle pump, substantial quantities of vegetables or other higher value crops can be grown and the farmers can profit from selling them. The farmers can also help meet the considerable demand for vegetables in towns and cities. In several cases, adoption of the bamboo treadle pump is known to have doubled the annual income of the farmer from the same piece of land, such that the farmer was able to recover his investment in the pump within one cropping season. Increased income levels also contribute towards improving the overall quality of life.

Benefits of Production

There are additional benefits to the economy of establishing treadle pump production facilities. Off-farm employment is created for rural mechanics and jobs are created in the manufacturing sector. There are also benefits to the product supply-chain members, such as wholesalers and retailers, and consequent benefits to consumers in the form of enhanced supply of agricultural / vegetable produce.

7. Scope for small enterprise development

A particular benefit of manufacturing the bamboo treadle pump is that it provides an excellent opportunity for small enterprise development by the private sector, particularly in view of the following:

- Attractive cost price to the ultimate customer.
- Large size of the market.
- Low initial investment for production.
- Simple manufacturing procedure.
- Easy availability of raw materials.
- Low manufacturing cost.
- Reasonable margins possible for all marketing channel members.
- Reasonable payback period on investment.
- The skills required for manufacture are usually easy to find in most rural areas.

The technology offers substantial scope for employment to skilled workers in the manufacturing sector for a large part of the year. It also offers scope for self-employment

as distributors and dealers. In the rural areas, it opens up considerable opportunities for trained manpower (known as *mistris* in India, Bangladesh and Nepal) to assist with installation and maintenance. Further, there is a considerable scope for NGO involvement in this enterprise development, particularly as catalysts in the predominantly rural areas where this product is likely to be used. Since rural areas in most developing countries are the weaker links in the marketing networks (which concentrate more on urban / semi urban areas), NGOs can play a positive role in bridging the gaps and take on this role.

8. Limitations of the technology

The average discharge of the pump is typically about 0.8 to 1.5 litres per second, depending upon the prevailing ground water depth and other conditions. In terms of manpower inputs, the efficiency of the pump declines rapidly with increasing depth of water source. The “comfortable discharge rate” is 50-55 litres per minute pumping from a depth of 3m but only 18 litres per minute at a depth of 5 m. This should be taken into consideration when deciding the area to be irrigated and the types of crops to be grown.

- It is normally possible for a single person to operate the pump for a maximum of about four hours every day. In most farming families, the work is shared amongst a number of family members.
- The pump body tends to rust very quickly, sometimes in just two or three months in areas with saline ground water such as coastal regions. This version of the bamboo treadle pump is not, therefore, suitable for use in such areas. A concrete version is available for these areas.
- It is important to bear in mind that the pump is only able to draw water from below itself and lets it pour out of the spout by gravity: It is not able to push water to an elevation higher than the pump itself. In other words, it is not possible to create pressurized pipe flow using the bamboo treadle pump. Therefore, it should not be used where the situation requires pressurized flow.

9. Requirements for success

The success of this technology will largely depend upon the hydro-geological suitability of the location, the interest and socio-economic characteristics of the target groups, the nature of the dissemination mechanism, market conditions for the new crops grown, and prevailing policies. According to current thinking, the best option is dissemination of the technology through the free market. However, this necessitates the creation and establishment of a functioning supply chain network, which has to be set up in the manner employed by IDE in several countries. This type of arrangement has the maximum chances of success, even though the gestation period is long. Skills in entrepreneurship development and market development will be useful in following this approach.

Alternatively if the local situation is favorable the bamboo treadle pump can also be distributed through government departments or NGOs. In order to do this it is important to have clear-cut policies and procedures with motivated manpower at the implementation level, strong linkages between all constituent departments and good administration at the headquarters level. If subsidies are planned, clear systems and procedures for implementation will attain greater strategic relevance.

The major conditions for success are the following:

- Availability of ground water to a maximum depth of 25 feet or alternatively, availability of adequate ponds / open bodies of water.
- Clayey soil with minimal stone content to permit manual boring.
- Availability of bamboos in adequate quantities in the region.
- Adequate population of small and marginal farmers owning one acre or less for vegetable growing.
- Existence of local vegetable markets.
- Availability of adequate manufacturing capabilities – machines, raw materials and manpower - though not necessarily in the vicinity.
- Creation of trained manpower (*mistris*) who can install these pumps. Usually, local *mistris* who manually drill bore-wells and install hand-pumps are trained in installing the pumps.
- Creation of an effective supply chain network consisting of distributors and dealers, NGOs or government departments who supply the pumps, provide support for installation and provide after sales service to the farmer.

