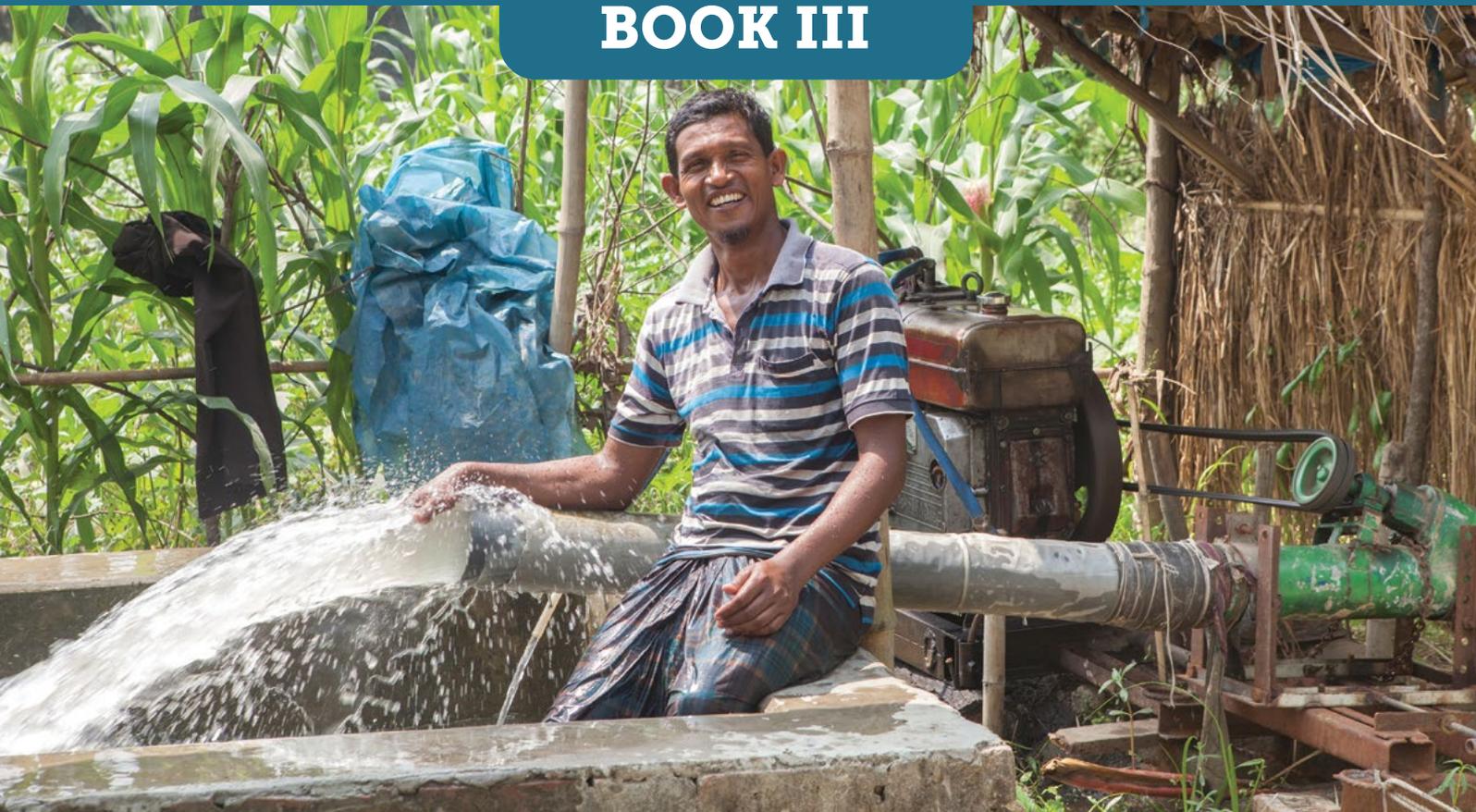


Axial flow pump and mixed flow pump for service providers

Experiential learning modules for sustainable intensification and agricultural service provision

BOOK III



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Cereal Systems Initiative for South Asia

AXIAL FLOW PUMP AND MIXED FLOW PUMP FOR SERVICE PROVIDERS

Experiential learning modules for sustainable intensification and agricultural service provision (Book III).

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CIMMYT – the International Maize and Wheat Improvement Center – is the global leader in publicly-funded maize and wheat research and related farming systems. Headquartered near Mexico City, CIMMYT works with hundreds of partners throughout the developing world to sustainably increase the productivity of maize and wheat cropping systems, thus improving global food security and reducing poverty. CIMMYT is a member of the CGIAR System and leads the CGIAR Research Programs on Maize and Wheat and the Excellence in Breeding Platform. The Center receives support from national governments, foundations, development banks and other public and private agencies.

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CSISA was established in 2009 with the goal of benefiting more than eight million farmers by the end of 2020. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). Operating in rural 'innovation hubs' in Bangladesh, India and Nepal, CSISA works to increase the adoption of various resource-conserving and climate-resilient technologies, and improve farmers' access to market information and enterprise development. CSISA supports women farmers by improving their access and exposure to modern and improved technological innovations, knowledge and entrepreneurial skills. CSISA works in synergy with regional and national efforts, collaborating with myriad public, civil society and private sector partners.

CSISA's goals are to:

- Promote widespread adoption of resource-conserving practices, technologies and services which increase yields with lower water, labor and input costs.
- Support mainstreaming innovations in national-, state- and district-level government programs to improve long-term impacts achieved through investments in the agricultural sector.
- Generate and disseminate new knowledge on cropping system management practices which can withstand the impacts of climate change in South Asia.
- Improve the policy environment to facilitate the adoption of sustainable intensification technologies.
- Build strategic partnerships that can sustain and enhance the scale of benefits accrued through improving cereal system productivity.

CSISA-MI emerged out of CSISA's ongoing efforts in the USAID/Bangladesh Mission-funded CSISA expansion project (2010-2015), and during CSISA Phase II. It continues to be strategically aligned with the broader CSISA Phase III program in Bangladesh, and is led by CIMMYT in partnership with International Development Enterprises (iDE). CSISA-MI is a five-year project (July 2013 – September 2018) that focuses on unlocking agricultural productivity through increased adoption of agricultural mechanization technologies and services.



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Table of Contents

Introduction

	1
Session 1 Introduction, training objectives and pre-training evaluation	7
Session 2 Introduction to the axial flow pump and mixed flow pump	9
Session 3 Main parts of the axial and mixed flow pumps and their functions	11
Session 4 How to set up and use an axial or mixed flow pump safely and effectively	13
Session 5 Troubleshooting and maintenance	15
Session 6 Starting an axial or mixed flow pump service business	17
Session 7 Review of key messages, post-training evaluation and close of training	21

Flipcharts and handout materials*

	22
Session 1 Introduction, training objectives and pre-training evaluation	23
Session 2 Introduction to the axial flow pump and mixed flow pump	28
Session 3 Main parts of the axial or mixed flow pump and their functions	35
Session 4 How to use an axial or mixed flow pump safely and effectively	43
Session 5 Troubleshooting and maintenance	55
Session 6 Starting an AFP/MFP service business	76
Session 7 Review of key messages, post-training evaluation and close of training	89

Annexes

	93
Annex 1 Evaluation questionnaires and answers	93
Annex 2 Video resources	97
Annex 3 Common tools used to repair the axial and mixed flow pumps	97

* PowerPoint files of the flip charts in 'ready to present' format can be downloaded from here: <https://bit.ly/2RJv3DR> (for English language) or here: https://csisa.org/wp-content/uploads/sites/2/2019/12/191204_AFP-SP-smh.pdf (for Bangla language).

Introduction

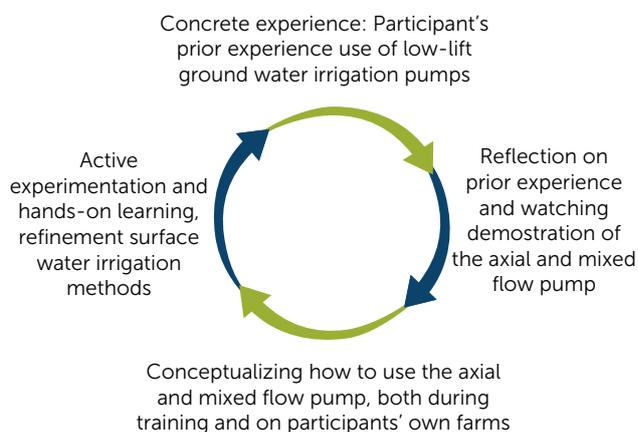
This training uses an experiential and hands-on modular format. It is based on a foundation of experiential and hands-on work, combined with discussion and reflection among participants. This means that although the facilitator is instructed on how to carry out the training and how to present materials, the format in which this is done should be horizontal and participatory, with room for adaptation and modification. We also underscore that farmers and agricultural machinery service providers – who are the target of this training – are experts in their own fields. They work daily on farms and have considerably more experience than most university educated technicians, researchers, or extension agents. Attentively listening to their opinions and working with them to respond to their needs and experiences will result in the facilitation of improved learning and will enhance the quality of any given training session. In this sense, it is the responsibility of the training facilitator to elicit participants' input, opinions and ideas, and to use these interactively to shape discussion and learning. Each facilitator therefore should think of him/herself as a guide whose goal is to elicit insight and ideas from the trainees, in order to enhance their learning process. The technical materials included in this document should therefore be seen as a guide to supplement the in-depth knowledge the trainee farmers and agricultural machinery service providers already have.

Experiential education and training format

The training format presented in these modules is loosely based on the experiential learning cycle described by Kolb (1984)¹, who posited that adults learn differently from children, with learning based on cycles involving concrete experience, learners reflecting on this experience, conceptualizing their experiences, and then doing experimentation. After this, the learning cycle is repeated. Kolb further hypothesized that there are generally four types of adult learners and learning styles that should be accommodated. In the production of this manual we have tried to account for these types of learners, who include those who learn by taking part in demonstration activities and critically thinking about them (whom Kolb called divergers), those who learn by thinking, reading, and watching

(assimilators), those who learn by hands-on thinking and doing (convergers), and those who learn by doing (accommodators).

Well-designed training should accommodate each participant's individual learning style, by providing a mixture of lecture and discussion, reading or visual material, hands-on experiential and experimental opportunities, and opportunities to watch demonstrations and to learn. The challenge thus given to training facilitators when using these modules is to accommodate different types of learners in an active learning process. Kolb's theories have been widely researched and validated in a number of contexts, and provide a solid foundation for educational programs aimed at experienced farmers and agricultural service providers, as well as farmer field school-oriented and action learning. In this training, we loosely attempt to formulate Kolb's learning styles, as shown below.



Kolb's (1986) experiential learning cycle as loosely applied to these training modules.

At every step of the process, facilitators should therefore work to generate discussion and hands-on learning through practical activities, to demonstrate the axial and mixed flow pumps and show participants how to use them, and to encourage critical but constructive reflection among the training participants. There is a certain art to this process, and facilitators should practice beforehand with their peers different techniques for eliciting discussion among participants.

¹ Kolb, D.A. 1984. *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall, Englewood Cliffs, NJ.

Here are some examples of how to ask questions of the training participants in a way that will encourage them to think and critically reflect on the training materials:

- 1. Arrange seating in a circle, not like in a classroom.** Circular seating arrangements encourage participants and facilitators to interact as equals, and improve the potential for discussion.
- 2. Rather than ask closed questions, ask open ones.** For example, rather than ask "What are the financial advantages to farmers using an axial or mixed flow pump?", ask "How can an axial or mixed flow pump help farmers to sow and harvest more crops from the same plot of land within one year?" Participants may require some additional encouragement to discuss this question, but gently push them towards realizing the answer.
- 3. Prompt questions that have open and multiple answers.** For example, rather than asking training participants "What can happen if the pulley on the pump wears out?", ask "If the pulley on the pump wears out, what are the implications for the condition of the V-belt or pulley and how might this cause reduced profits for farmers and service providers"?
- 4. Pick a particular participant to give an answer.** Rotate among students, picking different ones and asking them individually or as a group to answer a question. It may take time for some trainees to answer, but allow them to work through the process of reflection and coming up with a response. Engage with them and discuss their response, and ask others for their thoughts on the response. However, if a particular participant is naturally quiet or reserved, avoid asking him/her too many questions. The goal is to encourage an active learning atmosphere, but not to make participants feel uncomfortable.
- 5. Most importantly, ask logical questions based on the training materials.** This seems like a simple point, but it is important to stay on topic and make sure that participants are equipped to respond to questions. The ultimate goal is not to make training participants identify what they do not know, but rather to encourage training participants to engage with the training materials so they can succeed at mastering axial or mixed flow pump operation by applying a combination of what they already know and what they will learn.

- 6. Provide space for under-represented students to speak.** In many training sessions, men speak over women or dominate the conversation. Members of a particular economic or religious group or caste might speak over those who are not part of that group. Facilitators are encouraged to recognize this, and work to give space to under-represented groups to enable them to learn and speak out equally. This may require giving individuals an opportunity to contribute by asking other participants to wait to reply.

The field is the best classroom for farmers and service providers

Training sessions are to be held primarily outside and in the field, where participants are encouraged to learn with their own hands how to operate the pumps safely and effectively. It is only by setting up the pumps safely and operating them that trainees can learn how to benefit from them. To facilitate this, the flipchart material provided in this book can be printed on large paper and taken out into farmers' fields, where electricity for PowerPoint presentations or other learning formats may not be available (downloaded at: <https://bit.ly/2RJv3DR>).

Emphasis should be given to these participatory activities throughout the training. Last but not least, training and education does not end at the conclusion of the day. Participants should be encouraged to experiment with, learn from, modify and adapt the techniques they learn for using axial or mixed flow pumps on their own farm, emulating the cycle of continual learning articulated by Kolb, as discussed



above. For this reason, training facilitators should share their contact information with participants so they can backstop and assist with technical matters when needed over time. Similarly, trainers may wish to supply contact information of experienced extension agents with knowledge of axial flow and mixed flow pumps.

