Socio-economic-techno-environmental assessment of IDEI products

# Treadle Pump

March 2007

*Submitted to*
**International Development Enterprises (India)**
C 5/43, Safdarjung Development Area
New Delhi 110 016

Project Report No. 2006RR24

**The Energy and Resources Institute**
www.teriin.org

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*For more information*

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We would like to place on record our thanks to the manufacturers, dealers and villagers in the study location for the valuable time they spent with us during discussions.

# Abbreviations

| | |
|---|---|
| BTP | Bamboo Treadle Pump |
| CDM | Clean Development Mechanism |
| $CO_2$ | Carbon dioxide |
| DP | Diesel Pump |
| GHG | Green House Gases |
| HH | Households |
| HP | Horsepower |
| IDEI | International Development Enterprises India |
| IPCC | Inter-governmental Panel on Climate Change |
| KB | Krishak Bandhu |
| MoU | Memorandum of Understanding |
| MRP | Maximum Retail Price |
| MTP | Metallic Treadle Pump |
| PoP | Point of Purchase |
| PVC | Poly Vinyl Chloride |
| STP | Surface Treadle Pump |
| TP | Treadle Pump |
| UNFCCC | United Nations Framework Convention on Climate Change Units |

## Units

| | |
|---|---|
| kW | Kilo watt |
| kWh | Kilowatt hour |
| Lps | Litres per second |
| m2 | Metre square |
| m3 | Metre cube |

# Contents

# List of Tables

# List of Figures



# List of Annexures



# List of Boxes

# Executive Summary

The objective of the project was to assess the socio-economic and technical evaluation of the Treadle Pump (TP). The study also assessed the Green House Gases (GHG) mitigation potential.

The TP is a foot–operated device that uses bamboo or PVC or flexible pipe for suction, to pump water from shallow aquifers or shallow water bodies to maximum depth of 20 feet. The average discharge of water is in the range of one to two litres per second.

The present study was carried out in the districts of Balangir, Cooch Behar and Gorakhpur belonging to the states of Orissa, West Bengal and Uttar Pradesh respectively. Primary survey was conducted in these three regions using structured questionnaires. Focus Group Discussions (FGDs) were held in low intensity TP village and high intensity TP villages to understand the perceptions of TP users and non-users. In each of the discussions, on an average, 18 farmers participated amounting to a total of over 100. Discussions were held with Diesel Pump (DP) renters, dealers of TP, and manufacturers of TP and DP. The sample for user households (HHs) was 147 and non-users were 20. Technical assessment was conducted for 18 DPs and 18 TPs. The parameters measured were water discharge, input energy content, output in energy units, and efficiency of the device.

*IDEI plays a major role in marketing, advertising and providing quality assurance of the product. The promotional activities carried out are video shows, short campaigns, haat demonstration, village demonstrations, farmers' meetings etc.*

The average family size of the surveyed HHs in the study regions ranged from 6-8. Majority of the farmers belonged to the marginal and small farmer category with landholdings of less than five acres. Only in Balangir, a semi-arid region in Orissa few HHs (14%) belonged to the semi-medium category with landholding of 5-10 acres.

The various models of TP found in the study region were 3.5" bamboo TP, 3.5" metallic surface TP and 5" metallic TP. The TPs were locally sold by network of dealers who had mistries (mechanics) working with them. The mistries installed the pumps and attended to after-sales service of the TP.

IDEI plays a major role in marketing, advertising and providing quality assurance of the product. The promotional activities carried out are video shows, short campaigns, haat demonstration, village demonstrations, farmers' meetings etc.

The parts of the TP which were usually replaced by the farmers were check valves and washers, and the maintenance cost ranged from Rs. 30-100 per annum. The age of the pumps in the surveyed HHs ranged from one to 11 years, and it was found that the pumps installed 11 years ago were also functional. The traditional water lifting devices used in the region were tenda[1], swing basket[2] and

---

[1] *Tenda* is a manual irrigation device. It is a boat shaped wooden log which is typically 2-3 metres in length and is supported in the middle. The water output is 40-50 litres of water per minute. Water can be lifted from not more than 5-8 feet.

[2] *Swing basket* is a manual irrigation device. It is a metal sheet-lined bamboo basket to hold water, tied with ropes on both sides. It is operated by two persons, one on each side of the basket. The water is lifted in the basket and plunged into the field.

*dhekuli*[3]. Their water output is 40-50 litres per minute. These devices thus gave less water output and the operation was strenuous.

The advantages of TP operation were found to be:

a) Water flow was lighter when compared to DP. Irrigating with DP caused erosion of top fertile soil in certain patches and hence loss of crop in the particular patch.
b) There was no recurring cash expenditure towards TP irrigation; in case of DP the farmer had to spend Rs. 80-100 per hour of DP use and also the farmer incurred the cost of Rs. 20-40 towards transportation.
c) The farmers could irrigate their crop as and when required and at their convenience.
d) TP was easily portable and could be fixed in various locations, whereas two people were required to lift a DP.

*The TP provided the farmers with reliable access to irrigation. This enabled them to increase the area under irrigation and grow high-value crops such as vegetables. The quality of vegetables was found to be better with TP because of uniform, adequate and appropriate irrigation.*

There was a shift in cropping pattern after the adoption of TP. The gross cropped area under cultivation increased and so did the gross cropped area under vegetables. For example, in Balangir, gross irrigated area under cultivation increased by 50%, after adoption of TP. The cultivation of vegetables had increased by 205%. The incomes of the HHs increased and enabled them to improve their physical and human capital by purchasing land, livestock, televisions sets, farmland, renovating their houses and educating their children. In Balangir the average annual income per HH after adoption of TP is Rs. 25,517 while previously it was Rs. 9563.

The increase in average annual income ranged from 167-232% in the surveyed HH. The TP provided the farmers with reliable access to irrigation. This enabled them to increase the area under irrigation and grow high-value crops such as vegetables. The quality of vegetables was found to be better with TP because of uniform, adequate and appropriate irrigation.

The average hours of TP operation were found to be 1034 hours per annum. Most (>75%) farmers were hiring DP prior to TP use and the rest were either non-irrigating or using manual devices. Majority of these non-irrigating farmers wanted to use DP. Since the DP was available to farmers as and when required on hire and did not require capital investment, DP was the major form of irrigation. The scenarios observed with TP intervention were:

a) farmers cultivating under rain-fed conditions started irrigating;
b) farmers previously using traditional methods, adopted TP; and
c) farmers previously irrigating with DP started irrigating using TP.

All the factors mentioned above indicate that TP has fulfilled the suppressed demand for irrigation among the poor farmers and has helped the small and marginal farmers to increase their gross irrigated area and also grow more vegetables. There have

[3]*Dhekuli* is manual irrigation device. It has a bucket fixed to one end of a bamboo pole which is attached to a simple cantilever system made of bamboo and wooden poles. A stone is tied to the other end of the lever. The operator pushes the bucket into the water by pilling down the rope into the well and the bucket gets filled with water. The counter weight on the other side automatically pulls the bucket.

been more green vegetables (vegetables grown with TP) into the market due to TP intervention. The DP hiring has reduced due to TP use. The number of farmers hiring DP had reduced by 50-60% in the study region. In high-TP villages the hiring of DP has decreased to a large extent and in some villages the DP owners said that the profits from DP renting had decreased and they were using the DP mostly for their own use. In low-TP regions, non-users of TP are hiring DP but the overall DP hiring has reduced.

Technical assessment indicated that the efficiency of the TP ranged from 15-84%. It was found that the 5" metallic pumps were more efficient than the 3.5" bamboo TP (BTP). The primary reason being that the barrel size of the 5" TPs is larger than 3" BTPs. The variations can also be due to factors such as weight of operator, water recharge level in the region, condition of pump and even ease of operation. The discharge of water was found to range between 3600 litres per hour and 9120 litres per hour and the average water output was 4974 litres per hour. The efficiency of the DP ranged from 0.38% to 9.57% in the sample technical evaluation. The secondary literature states that the efficiency of DP ranged from 4 to 10%. The average discharge of water with DP was 30,000 litres per hour and ranged from 4623 to 36873 litres per hour.

The carbon dioxide mitigation potential of the project has been calculated using a methodology similar to the standardised baseline methodology AMS-1B (mechanical energy for the user) suggested by United Nations Framework Convention on Climate Change (UNFCCC). The average diesel savings for every hour of TP usage was found to be 169 ml. Using the density of diesel at 0.85gm per ml, every kg of diesel avoided abates 3.2kg of $CO_2$. It is hence estimated that the operation of one TP annually reduces 477 kg of $CO_2$.

*The carbon dioxide mitigation potential of the project has been calculated using a methodology similar to the standardised baseline methodology AMS- B (mechanical energy for the user) suggested by UNFCCC.*

The barriers to TP promotion were:

a) High upfront cost: The cost of installing the TP including the cost of drilling and tubewell, ranged from Rs. 800-1550, which was high for families with low incomes. Their priorities were expenses towards food, clothing, health and shelter.
b) High labour requirement: The TP is a manual, labour-based irrigation technology requiring the user to spend much more time and effort on the field than DP-based irrigation.
c) Dependence on awareness-raising activities: The sale of TPs depends on the promotional activities of IDEI. There is, however, a sustainable mechanism where the farmers pay for the TP without availing any subsidy.

The HH survey and FGD in the study sites revealed the contribution of the project to economic, social, environmental and technological well-being. The TP technology is simple and appropriate for the farmer. The marketing methodology adopted by IDEI ensures that the farmer sees value for the product. The farmer does not depend on government subsidy and he purchases it on his own. This ensures usage and sustainability of the technology.

Chapter 1

# Introduction

## 1.1 Introduction

International Development Enterprises (India) is an Indian not-for-profit organisation registered in 2001 under Section 25 of the Companies Act, 1956, with a mission "to improve equitably the social, economic and environmental conditions of families in need, with special emphasis on the rural poor, by identifying, developing and marketing affordable, appropriate and environmentally sustainable solutions through market forces".

IDEI had carried out an evaluation 'Alternatives to Micro-Irrigation in India: A Critical Assessment of the TP Option' through TERI in 1996. IDEI felt that there was a need to carry out detailed study for their products namely TP and drip irrigation system, to evaluate the socio-economic and technical aspects.

Working with the poorer sections of the society as their target group, they have developed several products and services such as:

- water-lifting devices for irrigation that are alternative to conventional methods of water pumping (treadle pumps or TPs to lift water from small depths of 20 feet, rope and washer pump to lift water from 50 feet, pressure pumps to lift water from 25 feet, etc.;
- water conservation devices (low-cost drip irrigation systems, improved sprinklers); and
- promotion of sustainable agricultural practices through promotion of:
  - vermi wash — liquid from vermi-composting for pesticides effects, nursery – with the concept of reducing cost of production; and
  - IPMAS – Integrating Poor Into Market Systems.

IDEI had carried out an evaluation 'Alternatives to Micro-irrigation in India: A Critical Assessment of the TP Option' through TERI in 1996. IDEI felt that there was a need to carry out detailed study for their products namely TP and drip irrigation system, to evaluate the socio-economic and technical aspects. TERI was assigned this study to conduct an assessment to update the status, and assess from the viewpoint of energy savings resulting in carbon reduction.

## 1.2 Role of IDEI in Promoting Treadle Pump

The TP is a foot-operated device and can pump water from shallow aquifers or surface water bodies such as ponds, tanks or tube well from a maximum depth of 20 feet. There are bamboo TPs (DTPs) and metallic TPs (MTPs). The average discharge of TP is about 4794 litres per hour.

The TP is marketed by IDEI in India through its network of manufacturers, dealers, distributors and mistries (mechanics).

The TP is sold under the brand name Krishak Bandhu (KB). The quality control aspects and promotional activities are closely monitored and carried out by IDEI. There are various promotional activities categorised as dynamic and static promotion. The dynamic promotion activities are village demonstration, haat demonstration, short campaigns, farmer meetings, *mela* demonstration and TP film shows. The static promotional activities are leaflets, banners, dealer board and wall paintings.

A region-wise meeting of dealers, distributors and IDEI functionaries is held annually. This is a platform where information is exchanged and sales targets discussed. The after-sales service is provided by business associates and dealers through mistries. IDEI bears the cost towards quality assurance, promotional activities and monitoring. An MoU is signed between IDEI and the manufacturer. Five to 10% of the product is checked for quality control. The structure for promotion of TPs is given in Figure 1.1.

The Maximum Retail Price (MRP) is fixed by IDEI after discussion with the manufacturers. The cost of the TP is about Rs. 450 (3.5 inch BTP). This does not include the cost towards administration and promotional activities by IDEI. The TP cost at ex-factory and dealer price is given in the Table 1.1.

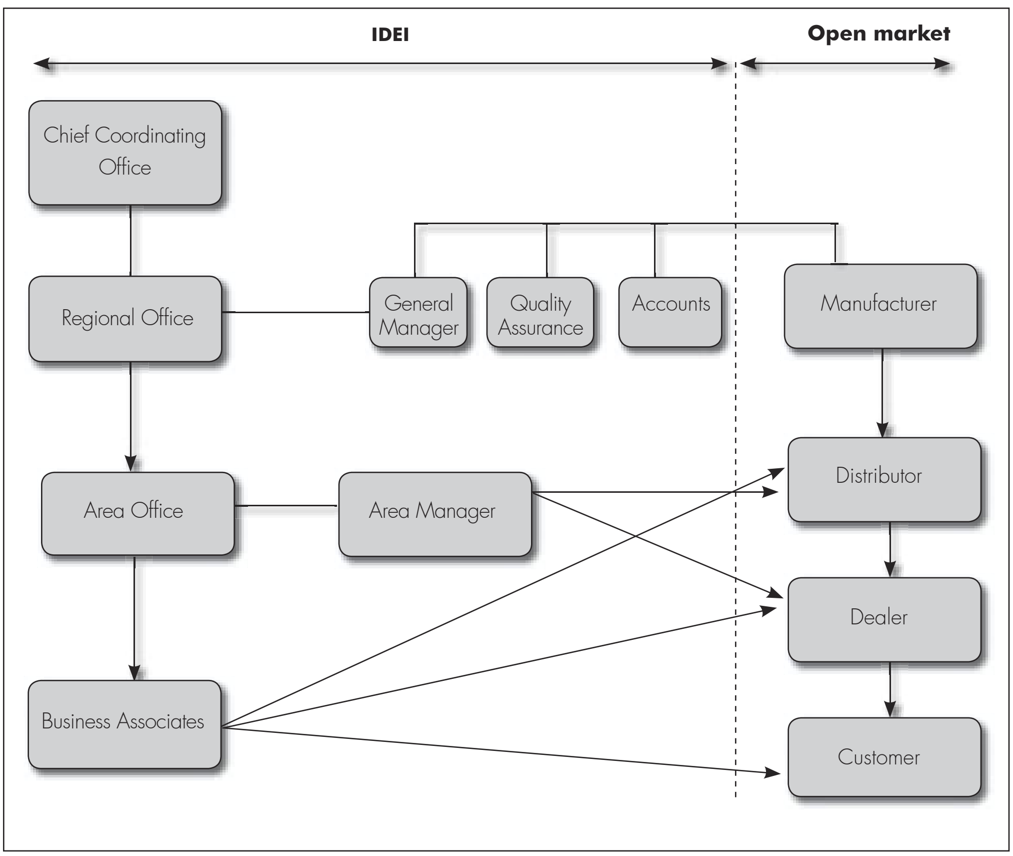
*The after-sales service is provided by the business associates and dealers through mistries. IDEI bears the cost towards quality assurance, promotional activities and monitoring.*

**Table 1.1 The cost of TP**

| Type of pump | Ex-factory price (Rs.) | Transportation (Rs.) | Dealer price (Rs.) | Price at installation and commissioning (Rs.) |
|---|---|---|---|---|
| Bamboo TP | 350 | 10-20 | 400 | 450 |
| Metallic TP | 950 | 10-20 | 1100 | 1250 |

The players in the open market for sale of TPs are the manufacturers of TPs, and distributors are the people who purchase the product in bulk from manufacturers and sell it to dealers. The dealers sell the TPs in the retail market.

**Figure 1.1 IDEI structure for promotion of TPs**



## 1.3 Scope of Work

The objective of the study was to conduct a socio-economic-technical analysis of TP adoption and assess the $CO_2$ emission reduction potential. The scope of work involves:

### 1.3.1 Products to be focused

- Water-lifting devices: TP
- Water-conservation devices: affordable drip irrigation systems.

This report focuses on the TP.

### 1.3.2 Technical assessment

To asses the comparative performance of TP vis-à-vis diesel pump (DP) the output, efficiency, operation and maintenance aspects will be analysed.

*The objective of the study was to conduct a socio- economic-technical analysis of TP adoption and assess the $CO_2$ emissions reduction potential.*

### 1.3.3 Socio-economic assessment

This would assess the impact on the socio-economic condition of the farmers adopting TP and cropping pattern.

### 1.3.4 Carbon dioxide emission reduction potential

To assess $CO_2$ emission reduction potential, based on the methodologies recommended by the CDM executive board and inputs of saving potential procured from the field.

## 1.4 Organisation of the Report

The report is organised into six chapters.

Chapter-1 gives the introduction and scope of work.

Chapter-2 gives the methodology indicating the study location, survey tools, and sample size.

Chapter-3 presents the findings of the socio-economic evaluation in the three regions.

Chapter-4 provides the market shift analysis, describing the non-user perception, diesel renters' perceptions and discussion with dealers.

Chapter-5 presents the findings of the technical evaluation.

Chapter-6 presents the assessment of Green house Gases (GHG) mitigation potential.

Chapter-7 provides the conclusion of the study.

# Methodology

To address the objectives of the study, a primary survey, technical measurements and secondary information collection was conducted. The household (HH) survey was conducted to assess the socio-economic condition of Treadle Pump (TP) adopters and perception of non-users. The technical analysis of TP and Diesel Pump (DP) was also conducted. The locations were chosen to represent the areas of TP interventions.

## 2.1 Study Location

The study was carried out in three regions namely Balangir, Cooch Behar and Gorakhpur in the states of **Uttar Pradesh**, **Orissa** and **West Bengal** respectively. The total number of villages covered under the study were 21. The names of villages covered are given in Annexure-2.1.

To address the objectives of the study a primary survey, technical measurements and secondary information collection was conducted. The household (HH) survey was conducted to assess the socio-economic condition of TP (Treadle Pump) adopters and perception of non-users.

The study regions were.
Balangir (profiling **Chhattisgarh, Jharkhand** and **Orissa** region)
Cooch Behar (profiling **West Bengal**)
Gorakhpur (profiling **Uttar Pradesh** and **Bihar** region)

A brief profile of the states is given below.

The physiography of **Orissa** can be classified into four regions: coastal plains, northern upland, central river basin and south-west hilly region.

**West Bengal** has two natural divisions – the Himalayan north and the alluvial plain south of it. The Bay of Bengal forms the southern coastline of the state.

The Himalayan region in north Bengal has three general divisions: the high altitude mountain region, the foothills or the Terai region and the mixed deciduous forest and grassland region known as the Doars. Rivers like the Teesta, Torsha, Rangeet and the Mahananda flow through these areas. Teesta and Mahananda also flow into Bangladesh where they finally create a huge river system along with the rivers Ganges and the Brahmaputra. The rivers of the north and the Ganges are perennial since they originate in the Himalayas. The plains of the Ganges and the other associated rivers form one of the most fertile regions in the world. The Ganges flows through the state at one of its narrowest points and flows into Bangladesh.