10. Potential improvements and research needs

The treadle pump can be produced with very basic tools, implements and skills. However, its quality, performance and rate of production could be improved significantly by using sophisticated machinery wherever possible (as described in the manufacturing process section). Presently the sheet metal version described in this report is the most popular and prevalent version, and is of the best possible configuration for the price. Unfortunately it is not possible to significantly improve the sheet metal version without large increases in costs. However, based on further research and development activities it may be possible to fabricate the pump from different materials at no extra cost.

A plastic version of the bamboo treadle pump made of HDPE has been developed by IDE Bangladesh. Plastic pumps are potentially a good alternative as they are lighter, smoother to operate and will not rust. However, they would need to be produced in large quantities due to the high costs of small-scale production of plastic products.

A number of other variants have been developed and tried by IDE Bangladesh and IDE India. More information on their experiences can be obtained directly from the organizations involved. For addresses, kindly refer to **Appendix II**

Concluding remarks

The bamboo treadle pump is a useful tool for the irrigation of small agricultural fields. This pump device is simple in design and operation, easy to manufacture and is very affordable to the small and marginal farmers who are its primary users. Popularized through an effective supply chain or through state organizations and NGOs, this technology can have a considerable contribution to agricultural development projects. In addition, the large market for this product offers a fair scope for enterprise development and off-farm employment, improving the livelihood of smallholders as well as landless people.



PART TWO

DESIGN and MANUFACTURE of the BAMBOO TREADLE PUMP

1. The principle of the pump

The bamboo treadle pump is a twin barrel, twin plunger reciprocating type of positive displacement pump. The upward stroke of the plunger creates a suction force that pulls the water up through the suction pipe and into the barrel. During the downward stroke, a non-return valve at the base of the barrel prevents the water from flowing back into the suction pipe and the cup washer (which acts like a valve) opens to allow the water below the plunger to move above it as it moves down through the barrel. During subsequent upward strokes, while pulling more water from below, accumulated water above the plunger is pushed upwards and spills out through the spout. The cycle is repeated alternately in both barrels as long as the operator keeps operating the pump.

2. Design of the pump

A schematic diagram of the bamboo treadle pump is shown in Figure 1. The figure depicts the essential components and principle of operation of the device. (For more detailed and dimensioned figures please refer to the production drawings).

The pump body is made of mild steel sheet metal. In India, cold rolled (CRC) sheet is used but in some countries hot rolled (HRC) sheet is also used. Cold rolled sheet is preferable as it reduces the chances of cracks developing during sheet bending processes such as barrel rolling. The main components of the bamboo treadle pump and their functions are described below.

2.1 Barrels

The pump consists of two cylindrical barrels fabricated from metal sheet with an internal diameter of 3.5 inches. The movement of the plungers inside these barrels lifts and pumps the water.

2.2 Spout

There is a spout at the top-end of each barrel to route the water out of the pump. A rod is welded on the outer end of the spout to form a carrying handle for the pump.

2.3 Bottom plates

At the base of each barrel is a bottom plate. This plate has a large circular hole that acts as a seat for the rubber flap valve. There are also two boltholes.