Organization of this book

This book is organized as follows: after a general introduction to the training format and style, and materials needed for one day's training, six independent learning sessions are presented. Each session covers a different topic, as follows:

1. Introduction, training objectives and pre-training evaluation
2. Introduction to the axial flow pump and mixed flow pump
3. Main parts of the axial and mixed flow pumps and their functions
4. How to set up and use an axial or mixed flow pump safely and effectively
5. Troubleshooting and maintenance
6. Starting an axial or mixed flow pump service business
7. Review of key messages, post-training evaluation and close of training

The individuals who are facilitating the training are then instructed on how to implement each training session. This includes a review of the learning objectives, key messages, required materials, and step-by-step instructions on how to conduct the session from start to finish. At each step of the process, training facilitators are expected to encourage experiential learning as articulated above. Most sessions include a component during which the facilitator will give a brief presentation on the topic. Presentations are intended to be discussion-oriented, and the facilitator should allow time for participants to ask questions, and in turn elicit questions and feedback, especially if few participants are speaking.

Flipchart materials are provided to guide the technical content of each of these presentations. Facilitators should simply follow the flipcharts and use the material presented to initiate discussion and make sure that all technical points are covered. Care should be taken to allow all participants to speak, and to make space for under-represented participants, specifically women, to speak and ask questions.

The flipchart section of this book is designed to be printed out on large poster-sized paper and used for the flipcharts. The same flipcharts are also intended to be printed on normal-sized paper, stapled together

and provided as handouts and reference material for participants. In many countries, training facilitators may also choose to use the flipcharts as projected PowerPoint slides, which is encouraged here as long as a reliable electricity source can be supplied, and as long as participants are able to easily view the slides. Some trainers even prefer to use the flipchart materials as a base for PowerPoint slides, modifying them and adding relevant material as they see fit. We fully encourage this approach (downloaded here).

Lastly, training begins with a pre-training evaluation of participants' knowledge, and finishes with a post-training evaluation of their knowledge at the end of the day. The change in participants' scores provides an indication of their progress in learning. Ready-made pre- and post-training evaluation questionnaires and their answers are provided in Annex 1. Simply print them on regular-sized paper for use. Some training facilitators also like to give post-training evaluations a second time, a week or more after the training, to gauge how much information participants retained over time. We also encourage this, as it can be instructive for training facilitators to learn how to improve and emphasize particular parts of the training that some participants may forget as time passes.

Training aims and objectives: Axial pumps and mixed flow pumps

The aims of this training are to (1) familiarize participants with axial flow and mixed flow pumps and ensure they know how to use them in a farmer's field, (2) increase participants' knowledge of the common causes of axial and mixed flow pump failure and breakdown experienced by farmers and service providers, and (3) improve their ability to repair the machine effectively and efficiently, with emphasis on operating viable rural businesses providing irrigation services to farmers.

By the end of the training, participants should be able to:

- understand and explain the usefulness of axial/mixed flow pumps
- identify the major mechanical parts of axial/mixed flow pumps and understand their functions
- operate the axial/mixed flow pump efficiently and safely
- understand the causes of major failures and breakdown associated with axial/mixed flow pumps, and find solutions for how to fix them
- provide irrigation and water pumping services to farmers efficiently and profitably

Whom is this training designed for?

This training is designed for irrigation service providers who have already procured an axial or mixed flow pump and are providing surface water irrigation or drainage services to farmers, or those who intend to buy a pump (i.e., potential service providers).

This module is also suitable for service providers (or potential service providers) wanting to offer to pump water for aquaculture purposes, as axial flow pumps (AFPs) and mixed flow pumps (MFPs) are also widely used in shrimp and fish production operations. Gender balance should be maintained when selecting the participants – it is ideal to have a mix of women and men, with no less than 25% being women.

Key considerations for training

Key considerations for planning, preparing and organizing the training are given below. The facilitator(s) should prepare well in advance, reading each section carefully to ensure the training is implemented effectively and efficiently. The information presented here is can be generalized for each training day in this series of books. More specific information pertaining to individual training days is also presented at the beginning of each module; be sure that you also review this material.

Participants

The number of participants per batch of trainees should be limited to around 10-15 (although this depends on the number of pumps that can be arranged for the training, since there needs to be one pump available for each group of roughly five participants). When selecting participants, priority should be given to service providers who have procured a pump (or are interested in doing so) and who are already providing services to farmers in their locality. Ideally, at least 25% of the participants (i.e., 2-3 out of a group of 10, 4 out of 15) should be women, preferably with leadership capability, who have at least a primary level of education, ideally with business experience, and able to work outside the household and run a rural business. Participants should be contacted well ahead (at least one week) of the training day, to allow them to prepare.

Venue

The venue should be selected carefully. Ideally there should be a classroom or similar room having sufficient light and electricity, and adequate space for up to 15 participants and the trainer(s), and also a surface water

source (e.g., a canal, pond or river, from which water can be lifted for the practical exercises). Note that the water should be no more than 2.5 m from the edge of the canal. In other words, the canal should be relatively full, with no more than 2.5 m of vertical height between the water and the soil surface. The space should be free from outside distractions. There should also be accessible restroom/toilet facilities nearby.

Training aids

At least one month before the training is due to start, please review the detailed list of training aids on the next page and make sure you get together all the materials needed before the training starts.

Facilitator(s)

Experienced AFP/MFP users, and/or extension agents with training in AFP/MFP use, should be selected to facilitate the training, after having passed a training course which familiarized them with (1) the principles of experiential learning, and (2) the training module and sessions. However, if not available locally, help may be obtained from other institutes (such as national research institutes or extension agencies).

Facilitator's preparation

Well ahead of the training start date, the facilitator(s) should go through each module and its respective topics, and practice the implementation techniques as per the allocated time. Each session contains different topics, implementation techniques and time allocation. Facilitators therefore need to read each module minutely and practice their delivery following the PowerPoint presentation/flipcharts to ensure a lively presentation that keeps to schedule (downloaded here).

Date of training

The date of the training should be decided following discussion and agreement with trainees to ensure their participation. It should preferably be during their weekly day off to avoid any financial loss to their business.

Registration

Participants should reach the training venue on time. On arrival, each participant should register his/her name and take a seat in the classroom or similar covered area allocated for training. They will later move to a nearby crop field for practical exercises. Registration should be completed before training begins, after which no new participant can be allowed to join.

Group formation

As part of the introduction, the facilitator should divide participants into three groups. Ideally there should be five participants per group; however, the number of groups or number of participants per group may vary depending on (1) the total number of participants, and (2) the number of axial or mixed flow pumps available. Working in smaller groups ensures a more action-oriented, hands-on approach to learning. Generally, four to five people should be assigned to one pump. Arrange any seating so these small groups can sit with one another. Participants should remain in the same group throughout the day, to take part in discussions, question and answer sessions, demonstrations and exercises. Do not set up the seats in classroom style; circular seating should always be used.

Participatory, experiential and hands-on learning

The training approach should be participatory, with an emphasis on hands-on and experiential learning, and actual operation of the AFPs/MFPs. This is why it is important to limit participant numbers relative to how many pumps are available, as each participant should get the opportunity to have hands-on experience of operating the machine. The facilitator should have been trained in these methods, and utilize techniques that aim to motivate participants to get involved in the training – for example, question and answer sessions, experience sharing, group exercises, group discussions, and group presentations. This guide explains how to do that.

Effective and enjoyable training

The training should be facilitated in such a way that participants understand the key messages and information clearly, and find it useful and valuable, rather than a waste of their time. To achieve this, the facilitator should work to ensure that the training is enjoyable (using fun games, quizzes, sing-along sessions, or other techniques to get trainees motivated and involved). One-way lecture formats are not acceptable and are discouraged as they reduce participants' potential to learn effectively through discussion and experience. The facilitator should arrange a short break (about two minutes) after each ten minutes of presentation, discussion and or exercise, during which they should ask questions to check whether participants are understanding the training well, and if necessary, adapt their teaching style.

Use of mobile phones

Use of mobile phones causes distraction and reduces the effectiveness of the learning experience. All participants, including the facilitator(s), should keep their mobile phone switched off during the training session. If they receive an urgent call, they should excuse themselves from the group to answer it.

A pre-training evaluation questionnaire at the start of the training day and post-training evaluation at the end are important and necessary to judge whether and to what degree the learning has been effective. These questionnaires are provided in Annex 1.

Course preparation, duration, materials and setting

This course is designed for a one-day training session of approximately 8 hours (excluding lunch and breaks). This is an intensive course; sessions are held in the field and not in a classroom. The facilitator(s) can decide the best time to take tea and lunch breaks (these times are not included in the estimates below and so should be accounted for when planning the training). It is important to keep the timing flexible, depending on the needs of the participants – some sessions may be faster than allowed for, others may be slower.

The content is divided into an introductory session plus six instructional sessions, as follows:

Session	Topic	Approximate duration (minutes)
1	Introduction, training objectives and pre-training evaluation	60
2	Introduction to the axial flow pump and mixed flow pump	50
3	Main parts of the axial and mixed flow pumps and their functions	30
4	How to set up and use an axial or mixed flow pump safely and effectively	130
5	Troubleshooting and maintenance	75
6	Starting an axial or mixed flow pump service business	90
7	Review of key messages, post-training evaluation and close of training	45

Planning and preparing for the training

Please review the 'Key considerations for training' section above. Note that the training requires a body of water with a level of water suitable for pumping, a safe and flat area next to it on which to set the pump and where training will take place, and next to it, land suitable for demonstrating irrigation. Several weeks of advanced preparation are therefore required. In addition to the items listed there, prepare for this training by considering the following:

Training venue

Provide space with adequate cover for 15-20 participants, and a water body nearby with water at the appropriate level for demonstrating the axial/mixed flow pumps. Note: water levels change throughout the year and affect the timing of the training; it is therefore the facilitator's responsibility to check the suitability of the location in advance but also close to the time scheduled for the training to take place. The venue should be easily accessible and safe for any vulnerable or non-able-bodied participants.

Required training aids

- ✓ multi-media projector and screen for showing the video
 - ✓ Axial flow pump video (see Annex 2)
 - ✓ printed flipcharts for each session (see Flipcharts and handouts, pages 29 to 99)
 - ✓ blank flipchart paper for group feedback (approximately 10 sheets)
 - ✓ whiteboard and flipchart/whiteboard stand
 - ✓ two or three whiteboard (dry erase) pens; two or three flipchart markers
 - ✓ a notebook, pencil and spare paper for each participant
 - ✓ participant registration form
- ✓ at least 1 printout of the pre-training and post-training evaluation questionnaires for each participant
 - ✓ 3 axial or mixed flow pumps (ideally 8-12 HP with a four-inch outlet, or similar sized) (depending on availability, but no fewer than one per group of around 5 participants)
 - ✓ for comparison, 1 centrifugal pump (if available), 8 HP with a four-inch outlet, though outlet sizes may vary depending on what is available)
 - ✓ faulty or broken AFP/MFP parts (if available), e.g., impeller, shaft, shaft bearing, oil seal, V-belt
 - ✓ spare AFP/MFP parts (if available) – these can be the same as the faulty or broken parts listed above
 - ✓ tables and chairs for participants
 - ✓ water source (e.g., a pond, canal or river) that has water no more than 2.5 m from the bank of the pond/canal/river. If the area is in a tidal region, make sure that sufficient water is available at the time of training, as the training will include practical exercises in pumping
 - ✓ participant registration form, pre- and post-evaluation questionnaires, participant evaluation form, facilitator evaluation form
 - ✓ notebooks and pens for each participant
 - ✓ if possible, one experienced AFP/MFP mechanic or operator to discuss common causes of pump failure and breakdown (Session 4), and a successful AFP/MFP service provider to answer participants' questions (Session 6).

Session 1

Introduction, training objectives and pre-training evaluation

Learning objectives

At the end of this introductory session, participants should be able to:

- state the names of the trainer(s) and the other participants
- state the anticipated objectives and content of the training
- understand the training guidelines about learning and cooperation, including the participatory approach and their expected contribution
- assess their own knowledge level regarding the content and intentions of the training.

Key messages to convey to participants throughout this session

The training day is composed of seven instructional sessions and will take about eight hours excluding lunch, tea and other breaks. Get ready to learn plenty of new things – and please be patient: there is a lot of material to complete.

1. This training is important because it will enable participants to provide better irrigation services to farmers and, at the same time, to earn more profits.
2. This training is participatory and fun – trainers and trainees will learn from each other.
3. The training is mostly hands-on. Participants should learn by working with axial and mixed flow pumps, and using them to irrigate a field, rather than just listening. Active participation works best.
4. Trainees should be attentive during the training and participate actively – either individually or as part of their group – in each task/assignment/exercise given to them.
5. There is a pre-training and post-training evaluation process, which is an essential part of the day and in which trainees should participate fully.
6. The facilitator and participants should keep their mobile phones switched off or on silence. If they receive an urgent call, they should excuse themselves from the group and go elsewhere to answer it.

How to conduct the session on Introduction, training objectives and pre-training evaluation

For this session, you will need the following resources and materials:

- the participant registration form
- the flipchart Session 1: *Introduction, training objectives and pre-training evaluation*
- A4 printed copies of the flipchart for each participant
- a notebook, pen and pre-training evaluation questionnaire for each participant
- several sheets of blank poster paper or a whiteboard, whiteboard stand and dry marker/whiteboard pens

Step 1 – Form groups (15 minutes)

Most adults learn best when they work in groups. Participants in a small group can interact and share ideas with each other, which allows peer-to-peer learning and stimulates more entertaining and rich learning experiences.

An ideal group size is a total of 10-15 participants, divided into smaller groups.



Divide the participants into groups of four or five by asking them to number themselves 1, 2, 3, 4, 5 recurring and asking those with the same number to rearrange their seats and sit together (all the 1s together in one group, 2s in another and so on). This splits up participants who are sitting with people they already know.

Next, ask each group to select a leader and choose a fun name for their group. It is helpful if the group leader can read and write, which is something the training facilitator can assess during the registration period. Also, try to ensure that someone in each group is competent in basic mathematics and calculations. This will be important later on, when learning about machine calibration and business models.

Ask each group to find five things they have in common with every other person in the group, and that have nothing to do with work. Please, no body parts, as we all have legs and arms! Also, no clothing, as we all wear clothes. Focus on more interesting commonalities, such as where they were born and how many children they have, or how many years of experience in farming they have, and so on. This helps the group explore shared interests more broadly.

Ask the group leaders to take notes and be ready to read their list to the whole group at the end of the session. This should generate discussion, and a lot of laughter and fun, while encouraging each group to think more like a team.

Step 2 – What are the participants' expectations? (10 minutes)

This is one of the most effective tools for breaking the ice and enabling a new group of trainees to get to know each other. Each group member is an important source of knowledge. Each participant also has his or her own style of thinking and learning. This means that for effective learning it is important for the trainers to understand each participant's expectations of the training module. It will also help the facilitator(s) be better equipped to deliver a successful learning experience during the training.