**Uttar Pradesh** is bound by Vindhyas in South with Gangetic Plains lying in between in an elongated shape in the west-east direction. Physiographically it is divided into three regions namely:

- the Gangetic plains: highly fertile alluvial soils, flat topography broken by numerous ponds, lakes and rivers;

- the southern plateau: hard rock strata, plains, valley and plateau; and
- The Himalayan Region: It is highly rugged with varied topography and terrain.

A map indicating the study location is given in Annexure-2.2.

## 2.2 Survey Tools

The tool used for the socio-economic survey was structured questionnaire. Inputs from IDEI and other experts were considered and integrated while finalising the survey tool. The questionnaire was developed for users, non-users, and diesel renters. The non-users were also interviewed to understand their perceptions on the TP.

*The tool used for the socio-economic survey was structured questionnaire. Inputs from IDEI and other experts were considered and integrated while finalising the survey tool.*

The aspects covered in the questionnaire for user feedback were as follows:

- General information: village, occupation, family size, details of land holdings;
- Type of water-lifting devices: device used at present, model, year of installation, cost of installation.
- Details of operation of TP: hours of operation in rainy, winter and summer seasons.
- Maintenance and sustainability: failure of the equipment, problems faced in operation, cost of repair and maintenance.
- Cropping pattern: crops grown at present and before TP adoption in rainy, winter and summer seasons.
- Socio-economic: annual income and perception on TP use.
- Market shift analysis: use of DP prior to TP adoption.

Questionnaire for non-users of TP covered the following aspects:

- DP-usage in rainy, winter and summer season.
- Perception on DP use.
- Demand for TP.

Questionnaire for diesel renters covered the following aspects:

- Number of years of DP renting.
- Change in renting pattern.
- Number of hours of DP renting in rainy, winter and summer seasons.

A checklist was also prepared to conduct FGD with the users and non-users. The discussion was focused on change in cropping pattern and diesel hiring due to TP adoption. The barriers in TP adoption were discussed with the non-users. A copy of the above mentioned questionnaires is enclosed in Annexure-2.3.

## 2.3 Survey and Sample Size

The sample survey was conducted for the purpose of assessing the socio-economic condition of TP adopters and also for technical assessment of TP and DP in the region. Random sample was chosen to gain a representative sample of TP adopters. Few TP non-user HHs and DP renter HHs were also surveyed. The FGDs were conducted in two to three villages in each region. The villages selected for FGD were chosen from high-density and low-density of TP adoption. The sample size of the study is given in Table 2.1.

**Table 2.1 Sample size for the survey and technical evaluation**

| Details | Balangir | Cooch Behar | Gorakhpur | Total |
|---|---|---|---|---|
| User HHs | 51 | 45 | 51 | 147 |
| Non-user HHs | 5 | 10 | 5 | 20 |
| Diesel renters | 5 | 5 | 5 | 15 |
| Technical evaluation of TP | 6 | 5 | 5 | 16 |
| Technical evaluation of DP | 5 | 8 | 5 | 18 |
| FGD | 2 | 4 | 2 | 8 |
| **Total** | **74** | **77** | **73** | **224** |

Discussion was also held with manufacturers, dealers and IDEI staff. The discussion helped in identifying the method of marketing, after-sales services and factors leading to TP adoption and trend in dissemination of TPs in the region.

The technical evaluation of TP and DP was conducted in three regions. The measurements were taken for parameters such as water discharge, input and output energy, and efficiency of the device. The instruments used for the measurements were: digital stopwatch, container of known volume, digital weighing machine and measuring tape. The sample size for the technical measurements is given in Table 2.1. The technical evaluation was conducted for TP and DP.

Chapter 3

# Findings – Socio-economic Evaluation

The findings of the socio-economic region-wise survey are given in this chapter. The details presented are the demographic and land details, types of water-lifting devices used for irrigation, installation and maintenance of TP, hours of operation of TP, cropping pattern, perceptions of users and their income.

## 3.1 Balangir Region (Orissa)

### 3.1.1 Demographic and land details

The number of households surveyed was 51 in the Balangir region. The average family size of the surveyed households (HHs) was seven. The total population was 329 with 127 men, 112 women and 90 children. The average landholding of the surveyed households was 3.4 acres. Majority (41%) of the HHs were small farmers with landholding of 0-2.5 acres, 45% (Figure 3.1) of the HHs were marginal farmers a few (14%) HHs belonged to the semi-medium category. The total land owned in the surveyed HHs was 174 acres and the area under irrigation was 85 acres (49%).

The main occupation of the surveyed HHs was agriculture and only 23% (12 HHs) were involved in a secondary occupation such as agriculture labour and brick-making.

### 3.1.2 Type of water lifting devices

The farmers in the surveyed households were using TP; only one farmer was using an electric pump along with the TP. The model of TPs was of 3.5" surface metallic pumps. The age of the pumps varies from one to three years. Majority (59%) of the TPs were installed in 2005-06. The details of year of installation of TP are given in Table 3.1.

**Figure 3.1 Category of farmers in Balangir**

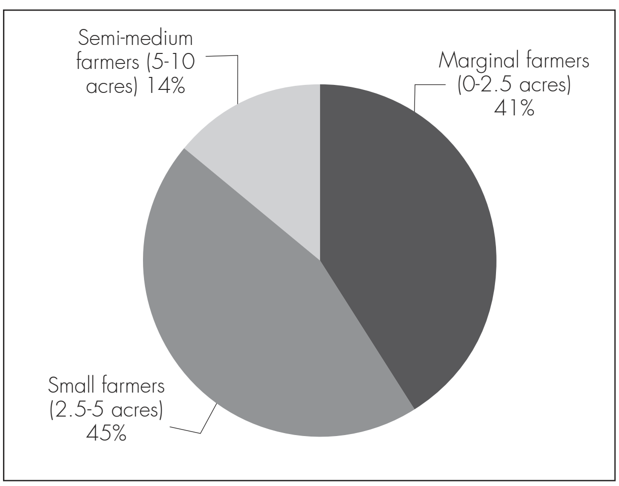



**Table 3.1 Year and number of installation of TPs in Balangir**

| Year of installation | Number of TPs | % of Total TPs 2003-04 |
|---|---|---|
| 2003-04 | 2 | 4 |
| 2004-05 | 14 | 27 |
| 2005-06 | 30 | 59 |
| 2006-07 | 5 | 10 |
| Total | 51 | 100 |

Majority (94%) of the farmers were irrigating their land before adoption of TP and the rest (6%) were cultivating under rain-fed conditions. The devices used for irrigation were the tenda, hired DP, and kerosene pump. The details are given in Table 3.2. The tenda operation was strenuous compared to TP use. The water table was high in the region and was in the range of 9 to 20 feet. There were ponds and shallow wells from which water was lifted using traditional methods such as the tenda. A tenda can lift water from the surface and the operation is strenuous. The farmers went in for tenda operation for critical irrigation whenever DP was not available. The farmers had hired DP prior to TP adoption for irrigating paddy.

**Table 3.2 Devices used for irrigation prior to TP adoption in Balangir**

| Devices used for irrigation | No. of HHs | % HHs |
|---|---|---|
| Diesel Pump (hired) | 6 | 12 |
| *Tenda* | 4 | 8 |
| *Tenda* and DP (hired) | 38 | 75 |
| No irrigation | 3 | 6 |
| Total | 51 | 100 |

Rounded off to closest whole number

### 3.1.3 Installation and maintenance of Treadle Pump

There were three dealers in Balangir district and two manufacturers in western Orissa. One was located in Balangir and the other in Kesinga, 60-70 km from Balangir. The respondents said that they approached the dealers for the purchase of TP and *mistries* installed the TP. The cost of the pump was Rs. 1200 and the cost of piping and drilling was Rs. 350 and hence the total installation cost was Rs. 1,550. The respondents had self-financed the purchase of TP.

The TPs were family operated and none of the HHs surveyed hired labour for TP operation. The farmers said that majority (77%) of them replaced parts once a year and a few (22%) replaced once in six months. The parts usually replaced were check valves and washers. Sometimes they had to weld the metal joints of the TP. The washers had to be replaced since they got corroded due to mud and sand in the water. On an average, the annual expenditure towards maintenance was Rs. 68. The expenditure towards consumables in the surveyed HHs ranged from Rs. 30-120 per annum. Details are given in Table 3.3.

**Table 3.3 Frequency of maintenance in Balangir**

| Frequency of maintenance | No. of HHs | % HHs |
|---|---|---|
| Half yearly | 11 | 22 |
| Once a year | 39 | 76 |
| Once in one and half year | 1 | 2 |
| Total | 51 | 100 |

Majority (82%) of the respondents said that they attended to the minor repairs themselves. Only a few (18%) of the farmers hired the services of the *mistires* (mechanics).

### 3.1.4 Hours of operation of Treadle Pump

The operation of TP in the surveyed village was 764 hours per year per person and 458 hrs per acre. The average hours of operation per day and average days of operation per season is given in Table 3.4. The hours of operation in the *rabi* and summer seasons were higher when compared to *kharif* (paddy being the prominent crop in *kharif*). Vegetables were grown in all the three seasons.

**Table 3.4 Average hours of operation of TP in Balangir**

| Season | Average hrs/day | Average days/season | Hrs of operation/ year |
|---|---|---|---|
| Kharif (rains) | 3 | 26 | 78 |
| Rabi (winter) | 5 | 66 | 330 |
| Zaid (summer) | 4 | 89 | 356 |
| | | Total | 764 |

### 3.1.5 Cropping pattern

The main crops grown in the region are paddy and vegetables. The vegetables grown are tomatoes, chilli, brinjal, onion, pumpkin, ladyfinger, radish, cabbage, cauliflower etc. The other minor crops are sunflower, watermelon and wheat. Paddy is grown only in the rainy season. After adoption of TP the area under vegetables increased in all three seasons as indicated in Figure 3.2. The gross irrigated area under cultivation also increased by 50% (Table 3.6), after adoption of TP. The cultivation of vegetables increased by 205% (Table 3.6) and the gross area under paddy had decreased by 6%. This clearly indicates that the vegetables coming into the market in the Balangir region are green vegetables since they would not have been produced if there was no TP.

### 3.1.6 Perception of Treadle Pump users and income

The farmers expressed that the adoption of TP enabled them to grow more vegetables, thus increasing their income. They said that they can irrigate their land at their convenience and also mentioned that the irrigation with TP is lighter compared to that of DP. The farmers said that they could operate the pump for two to three hours without getting fatigued. They said that there is no monetary cost involved in TP usage whereas irrigation with DP involved cost towards irrigation. The disadvantages in DP-use mentioned were that sometimes the farmers could not hire DP as and when required; they had to incur expenditure towards transportation cost and hiring of DP. The cost of hiring DP was Rs. 80 per hour; the charges included the cost of diesel. The farmers said that the operation of DP for one to two hours would dry up the shallow well and it took time to recharge. They did not face such problems in the operation of TP. It also indicates that water extraction is greater in case of DP operation and hence water gets wasted during irrigation. To maximise the use of DP hiring the farmers would irrigate at a stretch and this led to more water than required at a particular time.

Some of the changes in various HHs with increased income are purchase of buffaloes, renovation of houses, purchase of land, providing education to the children, and managing the expenses for daughter's marriage. A few households have purchased a television set.

**Figure 3.2 Cropping pattern in Balangir**

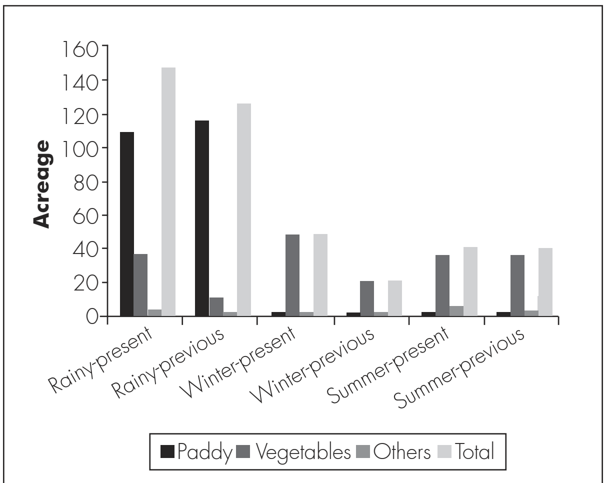



**Table 3.5 Acreage under cultivation at present and prior to TP adoption in Balangir**

| Season | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Kharif (rains) | 146 | 124 | 22 | 18 |
| Rabi (winter) | 47 | 20 | 27 | 135 |
| Zaid (summer) | 39 | 11 | 28 | 255 |
| **Total** | **232** | **155** | **77** | **50** |

**Table 3.6 Acreage under various crops at present and prior to TP adoption in Balangir**

| Crop | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Paddy | 107 | 115 | -7 | -7 |
| Vegetables | 118 | 38 | 79 | 210 |
| Others | 7 | 2 | 5 | 250 |
| **Total** | **232** | **155** | **77** | **50** |

The income of farmers increased after TP adoption due to increase in the area under irrigated cultivation. The average annual income per household after adoption of TP is Rs. 37,432 while, earlier it was Rs. 14,000. The per capita annual income was found to be Rs. 5000. The change in income of the various landholding categories is given in Table 3.7.

## 3.2 Cooch Behar Region (West Bengal)

### 3.2.1 Demographic and land details

The number of HHs surveyed was 45. The average family size of the surveyed HHs was 5.55. The total population was 250 and that of male, women and children was 100, 78 and 72 respectively. The total land of the surveyed HHs was 61.2 acres, of which 55.5 acres (90%) was irrigated. The average landholding of the HHs was 1.35 acres. Most (96%, Fig. 3.3) of the HHs belonged to the marginal farmers category. Only 4% HHs were small farmers with a landholding between (2.5-5) acres. The main occupation of the people in the region was agriculture. The landholdings were fragmented with small patches of land situated at various locations.

### 3.2.2 Type of water devices

The farmers in the surveyed households were using 3.5" BTPs. The age of the pumps ranged from 1 to 10 years. The first pumps were installed in 1996 and rest in 2000-2002. It was found that the life of a TP was about 10 years. The pumps installed in 1996 were still in operation. The details of TP installation are given in Table 3.8.

Majority of the farmers (56%, Table 3.9) were irrigating their field by hiring DP prior to TP adoption. About 20% of them were using traditional methods such as the *dhekuli* and hand pump. About 24% HHs did not have any means of irrigation prior to TP adoption. This indicates that TP helped non-irrigating farmers to take up irrigation. The farmers said that irrigating with *dhekuli* was cumbersome and it provided a lower water output of about 2000 litres per hour per person and the operator was usually exhausted in about 2 hours.

**Table 3.7 Annual income of household present and prior to TP adoption in Balangir**

| Landholding | No. of HHs | Present average income/ annum (Rs.) | Previous average income/ annum (Rs.) |
|---|---|---|---|
| 0-2.5 acre | 21 | 27068 | 10350 |
| 2.5- 5 acre | 23 | 36600 | 13932 |
| 5-10 acre | 7 | 65100 | 33557 |
| | 51 | | |

**Figure 3.3 Landholding classification of surveyed households (Cooch Behar)**

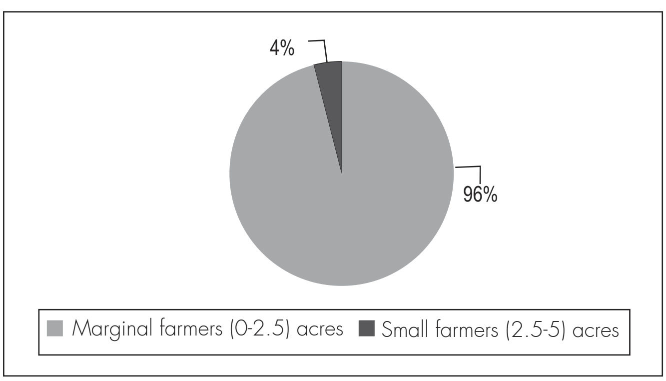



**Table 3.8 Year of installation of TPs in Cooch Behar**

| Year of installation | Number of HHs | % HHs |
|---|---|---|
| 1996-1998 | 7 | 16 |
| 1998-2000 | 10 | 22 |
| 2000-2002 | 12 | 27 |
| 2002-2004 | 8 | 18 |
| 2004-2006 | 8 | 18 |
| Total | 45 | 100 |

Rounded off to closest whole number

The swing basket could lift water only from surface such as ponds, channels etc. and required two persons to operate.

### 3.2.3 Installation and maintenance of Treadle Pump

There were 25 dealers and three distributors in Cooch Behar region. Each dealer had a team of *mistries* who attended to the after-sales service. In the surveyed villages the TP was mostly (96%, Table 3.10) operated by family members. In a few HHs it was self-operated by a single person. Usually it was operated by the adults. It was found that in HHs with small family size it was self-operated.

The parts usually replaced were check valves or washers. Most of the farmers replaced it once in a year. The details of frequency of repair and replacement are given in Table 3.11. Most (56%) of the HHs attended to the repair works themselves. Some HHs (44%) hired the services of the *mistries*. On an average, the annual expenditure towards repair and maintenance was found to be Rs. 96 per household including the bamboo replacement cost. In certain villages, bamboo was locally available and did not add up as an expense, however in certain villages farmers did have to purchase the bamboo. The cost of pump was Rs. 450 and the drilling charge was Rs. 450, amounting to Rs. 900 for the total installation. Some of the respondents had borrowed 50% of the amount from their relatives or friends and the rest had self-financed it.

### 3.2.4 Hours of operation of Treadle Pump

It was observed that most of the women were engaged in TP operation. Some women said that they pumped for five to six hours a day, taking breaks in between. Usually, they started early in the morning at 6 and pedal until 10 a.m., and start again at 4 p.m. and pedal until 6 p.m. The average hours of TP operation in the sampled households were found to be 920 per hrs per year (Table 3.12).

**Table 3.9 Devices used for irrigation prior to TP adoption, Cooch Behar**

| Device used for irrigation | No. of HHs | % HHs |
|---|---|---|
| Hiring DP | 25 | 56 |
| *Dhekuli* | 7 | 16 |
| Hand pump | 2 | 4 |
| Not irrigating | 11 | 24 |
| Total | 45 | 100 |

**Table 3.10 Operation of TP, Cooch Behar**

| Details | No. of HHs | % HHs |
|---|---|---|
| Family operated | 43 | 96 |
| Self operated | 2 | 4 |
| Total | 45 | 100 |

**Table 3.11 Frequency of repair**

| Details | No. of HHs | % HHs |
|---|---|---|
| Once a year | 39 | 87 |
| Once in two years | 3 | 7 |
| Once in three years | 3 | 7 |
| Total | 45 | 100 |

Rounded off to closest whole number

**Table 3.12 Average hours of operation of TP in Cooch Behar**

| Season | Average hrs/day | Average days/season | Average hrs of operation/year |
|---|---|---|---|
| Kharif (rains) | 4 | 26 | 104 |
| Rabi (winter) | 6 | 78 | 468 |
| Zaid (summer) | 6 | 58 | 348 |
| | | Total | 920 |

### 3.2.5 Cropping pattern

The main crops grown in the region are paddy, jute, vegetables and tobacco. The main vegetables grown were potatoes, cauliflower, peas and cabbage. The minor crops were maize and mustard. The gross cropped area under cultivation has increased significantly (53%, Table 3.13) with the adoption of TP. There is an increase in the area under cultivation in the three seasons. The gross area under vegetables has increased by 463%, thus indicating that the TP adoption has brought green vegetables[1] into the market (Table 3.14).