2.4 Junction box

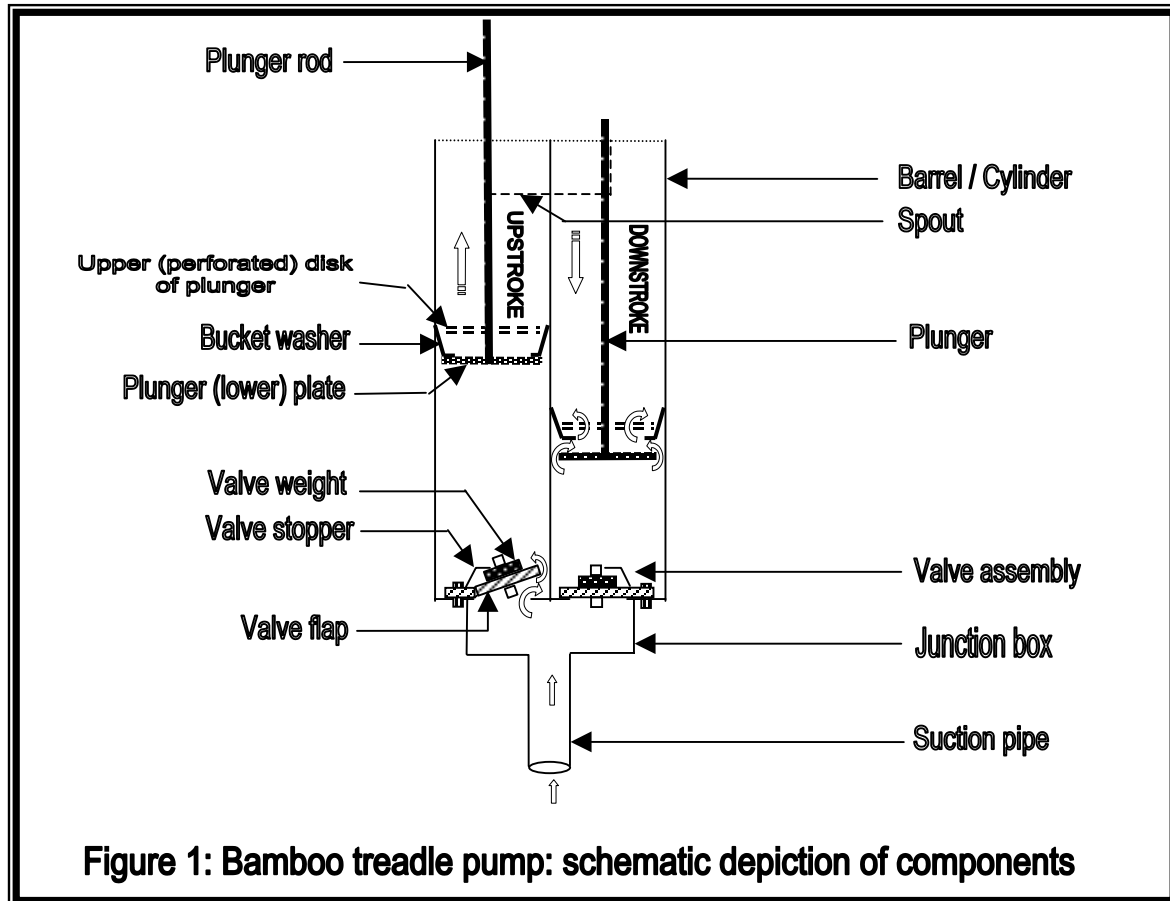
The junction box is attached below the bottom plates at the base of the two barrels. It facilitates the flow of water from the suction pipe into the barrels.

2.5 Support pieces

There is an uncovered gap over the junction box in the portion where the two barrels join. This is covered by two triangular support pieces.

2.6 Suction pipe or socket

A suction pipe made of mild steel or a threaded GI socket is attached below the junction box. This forms the interface through which the pump is connected to the tube-well or other source of water.



2.7 Valve assembly

The valve assembly consists of a rubber flap that covers the hole in the bottom plate and allows water to enter the cylinder, but prevents it from returning into the bore once it is inside the pump. A metal weight is bolted on the center of the rubber flap to enable the flap valve to open and close properly. The entire valve assembly is fixed inside the barrel on the bottom plate by two sets of nuts, bolts and washers that pass through two corresponding holes in the bottom plate. The rubber washers help to prevent leakage. Early practice was to make this flap of leather but long-term experience has shown that rubber is preferable in terms of its performance and longevity.

2.8 Plunger assembly

The plunger is a kind of piston that moves up and down inside the barrel to create the suction force that pulls water up from the bore. It is attached to the bamboo pedal, which is moved by the operator. The plunger assembly consists of a number of components:

2.8.1 Plunger rod:

This is an MS rod that is bent into a loop (eye) at one end, and is attached to the two circular plunger plates at the other end. To permit proper location of the upper plunger plate, a small locator washer is welded to the plunger rod.

2.8.2 Plunger (lower) plate:

This is a round plate smaller in diameter than the inner diameter of the barrel. It has a central hole through which the plunger rod passes and to which it is welded using a washer.

2.8.3 Plunger upper disk:

This is a perforated disk that also has a central hole for the plunger rod to pass through. It is welded above the plunger plate on the plunger rod, the spacing between them being determined by a spacer tube that fits snugly on the plunger rod between the two plates.

2.8.4 Bucket washer:

Also known as the cup washer, this is the component that enables the plunger to produce the required suction in the pipeline. Initially these were made of leather and in later versions also from rubber. However, experience over the years has shown that PVC washers give a more consistent performance and are preferable, even though they cost more than the other alternatives.

3. Manufacturing process

The components of the bamboo treadle pump can be classified into sub-assemblies and individual parts. These are discussed below with reference to the photographs (plates) in the accompanying album.

3.1 Sub-assemblies

There are three sub-assemblies in the bamboo treadle pump. They are as follows:

3.1.1 Cylinder sub-assembly:

The cylinder sub-assembly consists of two barrels, two bottom plates, a spout, a handle and two support pieces.