Use an icebreaker approach, during which participants can state what their learning expectations are at the beginning of the day. This will provide feedback from each participant about what they expect – and want – to get out of the training.

During the introduction of the training module, when it is time for participants to introduce themselves following group formation, the facilitator should explain that participants' expectations are very important, and that understanding them will be crucial for ensuring quality outcomes from the training. These expectations can later be compared with the module outline, and modifications and changes can be made where necessary.

Ask participants to:

- introduce themselves individually
- share their expectations of the training course (which should be summarized and presented by the group leader after 2-3 minutes of discussion)

Here is an example:

"Hi, my name is Sudhanshu. Our group wants to know how to solve major problems with axial and mixed flow pumps, the advantages of an AFP/MFP over a centrifugal pump, and how we can make money providing irrigation services to farmers. Will we learn how to do that?"

Try to limit responses to one from each group. Listen and list important expectations on blank poster paper or a whiteboard. At the end of this session, review the list of expectations that the groups made. Discuss any points not covered in the course and explain whether their expectations will be met, and if not, why.

Step 3 – Introducing the training (10 minutes)

Use flipchart *Session 1: Introduction, training objectives and pre-training evaluation* to present a brief overview of the training course, the training methods the course uses, the rules, and the responsibilities of the participants. Allow time for both the trainer(s) and participants to ask questions.

Step 4 – Pre-training evaluation questionnaire (25 minutes)

Distribute the 'Pre-training evaluation questionnaire' (see Annex 1) to each participant and allow 20 minutes or so to complete it. If necessary, help less literate participants to understand and answer the questions. The questionnaire can also be printed and put up on flipchart paper. Collect the answers; they will be compared with the post-test evaluation answers at the conclusion of the training. They should be corrected before the end of the day, prior to the closing session, during which the evaluation scores will be given to all participants.

Session 2

Introduction to the axial flow pump and mixed flow pump

Learning objectives

At the end of the session, participants should be able to:

- demonstrate awareness of the different types of irrigation pumps available on the market
- understand and explain the functions of the different pumps and their usefulness
- explain the comparative advantages and disadvantages of the AFP/MFP over conventional centrifugal pumps for lifting surface water from canals, ponds and rivers

Key messages to convey to participants during this session

1. The axial flow pump consists of a propeller (called an 'impeller') mounted on a shaft inside a long pipe. The pump is powered by a diesel engine or electric motor, enabling it to pump water from a surface source. It has been in

common use in Thailand and other Southeast Asian countries since the 1960s, and is only now emerging in Bangladesh.

2. Mixed flow pumps (MFPs) differ from AFPs in that the impeller is usually larger than the diameter of the pipe in which the shaft is encased; this provides extra water pumping power.
3. AFP and MFPs are available in different sizes and capacities.
4. Tests in Bangladesh have shown that when low lifting (less than 3 m in height), fuel consumption of the AFP is much lower (21-50%) than that of the traditional centrifugal pump, saving money for irrigation service providers².

² See Krupnik, T.J., Santos Valle, S., Islam, M.S., Hossain, M.A., Gathala, M.K., and A.S. Qureshi. 2015. Energetic, hydraulic, and economic efficiency of axial flow and centrifugal pumps for surface water irrigation in Bangladesh. Irrigation and Drainage. DOI: 10.1002/ird.1940.



Demonstrating the axial flow pump.

How to conduct the session on *Introduction to the axial flow pump and mixed flow pump*

For this session, you will need the following resources and materials:

- the flipchart *Session 2: Introduction to the axial flow pump and mixed flow pump*
- A4 printed copies of the flipchart as a handout for each participant
- a DVD of the film *Axial Flow Pump* (see Annex 2, Video resources)
- an electrical connection and multi-media facilities for showing the DVD *Axial Flow Pump* including speakers or small sound system
- several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens

Step 1 – Prepare participants for the DVD (5 minutes)

Display the following questions and ask participants to note down any answers they learn during the screening of the DVD, *Axial Flow Pump*. Before starting the DVD, ask the participants to read through the questions and ask for clarification if there is anything they would like to have explained. Encourage them to make notes during the screening of DVD, and to aim to have answers ready for discussion at the end.

- What is an axial flow pump?
- What two possible power sources can be used to operate the AFP/MFP?
- What are the power requirements of these power sources?
- What are the different types of AFPs available on the market?
- Why is the AFP/MFP useful?
- What are the differences between the AFP/MFP and the conventional centrifugal pump?
- How does a mixed flow pump differ from an axial flow pump?

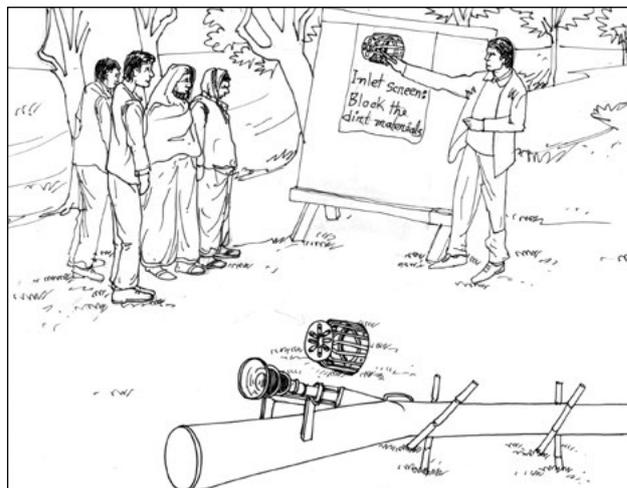
Step 2: Screen the DVD and use the questions to generate discussion about the AFP/MFP (35 minutes)

Show the DVD *Axial Flow Pump*, then ask the questions to find out what participants learned from the DVD presentation. Ask someone from each group in turn. Encourage the quieter participants to speak, without making those lacking in confidence feel uncomfortable. This requires sensitivity on the part of the facilitator, particularly when making sure that individuals do not dominate the group.

Listen to the participants carefully. Make a note of any points which they are unable to answer on blank poster paper or the whiteboard.

Step 3: (10 minutes)

Lead a discussion on the AFP, focusing on the points listed on the poster paper or whiteboard.



AFP/MFP training in the field.

Session 3

Main parts of the axial and mixed flow pumps and their functions

Learning objectives

At the end of this session, participants should be able to:

- identify the main parts of the AFP/MFP
- understand and state the functions of the main parts of an AFP/MFP

Key messages to convey to participants throughout this session

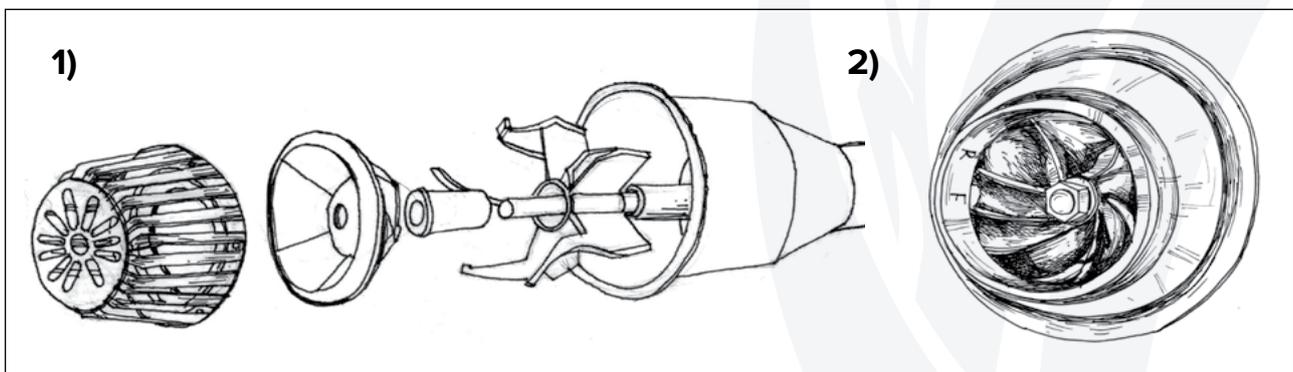
The main parts of the AFP and MFP include:

- inlet screen
- impeller
- stator
- driving shaft
- pipe or conduit
- bearing housing
- bushings
- pulleys
- diffuser vanes

How to conduct the session on *Main parts of the axial and mixed flow pumps and their functions*

For this session, you will need the following resources and materials:

- flipchart *Session 3: Main parts of the axial and mixed flow pumps and their functions*
- A4 printed copies of the flipcharts as a handout for each participant
- several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens
- spare AFP/MFP parts (e.g., impeller, bushings, pulleys, diffuser vanes, bushing mounts, center support bushings, external grease nipples); check – maybe these aren't needed until Session 5, troubleshooting (which is the case in bed planters)
- two/three AFPs or MFPs appropriate to the water source at the training venue and size of pump available



1. Major parts of an MFP, showing (from left to right) the inlet screen, the impeller, the suction end bushing, diffuser vane, and the bell at the end of the pipe conduit. 2. Detail of the MFP impeller in its housing.

Step 1: (5 minutes)

Take participants to a nearby water source where axial or mixed flow pumps have already been placed for learning exercises.

Start this session using the question-and-answer ice-breaking technique.

Ask: Can anybody name the main parts of an AFP or MFP?

Encourage one or two participants to answer, and list the parts they mention on blank poster paper or the whiteboard.

Step 2: Generate discussion and learning (10 minutes)

Lead a discussion on the AFP/MFP, using the flipchart *Session 3: Main parts of the axial and mixed flow pumps and their functions* to ensure that trainees can identify and state the functions of main pump parts as follows:

Name of part	Functions
Inlet screen	Blocks dirt and other stray materials from getting into the pump from the canal, pond or river from where water is pumped
Impeller	Pumps/pushes water upwards through the pipe or conduit
Driving shaft	Drives the impeller, which pushes water up the pump
Pipe or conduit	Holds the water pumped by the impeller until delivery
Bearing housing	Holds the bearings
Bushing	Works like a bearing and holds the shaft in place
Pulley	Drives the shaft (powered by an engine)
Diffuser vane	Straightens the water flow and reduces turbulence

Quick review (15 minutes)

At the end of Session 3, bring the participants together in their groups. Ask each group five to ten questions (each participant should be encouraged to answer one or two questions). If a participant is unable to answer a question, invite other members of their group to answer. If no one in the group can answer, pass the question on to the next group.

Session 4

How to set up and use an axial or mixed flow pump safely and effectively

Learning objectives

At the end of this session, participants should be able to:

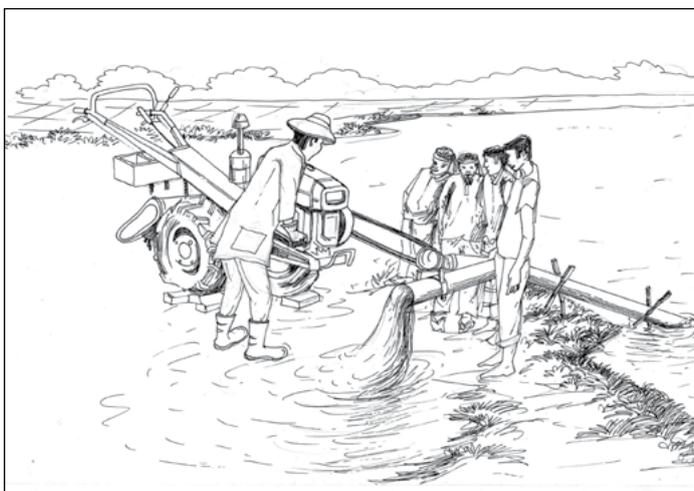
- select an appropriate site to set up an axial/mixed flow pump and talk about its characteristics
- set up an axial/mixed flow pump correctly
- demonstrate they know how to use the axial/mixed flow pump safely

Key messages to convey to participants during this session

1. Wear tight-fitting clothing while operating the axial or mixed flow pump. Never wear loose clothing: this can get stuck in the pump and injure the user.
2. Keep children away from the pump when it is in use – they can easily get hurt.
3. The axial pumps currently available in South Asia should be used only with non-saline water (plastic or stainless steel bodies are needed for use with saline water; these are available in Southeast Asia but not in South Asia).
4. Saline water corrodes and destroys most metal axial and mixed flow pumps (pumps suitable for saline water are being developed and will be available in the future).
5. To achieve high fuel efficiency, the selected river, canal or pond should not have water lifts much more than 2.5 m in height.
6. Tests of prototype axial/mixed flow pumps at the Bangladesh Agricultural Research Institute showed that at 1 m lift, the AFP is 51% more fuel efficient (water delivered to fuel used ratio) than centrifugal pumps. At 2 m lift, it is 21%. At 3 m, you still get more water with the AFP, but it will use more fuel

than centrifugal pumps. Lift height above 3 m will still deliver more water, but may not be as profitable as more fuel may be needed.

7. Use bamboo sticks placed in the river, pond or canal banks to provide support for the pump body and the end that houses the impeller. The impeller should never touch the bottom of the canal, river or pond in which the pump is being used.
8. The pulley and engine should be aligned.
9. Set the impeller end of the pump at least 0.60 m above from bottom of the water source (canal, pond or river) and 0.30 m below the water surface. This will avoid creating a whirlpool in the water (which will reduce pump efficiency).
10. Check the pump's most important parts before starting it. The check should include nuts, bolts, clamps, holes in the body, greasing points (bearings and bushings), cracks in or damage to the belt, oil levels in the engine, and the tightness of the pulley.
11. Keep hands away from all rotating parts, such as the engine, impeller, belt and pulley.



Demonstrating the use of a mixed flow pump in the field.

How to conduct the session on How to set up and use the axial and mixed flow pump safely and effectively

For this session, you will need the following resources and materials:

- flipchart *Session 4: How to set up and use the axial and mixed flow pumps safely and effectively*
- A4 printed copies of the flipcharts as a handout for each participant
- several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens
- 3 or 4 AFP/MFPs
- a centrifugal pump
- a suitable water source
- an experienced mechanic/machine operator
- bamboo for setting up the pump

Step 1: Generate discussion (10 minutes)

Begin Session 4 in the field after closing Session 3. An experienced axial or mixed flow pump service provider or mechanic who is able to operate the pump, should participate in the session (if available).

Use the ice-breaker technique to start the training in a lively way and generate questions and answers from the participants.