The change in area under various crops after adoption of TP is given in Figure 3.4.

### 3.2.6 Perception of Treadle Pump users and income

The farmers said that the advantages of irrigating with TP were that:

a) the water output was lighter when compared to DP, irrigating with DP and caused erosion of top soil in certain patches and hence loss of crop;
b) there was no cash expenditure towards irrigation;
c) the farmers could irrigate their crops as and when required and according to their convenience; and
d) in case of DP they had to spend towards transportation and it required two people to lift the pump. The TP is easily portable. It could be removed and fitted in various locations. This helped the farmers since most of them had fragmented lands located in different places, it also helped in minimising water losses because the water had to flow over a shorter distance. In Cooch Behar it was observed that some of the farmers who did not own a TP, borrowed it from their relatives or neighbours to irrigate their field.

Some HHs in Cooch Behar were using the TP for pumping drinking water. The HHs had drilled a bore near their homes and the TP was brought from a farmland and fixed whenever there was need to pump drinking water.

**Figure 3.4 Cropping pattern in Cooch Behar**

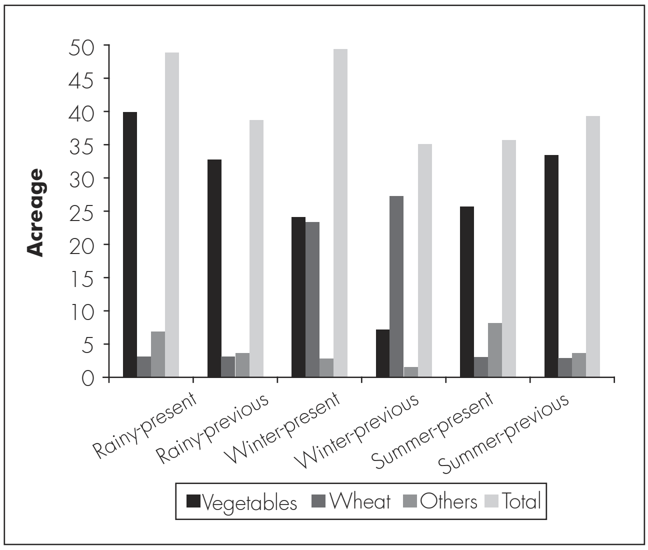



**Table 3.13 Acreage under cultivation at present and prior to TP adoption in Cooch Behar**

| Season | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Kharif (rains) | 46 | 37 | 9 | 24 |
| Rabi (winter) | 47 | 25 | 22 | 88 |
| Zaid (summer) | 47 | 29 | 18 | 62 |
| Total | 140 | 91 | 48 | 53 |

Rounded off to closest whole number

**Table 3.14 Acreage under various crops at present and prior to TP adoption in Cooch Behar**

| Crop | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Paddy | 59 | 44 | 16 | 36 |
| Vegetables | 16 | 3 | 13 | 43 |
| Jute | 35 | 25 | 10 | 40 |
| Tobacco | 18 | 13 | 5 | 38 |
| Others | 11 | 7 | 4 | 57 |
| Total | 139 | 92 | 47 | 51 |

Rounded off to closest whole number

[1]Green Vegetables – Vegetables grown by using Treadle Pump (TP) for irrigation

The present average annual income of the HHs was found to be Rs. 43,000 and the previous income was Rs. 10,000. The present per capita annual income in the surveyed HHs was found to be Rs. 7,500.

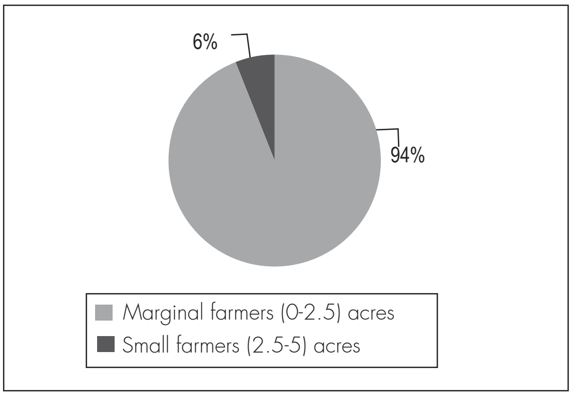
The average annual income across different categories of landholdings is given in Table 3.15.

## 3.3 Gorakhpur Region (Uttar Pradesh)

### 3.3.1 Demographic and land details

Fifty one households were surveyed, which had an average family size of eight. The population in the surveyed HHs was 412 with 132 men, 115 women and 165 children. The average landholding was 1.23 acres and majority (94%) of the HHs were marginal farmers with landholdings of 0-2.5 acres. Only a few (6%) HHs were small farmers (Figure3.5). Most farmers had fragmented landholdings. The total land of the surveyed HHs was 63 acres and all the land was irrigated using TP.

**Figure 3.5 Category of surveyed households in Gorakhpur**




Agriculture was the main occupation of the surveyed HHs, they had no secondary occupation.

### 3.3.2 Types of water-lifting devices

The preferred irrigation device of the farmers was TP, only few (4%) of the farmers are hired DP. Majority (67%) of the farmers had 3.5″ BTP and the others (33%, Table 3.16) had 5″ MTP. The age of the pump varied from one to 11 years. It was found that the pumps installed in 1995 were in operation and hence the life of pump was found to be 10 years. The TPs in the region were installed since 1995; majority (41%, Table 3.17) of the HHs had installed it during 1998-2000.

**Table 3.15 Annual income of HHs at present and prior to TP adoption in Cooch Behar**

| Landholding | No. of HHs | Present average income/annum (Rs.) | Previous average income/annum (Rs.) |
|---|---|---|---|
| 0-2.5 acres | 43 | 41145 | 8754 |
| 2.5-5 acres | 2 | 110350 | 44025 |
| Total | 51 | | |

**Table 3.16 Model of TP installed in Gorakhpur**

| Model of TP | Number of HHs | % HHs |
|---|---|---|
| 3.5″ bamboo TP | 34 | 67 |
| 5″ metallic TP | 17 | 33 |
| Total | 51 | 100 |

**Table 3.17 Year of installation of TPs in Gorakhpur**

| Year of installation | Number of HHs | % HHs |
|---|---|---|
| 1995-1997 | 5 | 10 |
| 1998-2000 | 21 | 41 |
| 2001-2003 | 19 | 37 |
| 2004-2006 | 6 | 12 |
| Total | 51 | 100 |

All the HHs were irrigating their land prior to adoption of TP. Most (96%) of the farmers had hired DPs and 4% of the HHs had used *dhekuli* for irrigating their lands (Table 3.18). The introduction of TP in the region had reduced the use of traditional irrigation devices such as the *dhekuli* and also the hiring of DP.

**Table 3.18 Devices used for irrigation prior to TP adoption, Gorkahpur**

| Device used for irrigation | No. of HHs | % HHs |
|---|---|---|
| Hiring DP | 49 | 96 |
| *Dhekuli* | 2 | 4 |
| Total | 51 | 100 |

### 3.3.3 Operation and maintenance of Treadle Pumps

The respondents had approached the dealer for purchase of the TP and the *mistries* installed it. There are about 100 dealers in Gorakhpur district and four manufacturers in the state of Uttar Pradesh (UP). The cost of 3.5" BTP was Rs. 450 and that of 5" MTP was Rs. 1,150. The overall cost incurred for installation of the TP was Rs 800-1500. Most of the farmers had self-financed the purchase of the pump.

The TP was mostly (90%, Table 3.19) operated by family members; a few (4%) households hired labour for the operation of the pump. The cost of hiring labour was Rs. 50 per day and the labour would pedal the pump for six to eight hours, taking breaks in between. In some (6%) of the HHs it was self-operated due to small family size.

**Table 3.19 Operation of TP, Gorakhpur**

| Details | No. of HHs | % HHs |
|---|---|---|
| Family operated | 46 | 90 |
| Self operated | 3 | 6 |
| Hired labour | 2 | 4 |
| Total | 51 | 100 |

The parts usually replaced were washers and check valves. About 25% of the farmers said that they did not face any problem with TP, 37% said that they replaced part such as the washer once in a year and 29% replaced it once in two years (Table 3.20). The farmers attended to the repairs themselves. The annual expenditure towards repair and replacement of these components ranged from Rs. 30-100 per annum and on an average it was Rs. 60.

**Table 3.20 Frequency of repair**

| Details | No. of HHs | % HHs |
|---|---|---|
| Not faced any problem | 13 | 26 |
| Once a year | 19 | 38 |
| Once in two years | 14 | 28 |
| Once in three years | 4 | 8 |
| Total | 50 | 100 |

### 3.3.4 Hours of operation of Treadle Pump

The hours of operation of TP in the surveyed villages was found to be 1418 hrs per year per household and 1425 hours per acre per year. The average hours of operation varied between four and eight hours per day in different seasons. The details of average days of operation and hours of operation of TP in the rainy, winter and summer seasons are given in Table 3.21.

**Table 3.21 Average hours of operation of TP in Gorakhpur**

| Season | Average hrs/day | Average days/ season | Average hrs of operation/ year |
|---|---|---|---|
| Kharif (rains) | 4 | 28 | 112 |
| Rabi (winter) | 6 | 71 | 426 |
| Zaid (summer) | 8 | 110 | 880 |
| | | Total | 1418 |

### 3.3.5 Cropping pattern

The main crops grown in the region are vegetables and wheat. The vegetables grown are peas, radish, cauliflower, potatoes, brinjal, ladyfinger etc. The other minor crops grown are sugarcane, maize and mustard. Wheat is grown mainly in the *rabi* season. The gross area under vegetables increased after TP adoption. The gross area under irrigation increased by 18% (Table 3.22). The gross cropped area under vegetables has increased by 22% thus bringing green vegetables into the market. The details of change in cropping pattern are indicated in Figure 3.6.

### 3.3.6 Perception of treadle users and income

**Table 3.22 Acreage under cultivation present and prior to TP adoption in Gorakhpur**

| Season | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Kharif (rains) | 49 | 38 | 10 | 29 |
| Rabi (winter) | 49 | 35 | 14 | 40 |
| *Zaid* (summer) | 35 | 39 | -4 | -10 |
| Total | 133 | 112 | 20 | 18 |

**Figure 3.6 Cropping pattern in Gorakhpur**

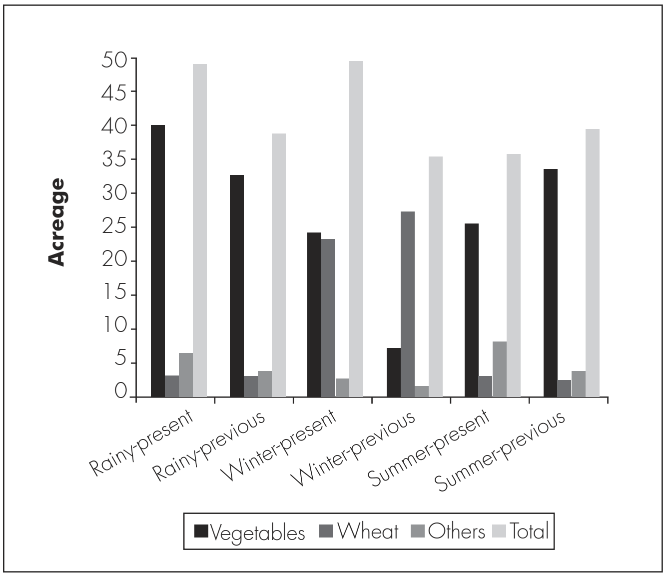



**Table 3.23 Acreage under various crops at present and prior to TP adoption**

| Season | Present acreage | Previous acreage | Change in acreage | % change |
|---|---|---|---|---|
| Vegetables | 89 | 73 | 16 | 22 |
| Wheat | 28 | 32 | -4 | -12 |
| Others | 16 | 8 | 8 | 100 |
| Total | 133 | 113 | 20 | 18 |

The farmers said that the TP operation had saved the cost towards irrigation; the cost of hiring DP was Rs. 80 per hour including the diesel cost. The TP was portable and could be easily transported when compared to a DP. They said that it was easy to operate and could be operated by all family members including women. Traditional methods such as the *dhekuli* were cumbersome. Irrigation with TP was lighter and was apt for vegetable growing; the light irrigation increased the size of the vegetables such as cauliflowers etc., thus increasing the yield. The incomes of the farmers had increased with TP adoption. The various changes in the HHs due to the increased income were purchase of cattle, purchase of land, renovation of house etc.

The present average annual income of the surveyed HHs in the region was found to be Rs. 35,061 and the previous income was Rs. 10,549. The annual per capita income in the surveyed HHs was Rs. 4,293. The details of average annual income as per landholding classification is given in Table 3.24.

**Table 3.24 Annual income of households at present and prior to TP adoption in Gorakhpur**

| Landholding | No. of HHs | Present average income/annum | Previous average income/annum |
|---|---|---|---|
| 0-2.5 acre | 49 | 35326 | 10258 |
| 2.5-5 acre | 2 | 46500 | 22500 |
| Total | 51 | | |

# Market Shift Analysis

This chapter analyses the market shifts and seeks to understand the reasons for shift to Treadle Pumps (TPs). Basis the findings from the survey (ref: annex 2.3) in the regions of Balangir, Gorakhpur and Cooch Behar, focus group discussions (FGDs) were held in high-intensity as well as low-density TP villages. The perceptions of non-users, Diesel Pump (DP) renters, and manufacturers and dealers of TP and DP were also analysed to understand the shift.

## 4.1 Perception of Farmers on Diesel Pump Use

The farmers in the surveyed households in Balangir and Gorakhpur said that they would hire DP if TP was not available. In Cooch Behar most households (64%) were of the same opinion. However, about 36% households said that they would not hire DP even if there were no TP. These farmers, most of whom are in the no man's land bordering Bangladesh and India, were very low-income farmers and even hiring DP was an expensive option for them. In addition to this, transportation of DP into this area was a hurdle. These farmers typically had landholdings less than an acre and all of them had not hired a DP prior to adoption of TP. A few were irrigating using the traditional method namely the *dhekuli* and the rest were cultivating under rain-fed conditions. They said that the cost of hiring was a constraint and hence they could not hire DP. The cost of hiring DP was Rs. 100 per hour.

The farmers who were previously non-irrigating have adopted TP. The introduction of TP in the region has led to non-irrigating farmers avoiding the use of DP. TP intervention has brought more green vegetables into the market. The opinion of the respondents was that they would continue to use TP in the future. This indicated the demand among the farmers for irrigation and TP as a feasible option.

The farmers who were previously non-irrigating have adopted TP. The introduction of TP in the region has led to non-irrigating farmers avoiding the use of DP. TP intervention has brought more green vegetables into the market. The opinion of the respondents was that they would continue to use TP in the future. This indicated the demand among the farmers for irrigation and TP as a feasible option.

In the surveyed HHs the average hours of operation of DP prior to TP adoption were 85 hours per year, 95 hours per year and 369 hours per year in the regions of Balangir, Cooch Behar and Gorakhpur respectively. The high usage of DP in the Gorakhpur region can be attributed to the fact that farmers were growing vegetables even prior to TP adoption. There were brown vegetables[2] in the market in Gorakhpur prior to TP intervention. With the adoption of TP more green vegetables and paddy are grown in the region and in Cooch Behar, paddy and tobacco was grown prior to TP adoption.

The response from non-users of TP, who are presently using DP, was that the average usage of DP was 53 hours per year, 68 hours per year and 276 hours per year in Balangir, Cooch Behar and Gorakhpur respectively.

There is a difference in the hours of operation mentioned by TP users and TP non-users. It has to be noted that the "before and after" method was deployed, which is based on recall of past decisions. The sample size for the users and non-users also

[2] Brown vegetables- vegetables grown by irrigating with diesel pumps (DP)

varies in the study. There is also a possibility of variation because of difference in cropping pattern.

## 4.2 Perception of Non-users of Treadle Pump

In each of the regions, discussions were held with non-users of TP to understand their views about TP adoption. Most of them were hiring DP for irrigating their agricultural lands. In Cooch Behar the non-users said that finance was the main limiting factor for adoption of TP. The expenses towards health, basic necessities such as clothes, food, agricultural inputs like seeds and education of the children were some of the priorities of the HHs. The farmers felt that the expenditure towards hiring of DP was staggered and hence they could manage the expenses. Purchasing TP would mean investing an upfront cost of Rs. 1000-1200. One of the farmers said that it took two years to save the money to install a TP. This indicates that there is a time lag between the interest to buy a TP and actual installation, due to the paucity of funds. The respondents were found to be either hiring DP or not irrigating. Most of them said that they would be interested in adopting TP in the future.

*The DP renters had been renting the DP for over a period of five years. The DP renters said that they had to increase the cost of DP renting because the cost of diesel is increasing and annual maintenance and repair charges are also high in case of DP.*

In Balangir one respondent who owned eight acres of land and owned a DP said that he would continue to use DP because his large holdings needed more water.

In villages where there were no promotional activities by IDEI, the farmers had not adopted TP. This perspective was obtained in the district of Cooch Behar in two villages from Banaswar and Alipur (Jalpaiguri district) where IDEI intervention had not occurred. Convincing farmers to adopt TP required considerable efforts due to the nature of the product, which involves manual operation: farmers were not immediately attracted because of the manual operation involved. Farmers preferred mechanisation available due to ease of operation and it also enhanced social status. The marketing and promotional activities were essential to market the product and create interest in the farmers.

## 4.3 Perception of Diesel Pump Renters

Discussions were held with DP renters to understand the renting pattern of DPs after availability of TPs. In areas where TP had been introduced, there has been a decrease in DP hiring in the villages surveyed. The average hours of renting and number of farmers hiring DP at present and before intervention of TP is given in Table 4.1. The DP renters had been renting out DP for over a period of five years, and said that they had to increase the rental of DP since the cost of diesel was increasing and annual maintenance and repair charges were also high. In Balangir, they said that procuring diesel was also a problem, as the DPs were located far away from the villages.

The main reason mentioned by them for decrease in DP hiring was due to the intervention of TP in the villages. The transportation of 5 hp and 7.5 hp pumps was laborious and required two people to shift the pump in the farmland. The TP was portable and could be easily shifted to various locations.

**Table 4.1 Hours of DP renting at present and prior to TP adoption**

| Details | Average hours of renting per year | Average number of farmers per year | % decrease in renting hours | % decrease in number of farmers |
|---|---|---|---|---|
| Balangir | | | | |
| Previous | 167 | 36 | | |
| Present | 42 | 12 | 75 | 66 |
| Cooch Behar | | | | |
| Previous | 72 | 5 | | |
| Present | 26 | 2 | 64 | 60 |
| Gorakhpur | | | | |
| Previous | 454 | 40 | | |
| Present | 300 | 20 | 33 | 50 |

## 4.4 Perception from Focus Group Discussion

FGDs were held in the three study regions. The discussions were held in high-density TP villages and low-density villages. In each of the discussions more than 20 participants were present, comprising users and non-users of TP. The information gathered was on aspects such as shift in cropping pattern, the impact of TP intervention on the hiring of DPs, and whether the farmers are getting better price for the vegetables grown by TP.

*The discussions were held in high density TP villages and low-density villages. In each of the discussions more than 20 participants were present comprising users and non-users of TP.*

During the FGD it was evident that TP adoption had encouraged the farmers to grow more vegetables. The three scenarios observed were:

a) farmers who were growing vegetables hiring DP had shifted to growing vegetables with TP;
b) farmers who were previously growing under rain-fed conditions had shifted to growing vegetables with TP; and
c) farmers who were irrigating using traditional methods had shifted to TP use with more area under cultivation and particularly vegetables.