3.1.2 Plunger sub-assembly:

The plunger sub-assembly consists of a plunger rod, an upper disc, a bottom disc (or plunger plate, one spacer tube, one PVC bucket washer and two metal washers. Two plunger assemblies are required per pump.

3.1.3 Valve sub-assembly:

This consists of a rubber valve flap, a metal valve weight, a valve stopper and nuts, bolts, metal washers, and rubber washers to attach the valve weight to the valve flap and the valve sub-assembly to the bottom plate. Each pump requires two valve sub-assemblies.

3.2 Parts

In addition to the sub-assemblies there are a number of separate parts that need to be manufactured or procured before the bamboo treadle pump can be assembled. These are the junction box, the suction pipe / socket, an axle rod and two plunger pins, and some locking / split pins.

3.3 Classification of parts based on origin

The components are also classified based on their source. The categories are:

3.3.1 Specially ordered components fabricated externally:

These include valve weights, rubber flaps, PVC bucket washers and small rubber washers.

3.3.2 Components purchased from the market:

These include items such as nuts and bolts, steel washers, split pins / locking pins

3.3.3 Components fabricated on the factory premises:

These include the remainder of the components mentioned earlier.

3.4 Material specifications and component dimensions

Exact material specifications and detailed production drawings are included in a separate part of this TOTEM.

3.5 Tools and machinery

The specifications of the tools and machinery required to manufacture treadle pumps are shown in table 3.5.1:

Large machines such as a power press are not required for small-scale production and these jobs could be done either manually on site or contracted out to specialists. Similarly, spray painting equipment could be omitted for smaller scale production and the painting done manually. Blacksmith's equipment is required only for one operation relating to plunger rods and is not required at all unless very high production volumes are planned. The approximate costs of this equipment are discussed in section 6. Several brands of this equipment are available, and there are dealers in most of the large cities in India. In the unit visited during the production of this TOTEM, the proprietor mentioned that Atlas and Godrej brands are popular in the Kolkata region.

Table: 3.5.1: Typical machinery and tools in a bamboo treadle pump manufacturing unit

S. No.	Name of machine	Size / capacity	Remarks
1	Shearing machine.	2 feet size.	Manually operated ones are available.
2	Manual sheet rolling machine.	2 feet size. Able to handle sheet 3 mm thick.	Roller diameter should be less than 89 mm.
3	Welding machine.	200 amp.	
4	Power press.	50 tonnes.	
5	Bench drill.	12 mm.	
6	Bench vice.	As required.	
7	Bench grinder, hand grinder.	As required.	
8	Spray painting equipment.	As required.	Compressor. Spray gun, etc.
9	Blacksmith's equipment.	Standard.	Oven, blower, etc.
10	Hand tools: hammers, spanners, chisels, etc.	As required.	
11	Jigs and fixtures.	As required.	

The jigs and fixtures required are very simple. A number of these are illustrated in the accompanying album. IDE India has designed a special standardized set of jigs for these operations. Details regarding these may be obtained directly from IDE.

3.6 Manufacturing procedure

The manufacturing process is fairly simple and is described in detail in the accompanying film.

3.6.1 Barrels:

The sheet is cut into a rectangular piece of the required size and a small, straight incision is cut at one end, as per specified dimensions, to enable the wall of the spout to be bent out later in the production process. Note that the left and right barrels will have this cut at different ends. Some manufacturers prefer purchasing pieces of sheet directly from the market, cut as per specified dimensions.

Before passing the sheet through the rolling machine a slight curve is given to the leading edge by hammering it slightly over a cylindrical surface to enable the sheet to enter the machine.

After being rolled, the barrels are held in a vice to bring the facing edges together and are then tack-welded at the seam. This work should be handled by a skilled worker since it involves a relatively high degree of workmanship. After tack welding, the barrel is hammered on a cylindrical surface to minimize ovality. The barrels are then fully welded along the seam. Thereafter, they are hammered again on a cylindrical surface as before, to ensure a circular cross section. After this, the side spout wall is hammered out.

3.6.2 Bottom plates:

These are produced on a press machine if possible. They can also be produced manually but this process is relatively time consuming and it is difficult to maintain accuracy. Similarly, it is also preferable to produce the base of the spout on a press machine.

3.6.3 Cylinder sub-assembly:

The two barrels are placed inverted (i.e. with the spout portion towards the ground) on a jig for accurate location. When they are properly aligned the seams of the two barrels face each other. They are rotated on the jig and aligned such that both the sidewalls of the spout are parallel (there is provision in the jig to achieve this). The spout (base) is then tack-welded into place.