Ask: How many of you have operated an irrigation pump, especially one for pumping from canals, ponds or rivers?

Listen to the responses and **ask:** What are the important considerations when starting up an axial or mixed flow pump?

Encourage one or two participants to answer. List the most significant responses on poster paper or the whiteboard.

Step 2: Practical exercise (120 minutes)

Take participants to a nearby water source (this should have been selected in advance; care must be taken to ensure that sufficient water is available). Before the training starts, set up an axial or mixed flow pump and a centrifugal pump. If available, an experienced mechanic/operator (or if not, the facilitator) should describe the procedure for setting up an axial or mixed flow pump, and demonstrate how to operate it safely. Particular emphasis must be placed on the importance of safely operating the pump. Demonstrate and discuss the following points:

- importance of having a suitable space beside the water source to place the pump and engine
- use of bamboo to support the pump body

- align the pulley and engine – they should be in a straight line, which may require elevating the engine slightly on one side with bricks or other materials
- set the impeller at least 0.60 m above the bottom of the water source (canal, pond or river) and 0.30 m below the water's surface
- do not wear loose clothing while operating a pump – this is dangerous!
- before starting the pump, check important parts/points, including: nuts, bolts, clamps, holes in the body of the pump, greasing points (bearings/bushings), cracks/damage to the belt, oil-fuel in the engine, tightness of the pulley. Make sure everything is ready for operation
- starting the engine/pump: place particular emphasis on how axial/mixed flow pumps do not need to be primed (no water must be added to the pump tubing) before starting. Simply place the pump in the water and begin pumping.
- emphasize which parts of the pump to keep hands away from: all rotating parts such as the engine, impeller, belt and pulley
- keep children away from the pump – it is not safe for them to be in the same area

Run the pump for some time to demonstrate its function. If a centrifugal pump is available for comparison, demonstrate water discharge from an axial flow pump and a centrifugal pump for two to three minutes to demonstrate the advantages of the axial flow pump over a centrifugal pump, emphasizing the following:

- The axial flow pump does not need priming (no water must be added to the pump tubing) like centrifugal pumps do. This saves time and labor.
- The axial flow pump discharges a larger amount of water than the centrifugal pump in a unit period of time (visual assessment makes this clear).

Refer to the session's flipchart and state again that at a 1-meter lift, the axial flow pump is 51% more fuel efficient (measured in terms of the ratio of water delivered-to-fuel used) than a centrifugal pump. At a 2-meter lift, it is 21% more fuel efficient. At a 3-meter lift, the axial flow pump discharges more water but uses more fuel than a centrifugal pump. Above a lift height of three meters, the axial/mixed flow pump is generally not profitable; however, higher powered mixed flow pumps may be profitable.

Next, each participant should practice starting and stopping the pump – this is essential for experiential learning. The mechanic/operator or the facilitator(s) should act as a guide, assisting anyone with problems. The facilitator should also monitor each participant and encourage trainees – particular anyone who is unskilled – to practice.

Session 5

Troubleshooting and maintenance

Learning objectives

At the end of the session, participants should be able to:

- understand the common reasons for failure and breakdown of the axial and mixed flow pumps
- make basic repairs and adjustments to solve different operational problems
- ensure good maintenance of the pumps

Key messages to convey to participants during this session

1. The pump shaft may break due to (1) over-running of the pump, (2) excessively high water lift heights, and/or (3) a faulty shaft.
2. Water leakage from the pipe or pump parts may occur during pumping. This is usually because of faulty oil seals which can result from the tearing of the oil seal or loosening of the nuts-bolts. Check for leaks before starting the pump and repair them.
3. The transmission belt can rip (1) if it is worn out, or (2) if the engine and pump pulley are misaligned.
4. The impeller may break if hard materials (e.g., bamboo, wood or brick) or dirt gets into the pump.
5. The pump pulley can wear out because of friction and having a rough surface, or if the V-belt is loose.
6. Deposition of sand in the pump damages shaft bushings; this can occur when operating the pump in sandy or muddy water.

How to conduct the session on *Troubleshooting and maintenance*

For this session, you will need the following resources and materials:

- flipchart *Session 5: Troubleshooting and maintenance*
- A4 printed copies of the flipcharts as a handout for each participant
- several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens
- faulty parts (if available)
- spare parts (e.g., impeller, inlet cage, shaft, V-belt, bearings, oil seal, pulley, bushing)
- an experienced mechanic (if available)

Step 1: Generate discussion (20 minutes)

To initiate the session, initiate a question-and-answer session with participants.

Ask: What might be the common failures/breakdowns of an axial or mixed flow pump?

List important points on poster paper/whiteboard. Using the list of key messages above and the Session 5 flipchart, briefly discuss common causes of AFP/MFP failure and breakdown, and possible solutions. The key points to clarify here include:

- pump shaft bends or breaks
- water leakage from the pipe or pump
- transmission belt rips
- pump impeller breaks
- pulleys overheat, stretch or break
- bushing jams or fails due to sand getting into the bushing casing

Using the same flipchart, discuss the importance of axial/mixed flow pump maintenance (the parts need regular maintenance) and proper storage of the machine.

Step 2: Practical session (40 minutes)

Moving to a location where an AFP has been placed for examination by the participants, an experienced mechanic and/or the facilitator should point out faulty parts of the pump and how to repair or replace them. These main points include:

- pump shaft bends or breaks
- water leakage from the pipe or pump
- ripping of transmission belts
- pump impeller breaks
- pulleys overheat, stretch or break
- bushing jam or failure due to sand getting into the bushing casing

Let participants know that if they want to learn more about mechanical repair of the pumps, they should participate in AFP/MFP mechanics training day.

Demonstrate and discuss maintenance and storage of the pumps, emphasizing the following:

- The pump should be stored carefully so that it does not get rusty from touching the ground.
- The best place to store the pump is on a roof or hanging from a roof beam.
- Keep the open ends of the pump covered to prevent children from putting hard materials inside it.

Quick review (15 minutes)

At the end of this session, conduct a quick review of Sessions 3 and 4 using the same procedure outlined above for Sessions 1 and 2 (at the end of Session 2). After completing Session 5, take the participants back to the training venue.

Session 6

Starting an axial or mixed flow pump service business

Learning objectives

At the end of the session, participants should be able to:

- understand and explain what a business plan is
- understand and follow a business plan/model for marketing an AFP/MFP service
- explain how they would provide AFP/MFP services to farmers efficiently and profitably
- record financial information (cost and benefit) and analyze profitability of marketing an AFP/MFP service

Key messages to convey to participants during this session

Service providers use business plans to make the most money possible while keeping farmer-clients happy, so that farmer-clients will come back time and again to ask for the service provider's assistance and business. Ask participants to consider their potential role as an AFP/MFP service provider and answer these questions:

- Where is the market for an irrigation service business?
- What is the demand for irrigation services?
- What is my capacity to provide irrigation services?
- What machinery and equipment do I need for running a business?
- What would the profit be from my proposed business?

How to conduct the session on *Main parts of the axial and mixed flow pumps and their functions*

For this session, you will need the following resources and materials:

- flipchart *Session 6: Starting an axial or mixed flow pump service business*

- A4 printed copies of the flipcharts as a handout for each participant
- several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens
- (if available) a service provider who is successfully marketing his/her AFP/MFP services

Step 1: Generating discussion with an AFP/MFP service provider (15 minutes)

If available, introduce a successful AFP/MFP service provider and invite him/her to share his/her business experience with participants. Ask him/her the following questions:

- Why did you decide to start an AFP/MFP business?
- How do you conduct the business?
- What are the costs and benefits of running an AFP/MFP business?
- How long did it take to break even (that is, the point at which income became equal to the start-up costs)?
- What activities and strategies do you follow to make your business profitable?
- Do you face any challenges when using the AFP/MFP?
- What benefits are farmers (clients) getting from your AFP/MFP business?

Encourage participants to interact with the service provider, and to discuss the use of the pump to run a business.

If a successful service provider is not available, present the generic AFP/MFP business model and cost-benefit analysis, based upon (a) the experience of a successful service provider, or (b) the general material in the flipcharts (which is Step 2 below). If a service provider is available, move on to Step 2 after the discussion.

Step 2: Group exercise to work out the cost of starting up and running an AFP/MFP business (60 minutes)

Begin the session by referring to the flipchart and discussing the following points:

- What do we mean by 'a business'?
- What is a business plan?

Lead a participatory/group exercise (participants should stay in the groups they formed at the beginning of the training) to develop a business plan and perform a cost-benefit analysis.

Step 3: How to make a profit selling AFP/MFP services while benefiting farmers

Following the flipchart, guide the discussion using the questions below, which participants should discuss in their group, arriving at answers that make sense to the group. Make a note of the decisions agreed upon by all the groups and enter them in the respective boxes on the flipchart. When all the boxes have been completed, the resulting information will provide a potential model of an AFP/MFP service business plan and its related costs and benefits. Note: this model is likely to change in different locations and for different crops, types of pump, time of year and so on. The goal here is to encourage participants to carefully think through the different aspects of running a service provision business in ways that benefit both themselves and the smallholder farming households that purchase their services.

- 1. What is the cost of irrigating a unit area of land with a centrifugal pump?** First, ask participants in their groups to agree upon a unit area of land to consider for this exercise. It should be one that they feel most comfortable with – for example, one hectare or percentage of a hectare, or an area in m², or a local land unit. It is probably best to use the average unit size of a farmer's field in their area (in Bangladesh this would be x decimal). Does the cost of irrigation vary with different crops (such as dry season boro rice, maize or wheat)?
- 2. How do irrigation service providers usually charge money for irrigation using a centrifugal pump?** For example, do they base their charge on the time and labor spent on drain-making, the cost of fuel and labor for within-field canal making, the area irrigated, the type of crop (e.g., dry boro season rice or maize) or any other basis? Work out these calculations and write the answers in boxes lettered A, H, and N on the flipchart. Make sure everyone agrees on the same land area to be irrigated, and include this in the boxes too.

- 7. How do farmers pay the service provider for the cost of irrigation?** For example, in cash, by contributing a share (a percentage) of their crop after harvest, by providing labor or a combination of these options?
- 4. Ask participants to agree (for the sake of the exercise) on one of these ways of charging and paying for irrigation,** so they can make the calculations necessary to work out how to develop a profitable business. For this learning exercise, the easiest way to calculate costs is in monetary terms; otherwise, convert the cost of the harvested crop (as in sharecropping systems) to a monetary value.
- 5. What is the cost of purchasing an AFP or MFP?** Write this value in box B.
- 6. Consider how to charge money for the irrigation of maize, dry season boro rice, and/or an alternative crop.** Write the cost of running a pump (including fuel and the cost of making canals to channel water from the pump to the farmer's field for maize, dry season rice, and other crops) in boxes C, I, and O. Note: these should be the seasonal charges for each crop, and participants should choose the crops based on what is relevant to their own circumstances. For example, if they are unfamiliar with maize, they can substitute it with another crop.
- 7. Service providers spend time and effort to attract farmer-clients.** This costs money, even if the service provider is not paid. This is because time is money, as the saying goes. The lost time can be valued as an 'opportunity cost'. Write the expected opportunity cost (which includes pump maintenance, and working to get farmer-clients) for maize, dry season boro rice or other crops, in boxes D, J, and P on the flipchart.

Because the AFP/MFP can save fuel and thus costs, the ideal business model is one in which the service providers make more money than they did when they used a centrifugal pump, and also by offering farmers irrigation for less money than they are accustomed to paying using a centrifugal pump, which consumes more fuel at low-lifts, and is thus more expensive to operate.

Considering the above, ask the participants to work out the net income (excluding operational and maintenance costs) or money savings on fuel per season for a mutually agreed upon land area. When the group has come to a decision on this, write the agreed upon cost to charge for maize, dry season boro rice, or other crops in boxes E, K and Q. Note: this should be the charge for a single day of irrigation on the land area (that the participants agreed on and which is now written in boxes A, H and N).

8. Next, calculate if farmers save any money for each of these crops and write the results in boxes E, K and Q. Work through this by using the costs the participants placed in earlier boxes, as follows:

- Farmers' savings/irrigation costs for 1 day's irrigation (maize) on the agreed land area: = $(A - E)$
- Farmers' savings/irrigation costs for 1 day's irrigation (dry season boro rice) on the agreed land area: = $(M - K)$
- Farmers' savings/irrigation costs for 1 day's irrigation (other crops) on the agreed land area: = $(N - Q)$

9. Encourage participants to work out the profit generated by using the AFP/MFP for each crop. Then calculate the farmers' savings, if any (making sure farmers save money is also very important for running a long-term and profitable business where farmers will be interested in continuing to pay for AFP/MFP irrigation).

10. To calculate the profit service providers obtain from irrigating maize for one day (using the land area agreed upon and noted in boxes A, H, and N), use the equation below and write the answer in box F. Use values in the equation that correspond to the values you wrote in the boxes earlier.

$$\text{Service provider's profit for one day of irrigating maize} = E - (C + D)$$

11. Similarly, to calculate service providers' profit from irrigating dry season boro for one day on the land areas designated in boxes A, H, and N, use the equation below and write the answer in box L.

$$\text{Service provider's profit for one day of irrigating maize} = K - (I + J)$$

12. For other crops:

$$\text{Service provider's profit for one day of irrigating maize} = Q - (O + P)$$

Given this land area, when could a service provider using an AFP break even in terms of the purchase cost of the pump? Walk the participants through each step of the calculations. First, in Box T, write the area you think you can irrigate in one day with an AFP/MFP, and in Box U write the number of days you expect to irrigate each crop in one year. The table below will help work out this information.

Crop	Area the service provider can irrigate in 1 day with an AFP/MFP (box T)	Days the service provider can irrigate in 1 year with an AFP/MFP (box U)
Maize	(AA)	(AD)
Dry season boro rice	(AB)	(AE)
Other crops	(AC)	(AF)

The numbers in parentheses will be referred to in later calculations.