This indicates that TP has displaced the DP usage and fulfilled the earlier suppressed demand for irrigation among the poor or marginal farmers. TP has not only reduced the hiring of DPs, but has also aided the “leap frogging” of farmers to cleaner technology without first getting dirty by the usage of DP (Winkler, 2002). There is a high probability that an approximate 20% of the farmers profiled in the regions of Cooch Behar and Balangir, who previously were not irrigating or were irrigating with manual devices would have shifted to DP irrigation in due course if TP was not available.

TP usage has also increased the area under vegetable cultivation as discussed in Chapter 3. The farmers said that TP use was more economical when compared to use of DP. The usage of DP involved costs towards irrigation; for example in Cooch Behar, to irrigate one bigha (0.33 acres) of land in case of potato crop, irrigation with DP would cost Rs. 4,500 per crop for providing 15 days of irrigation for three hours per day at the rate of Rs. 100 per hour for hiring DP.

To irrigate the same piece of land with TP would cost Rs. 1,200 for 20 days of irrigation at a wage rate of Rs. 60 per day for eight hours of labour. The farmers actually do not incur this cost because family members usually operate the TP.
Since it is more profitable to grow vegetables using TP the farmers have an incentive to bring more area under vegetable cultivation.

The vegetables grown by using DP and TP were sold in the same market. There was no distinction between vegetables grown with DP or TP, however, certain farmers said that they got a better price for the vegetables grown with TP. The reasons, according to them, were that the vegetables grown with TP were more uniform, bigger in size and had better colour. The better quality and yield of the produce was due to the uniform, adequate, and appropriate irrigation with TP use. One of the farmers in Cooch Behar said that the cabbages grown with TP were bigger in size. One farmer said that the size and colour of chillies was better when grown with TP and hence fetched a better price in the market.

*There was no distinction between vegetables grown with DP or TP, however, certain farmers said that they got a better price for the vegetables grown with TP. The reasons, according to them, were that the vegetables grown with TP were more uniform, bigger in size and had better colour.*

In all the villages the respondents said that DP hiring had reduced with the introduction of TP and resulted in providing more vegetables to the market. The farmers were of the opinion that there would have been fewer vegetables in the market if there was no TP. The diesel rentals have increased over the years due to increase in the diesel price.

### Table 4.2 Details of the villages where FGD was conducted

| District | Village | No. of HHs | No. of TP | No. of DP |
|---|---|---|---|---|
| Balangir | Assurmanda | 72 | 25 | 3 |
| Balangir | Chaurimara | 65 | 11 | 2 |
| Cooch Behar | Panishala 134 | 200 | 80 | 2 |
| Cooch Behar | Satmile | 250 | 8 | 20 |
| Gorakhpur | Mahani | 110 | 60 | 40 |
| Gorakhpur | Bela | 190 | 48 | 20 |

In conclusion, the following points become clear. There is an existent demand for irrigation by all categories of farmers. In the regions profiled there is a good possibility of irrigation due to the low water table depth of about 10-40 feet.

The lifting up of water from the water table however, requires each farmer to adopt an irrigation device. The different options available to the farmer are the DP, manual devices like the *dhekuli*, *tenda*, swing basket and now the TP. The use of the irrigation device depends on the income level of the farmer, and the acceptability of the farmer for manual labour.

The most important consideration, however, is the income of the farmer. Prior to TP technology, the DP and the manual devices were the sources of irrigation. The DP owners were generally big land owners who could afford the DP and its operation. Farmers holding land of about one to two acres were these who generally hired DPs and grew crops. The very low income farmers who couldn't afford a DP (sometimes even on hire) opted for manual irrigational devices like the *dhekuli*. However, if the TP was not available they would have shifted to DP in future.

In the FGD conducted with farmers, a majority of the farmers did express that expenditure on irrigation was possible only after meeting priorities, such as expenditure towards housing, food and family welfare. This being the case, most farmers in the areas profiled irrigated their land by hiring DP and could not grow water-intensive crops like vegetables.

With TP, the farmers could provide adequate water to their fields, as excess water did not mean more cash expenditure. This resulted in higher yields, more income and provided the flexibility to the farmer to choose water-intensive crops like vegetables. By the use of TP more vegetables are now being grown in the regions profiled.

*By the use of TP more vegetable are now being grown in the regions profiled. These vegetables are absorbed in the market at the same rates as those grown by DP.*

These vegetables are absorbed in the market at the same rates as those grown by DP. This also proves that earlier there was a demand for vegetables that were suppressed due to unavailability in the market or whose demand being met by inflow from some other places.

Farmers irrigating with manual devices like the *dhekuli* have a limitation of irrigating for extended hours (reasons outlined in Chapter 5). The TP as an alternative is an easier and a safer option, and it has given the farmer a clean technology option, Since the farmer previously had adapted to manual irrigation, the TP allows him to irrigate far more hours and hence again providing him access to more irrigation water and growing vegetables. If TP was not available they would have adopted DP in due course.

## 4.5 Discussion with Dealers and Manufacturers of Treadle Pumps

Discussions were held with a few dealers and manufactures to understand the trend in sales of TP. The sale of TP is mainly through the network of dealers and distributors. The manufacturers enter into an MoU with IDEI and the quality control aspects are checked by IDEI. IDEI plays a major role in promotional activities and marketing of the product. The discussion with a few dealers is elaborated in boxes 4.1, 4.2 and 4.3.

## 4.6 Discussion with Dealer of Diesel Pump

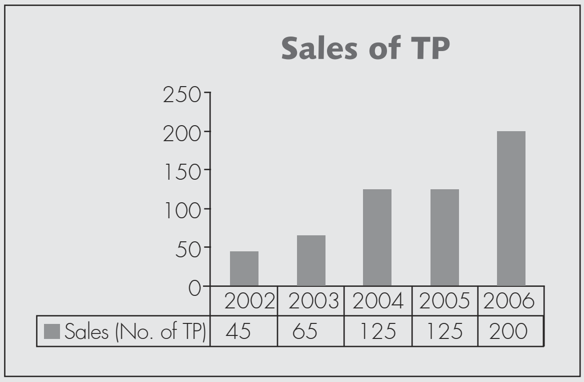
The DP dealer was interviewed in Cooch Behar to understand the sales of DPs in the region. The discussion with the dealer is given in Box-4.4.

## Box 4.1 Discussion with Mr. Sharma, Dealer-cum-distributor in Farida, Gorakhpur

Mr. Sharma has been in the business of agriculture implements for 40 years. He added the TP business about four years ago. Every year he sells about 100 to 150 pumps in retail and another 100 to 150 as a distributor. He mentioned there has been a growth of approximately 15% every year in the sale of TP. The cost of each pump is about Rs. 700, thus the turnover from the TP is about Rs. 210,000 per year. The MRP of sale is governed by IDEI. He gets a margin of about Rs. 80 per pump. His total turnover per year is about Rs. 35 lakh which includes about Rs. 12 lakh from retailing rest as distributor. He mainly gets customers by the effort of IDEI. One year warranty is given on the TP against manufacturing defect. He keeps an inventory of about 30 to 50 units of TP. He said that the TP offers unique advantages to each of the stakeholders. For farmers in the Gangetic plain and locations with good water table it is an ideal solution. It is much simpler than other manual systems like *dhekuli*, or swing basket. It also competes in economic terms with a diesel engine hired operation. Diesel engine hired operation requires higher degree of skill whereas a TP is very simple which can be run by anyone. Diesel engine hiring is another competing arrangement to TP. The diesel hiring cost ranges from Rs. 50 to Rs 80 per hour. However, DP irrigation is costlier. The farmer ends up taking only two crops if he uses a DP for irrigation. Timely irrigation using DP is an issue. Pump owner will irrigate his field first and then rent it out.

## Box 4.2 Discussion with Riaz-ur-Rehman, Dealer, Cooch Behar

Riaz-ur-Rehman took up TP dealership in 1996. He saw the TP somewhere and got interested. At present he has a fertiliser shop. IDEI and the distributor convinced him to take up the dealership. The sales was about 5 to 10 pumps per year prior to 2002. In 2002 there was a meeting with mechanics and dealers, and mechanics were trained by IDEI for after-sales service. Promotional activities such as video show and village demonstration were also done. These efforts by IDEI have resulted in increase in sales. The sales per annum since 2002 are given in the graph.




He said that IDEI played a major role in quality control and awareness-creation. They had also created a platform for all the stakeholders in the sector to meet and exchange knowledge and experiences. The unique selling point of the business was that the TP can irrigate as per need and convenience of the farmer. TP irrigation is lighter and hence damage to crops is less. The main source of his income was from sale of bio-fertilisers (75%) and 25% of his income was from the sale of TP. Regarding the future potential for TP he felt that the trend in villages is division of joint families, hence the land also gets divided. This could increase the TP sales, 95% of the farmers in the region have small holdings and are the potential customers.

It was observed that at the dealer's shop a TP was installed in front of the shop. This helped to advertise the product and called Point of Purchase (PoP) installation. The customers who come could get a feel of the TP at the shop.

## Box 4.3 Discussion with Nirmal Roy, TP Manufacturer, Calcutta

He established a unit to produce TP in 1996. First pump was produced in January 1997. Till 2007, about 30,000 pumps were sold. The sales this year (2007) have been about 6000. IDEI orders have been 5000 while orders directly from distributors from Assam (who were earlier in IDEI network) were 1000 (Trade India, Navagaon).

The products fabricated are, TP (75 to 90%); and the balance contributes to fabricating ploughs, threshers, hand pumps and other agriculture implements.

Transportation is an important parameter in cost control. Hence, efforts are made to dispatch full load against orders. The pumps are checked for specifications at the time of welding. IDEI staff also visit and test against specification. Raw material is sent for lab testing. Water leak test is carried out at the factory premises. However, there is no test bed. He has machines such as bending, rolling machine, arc welding. The production capacity is about 50 BPP per day plus 10 STP per day. The season with highest sale is October to March. 60 to 75% of the annual sale is during these months.

The ex factory price of BPP is Rs. 350 per pump. About 5000 are being sold per year. The ex factory price of surface TP is Rs. 950 per pump. The sales were about 1500 per year.

Profit margins: Rs. 30 per TP and Rs. 100 per STP. The ex factory price of TP pump is Rs. 350 per pump. About 5000 are being sold every year. The ex factory price of STP pump is Rs. 950 per pump. About 1500 are being sold every year.

License and Royalty: As claimed by Mr Roy, there is an agreement with IDEI to produce these pumps. There was no license fee paid by him and also there is no royalty.

Improvements carried out by M/s Roy; mouth/tray to the TP was provided. Single barrel hand pump was an offshoot.

Interaction of manufacturer with stakeholders: They attend the annual meeting of dealer, distributor, and IDEI staff. They also meet some farmers once in a year.

M/s Roy is one of the major producers of TPs in West Bengal since 1996.

Demand for IDEI pumps: Demand is increasing every year. Increase in diesel price is a positive factor for TP promotion. Diesel hiring cost per day is about Rs. 300 to 400 per day, when compared to this, the TP cost is very little.

## Box 4.4 Discussion with DP dealer Arun Sharma, Cooch Behar

He is the appointed distributor for Greaves brand of DP; in addition he also stocks pumps of Bharat and the pump sets made in China. He said that the demand of DP sets in the region of Cooch Behar saw a fall from 2003 onwards due to rise in diesel prices:

He however mentioned that from 2006 onwards he has seen a spurt in demand, primarily due to the influx of DP sets of Chinese make, which consumes lesser diesel than conventional engines.

He mentioned that the farmers avail a 50% subsidy on DP sets. The subsidy portion is coordinated by the Bank providing the loan; in addition there are a few schemes like the rain harvester schemes encouraging DP sales.

The demand currently exists for 3.5 HP pumps and as a dealer he recommends 3.5 HP Chinese pumps to the farmers. The major blocks in which he has sold DPs are in Natatwari, Shital Kushi and Betakudi.

Chapter 5

# Technical Assessment

This chapter focuses on the evaluations conducted to assess the performance of the Diesel Pump (DP) and the Treadle Pump (TP) sets in the three study regions.

## 5.1 Diesel Pumps

### 5.1.1 Methodology

There were two options for the methodology to be used in testing of pumps:

- Shop tests (Laboratory tests) – Tests conducted at shop floor or at manufacturers' plant.
- Field tests – Tests conducted on field in its exact environment and operating under field conditions.

The field tests were chosen as the methodology for a more realistic assessment of the pumps in the region.

### 5.1.2 Selection of pumps

A total of 18 DP (seven pumps in the region of Cooch Behar, five in the region of Gorakhpur and three in the region of Balangir) were selected for the testing process. Two kerosene pumps in the region of Balangir were tested. The selected pumps are listed below in Table 5.1 with details such as the name of the owner, make and age of the unit.

**Table 5.1 Pumps selected for technical analysis**

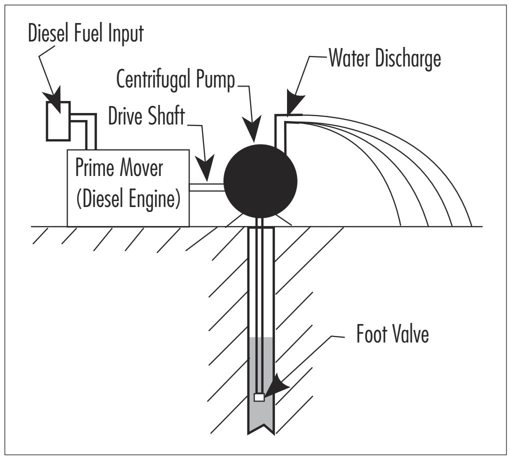
| Name of the owner of the pump | Village | District | State | Horse Power (BHP) | Make of the system | Age of the system (Yr) |
|---|---|---|---|---|---|---|
| Shankar Padhan | Assurmunda | Balangir | Orissa | 5 | Kirloskar | 15 |
| Sanathan Padhan | Assurmunda | Balangir | Orissa | 3 | Kirloskar | 14 |
| Digambar Majhi | Tellanpalli | Balangir | Orissa | 3 | Kirloskar | 6 |
| Mohan Burman | Giriya kuti | Cooch Behar | West Bengal | 5 | Atul Shakthi | 6 |
| Shri Krishna | Bagmara | Cooch Behar | West Bengal | 5 | Shreyas | 2.5 |
| Padmanath Burman | Giriya kuti | Cooch Behar | West Bengal | 5 | UL generators | 4 |
| Rosho Roy Biswas | Bagmara | Cooch Behar | West Bengal | 3.5 | China Power Machinery | 0.16 |
| Bharath Chandra Roy | Giriya kuti | Cooch Behar | West Bengal | 5 | Dipco | 10 |
| Shapan Biswas | Giriya kuti | Cooch Behar | West Bengal | 5 | Bharat | 5 |
| Abdul Rehman | Panishalla | Cooch Behar | West Bengal | 5 | Bharat Diesel Engine | 10 |
| Tyabul Rehman K | Panishalla 24 | Cooch Behar | West Bengal | 5 | Kirloskar | 5 |
| Suraj Narayan | Bela | Gorakhpur | UP | 7.5 | Field Marshall | 6 |
| Kanaiah | Mahani | Gorakhpur | UP | 7.5 | HTC | 10 |

| Name of the owner of the pump | Village | District | State | Horse Power (BHP) | Make of the system | Age of the system (Yr) |
|---|---|---|---|---|---|---|
| Mantri | Mahani | Gorakhpur | UP | 6.5 | Usha | 8 |
| Harish Chand | Bela | Gorakhpur | UP | 7 | Kirloskar | 6 |
| Ram Narayan | Mahani | Gorakhpur | UP | 7.5 | Field Marshal | 8 |
| Kerosene Pumps | | | | | | |
| Lajendra Biswal | Chareimara | Balangir | Orissa | 1.5 | Mahendra | 9 |
| Shatrugan Shatriya | Chareimara | Balangir | Orissa | 1.5 | Greaves itd | 8 |

### 5.1.3 Diesel Pump – Technical details

Schematic diagram of a DP system operation is given in figure 5.1.

**Figure 5.1 Schematic diagram of a DP system operation**




The diesel powered pumping system for irrigational purposes consists of four main parts:

1. Prime mover: This provides the necessary mechanical energy to the pump. In the case of pumps powered by diesel, the prime mover would be a diesel engine. The fuel burned moves a piston which, in turn, rotates the drive shaft. This drive shaft provides the mechanical energy required to the pump.
2. Power transmission system: This is a system to transmit rotary motion from the prime mover to the pump. It can be of the mono-block variety, directly coupled type, or a belt driving arrangement.
3. The pump: The primary part of the pumping system. It lifts water from a lower to a higher level. The pumping systems tested in the three study areas were of the centrifugal pump variety. A centrifugal pump basically converts the mechanical energy into hydraulic energy by applying centrifugal force on the liquid and providing the lift.
4. Suction and delivery pipes: Suction pipe is required to draw water from sources and delivery pipe to carry water to the required point on the ground. A foot valve is fixed to the end of the pipe to prevent back flow.

***Testing procedure adopted for the analysis***

**Table 5.2 Instruments used for the technical analysis (testing)**

| Instrument | Least count | Unit | Purpose |
|---|---|---|---|
| 2 ltr Measuring Jar | 10 ml | Litre | Diesel consumption measurement |
| Stopwatch | 1 millisecond | seconds | Time duration measurement |
| 200 ltr Measuring Drum | 100 ml | Litre | Water discharge measurement |
| 1 Foot Scale | 1 mm | Cms | Measurement of decrease in diesel level of the tank |

### ***Procedure adopted for Diesel Pump technical analysis***

- The pump was inspected and details of the pump noted after which it was primed with water and run for a long period of time.
- The pump was put off and the diesel inlet pipe detached. A calibrated 2 litre capacity measuring jar was attached to the diesel engine. Measured volume of diesel was filled in the calibrated cylinder and kept ready for the trial.
- The engine was restarted and the first diesel reading was noted when the pump attained a steady state after about 10 minutes. Diesel consumption was noted at suitable intervals of time with a minimum of five minutes interval between two readings.
- A 200 litre drum was used to collect water and a stopwatch was used to record time.
- The depth of water (suction head) was noted by enquiring with the owner of the bore from which water was being pumped. In selected sites the length and depth of the water table was measured with the help of a measuring scale.

*The objective of the study was to conduct a socio-economic-technical analysis of TP adoption and assess the $CO_2$ emission reduction potential.*

*Precautions taken during the testing process to maintain accuracy*

- Diesel consumption was measured only after the pump achieved a steady state. The diesel consumed due to initial operation or priming was not included.
- Fresh diesel was procured from diesel bunks for the testing purpose. This was done to avoid the usage of adulterated diesel which was the common practice of the users of the pump in the region.

### ***Results of the technical analysis***

The efficiencies of the pumps in the three regions profiled ranged from 0.38 in Gorakhpur to a pump with efficiency of 9.57 in Cooch Behar (Table 5.3). The pumps in the region of Cooch Behar had a relatively high efficiency as compared to pumps in the other regions. In the region of Balangir, diesel and kerosene pumps were being used to lift water from open surface wells or storage tanks. In the other two regions of Gorakhpur and Cooch Behar water was being lifted from the ground water source through tube wells. The performance of all 18 pumps in the technical analysis is detailed in Table 5.3.