The two bottom plates are positioned and tack-welded on the top (i.e. the base of the barrels). It is important to ensure that the single large hole of the bottom plates is closer to the seam (the point where the two barrels touch) and the two smaller holes are towards the opposite side of the seam.

Once tack welding is completed the sub-assembly is lifted off the jig. An MS rod with both ends bent at right angles is then welded along the mouth of the spout to form the handle. Finally, the triangular support pieces are tack-welded at the base of the barrels where they join each other. Full welding is carried out after this stage.

3.6.4 Junction box and suction pipe:

The junction box is fabricated from metal sheet. The corners of the sheet are cut off and the sides are bent upwards to form the junction box. The edges are welded together and a hole made in the centre. (Alternatively this can be done prior to assembly with a press machine). The junction box is placed on the bottom plates using a locating jig and tack-welded in place before full welding to make a leak proof joint. The suction pipe (or socket) is then welded over the hole in the junction box.

3.6.5 Plunger sub-assembly:

MS rods are cut to the required dimensions either by hand or on a press machine. The lower and upper discs of the plunger are best fabricated on a press machine. One end of the plunger rod is heated and is hammered into a loop or eye. A small locator washer is welded at the correct distance from the edge of the other end using a jig. Then the upper disc, spacer, lower disc and washer are placed in succession on this rod (plates 43 & 44) and welded together using a jig. Care has to be taken to maintain proper alignment of all the components.

3.6.6 Valve sub-assembly:

The valve sub-assembly is composed mainly of purchased components. These are then assembled together.

3.6.7 Axles and plunger pins:

These are also cut from MS rod and finished using appropriate jigs.

3.6.8 Painting:

The cylinder and plunger assemblies are first painted with primer and then with the recommended paint using standard spray painting techniques. They can also be painted manually.

3.6.9 Leakage testing, final assembly and packing:

After the pumps are dry, the valve assembly is fitted in place and the pumps are checked for leaks. This is done by blocking the suction pipe with a hand, filling the barrels with water and observing the welds carefully. Re-welding will fix any leaks. In India a quality punch plate is installed on all successfully tested pumps.

Plungers with bucket washers are fitted on to the pumps after leakage testing. Brand decals are applied and the entire unit is packed with accessories such as axle rods, plunger pins and locking pins.

4. Input requirements

Labour

The manpower required to manufacture bamboo treadle pumps is normally available in most places in India and neighbouring countries. The main skills required are as follows:

Table 4.1: Details of manpower required for bamboo treadle pump manufacture

S. No.	Type of worker	Skill level	Remarks
1	Welder	High Low	For tack-welding For final welding
2	Hydraulic press operator	High	
3	Fitter	Average	For all jobs involving jigs
4	Blacksmith	High	Not required full-time
5	Helpers	Low	
6	Painter	Average	

In India, a skilled worker is available for a monthly salary of between INR 1,500/- to 2,000/-. Unskilled workers and helpers cost around INR 1,200/- to 1,800/- per month.



PART THREE

INSTALLATION and OPERATION

5. Field Installation

The field installation of a bamboo treadle pump involves mainly the fabrication and installation of the bamboo pedal mechanism. The dimensions of this mechanism depend upon the location of the pump unit. A typical installation of farmers in India is described below.

5.1 Pump unit

The pump units are available in two versions: one with a smooth suction pipe and the other with a threaded socket. Where a suction pipe is supplied, some cloth/gunny sack material or rubber strip (made from bicycle inner tube) is wrapped around the pipe which itself is usually narrower than the boring pipe. The wrapping is done in such a way that the wrapped material is thicker nearer the junction box.

The suction pipe, thus wrapped, is placed on the opening of the boring and forced in. If this arrangement is not sufficiently leak proof, a horizontal piece of half cut bamboo is placed on the spout, pressed in and tied down at both ends.

Pumps are supplied with sockets with a 1.5 inch-diameter male threading. The pump socket (with matching female threading) is fitted over it and screwed on. If the boring pipe is larger than 1.5 inches an appropriate reducer socket can be installed. Once the pump is fixed, the task of erecting the bamboo superstructure can begin.

5.2 Bamboo superstructure

The complete bamboo pump installation consists of two vertical support stands made of sturdy bamboo members that are embedded in the ground. A check bar is fixed between these on which the operator places his hands during use. There is a pump stopper (*discussed in the previous section*) that helps anchor the pump in place.

Two bamboo pedals are attached to the support stands by means of an axle made of MS rod. The plungers are attached to the same bamboo pedals at a distance from this axle. The pedals are optimally spaced from each other by a small spacer piece made of bamboo that is installed on the axle between the pedals. The length of the spacer piece is adjusted such that the plungers are exactly in the center of their respective barrels. There is a vertical piece of bamboo that acts as a pedal guide between the pedals at their free end that prevents the pedals from clashing with each other.