13. Work out the expected yearly profit for each crop, by asking participants to do the calculations, writing the results in box V. The necessary equations are:

- **Maize:** $AG = [AA \times AD \times (E - C + D)]$
- **Dry season rice:** $AH = [AB \times AE \times (K - (I + J))]$
- **Other crops:** $AI = [AC \times AF \times (Q - (O + P))]$

17. Breaking even means that the profits earned by a service provider are equal or greater than the cost of purchasing a pump (and engine, if service providers think purchasing an engine is necessary), including maintenance and opportunity costs. This is important to work out, so that service providers know how long it will take until they start generating substantial profits by serving farmers. Work out these calculations in Box W, using the following equation:

$$\text{Time (year) required} = \frac{B}{(AG + AH + AI)}$$

18. Now ask participants what they should say if a farmer asks for a lower water charge, on the basis that an axial/mixed flow pump saves fuel compared to a centrifugal pump? Work with each group to develop a business model that allows them to save money compared to using a centrifugal pump, but also allows farmers to save some money. This will attract farmers as clients, and allow new farmers who may not be able to afford irrigation at the cost needed for a centrifugal pump, to begin irrigating.

19. Taking all the above into consideration, if the axial/mixed flow pump service costs less than using a centrifugal pump, how can a service provider make at least the same or more money using the AFP or MFP, compared to a centrifugal pump? Work with the participants to work out the price-point where they can save fuel and profit, while also saving money for farmers and attracting new farmer clients.

20. Many irrigation pump owners offer special rates to farmers who hire other machinery services from them, for example tilling their land and also irrigating, or irrigating and also reaping. Ask participants if they would consider this kind of service 'bundling' to make paying for irrigation with an irrigation pump or AFP or MFP more attractive?

21. To break even on the cost of investing in an AFP/MFP in one year, what activities/strategies should potential service providers consider? What would be the best crop to irrigate, and what arrangements should they make with farmers to ensure they pay for irrigation, and that the service provider and the farmer both profit?

Ask each group to identify any difference(s) between (1) a business run by a service provider they know who uses an AFP/MFP, and (2) the business model/plan presented. Suggest strategies/activities for profitable AFP services, emphasizing ways to reduce costs for farmers while still making profits for service providers. Each group should then present their assignment on a sheet of poster paper (or if time does not permit, just one group should present its proposed business model analysis).

Step 4: Further discussion (10 minutes)

Use the flipchart to discuss the following points, and note down any important information or data on running an AFP/MFP service business:

- primary investment
- monthly expenditure and income on an axial/mixed flow pump
- list of potential farmers to whom AFP/MFP services will be provided
- (for advanced groups) cost of a loan, interest and other financial considerations

Step 4: Review of key messages (5 minutes)

Use the flipchart to review the key messages of this session.

Session 7

Review of key messages, post-training evaluation and close of training

How to conduct the session on *Review of key messages, post-training evaluation and close of training*

For this session, you will need the following resources and materials:

- flipchart *Session 7: Review of key messages, post-training evaluation and close of training*
 - A4 printed copies of the flipcharts as a handout for each participant
 - several sheets of blank poster paper/whiteboard, flipchart stand, whiteboard stand, dry markers/whiteboard pens
 - post-evaluation questionnaire (see Annex 1)
 - handouts or other materials (e.g., leaflets, brochures, if available) for participants
- What are the most important considerations for starting up and safely operating an axial/mixed flow pump?
 - What are the major causes of failure or breakdown of the axial/mixed flow pump? What are their solutions?
 - What do we mean by a 'business'? What is a business plan?
 - How long might it take to break even if you buy an axial/mixed flow pump?
 - How can you make sure your axial/mixed flow pump service is profitable, while at the same time benefiting farmers?
 - Why is financial record-keeping important?
 - ✓ For what types of crops and/or farm enterprises does the axial/mixed flow pump work best?

Step 1: Generate discussion to recap the important questions of the day (20 minutes)

Review all the sessions by asking the participants the questions listed on the Session 7 'Review of key messages' flipchart. This gives a good indication of whether all the participants have learned from the training, and to what extent.

- Use the following questions to stimulate discussion:
- What are the differences between the axial flow pump, the mixed flow pump and the centrifugal pump?
- What are the advantages of an axial/mixed flow pump over a traditional centrifugal pump?
- In which environments (i.e., saline or non-saline water) and water lift heights can the axial/mixed flow pumps be used profitably?
- What are main functional parts of an axial/mixed flow pump?

Look back at what was written at the start of the day under "participants' expectations". Were most expectations fulfilled? If not, follow up with additional discussion to make sure any remaining questions are answered.

Step 2: Post-training evaluation (10 minutes)

Give out the post-evaluation questionnaire and allow 10 minutes for participants to complete it. Be available to answer questions and assist anyone who may need it.

Step 3: Distribution of any materials to take away (5 minutes)

Distribute any handouts, leaflets, brochures or other materials among the participants.

Step 4: Acknowledgments and close of training (10 minutes)

Thank all participants and guests and close the training with concluding remarks.



Flipcharts and handout materials*

* PowerPoint files of the flip charts in 'ready to present' format can be downloaded from here: <https://bit.ly/2RJv3DR> (for English language) or here: https://csisa.org/wp-content/uploads/sites/2/2019/12/191204_AFP-SP-smh.pdf (for Bangla language).

Session 1

Introduction, training objectives and pre-training evaluation

Axial and mixed flow pump
one-day training flipchart



What do you expect to learn from this training?

- ◆ In groups, discuss what you think you'll learn today.



- ◆ Choose someone from each group to speak for the group.
- ◆ Take notes.



Today's sessions

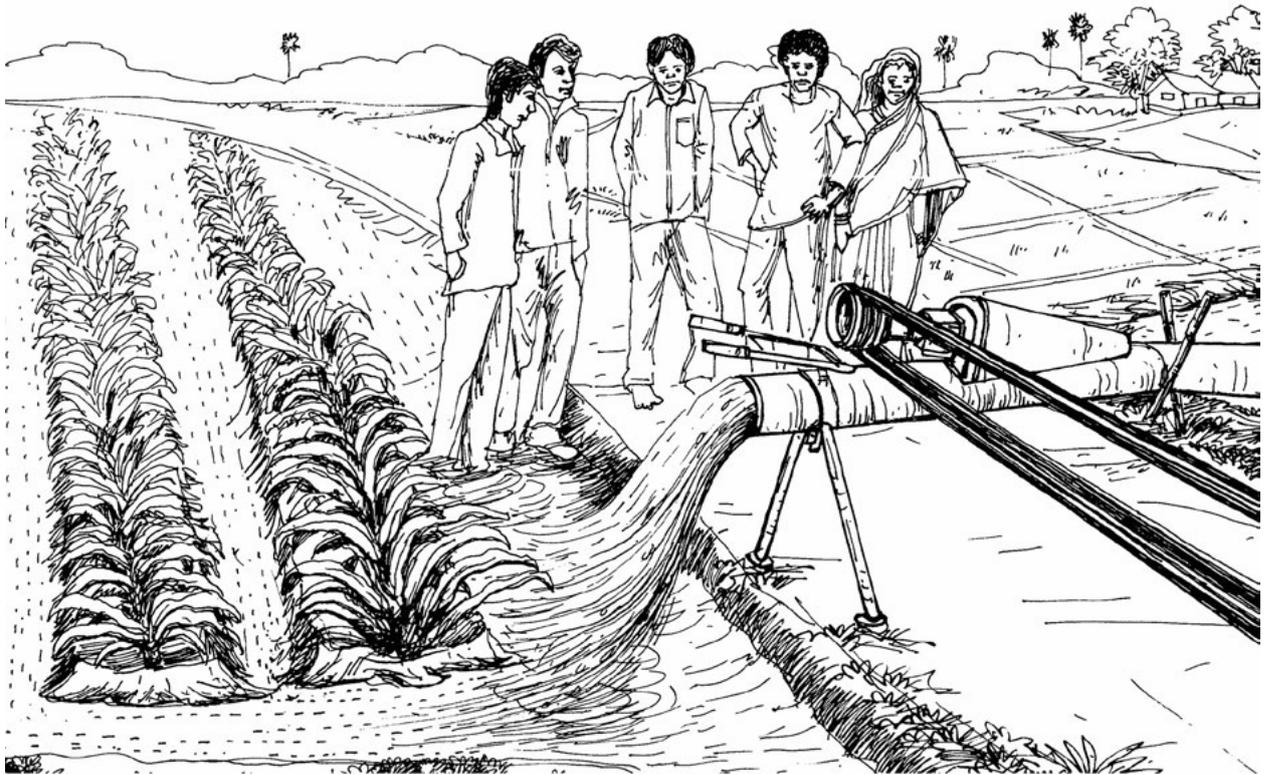
- 1. Introduction, training objectives and pre-training evaluation**
- 2. Introduction to the axial flow pump and mixed flow pump**
- 3. Main parts of the axial and mixed flow pumps and their functions**
- 4. How to set up and use an axial or mixed flow pump safely and effectively**
- 5. Troubleshooting and maintenance**
- 6. Starting an axial or mixed flow pump service business**
- 7. Review of key messages, post-training evaluation and close of training**

What kind of training is this?

This is *participatory* training, so:

- ◆ Ask questions and speak up.
 - ◆ Learn by experience – run irrigation pumps yourself and learn how to operate them.
- ◆ Learn by discussing each topic with your group.
 - ◆ Speak up when the facilitator asks questions – and ask questions yourself. This way we can learn from each other.

Please enjoy this training!

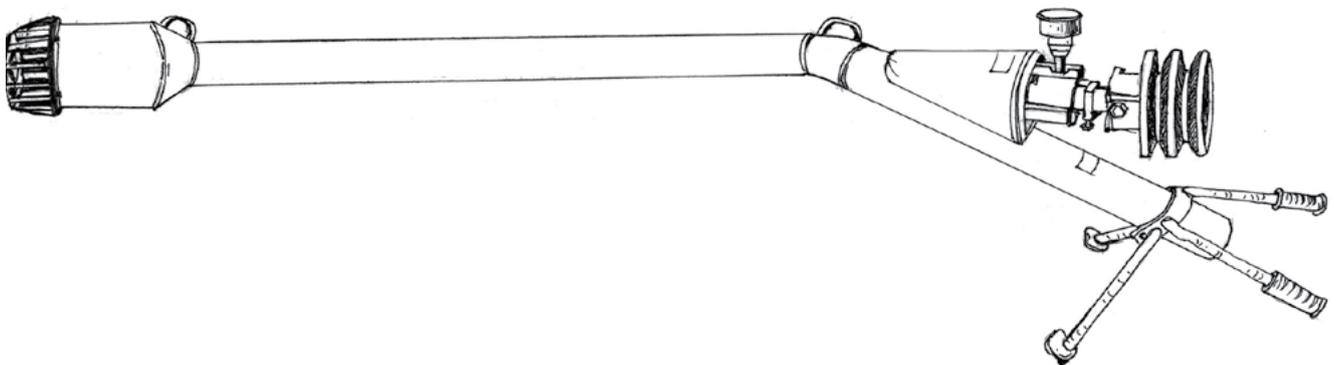


- ◆ **Feel free to ask questions and to contribute your knowledge.**
- ◆ **Make sure you get time to practice how to set up and operate the pump.**
- ◆ **Have fun!**

Session 2

Introduction to the axial flow pump and mixed flow pump

Axial and mixed flow pump
one-day training flipchart





What are the axial flow pump and mixed flow pump?

- ◆ An axial or mixed flow pump (AFP/MFP) is driven by (1) a shaft encased in a long pipe, and (2) an impeller (this is a reverse directed propeller – like on a boat – which operates using power from a diesel engine or electric motor).
 - ◆ The mixed flow pump impeller is usually larger than the pipe in which the shaft is encased, which provides extra power to lift water.
- ◆ AFPs can be traced back to Vietnam and Thailand in the 1960s, where they were developed by innovative farmers. They are now common throughout Southeast Asia.

What are the axial flow pump and mixed flow pump? *(continued)*

- ◆ Both pumps are also known as 'propeller pumps' because the impeller works much like a boat propeller.
 - ◆ To run an AFP, a two-wheeled tractor or a 12-16 HP diesel engine is necessary (unless engines are directly coupled). However, these are rare in South Asia.
- ◆ Using a AFP to irrigate farmers' fields can be profitable – both for the pump owner and for the farmer!



Differences between the AFP/ MFP and the centrifugal pump

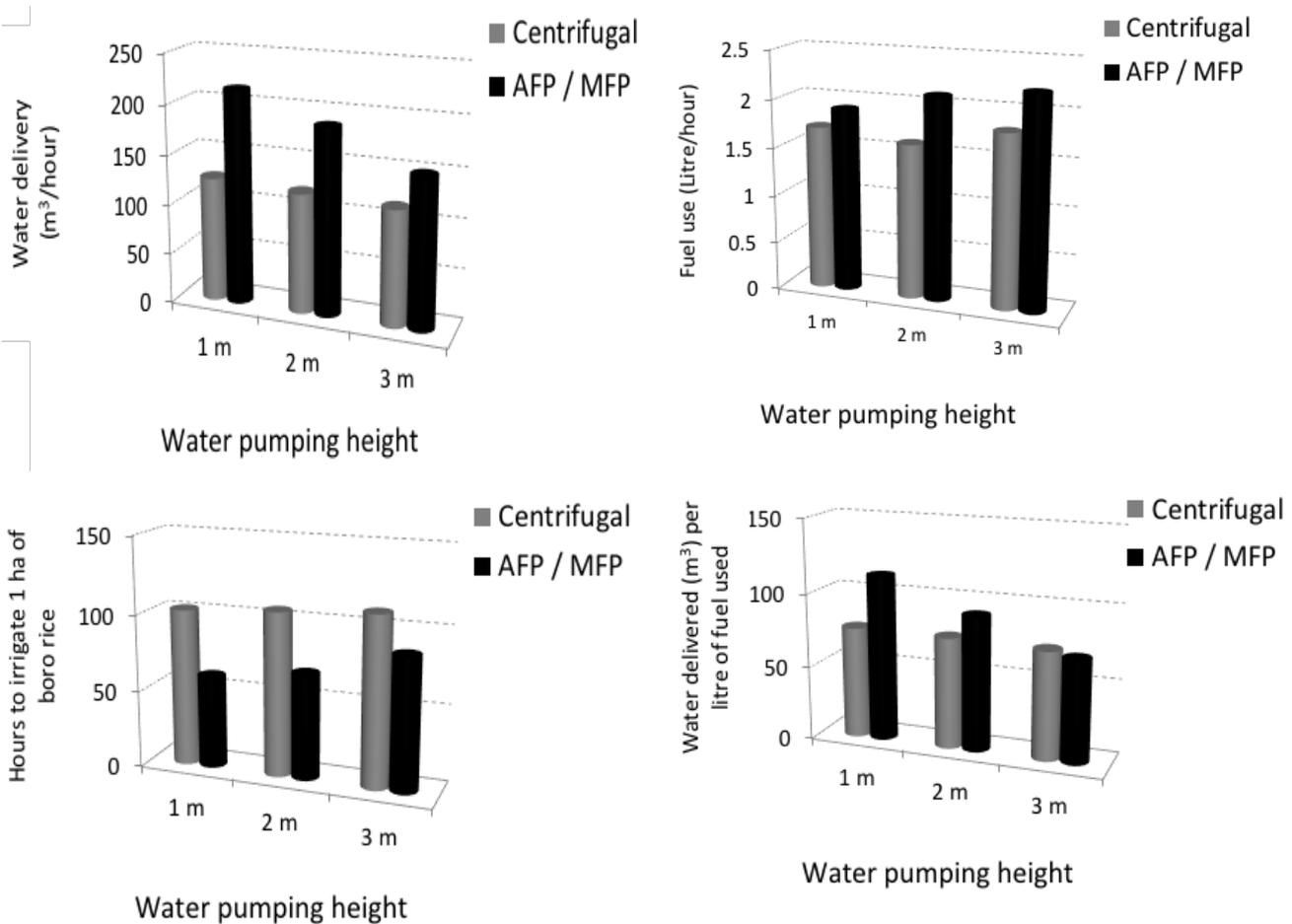
Criteria	AFP/MFP	Centrifugal pump
Capacity	high	low
Frictional loss	low	high
Operating cost	low	high
Power transmission	high efficiency	low efficiency
Operating time required	less	more
Manufacture	easy to fabricate	difficult to fabricate
Fuel consumption	low	high
Water lifting height	up to about 3 m (and fuel efficient)	over 3 m (but with low fuel efficiency when lifting < 3m)