**Table 5.3 Results of technical analysis**

| Pump code | Name of the owner | Rating of the pump (HP) | Water discharge (l/h) | Head (m) | Fuel consumed (ml/hr) (owner's perception) | Fuel consumed (ml/h) (measured) | Efficiency (%) | Fuel used |
|---|---|---|---|---|---|---|---|---|
| Blg-Te-Dp-01 | Shankar Padhan | 5 | 26232 | 5.05 | 1000 | 943 | 3.83 | Diesel |
| Blg-Te-Dp-02 | Sanathan Padhan | 3 | 28957.67 | 4 | 1000 | 1020 | 3.1 | Diesel |
| Blg-Te-Dp-03 | Digambar Majhi | 3 | 22137.33 | 6 | 1000 | 1122 | 3.23 | Diesel |
| Blg-Te-Kp-04 | Lajendra Biswal | 1.5 | 21426.33 | 5.3 | 750 | 975 | 3.15 | Kerosene |
| Blg-Te-Kp-05 | Shatrugan Shatriya | 1.5 | 18181.67 | 3.58 | 1250 | 1005 | 1.75 | Kerosene |

| Pump code | Name of the owner | Rating of the pump (HP) | Water discharge (l/h) | Head (m) | Fuel consumed (ml/hr) (owner's perception) | Fuel consumed (ml/h) (measured) | Efficiency (%) | Fuel used |
|---|---|---|---|---|---|---|---|---|
| Co-Te-Dp-01 | Mohan Burman | 5 | 27662.79 | 6.71 | 1200 | 963 | 5.26 | Diesel |
| Co-Te-Dp-02 | Krishna | 5 | 24427.41 | 6.1 | 1000 | 860 | 4.73 | Diesel |
| Co-Te-Dp-03 | Padmanath Burman | 5 | 28782.9 | 7.31 | 1000 | 600 | 9.57 | Diesel |
| Co-Te-Dp-04 | Rosho Roy Biswas | 3.5 | 30191.78 | 6.1 | 1000 | 552 | 9.1 | Diesel |
| Co-Te-Dp-05 | Bharath Chandra Roy | 5 | 34559.61 | 7.62 | 1000 | 875 | 8.21 | Diesel |
| Co-Te-Dp-06 | Shapan Biswas | 5 | 36873.77 | 7.01 | 1000 | 825 | 8.55 | Diesel |
| Co-Te-Dp-07 | Abdul Rehman | 5 | 28844.67 | 2 | 1000 | 933 | 1.64 | Diesel |
| Co-Te-Dp-08 | Tyabul Rehman K | 5 | 29219.02 | 6.09 | 900 | 875 | 6.44 | Diesel |
| Go-Te-Di-01 | Suraj Narayan | 7.50 | 4623.89 | 3.10 | 1250.00 | 845.00 | 0.44 | Diesel |
| Go-Te-Di-02 | Kanaiah | 7.5 | 11609.09 | 3.04 | 1000 | 957 | 0.96 | Diesel |
| Go-Te-Di-03 | Mantri | 6.5 | 8869 | 3.65 | 1100 | 573.6 | 1.47 | Diesel |
| Go-Te-Di-04 | Harish Chand | 7.00 | 7320.00 | 3.45 | 1000.00 | 1749.60 | 0.38 | Diesel |
| Go-Te-Di-05 | Ram Narayan | 7.5 | 23640 | 3.45 | 1000 | 865.55 | 2.45 | Diesel |

**Sample Calculation**

| | |
|---|---|
| Name of the owner | Iyabul Rehman |
| Village | Panischalla24 |
| Taluk | Cooch Behar 1 |
| District | Cooch Behar |
| Diesel engine | 5 hp |
| Manufactures of pump | Kirloskar |
| Age of pump | 5 years |
| Total head | 6.09 meter. |
| Flow rate (Q) | 29219 litre/hr |
| Diesel consumption | 0.875 litre/ |

**Efficiency = (E output/E input ) X 100**

Output = Flow rate ($m^3$/s) X head (m)x density of water (kg/l )

kg/m X acceleration due to gravity (m/s )

1000

= (0.009417 (m/s ) X 6.09X 1000kg/m * 9.81) /1000

= 0.562 kW

Input = Diesel consumption (l/s) X Specific gravity(kg\l) X calorific value(kcal/kg)

= 0.0002430 l/s X 0.831 kg/l X 10.000 kcal/kg

= 2.3 kcal/s X 4.18 kilojoules.

= 8.44 kJ/s

= 8.44 kW

$$\frac{\text{E output}}{\text{E input}} = \frac{0.562\ \text{kw}}{8.44\ \text{kw}} = 6.44\%$$

### *Analysis of the results obtained*

*Efficiencies obtained*

Almost 34% of the pumps tested in the region fell into the low efficiency bracket of under 2%. These pumps were included in the analysis to truly indicate field conditions. Most of the pumps (four) in this bracket were tested in the region of Gorakhpur, and one each from Balangir and Cooch Behar. Twenty-four of the pumps tested had efficiency in the range of 8 to 10%, all of which were tested in Cooch Behar. Pumps appeared well-maintained resulting in better efficiency values. Possible reasons for the losses in efficiencies of these DP systems in field conditions are detailed further below.

Figure 5.4 indicates the performance of the pumps in the three regions profiled. Pumps in the region of Gorakhpur had an average efficiency of 0.81% and an average water discharge of 8105 l/h. Pumps tested in Balangir included two kerosene pumps and the average pump efficiency in this region was 2.92% with water discharge around 13,000 l/h. Pumps in Cooch Behar had a comparatively good performance with an average efficiency of 6.69% and average discharge of 30,000 (l/h). The indication of rate of diesel consumption of these pumps tested is provided in Annexure-5.2.

**Figure 5.2 Percentage distribution of DPs tested based on efficiency**

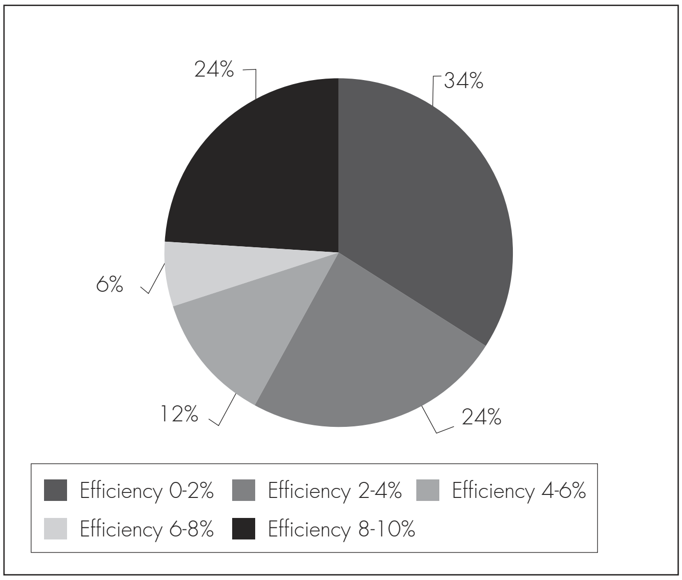
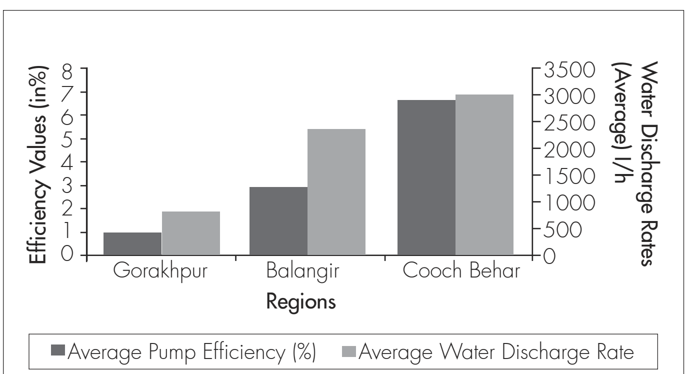



**Figure 5.3 Graph indicating the performance of DPs in the study area**




### *Factors affecting efficiency of the pumping system*

The characteristics of a centrifugal pump and theoretical explanation of efficiency in relation to operating and geographical characteristics is given in Annexure-5.1.

Based on field observations the following reasons were identified for the losses in efficiency of these field pump sets:

1. Mismatch of capacity and load.

- The required rate of water discharge for irrigating certain crops by the farmers is not met by the water available in the well and the pumping system installed to lift this water has a capacity much higher than required for the water available. Particularly in Gorakhpur, 7.5 hp pumps were being used for drawing water from a small depth of 10-12 feet.
- Improper foundation causes vibrations in the engine.

2. Geological factors.

- The soil in the Gangetic plain, in which a region like Gorakhpur is situated, is extremely fine-grained and hence increases chances of the foot valve getting clogged. This clogging increases the chances of air gaps within the suction pipe drawing additional energy during operation and decreasing the efficiency.

- The recharge rate of ground water in Gorakhpur was low, hence water availability was less.

3. Improper usage and lack of knowledge.

- It was noticed that almost all farmers in the study region profiled used kerosene blend into the engine at different percentages. The effect of this blending results in sedimentation of un-burnt carbon particles. This continuous sedimentation damages the engine performance in general, constantly reducing efficiencies.
- Lack of knowledge or effort for routine corrective or preventive maintenance.
- The application for which these pumps were being used work on a negative suction, meaning water is being pulled from the ground table. Such an application increases the chances of air gaps within the suction system resulting at times in nil water discharge, however, consuming diesel. This directly impacts the efficiency of the system.
- There is a loss of discharge head due to the pumps being used for irrigational applications. The water being pumped from the water table is not pumped to a height above the ground, rather it is being utilised at almost ground level itself. The discharge head, hence, is not factored into the efficiency calculations. In other words, if the water would instead have been allowed to flow vertically the head would increase and correspondingly efficiencies would be higher.

## 5.2 Treadle Pump

### 5.2.1 Methodology

The technical analysis was done by testing TP on field. The operator of the TP was selected based on age and the pump was selected by the operator.

### 5.2.2 Selection of pumps

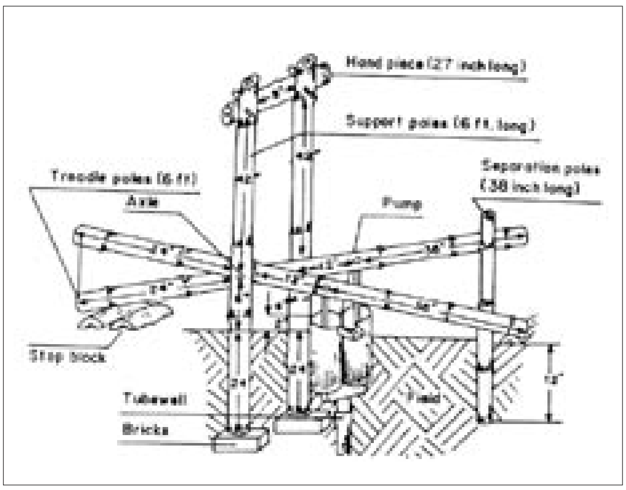
A total of 18 TPs were studied in the three regions. The name, age, the weight of the operator, and the age of the pump is given in Table 5.4. The age of the operator ranged from 17 years to 65 years. The age of the pump ranged from a year to as old as 10 years.

**Table 5.4 TPs tested in the three regions profiled**

| Code | Name of the operator | Village | Age of the operator (years) | Weight (Kg) | Age of pump (years) | Type of pump |
|---|---|---|---|---|---|---|
| Bo-Te-Tr-01 | Chandramani Padhan | Assurmunda | 38 | 48.2 | 3 | 3.5" STP |
| Bo-Te-Tr-02 | Jaduraj Bag | Chareimara | 32 | 53.8 | 2 | 3.5" STP |
| Bo-Te-Tr-03 | Kabichatria | Telanapalli | 30 | 53.9 | 3 | 3.5" STP |
| Bo-Te-Tr-04 | Kusha Chandra Padhan | Assurmunda | 19 | 48.6 | 3 | 3.5" STP |
| Bo-Te-Tr-05 | Shankar Bagh | Chareimara | 32 | 40.3 | 1 | 3.5" STP |

| Code | Name of the operator | Village | Age of the operator (years) | Weight (Kg) | Age of pump (years) | Type of pump |
|---|---|---|---|---|---|---|
| Bo-Te-Tr-06 | Tripurari Bagh | Chareimara | 40 | 49.4 | 1 | 3.5" STP |
| Co-Te-Tr-01 | Ramanath Burman | Mekhli Ganj | 26 | 48 | 3 | 3.5" BTP |
| Co-Te-Tr-02 | Nikhil Raj | Chilki Dat | 40 | 56.3 | 8 | 3.5" BTP |
| Co-Te-Tr-03 | Atowar Hussain | Sisab Gudi | 27 | 53.8 | 2.8 | 3.5" BTP |
| Co-Te-Tr-04 | Bishnupadaroi | Mekhli Ganj | 38 | 50.1 | 8 | 3.5" BTP |
| Co-Te-Tr-05 | Ponwar Burman | Mekhli Ganj | 40 | 51.3 | 10 | 3.5" BTP |
| Go-Te-Tp-01 | Param Hans | Mahani | 25 | 45.5 | 4 | 3.5" BTP |
| Go-Te-Tp-02 | Bachan | Mahani | 46 | 51 | 3 | 3.5" BTP |
| Go-Te-Tp-03 | Rang Lal | Mahani | 65 | 68.5 | 10 | 3.5" BTP |
| Go-Te-Tp-04 | Ajay Bahadur Singh | Mahani | 25 | 54.8 | 4 | 3.5" BTP |
| Go-Te-Tp-05 | Ramesh | Bela | 18 | 55.6 | 7 | 5" MTP |
| Go-Te-Tp-06 | Chinnu | Bela | 27 | 52 | 2 | 5" MTP |
| Go-Te-Tp-07 | Ram Rathan | Bela | 17 | 60.6 | 8 | 5" MTP |

**Figure: 5.4 Schematic diagram of a 3.5" TP**




BTP - Bamboo Treadle Pump
STP - Surface Treadle Pump
MTP - Metallic Treadle pump

### 5.2.3 Treadle pump – Technical details

A TP is a foot-operated double-acting double cylinder piston pump for low-lift irrigation. In its simplest form, it consists of two metallic cylinders with plungers fitted to a pair of treadles. The TP is either made of locally available materials like bamboo or made of fabricated metal steppers.

***Procedure adopted for Treadle Pump technical analysis***

- The operator was asked to initiate operation of the pump.
- In the initial ten minutes, trial readings were taken to assess average discharge rates.

**Table 5.5 Instruments used for the technical analysis (testing)**

| Instrument | Least count | Unit | Purpose |
|---|---|---|---|
| Stop watch | 1 millisecond | seconds | Time duration measurement |
| 12 ltr bucket | 100 ml | ltr | Water discharge measurement |
| 1 foot scale | 1 mm | cm | Measurement of stroke length |
| Digital weighing machine | 1 kg | kg | To record weight of the operator |
| Spring balance | 10 gm | kg | To record weight of empty bucket |

- A container of known volume was kept at the outlet and the time taken was measured using the stopwatch.
- The trials were repeated for at least three values and the discharge rates recorded.
- The operator's age and weight were recorded in addition to basic details of the pump.
- The frequency of the movement of the TP was recorded in strokes per minute.
- The stroke length, that is the length of the plunger from the washer to the level at which it is completely immersed in water in each stroke was recorded.

*Precautions taken during testing*

- The pump was checked so that it is in proper condition
- The operator's health and age were taken into account before the testing
- Care was taken to bring to a minimum the spillage of water behind the cylinder, due to the reverse stroke of the plunger
- The operator was asked to operate the pump in a normal, steady way.

| **Sample Calculation** | |
|---|---|
| Name of the operator | Param Hans |
| Age | 25 |
| Weight of the operator | 45.5 |
| Location | Mahani, Uska, Siddarth Nagar, UP |
| Pump details | 3.5" BTP |
| Age of the pump | 4 years |
| Total head | 3.04 m |
| Flow of water | 57.61 l/m |
| Stroke length | 0.22 m |
| Strokes/min | 81 |

Efficiency Calculation [Energy Efficiency]

E Input = Mass of the operator * Acceleration due to gravity * Strokes/min * Stroke length
= 45.5 Kg * 9.8 $m/s^2$ * 81 strokes/min * 0.22 m
= 7223.5 Joules/min

E Output = Discharge of water * Acceleration due to gravity * Total head
= 57.6l/min * 9.89 m/sec * 3.04 metre
= 1732 Joules/min

= E Output/E Input * 100 = 23.7%

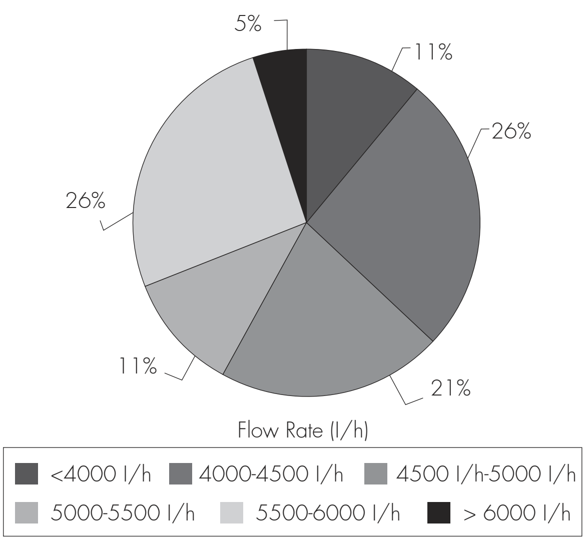
### 5.2.4 Results of the technical analysis

The technical analysis provided the results as detailed in Table 5.5. The efficiency values indicate the TP's ability to convert input energy to output energy. The efficiencies ranged from as low as 15% to as high as 84% efficiency. The variation is due to many factors, primarily due to the weight of the operator and the water recharge level in the region. The discharge of water from the pumps tested ranged from about 3600 l/h to 9120 l/h.

**Table 5.6 TPs tested in the three regions profiled**

| Name | Weight | Type of pump | Total head ( m) | Water discharge (l/m) | Strokes /minute | Efficiency (%) |
|---|---|---|---|---|---|---|
| Chandramani Padhan | 48.2 | 3.5" STP | 4.0 | 73.9 | 72.0 | 77.5 |
| Jaduraj Bag | 53.8 | 3.5" STP | 4.8 | 66.7 | 72.0 | 61.6 |
| Kabichatria | 53.9 | 3.5" STP | 5.6 | 60.2 | 93.0 | 50.2 |
| Kusha Chandra Padhan | 48.6 | 3.5" STP | 2.7 | 74.1 | 90.0 | 35.6 |
| Shankar Bagh | 40.3 | 3.5" STP | 3.2 | 82.7 | 97.0 | 57.0 |
| Tripurari Bagh | 49.4 | 3.5" STP | 4.5 | 91.7 | 112.0 | 52.9 |
| Param Hans | 45.5 | 3.5" BTP | 3.0 | 59.6 | 82.0 | 23.0 |
| Bachan | 51.0 | 3.5" BTP | 3.0 | 67.3 | 78.3 | 28.5 |
| Rang Lal | 68.5 | 3.5" BTP | 3.1 | 78.2 | 103.0 | 15.1 |
| Ajay Bahadur Singh | 54.8 | 3.5" BTP | 3.0 | 77.0 | 106.0 | 18.1 |
| Ramesh | 55.6 | 5" MTP | 3.0 | 91.8 | 72.0 | 57.3 |
| Chinnu | 52 | 5" MTP | 3.0 | 92.0 | 92.0 | 58.9 |
| Ram Rathan | 60.6 | 5" BTP | 2.4 | 152.6 | 62.0 | 83.8 |
| Ramanath Burman | 48.0 | 3.5" BTP | 6.1 | 77.0 | 109.0 | 78.0 |
| Nikhil Raj | 56.3 | 3.5" BTP | 6.1 | 87.1 | 100.0 | 62.9 |
| Atowar Hussain | 53.8 | 3.5" BTP | 6.1 | 72.6 | 90.0 | 76.1 |
| Bishnupadaroi | 50.1 | 3.5" BTP | 8.1 | 90.6 | 131.0 | 72.1 |
| Ponwar Burman | 51.3 | 3.5" BTP | 6.1 | 98.9 | 110.0 | 68.7 |

**Figure 5.5 Percentage distribution of TP based on discharge**




### 5.2.5 Analysis of the results

***Discharge rate obtained***

As can be seen in Figure 5.4, a high percentage, i.e. 47% of pumps tested in the region almost had a discharge rate between 4000-5000 l/h, i.e. in the range between 1.11 (l/sec) and 1.38 (l/sec) and 32% of the pumps had a hourly discharge rate in the range of 1.38-1.66 (l/sec) [?]. Hence 79% of the pumps tested in the region had discharge rates in the range of 1.11 l/sec to 1.66 l/sec.