Some users install a small bamboo structure below the end of the pedals, which prevents the pedals from dropping below a specific height. This helps prevent the pedals from repeatedly hitting the pump body causing damage. Finally some users also make a seat so they can rest in a sitting position while still operating the pump with their feet. Below, we discuss the method of construction of the bamboo superstructure.

5.2.1 Support stands:

The length of each of these members is about 7 feet and they are embedded in the ground to a depth of about 1.5 to 2 feet. Since the entire weight of the operator is borne by these

two bamboo supports, they sometimes tend to sink slowly into the ground. This can be prevented by putting pieces of brick or stone at the base of the hole in which the poles are to be embedded. Ideally, the bamboo should be cut at a node so it is less likely to split during use.

The lower the pump itself is buried, the better it will work and the more convenient it will be. Ideally about half the barrel length should be buried in the ground but this could be a hindrance to those farmers who intend to shift it from place to place. Therefore, this decision is best left to the discretion of the user.

After the pump is fixed, a mark is made on the bamboo indicating the location of the axle hole, which should be located just above a node. This prevents the bamboo from splitting due to the operator's weight. The height of the hole should be adjusted so that it is about 4 to 6 inches vertically above the top edge of the pump barrels. The horizontal distance should be such that the center of the bamboo supports is slightly less than 9 inches from the center of the barrels. The hole should be made in the bamboo support preferably using an auger. Hammers and chisels should not be used since it is difficult to make accurate holes with them. The support stands should be fixed vertically in the ground by packing earth around them to make them rigid. On top of these support stands a horizontal piece of bamboo is tied to act as an armrest for the operator.

5.2.2 Bamboo pedals:

To make the bamboo pedals choose two straight pieces of bamboo about 5.5 feet long. Drill a hole just beyond a node approximately 2 feet from one end of one of the bamboo poles. Exactly 9 inches further down from the center of this hole, make another hole. Then cut a slot about 1.5 inches wide and 1.5 inches long perpendicularly below the second hole which is deep enough to reach the center of the bamboo through which the earlier hole passed transversely. The eye of the plunger will fit into this slot with the plunger pin fitting into the hole and passing through the eye of the plunger. Secure the plunger by putting a locking pin on the plunger pin. Make the other pedal in the same fashion.

5.2.3 Alignment and spacing of bamboo pedals:

After the bamboo pedals are ready, fit the plunger assembly in the appropriate slot and push the plungers inside the barrels of the pump. Pass the axle pin through one bamboo support, then through the axle hole in each of the two pedals and finally through the second bamboo support. Move the pedals horizontally along the axle pin such that they are exactly perpendicular to the line connecting the centers of the two barrels of the pump. Ensure that the plunger rod is exactly in the center of the barrel when the pedals are held horizontal, parallel to the ground. After they are aligned, the edge-to-edge distance between the two pedals is measured accurately. The spacer is formed by sawing off a small piece of bamboo exactly the same length as the edge-to-edge distance. The axle is removed from one of the supports and one of the pedals by pulling it out, the spacer is placed between the two pedals and the axle rod re-inserted into the second pedal and the second support. It is then secured with a locking pin. In this way the pedal mechanism is ready.

5.2.4 Pedal guide:

This is a vertical piece of bamboo about 3 to 5 feet long. It is installed vertically in the ground between the two bamboo pedals so as to prevent them from clashing with each other.

5.3 Method of Operation

The bamboo treadle pump, once installed, is fairly simple to operate. Climb on to the pedals keeping your feet initially close to, or on, the axle. Depress the pedals alternately using your heel as the pump starts throwing out water. If water does not come out, fill the barrels with some water and repeat until the pump starts pumping. After a few pedal strokes, try to move your feet along the length of the pedal until you reach a position that is comfortable for you. Each person is likely to prefer a different position on the pedals at which s/he is comfortable.

5.4 Pumping from surface reservoirs of water

A socket model is more suitable for pumping from open reservoirs of water. A bendy pipe is screwed on to the socket to which a flexible hose can be attached. The pump should be propped up using a wooden or metal support stand but the bamboo superstructure remains the same.