**Why did my
neighbor get
such a high
yield?**

**Because an
AFP or MFP
provided
enough water
at the right
time, that's
why I got a
higher yield!**



Advantages of the AFP/MFP

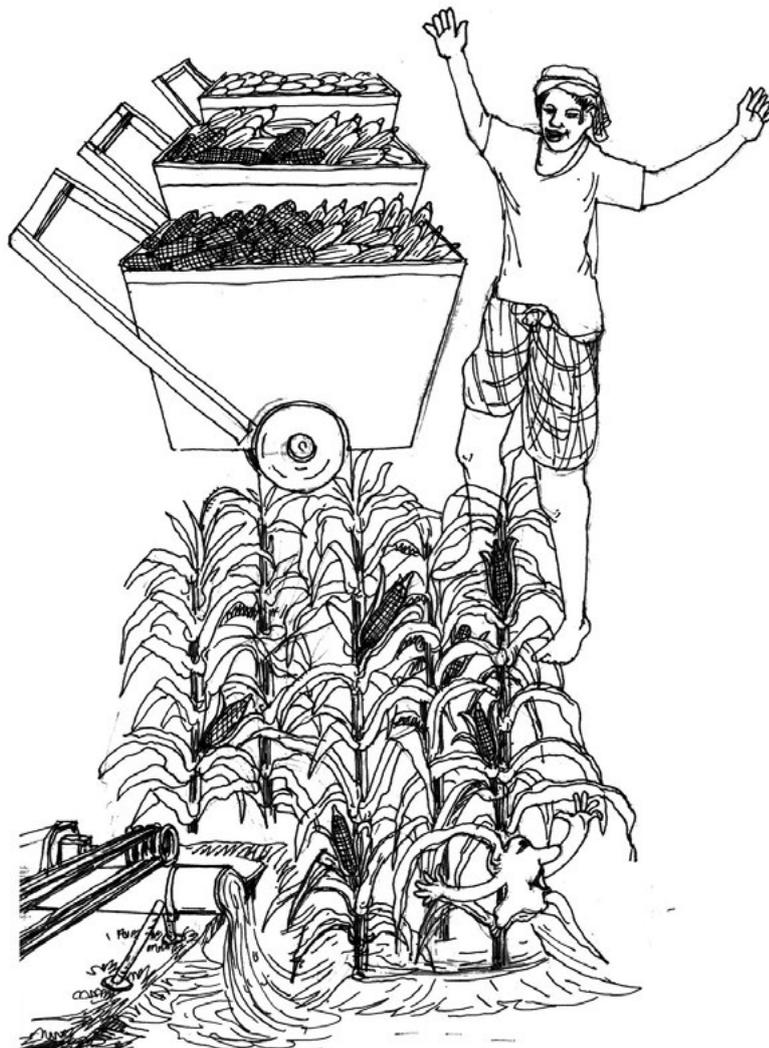


Early experiments show that:

- ◆ **At 1-m lift, the AFP is 51% more fuel efficient than the centrifugal pump.**
- ◆ **At 2-m lift, the AFP is 21% more fuel efficient than the centrifugal pump.**

◆ At 3-m lift, the AFP discharges more water but the fuel cost is higher.

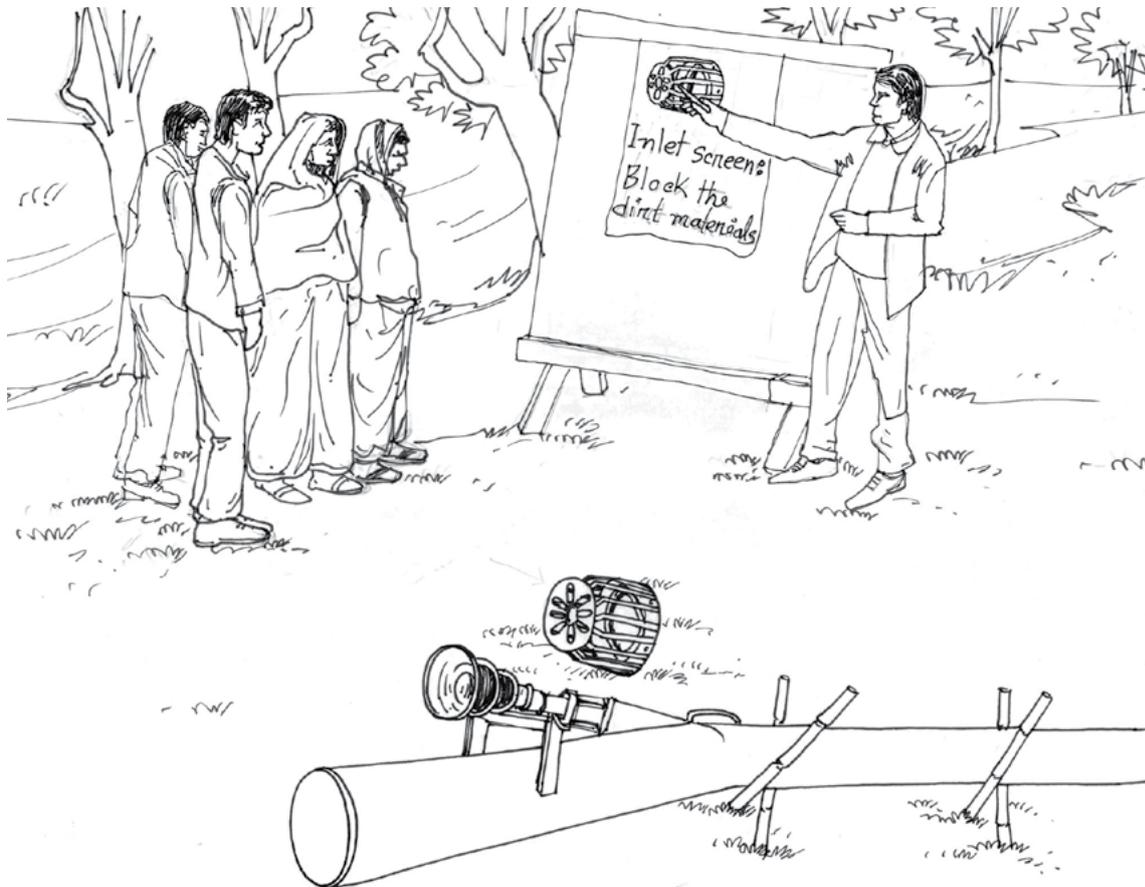
Axial flow pumps can provide increased lift height. Experiments are under way to determine the best engineering approach to developing highly fuel efficient MFPs.



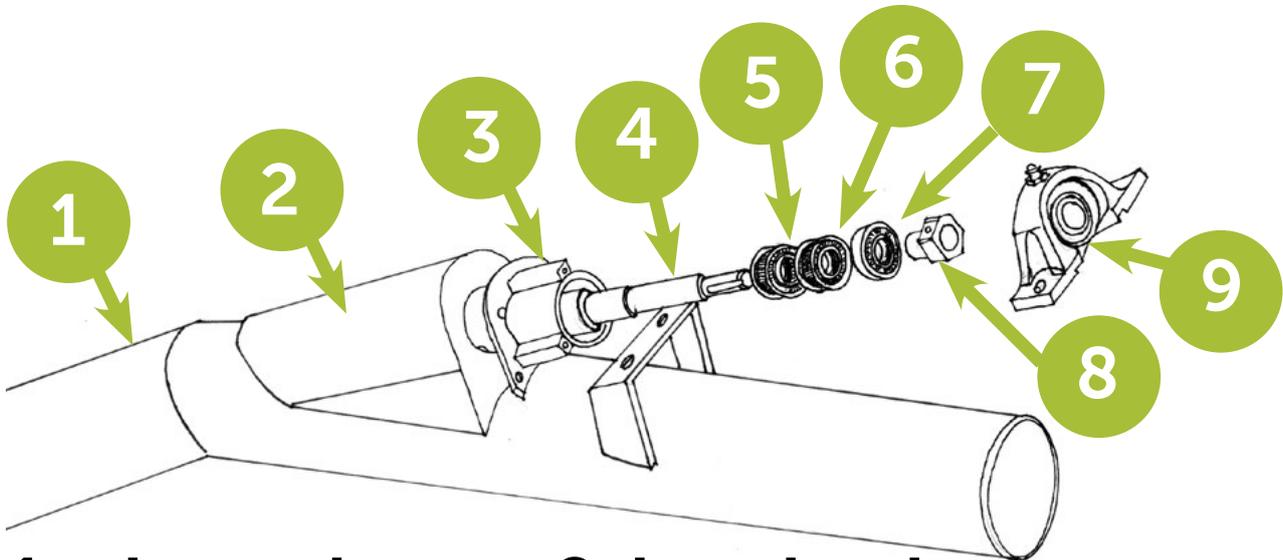
Session 3

Main parts of the axial or mixed flow pump and their functions

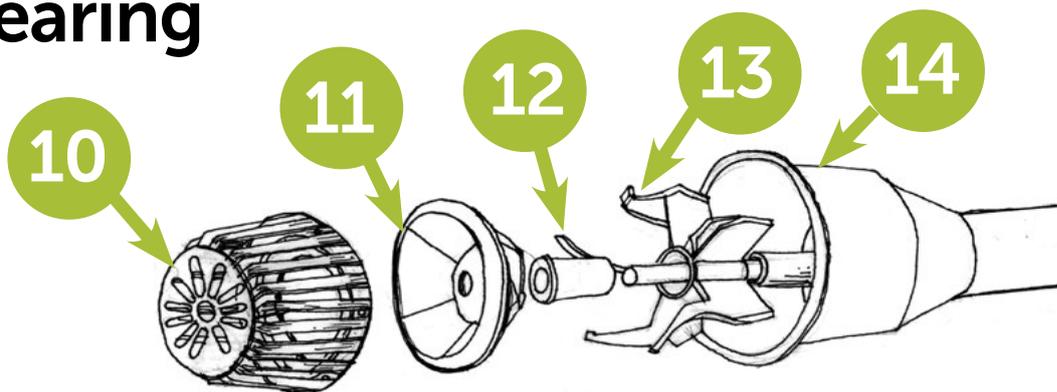
Axial and mixed flow pump
one-day training flipchart



Main parts of the axial flow pump and their functions (1)



1. pipe column 2. bearing house mount 3. bearing housing 4. inlet side drive shaft 5. thrust bearing 6. ball bearing 7. additional ball bearing 8. shaft collar 9. mounted bearing

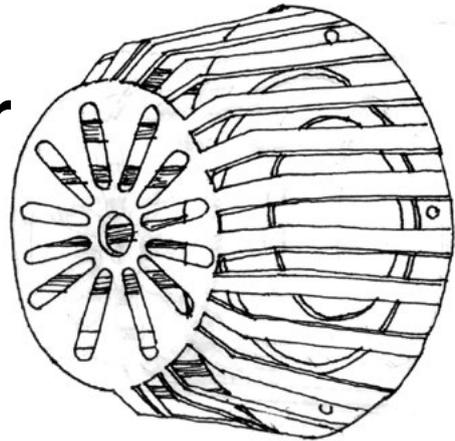


10. inlet screen 11. impeller 12. suction end bushing 13. suction end stator 14. suction bell

Main parts of the axial flow pump and their functions (2)

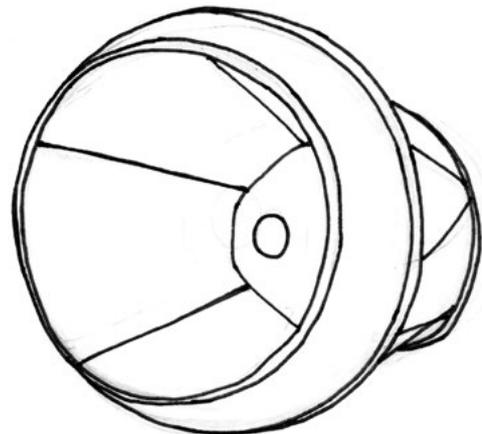
The inlet screen

Prevents dirt and other stray materials from getting into the pump from the canal, pond or river that the water is pumped from