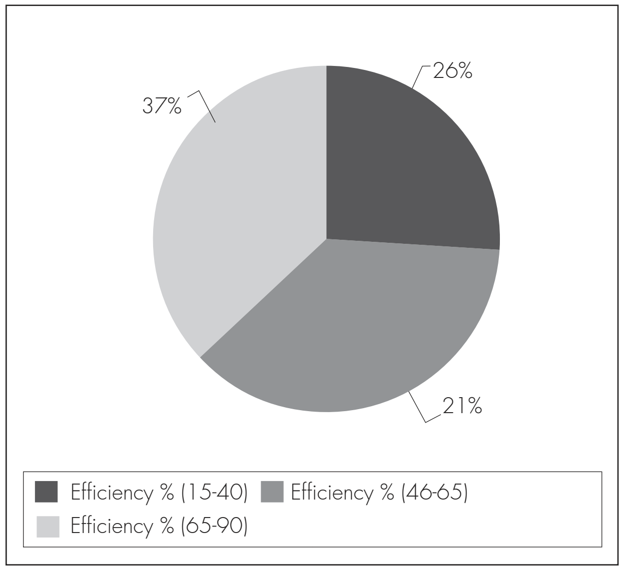
***Efficiency range obtained***

34% of the pumps tested were in the high efficiency range of 65-90%. The efficiency of other manual devices like the *dhekuli* would be in the range of 6 to 10% (refer appendix for graph).

Reasons for higher efficiencies of the TP in comparison to other manual water-lifting devices are.

- A constant flow of water is available as compared to the intermittent flow of the *dhekuli*.
- The other manual devices use an open or dug well as the water source as compared to a closed bore (tubewell) of the TP. The rate of water evaporation is low and hence maintains the water recharge level.
- Since the TP is foot-operated it is less strenuous on the operator.
- The principle of a simple lever with the fulcrum placed in the middle of the load, and effort assists the effective conversion of input power to output power.

**Figure 5.6 Percentage distribution of TP based on efficiency**



Chapter 6

# Assessment of GHG Mitigation Potential

Any technology that reduces dependence on fossil fuels in agriculture would contribute to both national energy security and global GHG mitigation.

In India, agriculture constitutes an important share of the demand for energy. In 2003-04, electricity consumption in agriculture was 87,089 GWh, which was 24.13% of total electricity consumption in the country. The sector accounted for 712,3000 tonnes (19.2%) of high-speed diesel consumed and 44000 tonnes (2.7%) of light diesel oil consumed (TERI 2006). Hence, any technology that reduces dependence on fossil fuels in agriculture would contribute to both national energy security and global GHG mitigation. This chapter estimates potential GHG savings from the adoption of Treadle Pump (TP) technology for irrigation in the study sites. It also addresses issues related to barriers, monitoring, and sustainable development benefits, which are relevant to develop this project under the Clean Development Mechanism (CDM).

## 6.1 Potential GHG Savings

### 6.1.1 Baseline

Indian agriculture is predominantly rain-fed, with net irrigated area comprising only 39% of the net sown area in 2000-01 (MoA 2004). As presented in Chapter 3, however, the IDEI TP project has been implemented in sites with high share of irrigated cultivation. Irrigation is feasible in these sites due to the high water tables in the Gangetic plain, ranging from 10 feet in Gorakhpur to 35 feet in Cooch Behar. The most common method of irrigation used prior to TP adoption was hiring of Diesel Pumps (DPs) (Table 6.1). Manual devices such as *tenda* and *dhekuli* were also used to some extent.

**Table 6.1 Irrigation pattern of study sites before TP adoption**

| District | % of farmers irrigating previously | Device used by majority of farmers irrigating previously |
|---|---|---|
| Gorakhpur (UP) | 100 | DP hire (96%) |
| Balangir (Orissa) | 94 | DP hire with tenda (70%) |
| Cooch Behar (WB) | 76 | DP hire (74%) |

Source: Household surveys

### 6.1.2 Methodology

The GHG saving estimate is based on the standardised baseline methodology AMS-1B (Mechanical energy for the user) suggested by the United Nations Framework Convention on Climate Change (UNFCCC). This methodology applies to renewable energy generation units that directly supply individual users with a small amount of mechanical energy, all of which is used on site. Although this methodology was developed for technologies like hydro, solar, or wind energy, we feel that the same principles are applicable in the case of manual energy. The TP converts manual energy into mechanical energy for pumping water using a simple lever without using of fossil fuels. Energy is generated and utilised on site without any transmission of power.

According to methodology AMS-1.B, the baseline is the estimated emissions due to serving the same load with diesel. The diesel emissions displaced annually can be calculated as the diesel consumption per hour times hours of operation per year times the emission coefficient for diesel.

The boundary of the project within which emissions created and reduced must be measured is assumed to be the physical, geographical site of the equipment that produces and uses the mechanical energy, i.e. the TP.

*The boundary of the project within which emissions created and reduced must be measured, is assumed to be the physical, geographical site of the equipment that produces and uses the mechanical energy, i.e. the TP.*

### 6.1.3 Diesel saving estimate

Technical trials were conducted at the three study sites to estimate the diesel saved by using one TP. The performance of 16 DP sets, two kerosene sets and 18 TPs was studied.

In estimating the diesel saving, it is assumed that:

- the user currently employs only TPs for irrigation; and
- the same quantity of water (same irrigation activity level) currently pumped by the farmer with a treadle device would otherwise have been pumped with a DP set.

The steps involved in the estimate are as follows:

- Three trials were conducted to measure the volumetric discharge rate of water from each of the DPs tested.
- The diesel consumption was monitored as described in Chapter 5.
- The TPs were tested and the rate of water discharge measured.
- Using the rate of water discharge values of both the TP and the DP, the quantity of diesel replaced by the hourly operation of the TP was calculated.
- The diesel replaced per hour was multiplied by the annual TP usage factor (in hours/year) to obtain the quantity of diesel replaced by the operation of one TP annually.
- The default $CO_2$ emission factor for diesel (as per IPCC guidelines) was used to estimate the annual reduction in carbon dioxide per TP.

A sample calculation is provided in Box 6.1 and the results are presented in Table 6.2.

**Box 6.1 Sample calculation of diesel saving**

Name of the owner: Abdul Rehman
District: Cooch Behar
Make of the pump: Bharat Diesel Engine
Horse power of the pump: 5 BHP
Average water discharge from the pump: 28844 l/h
Diesel consumption: 933 ml/hour (D)
1 hour of operation of the above pump provided 28844 litres of water (Qa)
Average water discharge of a TP in Cooch Behar: 4993 l/h (Qb)
Formula for diesel savings calculation:
1 hour of TP operation displaces (Qb)/(Qa)*(D) ml of diesel
= (4993/28844)*933 ml of diesel
= 162 ml of diesel

## Table 6.2 Fuel savings potential of each pump tested in the three regions profiled

| Code | Name of owner | Age of the system (years) | Average water output (l/h) | Head (m) | Fuel consumed (ml/h) | Efficiency (%) | Fuel savings (ml/h) | Water output from TP (l/h) in the region |
|---|---|---|---|---|---|---|---|---|
| Balangir region (Diesel) | | | | | | | | |
| Blg-Te-Dp-01 | Shankar | 5 | 26232 | 5.05 | 943 | 3.83 | 161 | 4491 |
| Blg-Te-Dp-02 | Sanathan Padhan | 3 | 28957 | 4 | 1020 | 3.1 | 158 | |
| Blg-Te-Dp-03 | Digambar Majhi | 3 | 22137 | 6 | 1122 | 3.23 | 228 | |
| Balangir region (Kerosene) | | | | | | | | |
| Blg-Te-Kp-04 | Lajendra Biswal | 1.5 | 21426 | 5.3 | 975 | 3.15 | 204 | |
| Blg-Te-Kp-05 | Shatrugan Shatriya | 1.5 | 18181 | 3.58 | 1005 | 1.75 | 248 | |
| Cooch Behar region | | | | | | | | |
| Co-Te-Dp-01 | Mohan Burman | 6 | 27662 | 6.71 | 962 | 5.26 | 174 | 4993 |
| Co-Te-Dp-02 | Shri Krishna | 2.5 | 24426 | 6.1 | 860 | 4.73 | 176 | |
| Co-Te-Dp-03 | Padmanath Burman | 4 | 28782 | 7.31 | 600 | 9.57 | 104 | |
| Co-Te-Dp-04 | Rosho Roy Biswas | 0.16 | 30191 | 6.1 | 552 | 9.1 | 92 | |
| Co-Te-Dp-05 | Bharath Chandra Roy | 10 | 34559 | 7.62 | 875 | 8.21 | 126 | |
| Co-Te-Dp-06 | Shapan Biswas | 5 | 36873 | 7.01 | 825 | 8.55 | 112 | |
| Co-Te-Dp-07 | Abdul Rehman | 10 | 28844 | 2 | 933 | 1.64 | 162 | |
| Co-Te-Dp-08 | Tyabul Rehman K | 5 | 29218 | 6.09 | 875 | 6.44 | 150 | |
| Gorakhpur region | | | | | | | | |
| Go-Te-Di-01 | Suraj Narayan | 6 | 4623 | 3.1 | 845 | 0.44 | 775 | 4246 |
| Go-Te-Di-02 | Kanaiah | 10 | 11609 | 3.04 | 957 | 0.96 | 350 | |
| Go-Te-Di-03 | Mantri | 8 | 8869 | 3.65 | 574 | 1.47 | 275 | |
| Go-Te-Di-04 | Harish Chand | 6 | 7320 | 3.45 | 1750 | 0.38 | 1015 | |
| Go-Te-Di-05 | Ram Narayan | 8 | 23640 | 3.45 | 866 | 2.45 | 155 | |
| Grand Average | | | | | | | | 260 |

The efficiency of the DPs ranged from 0.38-9.56%. The diesel savings from using TP in place of DP ranged from 92 ml in Cooch Behar to about 1015 ml in Gorakhpur. The efficiency values given above are total system efficiency values comprising primarily two components, the diesel engine efficiency, and the centrifugal pump efficiency. The reasons noticed for the variations in the pump efficiencies and possible reasons for the extremely low efficiency of certain pumps are detailed in Chapter 5. Similar studies conducted on DP set in field conditions indicate a range of 4 to 11% (ref Table 6.3).

Figure 6.1 indicates the relationship between the efficiencies of the DP tested and the diesel savings achievable by replacing that pump in that region by a TP. It can be seen that relatively high diesel savings (and hence GHG savings) can be achieved by displacing very low efficiency pumps.

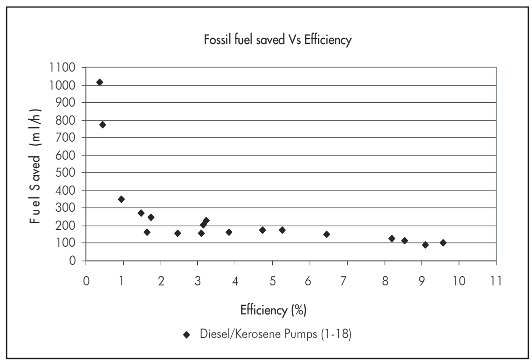
In line with field observations and secondary data provided in Table 6.3, it was decided not to consider pump sets below 1% efficiency in the diesel savings calculation. This would ensure that credit is not taken for substituting highly inefficient DP sets and the carbon-saving calculation is conservative. The pumps tested in Gorakhpur were extremely inefficient, with the maximum efficiency of only 2.45%, with three out of five pumps having an efficiency less than 1%. The pumps included in the diesel saving calculation are listed in Table 6.4.

### Table 6.3 Data on DP set efficiencies in field conditions

| Components of pumping system | Maximum achievable in field conditions | Usually observed on field |
|---|---|---|
| Thermal efficiencies of diesel engines | 32% | 25-30% |
| Power transmission efficiencies | 100% | 90-95% |
| Pump efficiency | 70% | 35-50% |
| System efficiency | 20.16% | 4.72-11.40% |

Source: *Saving of diesel and electricity through rectification of agricultural pumping systems.* Dr S M Patel.

### Figure 6.1 Graph showing the relationship of diesel savings with efficiency




### Table 6.4 Pumps selected for the diesel savings calculations

| Pump no. (Graph) | Name of the owner | Pump location | Efficiency (%) | Fossil fuel avoided (ml/h) |
|---|---|---|---|---|
| Go-Te-Di-03 | Mantri | Gorakhpur | 1.47 | 275 |
| Go-Te-Di-05 | Ram Narayan | Gorakhpur | 2.45 | 155 |
| Blg-Te-Dp-01 | Shankar | Balangir | 3.83 | 161 |
| Blg-Te-Dp-02 | Sanathan Padhan | Balangir | 3.10 | 158 |
| Blg-Te-Dp-03 | Digambar Majhi | Balangir | 3.23 | 228 |
| Blg-Te-Kp-04 | Lajendra Biswal | Balangir | 3.15 | 204 |
| Blg-Te-Kp-05 | Shatrugan Shatriya | Balangir | 1.75 | 248 |
| Co-Te-Dp-01 | Mohan Burman | Cooch Behar | 5.26 | 174 |
| Co-Te-Dp-02 | Shri Krishna | Cooch Behar | 4.73 | 176 |
| Co-Te-Dp-03 | Padmanath Burman | Cooch Behar | 9.57 | 104 |
| Co-Te-Dp-04 | Rosho Roy Biswas | Cooch Behar | 9.10 | 92 |
| Co-Te-Dp-05 | Bharath Chandra Roy | Cooch Behar | 8.21 | 126 |
| Co-Te-Dp-06 | Shapan Biswas | Cooch Behar | 8.55 | 112 |
| Co-Te-Dp-07 | Abdul Rehman | Cooch Behar | 1.64 | 162 |
| Co-Te-Dp-08 | Tyabul Rehman K | Cooch Behar | 6.44 | 150 |
| Average diesel savings | | | | 169 |

Hence the quantity of diesel saved due to the operation of the TP on an hourly basis specifically in to the regions of Balangir, Cooch Behar and Gorakhpur is 169 ml.

### 6.1.4 Treadle Pump use

Table 6.5 provides the pattern of TP-use based on farmer interviews in the three study sites.

**Table 6.5 TP usage pattern**

| Season | Average hrs/day | Average days/season | Average hrs of operation/year |
|---|---|---|---|
| **Balangir** | | | |
| Season | Average hrs/day | Average days/season | Average Hrs of operation/year |
| Kharif (rains) | 3 | 26 | 78 |
| Rabi (winter) | 5 | 66 | 330 |
| Zaid (summer) | 4 | 89 | 356 |
| | | Total | **764** |
| **Cooch Behar** | | | |
| Kharif (rains) | 4 | 26 | 104 |
| Rabi (winter) | 6 | 78 | 468 |
| Zaid (summer) | 6 | 58 | 348 |
| | | Total | **920** |
| **Gorakhpur** | | | |
| Kharif (rains) | 4 | 28 | 112 |
| Rabi (winter) | 6 | 71 | 426 |
| Zaid (summer) | 8 | 110 | 880 |
| | | Total | **1418** |

**Table 6.6 Calculation of emission savings**

| Parameter | Factor | Value | Unit |
|---|---|---|---|
| Quantity of diesel replaced due to operation of a TP in the three sites (Average) | (a) | 169 | ml/hr |
| Number of hours of operation of a TP operation per year | (b) | 1034 | hr/year |
| Quantity of diesel saved by a TP | (C)=(a)* (b) | 175 | l/year |
| Density of diesel | 0.85 | | kg/ltr |
| IPCC default emission factor for diesel | 3.2 | | kg $CO_2$/ kg diesel |
| Diesel saved by a TP per year | D=(C)* 0.85 | 149 | Kg |
| Emissions saved by a TP per year | E=(D)* 3.2 | 477 | kg $CO_2$ |

The weighted average number of hours of TP usage was found to be approximately 1034 per annum. It should be noted, however, that while TP usage is highest in Gorakhpur, very low efficiency DP sets were from this region.

### 6.1.5 Emission saving estimate

The estimated reduction of carbon dioxide due to adoption of TP in the three study sites is presented in Table 6.6.

Hence, it is estimated that the operation of one TP annually reduces **477 kg** $CO_2$.

Table 6.7 uses this figure to estimate the annual emission savings for TPs installed in the three regions over the last five years. The last column incorporates an element of conservativeness, by not including in the calculations, certain TPs which were sold to farmers in Balangir and Cooch Behar who may not have been previously using DP for irrigation (Table 6.1) but rather relied on manual irrigation devices. The factor of 20% is reduced from the sales of TP in the region of Cooch Behar and Balangir to account for these TP users.

However, (as elaborated in the chapter on market shift analysis) the TP technology has in a way helped move this section of farmers from a manual device to the TP, preventing these farmers from otherwise using a DP, hence saving potential emissions. This scenario is indicated in column 6 of Table 6.7.

## 6.2 CDM-relevant Issues

In order to develop a GHG mitigation project under the CDM, it is important that the project contributes to sustainable development in the host country, that it be additional to the business scenario, and that a transparent plan be developed for monitoring the emission savings from the project.

### Table 6.7 Calculation of emission reductions

| 1 | 2 | | | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Years | Sales of TP in years from (2002-2007) | | | Number of TPs in 3 regions | Number of TPs abating $CO_2$ emissions (cumulative) | Kilograms of $CO_2$ abated annually (EF @ 477 kg $Co_2$/ pump/annum) | Tonnes of $Co_2$ reduced (annually) | Tonnes of $Co_2$ reduced annually (conservative) |
| | Gorakhpur | Balangir | Cooch Behar | | | | | |
| 2002-2003 | 931 | 186 | 1208 | 2325 | 2325 | 1109025 | 1109 | 976 |
| 2003-2004 | 908 | 215 | 1292 | 2415 | 4740 | 2260980 | 2261 | 1984 |
| 2004-2005 | 858 | 315 | 1260 | 2433 | 7173 | 3421521 | 3422 | 2995 |
| 2005-2006 | 1181 | 355 | 1272 | 2808 | 9981 | 4760937 | 4761 | 4179 |
| 2006-2007 (till Jan) | 880 | 279 | 1594 | 2753 | 12734 | 6074118 | 6074 | 5313 |

### 6.2.1 Sustainable development

Household survey data and focuss group discussions (FGDs) in the study sites revealed the contribution of the project to economic, social, environmental, and technological well-being, both at the micro and macro levels.