5.5 Troubleshooting and maintenance

Usually there are no major problems associated with the bamboo treadle pump. However, a few minor problems may occur once in a while and can easily be tackled. Typical problems encountered in the field are listed below with ways to solve them:

Problem	Symptom	Solution
Leakage at welds.	Water leakage from pump body. Air bubbles in pumped water.	Use coal tar or plumber's sealing cement to plug the leak.
Leakage around the nuts and bolts below the barrels that hold the valve assembly.	Droplets of water leak from base of barrel. Air bubbles in pumped water. Holes in bottom plate are larger than the bolts that pass through them. Rubber washers on these bolts are torn or cracked.	Change the rubber washers. If necessary, change the check valve.
Leakage in the valve around the weight and the nut and-bolt joints.	Valve flap is cracked around the weight and / or nut-and bolt joints or a nut is loose.	Try tightening the loose nut or change the valve flap.
The bucket washer is coming loose due to constant use.	There is a gap between the inner wall of the barrel and the outer surface of the bucket washer, discharge is reduced or the barrel is not able to lift any water at all.	Replace the bucket washer and ensure that the new one is tight and secure. If the bucket washers tend to wear out very soon, check for sediments in the water. The filter of the boring may be defective.

6. Financial analysis

6.1. Costs of various inputs

A study was conducted by IDE India to determine the costs of raw materials, labour and other inputs in the production of the bamboo treadle pump, and to estimate its price at the factory gate. According to this study, the various costs are as follows:

Table 6.1.1: Cost of various inputs in bamboo treadle pump manufacture

S. No.	Particulars	Amount (INR)
1	Raw materials	165.55
2	Labor	30.00
3	Power and electricity	10.00
4	Direct cost	205.55
5	Overheads	20.55
6	Total cost	226.10
7	Margin (15%)	33.90
8	Cost at factory gate	260.00

Details of how the figures were calculated are included in **Appendix I**.

6.2 Investment required for machines

A list of the important machines used in the manufacture of the bamboo treadle pump along with their approximate costs is shown below. The details in the table are for a unit that manufactures about 500 pumps per month, which is assumed to be the optimal monthly production. All calculations made in this section are for this level of production.

Table 6.2.1: Costs of various machines involved in bamboo treadle pump manufacture

Machine	Unit cost	Numbers*	Amount (INR)
Shearing machine	4000	1	4000
Rolling machine	10000	1	10000
Welding machine	12000	2	24000
Power press	80000	-	0
Bench grinder	4000	1	4000
Angle grinder	2500	-	0
Bench drill 12 mm	8000	2	16000
Spray painting set up	22000	-	0
Blacksmith equipment and tools	4000	1	4000
Hand tools (hammers, spanners, vice, etc)	20000	1	20000
Typical investment required for a monthly production of 500 units**			82000

* Suggested number of machines for a production of 500 pumps per month

** The assumption is that a power press and spray painting set up is not required for this level of production. These machines may be added if the production levels are higher.

6.3 Working capital

It is assumed that about 15 days' stock of raw material is sufficient to maintain production at an optimum pace. On the basis of the raw material cost per pump shown in Table 6.1.1, the cost of 15 days' raw material (i.e., for 250 pumps) is calculated as about INR 40, 000/-. *This figure is taken to be the working capital requirement.* The total cash outflow, which is the sum of the investment on machines (INR 82,000/-) and the working capital (INR 40,000/-), is INR 122, 000/-.

6.4 Cash flow

Depreciation was calculated assuming a project period of 5 years. The rate of depreciation of the machinery was assumed to be 20% on the straight-line method and it is assumed that production takes place for eight months per year. The cash flow statement thus generated is displayed in Table 6.4.1. and perusal of the figures suggests it is a profitable venture for the entrepreneur.

Table 6.4.1: Cash flow statement

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5
Source of funds (INR)					
Capital	122,000	Nil	Nil	Nil	Nil
Operating Profit	135,660	135,660	135,660	135,660	135,660
Depreciation	16,400	16,400	16,400	16,400	16,400
Total	274,060	152,060	152,060	152,060	152,060
Application of funds (INR)					
Fixed assets	82,000	Nil	Nil	Nil	Nil
Increase on working capital	40,000	Nil	Nil	Nil	Nil
Proprietor's drawings	152,060	152,060	152,060	152,060	152,060
Total	174,061	152,060	152,060	152,060	152,060

6.5 Net present value

Annual profit was calculated from the figure for margin per pump shown in table 6.1.1. Adding depreciation to this gave the total cash inflow of INR 266,800/- that was expected in each of the five years of the project period (see table 6.5.1).

The present value (PV) of the cash inflow each year was calculated using the formula:

$$PV = 1 / (1 + r)^n$$

Where r is the rate of interest in the nth year of the project period in question. The rate of interest " r " was assumed to be 18%. Table 6.5.1. shows the values calculated for each year from the first to the fifth year of the project period.