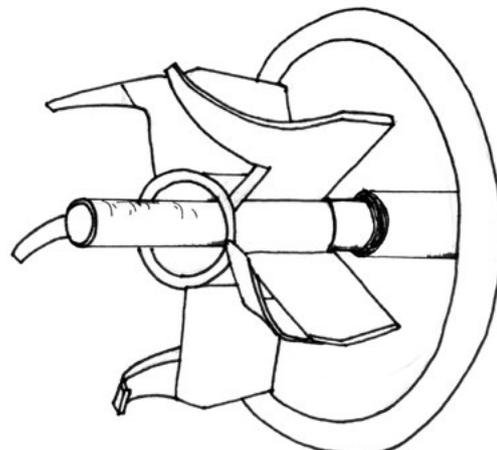
The impeller

Pumps/pushes water upward through the pipe or conduit



The suction end stator

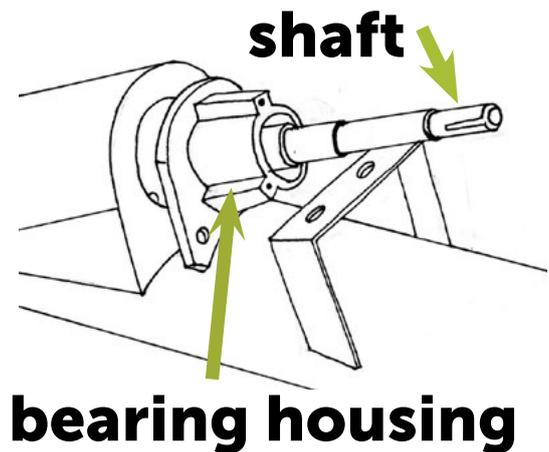
Straightens water flow and reduces turbulence



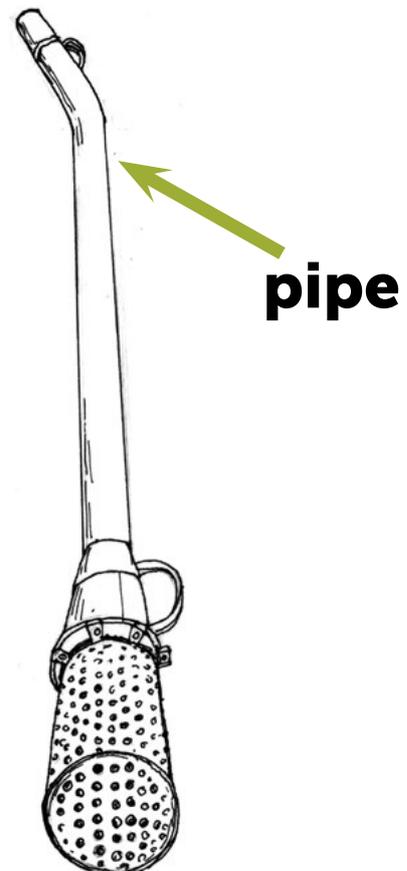
Main parts of the axial flow pump and their functions (3)

The driving shaft
Drives the impeller

The bearing housing
Holds the bearings



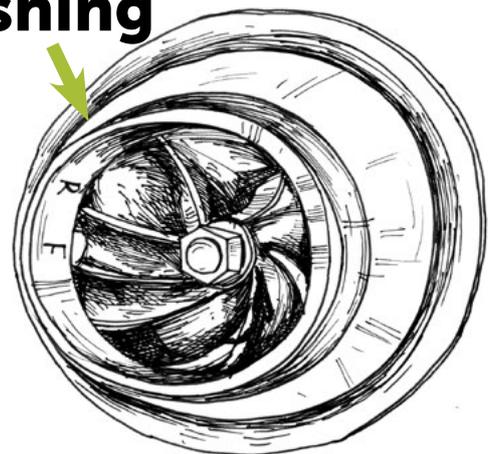
The pipe/conduit
Transfers the water pumped by the impeller until delivery. Note: This pump is an AFP (not an MFP) because it does not have a 'bell' shape at the end of the pump from where water is drawn.



Main parts of the axial flow pump and their functions (4)

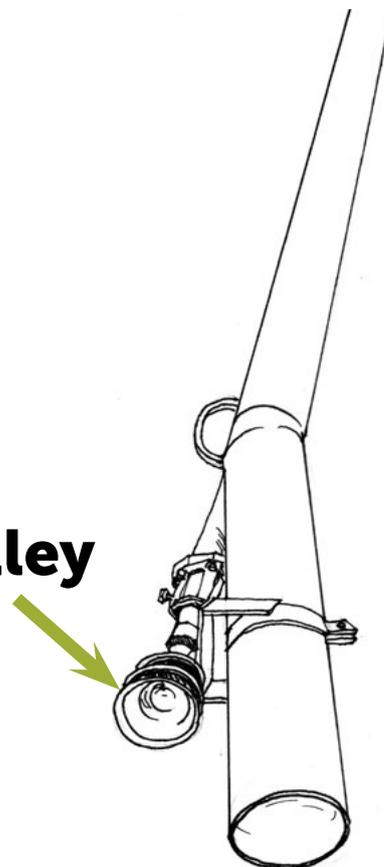
The bushing
Holds the impeller and shaft in place

bushing



The pulley
Drives the shaft to rotate the impeller
(powered by an engine)

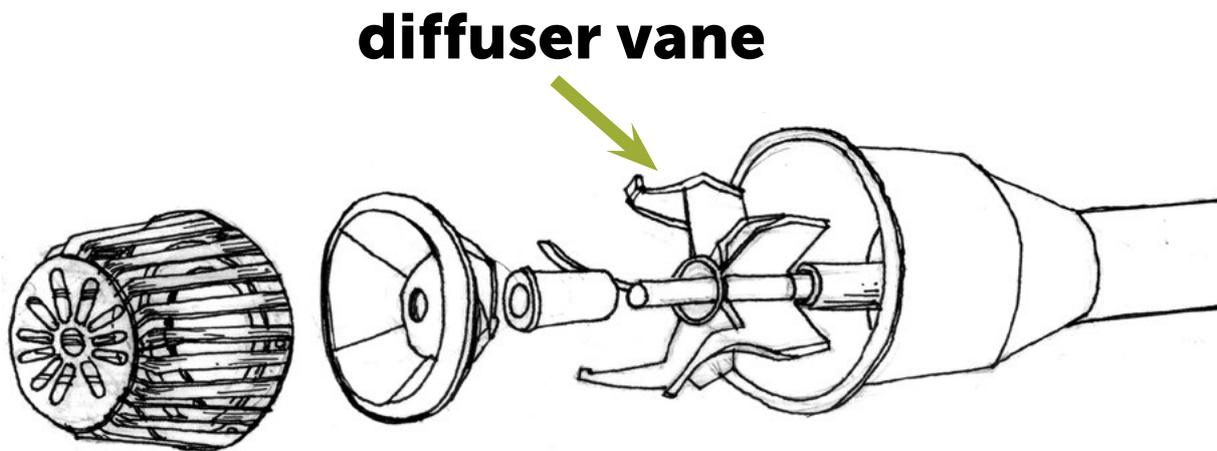
pulley



Main parts of the axial flow pump and their functions (5)

The diffuser vane

Straightens the water after it is transferred by the impeller into the conduit pipe





Key messages

- ◆ The axial pump and the mixed flow pump are very similar.
 - ◆ Axial flow pumps have smaller impellers – these fit inside the conduit pipe.
- ◆ Mixed flow pumps have larger impellers which are wider than the conduit pipe. They deliver more water than axial flow pumps.

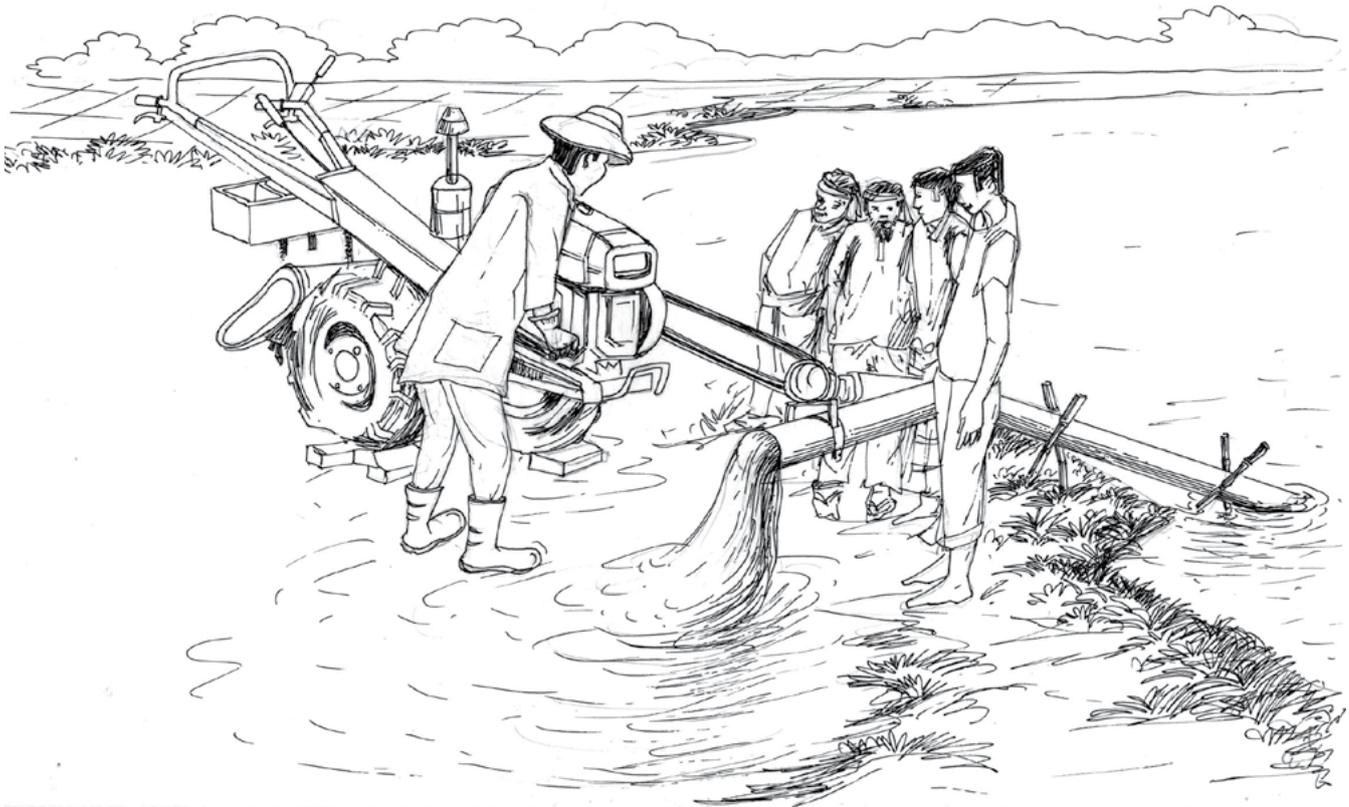
The main parts of both pumps are:

Name of part	Function
Inlet screen	Stops dirt and other stray materials from getting into the pump from the canal, pond or river from where the water is pumped
Impeller	Pumps/pushes water upward through the pipe or conduit
Driving shaft	Drives the impeller, which pushes water up the pump
Pipe or conduit	Holds the water pumped by the impeller until delivery
Bearing housing	Holds the bearings
Bushing	Works like a bearing and holds the shaft in place
Pulley	Drives the shaft (powered by an engine)
Diffuser vane	Straightens the water flow and reduces turbulence

Session 4

How to use an axial or mixed flow pump safely and effectively

Axial and mixed flow pump
one-day training flipchart



Setting up an AFP/MFP: Site selection

When deciding where to set up an AFP/MFP, it is essential to consider the following:

1. Quality of the water

Clearer and cleaner water extends the life of the pump; water containing sand or mud causes pump deterioration over time.

2. Lift height

The selected site should have a lift height of less than 3 m, in order to improve fuel efficiency. Excess lift leads to wasted fuel (although water pumping rates may still be higher than when using a centrifugal pump).



- 3. A safe place to put the engine or two-wheeled tractor (if used to power the pump). This should be:**
- ◆ on level and stable ground
 - ◆ with sufficient distance between the engine and the AFP to allow belt coupling

4. Appropriate water depth

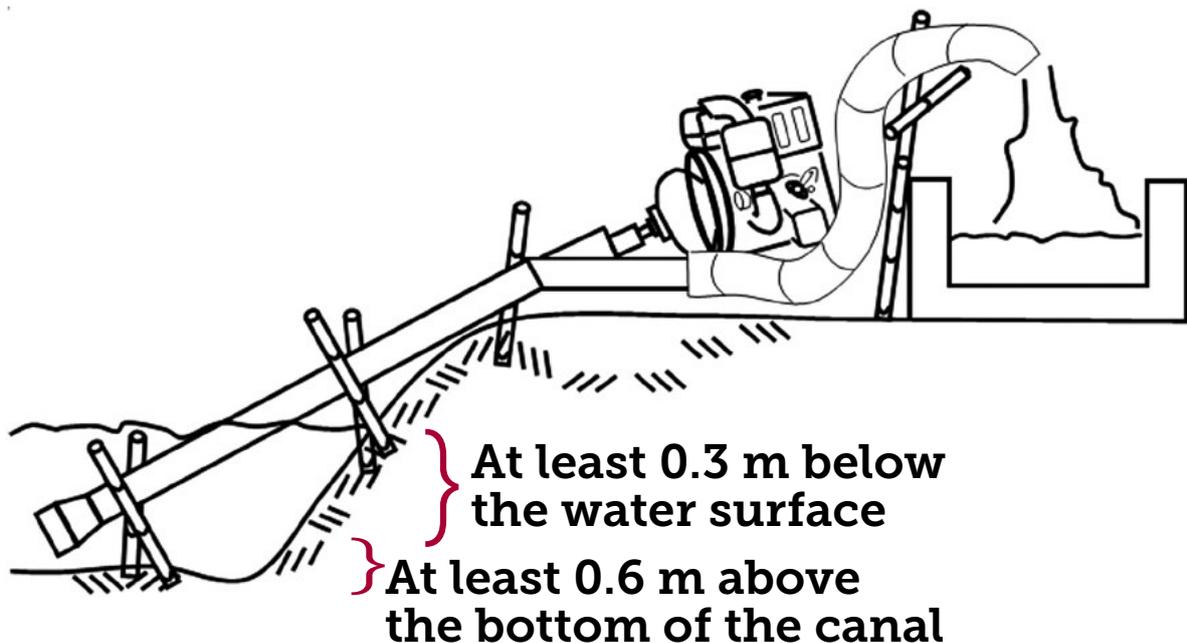
- ◆ enough water to keep the axial flow pump from running dry
- ◆ in some coastal areas, where there is still freshwater in canals, pump during high tide
- ◆ the water must be deep enough to allow an additional 0.6 m between the axial flow pump and the bottom of the river, canal or pond

5. Distance of the pump from where the water needs to be

A flexible hosepipe is a cheap and easy way to reach longer distances when moving water from a canal to farmers' fields

Setting up an axial flow pump

The outlet of the pump should be parallel to the ground. The inlet needs to be at least 0.3 m below the water surface and at least 0.6 m above the bottom of the river, pond or canal.