### Table 6.8 Impact of TP adoption

| Site | % increase in gross irrigated area | % increase in average annual household income |
|---|---|---|
| Balangir | 50 | 167 |
| Cooch Behar | 53* | 330 |
| Gorakhpur | 18 | 232 |

*gross cropped area

***Economic well-being***

The TP technology provides farmers with reliable access to irrigation. This enables them to increase the area under irrigation and grow high-yielding crops like vegetables, which translates into an increase in income (Table 6.8). The quality of vegetables is also found to be better under TP irrigation, and hence commands a better price.

In addition to directly benefiting farmers, the project also creates employment for dealers, manufacturers, and other business associates involved in the marketing chain.

*Household survey data and focus group discussions (FGDs) in the study sites revealed the contribution of the project to economic, social, environmental, and technological well-being, both at the micro and macro levels.*

***Social well-being***

The TP technology directly affects the lives of farmers by improving equity in irrigation access. Moreover, the increase in income after adoption of TP has enabled farming households to improve their physical and human capital by purchasing land, livestock, TVs, and other assets, and by educating their children (Balangir survey).

***Environmental well-being***

By using manual energy for irrigation, the operation of TPs does not create any pollution. Further, it reduces excessive water extraction and top soil erosion due to inappropriate use of DPs (Cooch Behar survey).

***Technological well-being***

The TP technology is simple and appropriate for the farmer. The marketing methodology adopted by IDEI ensures that the farmer sees value for himself in the product and purchases the product of his own capacity and is not dependent on any government support or subsidy. This ensures usage and sustainability of the technology.

Thus, the TP project clearly contributes to poverty reduction, energy security, and sustainable development.

There is need for irrigation due to a possible increase in income of the farmer. In areas profiled in the study region the possibility of irrigation is more due to high water table. With the introduction of technology like the TP, the otherwise suppressed demand for irrigation has been fulfilled. For farmers previously irrigating with manual devices, TP is a more convenient option. For the farmers irrigating by hiring DP, the TP reduces the cost of irrigation, which enables him to grow water-intensive crops like vegetables, leading to an increase in income.

### 6.2.2 Barriers

While TP technology first originated in Bangladesh in the late 1980s, its penetration in India is quite low. Though there are government subsidies on electricity for pump sets, diesel, and renewable energy-based irrigation devices, there are no such benefits for TP technology. There are other barriers related to the nature of the technology and the preferences of farmers. To understand the barriers faced by the project, and understand the prevailing practice, a combination of tools was used, including FGDs with TP users in the three study sites: interviews with non-users, DP set renters, and TP dealers; and visit to sites in Cooch Behar and the neighbouring Jalpaiguri district where there has been no penetration of TPs.

#### *High upfront cost*

TPs are sold on purely commercial terms, without any subsidy or credit scheme. The total cost of installing a TP ranges from Rs. 800-1550, which represents a significant upfront cost for households with relatively low incomes. Other expenses such as food, clothing, shelter, and medical care take priority. Small and marginal farmers find it particularly difficult to raise the cost of purchasing a TP outright and instead resort to hiring DPs for irrigation.

#### *High labour requirement*

The TP technology is a manual labour-based irrigation technology requiring the user to spend much more time and effort on the field than DP-based irrigation. Either family members have to put in the necessary hours, or labour has to be hired at market rates. With increasing labour rates and farmers opting for secondary occupations, any device requiring the farmer to spare time and effort which wasn't in his daily schedule before would not be readily accepted.

**Table 6.9 Comparison of TP installation cost with household income**

| Site | Average monthly household income before adoption of TP (Rs) | Average total installation cost of TP (Rs) |
|---|---|---|
| Balangir | 1166 | 1550 |
| Cooch Behar | 833 | 900 |
| Gorakhpur | 879 | 800-1500 |

Source: Household surveys

#### *Preference for mechanisation*

Use of DPs has been the prevailing practice in the region for close to 80 years now. Over time, farmers have established a hiring system, with cost-reduction mechanisms like formation of farmer groups and combined sharing. Manual devices like the *dhekuli* and *tenda* provide inadequate irrigation levels, are highly inconvenient, less efficient (6%) and dangerous to operate (Srinivas and Jalajakshi 2004). In fact, farmers have a strong preference for mechanisation, and resist the idea of shifting to manual irrigation. In villages where IDEI had not intervened, 85% of farmers confirmed this barrier and considered the manual operation of pumps highly inconvenient.

***Dependence on awareness raising activities***

The marketing strategy adopted by IDEI treats farmers as rural consumers and not beneficiaries. Instead of depending on subsidies, farmers rely on their own finances to purchase TPs, hence ensuring the continued use of the device, and the sustainability of the initiative. The flip side, however, is that the sale of TPs is almost completely dependent on the awareness raising activities of IDEI. IDEI is forced to engage in massive promotional activities, conduct road shows, and employ staff to build and maintain the relationship with the rural consumer. Dealers of TPs emphasised that sales would be affected by any dip in these activities. In addition, since the margins maintained through the product chain from manufacturer to the dealer are low, there is no option for any intermediary to spend on advertising, a vital requirement for value-based marketing. Many non-users despite knowing about TPs had not yet taken the final step towards purchase, indicating the importance of constant support and reminders from IDEI field staff.

### 6.2.3 Monitoring

According to methodology AMS-I.B, the project proponent should: (i) record the number of systems operating annually; and (ii) estimate the annual hours of operation (using sampling methods).

*According to methodology AMS-I.B, the project proponent should : (i) record the number of systems operating annually; and (ii) estimate the annual hours of operation (using sampling methods).*

For monitoring the first parameter, it is suggested that IDEI's sales records in the three regions profiled be recorded. The number of TPs sold (annual data for the years for which emission reduction units are being claimed) multiplied by the emission factor derived earlier would provide the annual emission reductions. This record can be verified in accordance with the revenue of the project proponent made available through the annual report or similar published document. This record can be further confirmed by the records of individual dealers in the blocks profiled.

The second parameter to be monitored is the number of hours of TP usage. It was observed that the cropping pattern of the farmers in the region profiled is not on a year-on-year basis. In addition, the cropping pattern varied from user to user and from region to region. Hence a monitoring plan based on the pattern would not be exact and subject to variation. Instead it is recommended that monitoring of number of hours of TP usage be done by actual measurement using appropriate methods and ideally with instrumentation.

Instrumentation can be in the form of a traffic counter (light-based sensor, monitoring movement) that can count the strokes of operation of the TP by the user recording the oscillations on daily basis for a specified time period (for example, one month of every season). This device could be installed on select TPs comprising 1% of the user population.

A more appropriate and a less expensive method for monitoring such field-based activity would be by physically keeping a record of hours of operation per week (one month every season) of select farmers (1% of users in a region). This record can be maintained by an individual appointed by the project proponent who has daily interactions with the farmers of the region. It is also recommended that the use of other irrigation devices such as DPs and electric pumps can be done by the individual to check any leakage. The important parameter to be monitored for such devices would be the average number of hours of operation (annual) of DPs in a selected sample size (1% of DP users in the region). This monitored value multiplied with the average diesel consumed per hr (0.918ml/hr; Ref-Chapter 5) would help in determining the actual diesel consumption level and further estimate the actual litres of diesel replaced by the TP in the region. This monitoring activity can be done for select villages in select blocks which have a high DP penetration currently.

# Conclusion

The study was conducted to evaluate the socio-economic condition of Treadle Pump (TP) adopters and to quantify potential energy savings through technical evaluation of TP vis-a-vis Diesel Pump (DP) and to estimate the $CO_2$ based on the above. The study was conducted in the regions of Balangir (Orissa), Cooch Behar (West Bengal) and Gorakhpur (Uttar Pradesh).

*The study was conducted to evaluate the socio-economic condition of Treadle Pump (TP) adopters and to quantify potential energy savings through technical evaluation of TP vis-a-vis Diesel Pump (DP) and to estimate the $CO_2$ based on the above.*

The approach involved a primary survey, Focus Group Discussions (FGDs) for socio-economic assessment, technical measurements backed with survey feedback for technical evaluation, and estimating the $CO_2$ reduction potential using feedback from various stakeholders and measurement results.

Primary survey was conducted through structured questionnaires covering 147 household in 21 villages. Non-users of TP, DP renters, TP manufacturers were also interviewed. The FGDs were held with users and non-users of TP to understand the cropping pattern change, and trend in DP hiring after TP intervention.

Technical measurements were made for parameters such as water discharge, input and output energy, efficiency of the device for DP and TP. The technical assessment was conducted for 18 DPs and 16 TPs.

The family size in the surveyed households in the three regions varied from six to eight members. Majority of the households belonged to the marginal and small farmer's category with landholdings of less than five acres. Only a few households (HHs) in Balangir (14%) belonged to the semi-medium category of farmers.

In Balangir, the TPs were installed since 2000-04 and in the regions of Cooch Behar and Gorakhpur they were installed since 1996. Thus the age of the pumps ranged from 1 to 11 years. All the pumps were functional in the surveyed HHs. The type of TP found was the 3.5" bamboo TP (BTP) and 5" metallic pumps. Most of the farmers were irrigating their field using DP before the adoption of TP. A few farmers were irrigating using traditional methods such as *dhekhuli, tenda* and swing basket. The operation of these devices was found to be strenuous and the water discharge was about 2,000 to 2,500 litres per hour less compared to TP which is about 4,500 litres per hour.

IDEI plays a major role in promotional activities categorised as dynamic and static promotion. The dynamic promotional activities are village demonstration, haat demonstration, short campaigns, farmers meetings, TP films etc. The static activities are through leaflets, banners, wall paintings and dealer boards. The quality control, promotional activities and monitoring is conducted by IDEI. The after-sales service is provided by the business associates of IDEI through a network of dealers and mechanics.

The average hours of operation of TP were 1,034 per year in the surveyed HHs. There was an increase in the gross area under vegetables after the adoption of TP. The quality of vegetables grown with TP irrigation was found to be better; for example, in Cooch Behar the farmers said that the cabbages grown with TP were bigger in size. However, these aspects need to be strengthened with scientific study.

The income of the HHs had increased due to TP adoption. This enabled them to improve their physical capital such as purchase of land, livestock, repair of house, purchase of TV etc. On an average annual income per HH after adoption of TP was Rs. 34,500; previously it was Rs. 10,000.

*All the factors indicate that TP has fulfilled the suppressed demand for irrigation among the poor farmers and has helped the small and marginal farmers to increase their gross irrigated area and also grow more vegetables.*

During FGD it was found that most of the farmers were hiring DP prior to TP adoption. The scenarios observed with TP intervention are:

a) farmers cultivating under rain- fed conditions have started irrigating;
b) farmers who were previously using traditional methods have adopted TP; and
c) farmers previously irrigating with DP have  started irrigating using TP.

All the factors mentioned above indicate that TP has fulfilled the suppressed demand for irrigation among the poor farmers and has helped the small and marginal farmers to increase their gross irrigated area and also grow more vegetables. There have been more green vegetables in the market due to TP intervention. The number of farmers hiring DP had reduced by 50-60% in the study region.

The technical assessment indicated that the average efficiency of the TPs was 61%. The 5'' metallic TP, 3.5" surface TP and the 3.5" bamboo TP were tested in the three regions. In comparison to the other manual devices it was found that TPs have much higher efficiency primarily due to an efficient system design. The efficiencies of the DP systems tested in the region ranged from 0.38-9.57%. The reasons for low efficiencies of these systems include inappropriate system selection for the application, geological factors and lack of knowledge on the part of the user in operation and maintenance and choice of pump size.

The carbon dioxide mitigation potential of the project was assessed by calculating the quantity of diesel replaced by the operation of the TP for one hour multiplied by the average number of hours of TP usage per annum. This product is multiplied by the default emission factor of diesel at 3.2 kg per ltr. It was found that one TP replaces 169 ml of diesel per hour, thus annually mitigating about 477 kg of carbon dioxide (for 1034 hours operation).  The TP technology intervention aids in poverty alleviation and provides socio-economic benefits to the farming community.

# Annexure

## Villages Covered under the Study

| Sl. No. | Name of the Village | Name of the Block |
|---|---|---|
| | District - Balangir (Orissa) | |
| 1 | Assurmunda | Agalpur |
| 2 | Chareimara | Balangir |
| 3 | Dudakasira | Balangir |
| 4 | Tellanpalli | Khaprakhol |
| | District - Cooch Behar ( West Bengal) | |
| 5 | Alokjhari | Malhliganj |
| 6 | Bharum payasti | Deenahatae |
| 7 | 141, Changrabnada | Mekhliganj |
| 8 | Dewanbose | Deenahatae |
| 9 | Dhairhat | Cooch Behar-I |
| 10 | Giriyakuhti | Cooch Behar-I |
| 11 | Haladiman | Cooch Behar-I |
| 12 | 125 Kharikia | Mekhliganj |
| 13 | Mainagudi kankangudi | Cooch Behar-I |
| 14 | Panishala | Cooch Behar-I |
| 15 | 134 Panishala | Methi |
| 16 | Sishabgori | Cooch Behar-I |
| 17 | Silkudiwas | Cooch Behar-I |
| | District - Gorakhpur (Uttar Pradesh) | |
| 18 | Mahani | Uska |
| 19 | Singhpur | Motichak |
| 20 | Tharuadiah | Hata |
| 21 | Bela | Bridge man ganj |

## Map of Study Location

# Questionnaire for Feedback from Farmer on the Device

Project: "Techno-economic-socio-environmental assessment of IDE products
(water lifting and water saving products)"

The Energy and Resources Institute
No 7117, 4th Main, 2nd Cross
Domlur 2nd Stage, Bangalore – 560 071

A. (General Information)

1. Name of the Person :______________________________________________
2. Details of Location

| Village | Taluk/Block | District | State |
|---|---|---|---|
| | | | |

3. Family Size:

| | |
|---|---|
| Men | |
| Women | |
| Children | |

4. Primary Occupation:
   Agriculture ☐
   Non-agriculture ☐
   If Non-agriculture, Specify? ___________________________
5. Secondary Occupation:
   Agriculture ☐
   Non-agriculture ☐
   If Non-agriculture, Specify? ______________________________

B. (Details of Land)

| | |
|---|---|
| Total land owned (acres) | |
| Total irrigated land (acres) | |
| Un-irrigated land (acres) | |
| Fallow land (acres) | |

C. (Type of Water Lifting Device)

1. Type of device used for irrigation (present):___________________
2. Previously, was the land under irrigation: Yes ☐
   No ☐
3. If yes, type of device used for irrigation (previous):___________________
4. Model of TP _________________
   4.1 Barrel size of the pump _____________
   4.2 Reason for buying this model of TP :______________________________

5. Installed date: ______________________________
   Years of use of TP : ______________________________
6. Installed by: NGO ☐ Dealer ☐ Manufacturer ☐
7. Cost of the pump (Rs.) ________________ subsidies if any (Rs.) ___________
8. Information regarding loan availed (Rs.): __________Name of Bank__________
9. Area under irrigation/using pump (Acres): ___________________________
10. Is TP used for any other purpose, if yes, mention: __________________

**D. (Details of Operation of Water Lifting Device)**

1. Operating system: Only self-operated ☐ Family operated ☐ Labour ☐
   Cost of labour (if hired)(Rs/day): __________
2. Number of hrs of operation per day
   (A) Rainy — (B) Winter — (C) Summer —
3. Days of operation per week
   (A) Rainy — (B) Winter — (C) Summer —
4. Weeks of operation in a season
   (A) Rainy — (B) Winter — (C) Summer —

**E. (Maintenance and Sustainability)**

1. Failure of the equipment (mention the type of failure): ______________________
2. Duration of failure (days/month/year) _______________________
3. During failure what will you do (whether attend yourself or go to a supplier):_______
   ____________________________________________________________
4. Total cost of repair (per year): ______________________________________
5. Problems faced in operating the pump: ________________________________
6. For purchasing new device, what is the process: __________________________
7. How he feels about new equipment? __________________________________

**F. (Details of Cropping Pattern)**

1. Name of crops grown

| Sl. No. | Present | | Previous | |
|---|---|---|---|---|
| | Crop | Acres | Crop | Acres |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

**G. (Socio-economic)**

1. Total income/year/acre: From TP irrigated area__________
2. Impact on the family after using TP (change in cropping pattern, time saving etc):
   ____________________________________________________________
3. Other perceptions ____________________________________________

Market Shift Analysis (Understanding need/reason to shift to Treadle Pump):

## H. TP Owners

1. Would you have used DP, if TP were not available? Yes ☐ No ☐
   1.1. If yes then you would have hired it or bought one: __________
2. Were you irrigating your field prior to purchase of TP? Yes ☐ No ☐
   2.1. If yes, then mention device ____________
      2.1.1. If irrigating by Diesel Pump, mention
         2.1.1.1. No. of hours of operation per day
         (A) Rainy —— (B) Winter —— (C) Summer ——
         2.1.1.2. Number of days per week
         (A) Rainy —— (B) Winter —— (C) Summer ——
         2.1.1.3. Number of weeks in a season
         (A) Rainy —— (B) Winter —— (C) Summer ——
   2.2. If not irrigating by DP, then did you desire to do it? Yes ☐ No ☐
      2.2.1. Was cost of hiring a constraint? Yes ☐ No ☐
3. Will you continue using TP (Y/N)
   3.1. if yes why ________________________________________________
   3.2 if no why ________________________________________________

## I. Interview of Non-users of TP

1. What are you using now to irrigate ______________________________
2. Do you irrigate by Diesel Pump? Yes ☐ No ☐
   If yes:
   2.1. Is the DP : Owned ☐ Hired ☐
   2.2. If hired then, Details of Hiring
      2.2.1. No. of hours per day
      (A) Rainy —— (B) Winter —— (C) Summer ——
      2.2.2. No. of days in week
      (A) Rainy —— (B) Winter —— (C) Summer ——
      2.2.3. No. of weeks per season
      2.2.4. Rate per hour
   (A) Rainy —— (B) Winter —— (C) Summer ——
3. Are you able to give sufficient water to your field by hiring DP? Yes ☐ No ☐
4. If you learn that TP can provide similar irrigation at less cost but more labour, would you consider changing to TP? Yes ☐ No ☐
   If no, what would convince you to change? __________
5. If you are not using TP or DP,
   5.1 What stops you from using DP? (no DP rental service available, cost of rental too high, cost of purchase, difficult to operate, any other reason) ________________
   ________________________________________________________________
   5.2. Is it possible this constraint could disappear this year or next year, and how likely is that? ________________________________________________________________

5.3. If constraint to DP did disappear (ie a rental service became available near you, or you had more money, etc) and you learned about treadle pump and found it could also provide similar irrigation at less cost but with some labour input, would you choose TP and not DP? ____________________________________

5.4. Do you know about Treadle Pump?

5.5. Do you want to buy a TP ?.

5.6. What is limiting you to buy TP …and same follow-up questions as above 3.2 – 3.4 above

5.7. If TP were not available; what stops you to buy DP

6. What advantages and disadvantages of TP and DP do you perceive?

| | Treadle Pump | Diesel Pump |
|---|---|---|
| Advantages | | |
| Disadvantages | | |

J. Diesel Pump Renter Interview (5 numbers/region)

1. Since when you own Diesel Pump ________________
2. Since when are you renting _________________
3. Do you perceive that there has been any change in the rate of renting? (That is, you were getting more customers before and now you are getting less, or the rate at which you are getting more has slowed down)

   a. If yes then

      i. Is it because of change in fuel price

      ii. Change in demand

      iii. If ii, what do you think has caused change in demand?