Table 6.5.1: Calculation of Net Present Value

PROJECT YEAR	Cash inflow	Interest rate	Present value
YEAR 1	266800	0.18	226102
YEAR 2	266800	0.18	191612
YEAR 3	266800	0.18	162383
YEAR 4	266800	0.18	137612
YEAR 5	266800	0.18	116621
Total	1067200	Total	834329
Less cash outflow			122000
Net Present Value			712329

Note: All values are in Indian Rupees (INR)

The Net Present Value (NPV), which is the difference between the total present value of cash inflow over 5 years and the total cash outflow, was calculated to be INR 712,329/-. As can be seen, the NPV is positive and hence signifies a profitable venture.

6.6 Break-even and other financial indicators

The other financial indicators calculated are discussed below:

CONTRIBUTION (in Rs.)

Sale price	260	
Less variable cost	214	(Production cost less fixed overhead)
Contribution	46	

BREAK EVEN POINT 1578.26 units produced in one year
(Annual fixed overhead / contribution)

BREAK EVEN PERIOD 0.39457 years (break even point / yearly
production)
or 4.73478 months

BENEFIT COST RATIO 6.83876 (Total present value of inflow / total
present value of outflow)

As can be seen from these indicators, bamboo treadle pump production can be a good venture with a break-even period of only 5 months and benefit-cost ratio of approximately 7. Also, it is interesting to note that the financial attributes still remain good if a power press machine is included in the capital expenses for the same level of production.

APPENDICES

APPENDIX I

Details of pump cost calculations

Cost of individual raw materials

S. No.	Description	Weight (Kg)	Rate (INR)	Amount (INR)
1	CRC Sheet	4.300	22.00	94.60
2	M.S. Round	1.050	16.00	16.80
3	M.S. Pipes	131 mm	18.00	7.85
TOTAL				119.25
4	Waste recovery	0.255	4.00	(1.00)
NET TOTAL				118.25

Cost of purchased parts

S. No.	Description	Quantity	Rate (INR)	Amount (INR)
1	Bucket washer	2	6.75	13.50
2	Check valve	2	3.00	6.00
3	Nuts	6	0.15	0.90
4	Cotter pins	3	0.20	0.60
5	MS washer (20 3 12.5 3 2)	2	0.15	0.30
6	MS washer (20 3 12.5 3 2)	6	0.25	1.50
7	MS washer	4	0.10	0.40
8	Rubber washer	4	0.15	0.60
9	Screw	6	0.75	4.50
10	Washer stopper	4	0.25	1.00
			TOTAL	29.30

Consumables

S. No.	Description	Quantity	Rate (INR)	Amount (INR)
1	Welding rods	6 Nos	1.00	6.00
2	Primer	60 ml	60.00	3.60
3	Enamel Paint	90 ml	80.00	7.20
4	Others			1.20
			TOTAL	18.00

Labor cost

	Worker	Requirement
1	Fitters / Operators	5 nos
2	Helpers	6 nos
3	Wage rate for fitter per month	1500/-
4	Wage rate for helper per month	1200/-
5	Cost per month	14,700
6	Pumps per month	500 nos
7	Cost per pump	30/-

Power and electricity

	Description	
1	Units per month	2000
2	Rate per unit (INR)	2.50
3	Cost per month (INR)	5000
4	Pumps per month	500
5	Cost per pump (INR)	10

APPENDIX II

Contact addresses of International Development Enterprises

The International Development Enterprises is an NGO with a worldwide network that has been promoting the bamboo treadle pump amongst a number of other cheap and affordable technologies. More information regarding this technology can be obtained from the offices listed below:

Head Office

10403 W. Colfax Ave. Suite 500
Lakewood, Colorado 80215 U.S.A.
Telephone: (303) 232-4336
Fax: (303) 232-8346
E-Mail: ide@ideorg.org

India Country Office

C5/43, Safdarjung Development Area
New Delhi – 110 016
Telephone : 91-11-696 9812, 696 9813, 696 4632
Fax : 91-11-696 5313
E-mail : ide@ide-india.org

Bangladesh Country Office

Post Office Box 5055
Govt. New Market
Dhaka 1205, Bangladesh
Office: 011-880-286-3506 / 286-4485
Fax: [011-880-286-3506](tel:011-880-286-3506)
Email: acd@bangla.net

Or Visit the web site at <http://www.ide-india.org>

Major reference used in the first part of this report:

Shah, T., Alam, M., Dinesh Kumar, Nagar, R. K. and Mahendra Singh. 1999. Pedalling out of Poverty: Social impact of a Manual Irrigation Technology in South Asia.
<http://www.cgiar.org/iwmi/pubs/Pub045/Pub045.htm>