4. How many people in the village who used to rent diesel pump own Treadle Pump now? ________________________________________________________________
5. To help us calculate, do you have records or a good memory of the details? _______ _____________If so…
6. Details of Renting, at the time when you started this business

   6.1. No. of days per season

   (A) Rainy ——— (B) Winter ——— (C) Summer ———

   6.2. Hours per season

   (A) Rainy ——— (B) Winter ——— (C) Summer ———

   6.3. Number of farmers

   (A) Rainy ——— (B) Winter ——— (C) Summer ———

7. Details of Renting half way through the period of renting, or at time TPs were introduced in your area

   7.1. No. of days

   (A) Rainy ——— (B) Winter ———— (C) Summer ————

   7.2. Hours per season

   (A) Rainy ——— (B) Winter ———— (C) Summer ————

7.3. Number of farmers

(A) Rainy ———— (B) Winter ————— (C) Summer —————

8. Details of Renting at end of the period of renting,

8.1. No. of days

(A) Rainy ——— (B) Winter ——— (C) Summer ———

8.2. Hours per season

(A) Rainy ——— (B) Winter ——— (C) Summer ———

8.3. Number of farmers

(A) Rainy ——— (B) Winter ——— (C) Summer ———

9. Looking at these records, calculate if there has been a change in the rate of renting

a. If yes, then

i. Is it because of change in fuel price

ii. Change in demand

iii. What has caused change in demand?

10. How many people in the village who used to rent Diesel Pump own Treadle Pump now?

______________________________________________________________________

**K. Guidelines for Focus Group Discussion (2 villages/state)**

Two villages (with same amount of farming activity/production of vegetables) will be selected in which one will have high concentration of TP and one will have low concentration of TP. The discussion will be focused towards finding the response to following:

1. How many people in the village were cultivating vegetable
   a. before five years, and
   b. how many are cultivating vegetable now?
2. Has the number increased (Y/N) ____
   a. Any reason for increase ________________________________________
3. Has the area under vegetable cultivation increased or stayed the same?
4. Do all sell in the same market (TP and DP users) (Y/N) ____________________
5. Is there any difference in price for TP users as compared to DP users and any reasons?
6. Which is better and more economical: DP or TP and reasons
7. Has the number of Diesel Pump rentals increased in the village?
8. Has the increase in diesel pump rentals slowed down because people are buying TPs?
9. If there were no TPs would there be less, same or more quantity of vegetables grown?
10. Probing with farmers who are not irrigating, barriers in adoption of irrigation devices. (technical, financial)

(Record the opinions expressed in this focus group with regard to whether or not there would be as many vegetables in the market if no TPs were being used. If so, would some of these be grown with DPs. If so, is it perceived that the number of vegetables grown by TPs ("green vegetables") would be in the market if TP wasn't available, but they would be grown by DPs ("brown vegetables")?).

## Technical Evaluation of Treadle Pump/Diesel Pump/ Electrical Pump

Project: "Techno-economic-socio-environmental assessment of IDEI products (water lifting and water saving products)"

The Energy and Resources Institute
No 7117, 4th Main, 2nd Cross
Domlur 2nd stage, Bangalore – 560 071

A. Treadle Pump

1. Name and location: ____________________
2. Operator's age and weight: ____________________
3. Age of the pump: ____________________
4. Type of the pump: ____________________
5. Type of washer used: ____________________
6. Name of the supplier: ____________________
7. Location of the supplier: ____________________
8. Condition of the pump (mention the problems if any): ____________________
9. Diameter of Cylinder (m): ____________________
10. Stroke length (m): ____________________
11. Discharge from the pump (litres/sec): ____________________
12. Peddling length (m): ____________________
13. Total head (in m considering all the losses): ____________________

Operator

14. Age and health condition of operator (self or hired): ____________________
15. Number of strokes per minute? ____________________
16. Number of hrs of continuous operation: ____________________
17. Total number of hrs of operation per day: ____________________
18. Gaps between two cycles: ____________________
19. Position of supports (to evaluate human attributes): ____________________
20. Observation on operation after each cycle (physical condition): ____________________
21. Problems faced while operating: ____________________

Specimen calculations for Treadle Pump

System efficiency : $\eta_s$

Energy input : $E_i$ J/sec

Energy output : $E_o$ J/min

Density of water: $\rho$ Kg/m$^3$

Total head: $H$ in m

Stroke length: $L_s$ in m

Cylinder diameter: $D_c$ in m

Mass of the operator: $M$ in Kg

Strokes per min: $N_s$

Acceleration due to gravity = **g** in m/sec2

Discharge: **Q** in lts/min

$E_i = M \;\; g \;\; L_s \;\; N_s$

$E_o = Q \;\; g \;\; H$

$\eta_s = [E_o/E_i] \;\; 100$ in %

**List of instruments:**

1. Water measuring bucket ( Measuring the discharge of water)
2. Stopwatch ( Measuring the time)
3. Weighing machine (Round type )

Measuring tape (3 metres)

**B. Diesel Pump:**

1. Make of the Diesel Pump system: ________________________________________
2. Rating of the system (HP): ______________________________________________
3. Age of the system: ____________________________________________________
4. Working condition of the system (mention problems if any):_____________________

**Operation and maintenance:**

5. Number of hours of operation per day: ___________________________________
6. Number of days of operation per year: ___________________________________
7. Diesel consumption per hr: ______________________________________________
8. Diesel cost (Rs/litre):__________________________________________________
9. Cost of the pumping system (Rs): ________________________________________
10. Maintenance costs with details (Rs/year): _________________________________

**Specimen calculations:**

System efficiency : $\eta s$

Energy input : $E_i$ J/min

Energy output : $E_o$ J/min

Density of water : $\rho$ Kg/$m^3$

Total head : **H** in m

Acceleration due to gravity = **g =** 9.81/sec2

Specific gravity for diesel = 0.831

Discharge : **Q** in lts/min

Calorific value of diesel = **K** J/kg

Diesel consumption = **q** kg/min

$Ei = q \;\; 0.831 \;\; K$

$Eo = Q \;\; g \;\; H$

$\eta s = [E_o/E_i] \;\; 100$ in %

**List of instruments:**

1. Measuring jar (2 litres)
2. Water measuring bucket
3. Stopwatch
4. Measuring tape

## Technical Trial – Manual measurement of data for estimation of diesel savings

Energy input calculation

Data Required – Diesel consumed/hour of operation

Method 1: Direct Measurement

a. Initial quantity of diesel in tank(before operation) ________________

b. Final quantity of diesel in tank(after operation) ________________

c. Volume of diesel consumed [a-b](ltrs) __________________________

d. Duration of operation (hrs) _________________________________

e) Diesel consumed( ltr/hr) ____________________________________

Method 2:Indirect Measurement-difference in height method)

a. Initial depth of diesel in tank (before operation) ________________

b. Final depth of diesel in tank (after operation) ________________

c. Difference in height (H) ________________

d. Volume of diesel consumed= H *(L*B) ________________

e) Duration of operation ________________

f) Diesel consumed (ltr/hr) _________________

Energy output calculation

Data Required -Flow rate of water being pumped during operation

Method 1: Direct Measurement (using Ultrasonic Flow meter)

a) Litres of water pumped/hr of water _____________________

Method 2: Manual Measurement

a) Initial time (at the start of operation) ______________________

b) Final time (at the end of operation) ______________________

c) Total time of operation (hr) ______________________

d) Quantity of water collected in the drum (ltr) _____________________

e) Litres of water pumped/hr of operation ___________________

C. Electrical Pump:

1. Make of the Diesel Pump system: ___________________________________________

2. Rating of the system (HP):__________________________________________________

3. Age of the system: _______________________________________________________

4. Working condition of the system, (mention problems if any):______________________

Operation and maintenance:

5. Number of hours of operation per day: ______________________________________

6. Number of days of operation per year: ______________________________________

7. Power consumption kW/hr: _______________________________________________

8. Cost of electricity (Rs/kW): _______________________________________________

9. Cost of the pumping system (Rs): ___________________________________________

10. Maintenance costs with details (Rs/year): ____________________________________

**Specimen calculations:**

System efficiency: $\eta s$

Energy input : $E_i$ J/min

Energy output : $E_o$ J/min

Density of water : $\rho$ Kg/m3

Total head: **H** in m

Acceleration due to gravity = **g** = 9.81/sec2

Discharge : **Q** in lts/hr

Power consumption = **P** Kw-hr

P = V x I = Voltage x Current

$E_i = P$

$E_o = Q \quad g \quad H$

$\eta s = [E_o/E_i] \quad 100$ in %

**List of instruments:**

1. Water measuring bucket
2. Stopwatch
3. Measuring tape
4. Portable power analyser

## Characteristics of a Pumping system

The pump is the major component in the pumping system affecting the efficiency of the system. The hydraulic performance of a centrifugal pump is based on operating characteristics like:

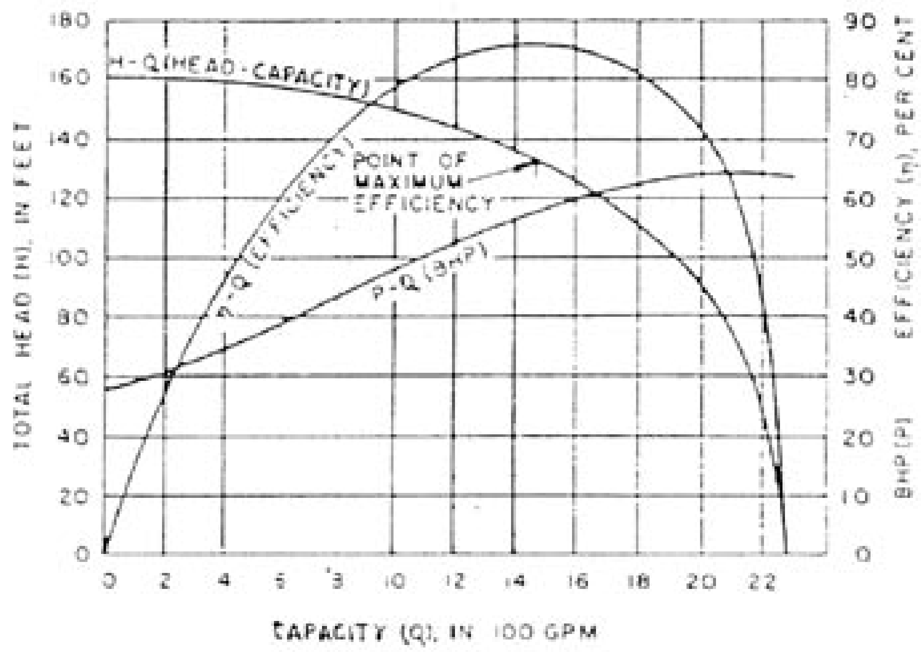
Capacity, Q : expressed in units of volume per unit of time, such as, m /h or litres per sec (lps)

Head, H : expressed in units of height of liquid column, to which the liquid is pumped, such as, ft or m

Power, P : expressed in units of energy, kW or HP

Efficiency, h: expressed as %

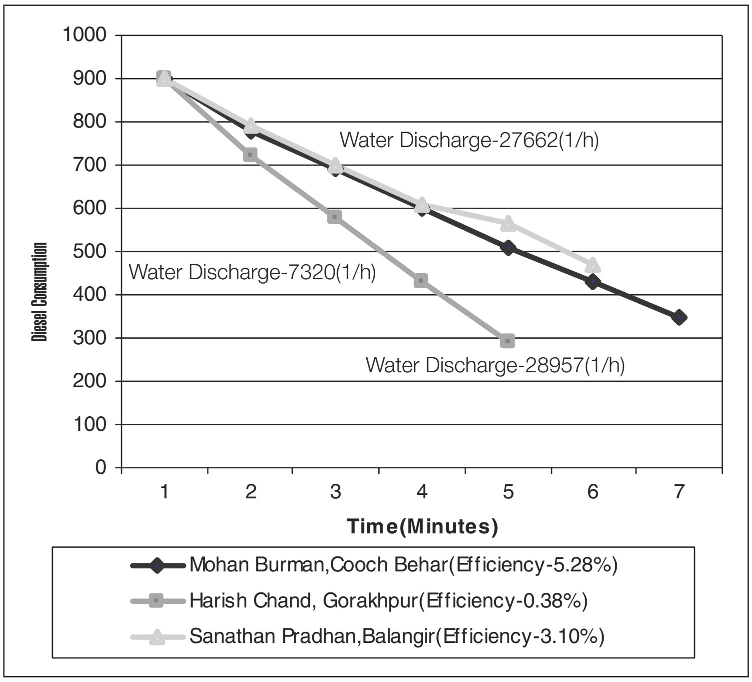
**Figure 5.2 Performance curve of a centrifugal pump**




Source: Practical Energy Audit Manual –Teri- 1999

The characteristic curve of a centrifugal pump is shown in Figure 5.1. The graph gives the relationship of the H-Q (Head-Capacity), P-Q (Power-capacity) and η-Q (Efficiency-Capacity) characteristic of a typical pump. As indicated in the graph at a particular head and flow rate the efficiency of the pump is at its maximum and a decrease in head results in a decrease in efficiency. Also an increase in head beyond the design head results in a proportional decrease in efficiency (refer point of maximum efficiency shown in the graph). Hence the selection of the pump based on the existent head in the region and pump application is critical for the overall efficiency of the system.

## Rate of Diesel Consumption




### Diesel Consumption

The diesel consumption rates of the 16 diesel pumps tested in the region ranged from 1749 ml to 552 ml per hour of operation. The average fuel consumption of the 16 diesel pumps and 2 kerosene pumps is 916 ml. The graph below shows the correlation of diesel consumption vs time for three pumps one each from the three regions profiled. Although a direct relationship of diesel consumption to efficiency may not exist in all cases, it is noticed that pumps with a higher rate of diesel consumption generally have low efficiencies.

# Balangir

Photo-1: Discussion with farmers in Assurmunda village, Balangir district, Orissa

Photo-2: Discussion with farmers in Tellanpalli village, Balangir district, Orissa

Photo-3: Focus Group Discussion with farmers in Assurmunda village, Balangir district, Orissa

Photo-4: Focus Group Discussion with farmers in Chareimara village, Balangir district, Orissa

Photo-5: Technical evaluation of Diesel pump in Tellanpalli village, Balangir district, Orissa

Photo-6: Technical evaluation of treadle pump in Tellanpalli village, Balangir district, Orissa

Photo-7: Technical evaluation of Diesel pump in Tellanpalli village, Balangir district, Orissa

Photo-8: Measuring of Depth of well in Tellanpalli village, Balangir district, Orissa

Photo-9: Discussions with treadle pump dealer in Balangir, Orissa

Photo-10: Sunflower crop grown by using Treadle pump in Chareimara village, Balangir, Orissa

## Cooch Behar

Photo-1: FGD in Cooch Behar I block

Photo-2: FGD in Mathabanga

Photo-3: Ten years old diesel pump in Panishala, Cooch Behar I block

Photo-4: Diesel pump operator in Cooch Behar I block

Photo-5: TERI personal measuring potato crop in Chilkir hat, Kothwali block

Photo-6: Man irrigating potato farm by using treadle pump in Chilkir hat, Kothwali block

Photo-7: Woman operating Treadle pump in Chilkirhat

Photo-8: Tobacco crop irrigated by treadle pump in Mathabanga

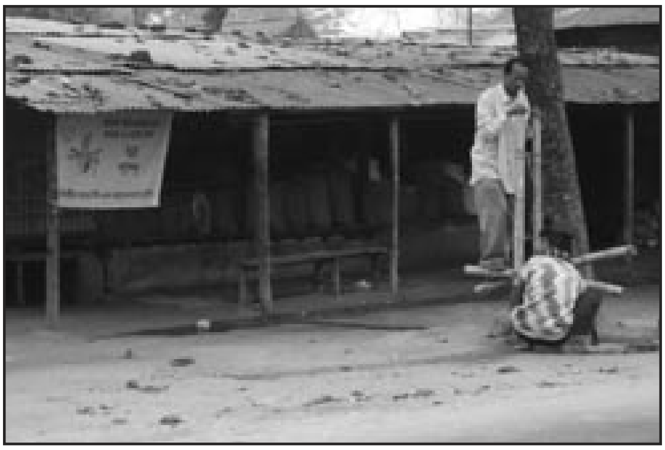


Photo-9: Point of purchase (POP) of treadle pump in Mathabanga block

## Gorakhpur

Photo-1: Discussion with farmers in Mahani village, Gorakhpur, UP

Photo-2: Discussion with farmers in Bela village, Gorakhpur, UP

Photo-3: Focus Group Discussion with farmers in Bela village, Gorakhpur district, UP

Photo-4: Weight measurement of treadle pump operator in Bela village Gorakhpur, UP

Photo-5: Technical evaluation of treadle pump in Bela village, Gorakhpur, UP

Photo-6: Technical evaluation of Diesel pump in Bela village, Gorakhpur, UP

Photo-7: Using of Traditional water lifting devices (Dhekuli) in Bela village, Gorakhpur, UP

Photo-8: Radish grown by using treadle pump in Mahani village, Gorakhpur, UP


Photo-9 Treadle pump dealer shop in Farinda village, Gorakhpur, UP

Photo-10: Cabbage grown by using treadle pump in Bela village, Gorakhpur, UP

# References

Agricultural statistics at a glance, 2004. New Delhi: Agricultural Statistics Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture.

Agriculture [2004]. Centre for Monitoring Indian Economy Pvt Ltd (CMIE)

Energy Efficiency in Pumping Systems. Bureau of Energy Efficiency, 2005

Gert Jan Bom et al (2002) Technology, innovation and promotion in practice: pumps, channels and wells: reducing fuel consumption, emission and costs, PRCTICA, ARCADIS, TERI.

Harald Winkler [2002] 'Baseline for Suppressed Demand: CDM Projects Contribution to Poverty Alleviation', Paper – Energy and Development Research Centre, University of Cape Town, South African Journal Economic and Management Sciences, Vol 5 (2002) No 2

ICM [1988] Saving of Diesel and Electricity through Rectification of Agriculture pumping systems. Institute of Co-operative Management

Practical Energy Audit Manual, Tata Energy Research Institute, 1999

Programme on Conservation of Energy in Agriculture Pumping Systems, Central Institute For Rural Electrification of Rural Electrification Corporation Ltd, 1999

Shah et al [2000] Pedalling out of Poverty; Social impact of a manual irrigation technology in South Asia.International Water Management Institute

Srinivas S N and Jalajakshi C K. [2004]. 'Alternatives to micro-irrigation: evaluation of the Treadle Pump'. Economic and Political Weekly, 18 September 2004. pp. 4271-4275.

Tamil Nadu State Report [1991]. 'Improving efficiency of agriculture pumping systems for energy conservation'. Operations Research Group (ORG).

TERI (1996) 'Alternatives to micro-irrigation in India: a critical assessment of the Treadle Pump option'. TERI.

TERI [1996] 'Alternatives to micro-irrigation in India: a critical assessment of the Treadle Pump option'. The Energy and Resources Institute (TERI).

TERI [2006] Scoping Study for Solar Still Based water Distillation Units in India. The Energy and Resources Institute (TERI)

TERI [2006]. TERI Energy Directory Database and Yearbook 2004/05 [TEDDY]. New Delhi: The Energy and Resources Institute.

Uttar Pradesh State Report [1991]. 'Improving efficiency of agriculture pumping systems for energy conservation' Operations Research Group (ORG).

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