Safe operation is essential! (1)

- ◆ The AFP/MFP can be a dangerous machine – it is important to stay safe when using it.
- ◆ Wear tight clothing when operating one of these pumps. Loose clothing can become tangled in the moving parts of the machine, causing injury or even death.

UNSAFE OPERATION



Never wear loose fitting clothing around agricultural machinery!
Never work without shoes!

SAFE OPERATION



YES!

Safe operation is essential! (2)

NEVER use the axial or mixed flow around children – they can easily be hurt by the machine.



NEVER use the AFP/MFP around children: they can easily be hurt by it



Safe operation of the axial and mixed flow pumps: essential points to consider (1)

- ◆ Check that important parts (e.g., bolts, nuts, clamp) are tight.
 - ◆ Check for any holes in the pump body and repair.
- ◆ Check the bearings and bushings are greased.
 - ◆ Clean the strainer of the pump of any foreign materials.
- ◆ Check oil and fuel levels in the engine.
 - ◆ Check the belts for any cracks or damage.
- ◆ Check the tightness of the pulley.

Safe operation of the axial and mixed flow pumps: essential points to consider (2)

- ◆ Set up the belts.
- ◆ Make sure both belts are correctly aligned to ensure they do not twist when the pump is in use. To do this, you may need to elevate one side of the engine to obtain correct parallel alignment.
 - ◆ Make sure the pump is not touching the bottom of the canal, pond or river, and that it is not above the surface of the water.
- ◆ Check both the engine and the pump are securely attached to the ground so they do not move when in use.
 - ◆ Select the correct rpm of the engine and pump.
- ◆ Check the delivery hose is properly attached.



Review of key messages (1)

- ◆ **The AFPs currently available in South Asia should be used only with non-saline water. For saline water, plastic or stainless steel bodies are needed, which are available in Southeast Asia, but not yet in South Asia.**
 - ◆ **Saline water corrodes and destroys most metal AFPs/MFPs. In the future, pumps suitable for saline water will become available.**
- ◆ **To achieve high fuel efficiency, the selected canal or river should not have water lifts of much more than 3 m in height.**

Review of key messages (2)

- ◆ **Tests of prototype AFP/MFPs at the Bangladesh Agricultural Research Institute showed that at a 1-m lift, the AFP is 51% more fuel efficient (water delivered to fuel used ratio) than centrifugal pumps. At a 2-m lift, it is 21%. At 3-m, the AFP continues to lift more water, but uses more fuel than a centrifugal pump. This means that although a lift height above 3 m delivers more water, it may not be as profitable because more fuel may be needed.**
- ◆ **Use bamboo sticks placed into banks of the river, canal or pond to provide support to the pump body and the end that houses the impeller. The impeller should never touch the bottom of the pond, canal or river where the pump is being used.**



Review of key messages (3)

- ◆ Set up the impeller end of the pump at least 0.60 m above from bottom of the water source (river, pond or canal) and 0.30 m below the water surface. This will avoid creating a whirlpool in the water that will reduce pump efficiency.
 - ◆ Make sure the pulley and engine are correctly aligned (i.e., in a straight line).
- ◆ Wear tight clothing while operating an axial/mixed flow pump (do not wear loose clothing, as it can become stuck in the pump and can injure users).

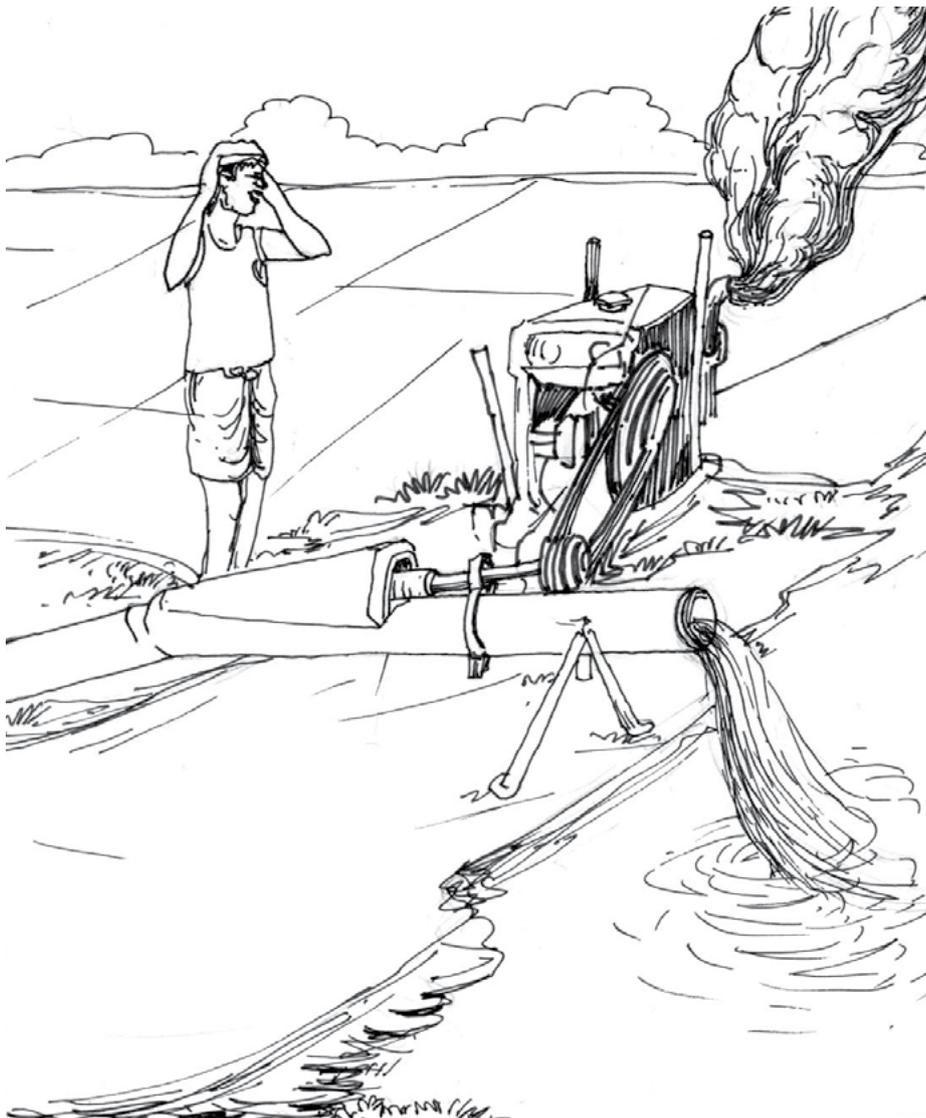
Review of key messages (4)

- ◆ Check important parts/points: nuts, bolts, clamps, holes in the body, greasing points (bearings and bushings), cracks/damage in the belt, oil-fuel in the engine, and tightness of the pulley, before starting the pump.
 - ◆ Keep hands away from all rotating parts, such as the engine, impeller, belt and pulley.
- ◆ Keep children away from the pump when it is in use.

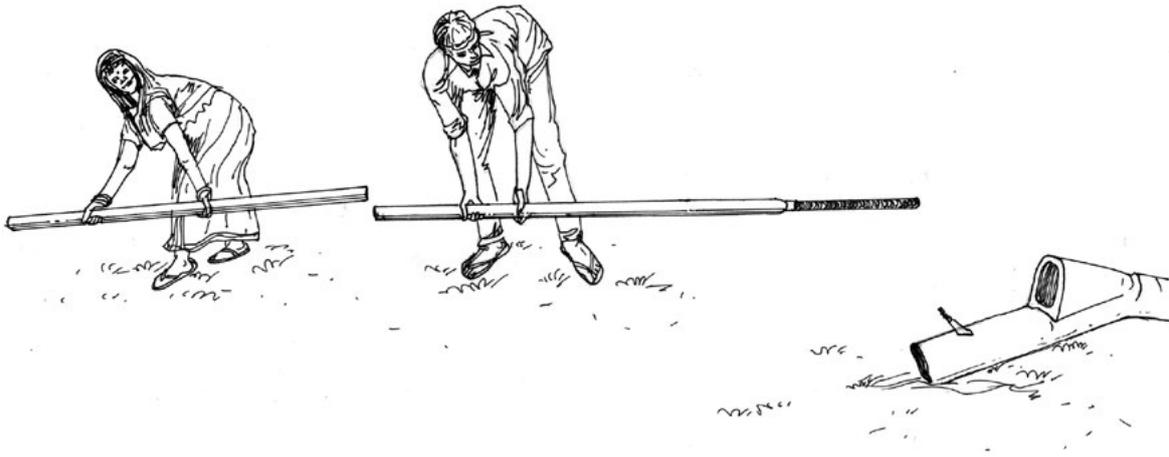
Session 5

Troubleshooting and maintenance

**Axial and mixed flow pump
one-day training flipchart**



Problem 1: The pump shaft bends or breaks (1)



Symptoms:

Abnormal sounds from the pump and/or no water discharge

Causes:

(1) over-running the pump, (2) excessively high water lift height, or (3) faulty shaft

Effects:

Complete pump failure (AFP/MFP cannot be used)



Problem 1: The pump shaft bends or breaks (2)

Solutions:

(1) straighten the shaft, or (2) weld the broken shaft, or (3) if necessary, replace

Spare part required:

Shaft

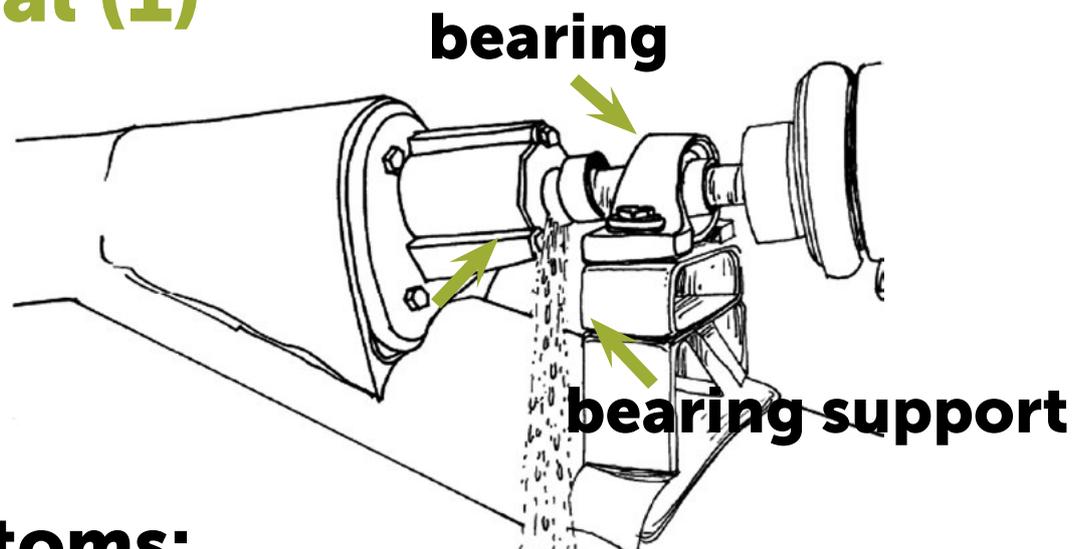
Where to get or make/repair spare part:

Obtain a new shaft from a dealer or make one using a new pipe

Tools required:

Dual wrench, adjustable wrench, screwdriver, hammer puller

Problem 2: Water leakage during pumping due to faulty oil seal (1)



Symptoms:

Water leakage from the base of oil seal

Causes:

(1) tearing or loosening of the oil seal, (2) loosening of nuts and bolts, (3) bent shaft

Effects:

(1) water gets into the bearing and causes bearing damage, (2) reduced water discharge/efficiency, (3) increased fuel cost



Problem 2: Water leakage during pumping due to faulty oil seal (2)

Solution(s):

- (1) straighten the shaft,**
- (2) replace oil seal,**
- (3) tighten nuts and bolts,**
- (4) replace bearing support,**
- (5) replace faulty bearings**

Spare parts required:

Oil seal, bearings

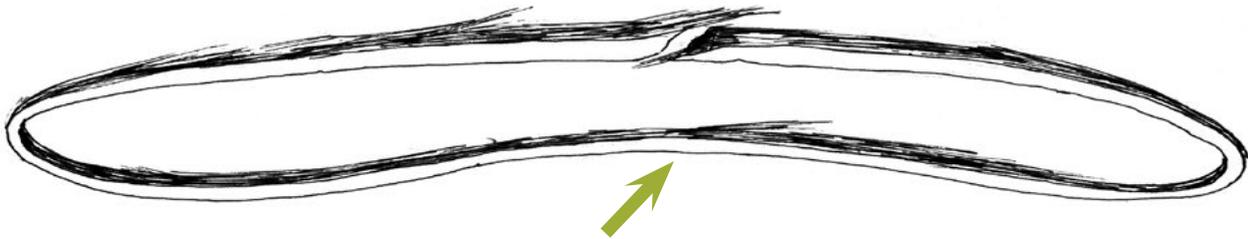
Where to get spare parts:

At a shop dealing in pump/engine spare parts

Tools required:

Dual wrench, adjustable wrench, screwdriver

Problem 3: The transmission V-belt rips (1)



Symptoms:

The V-belt connecting the engine to the pump cracks or tears

Causes:

(1) misalignment of the engine and pump and pulleys, (2) engine speed too high, (3) pump pulley close to the engine, (4) rough surface of the pulley, (5) old belts

Effects:

(1) belt slippage, (2) reduced discharge, (3) increased cost, (4) pump failure



Problem 3: The transmission V-belt rips (2)

Solution:

(1) align the pulley properly in a straight line with the pump,
(2) replace belt (full set), (3) use large belt if water level is too low,
(4) file the pulley until smooth

Spare part required:
V-belt

Where to get spare part:
At a shop dealing in pump/engine spare parts

Tools required:
File or sand/glass paper

Problem 4: The pump impeller breaks (1)



Symptoms:

Low discharge of water, abnormal vibration of the pump, lack of water flow

Cause:

Foreign objects or dirt are sucked into the pump, breaking the blades or causing their disruption

Effects:

(1) reduced discharge due to partial break of blade(s), (2) zero discharge due to complete break of blade(s)



Problem 4: The pump impeller breaks (2)

Solution:

(1) repair the blade(s), and/or (2) replace the impeller

Spare parts required:

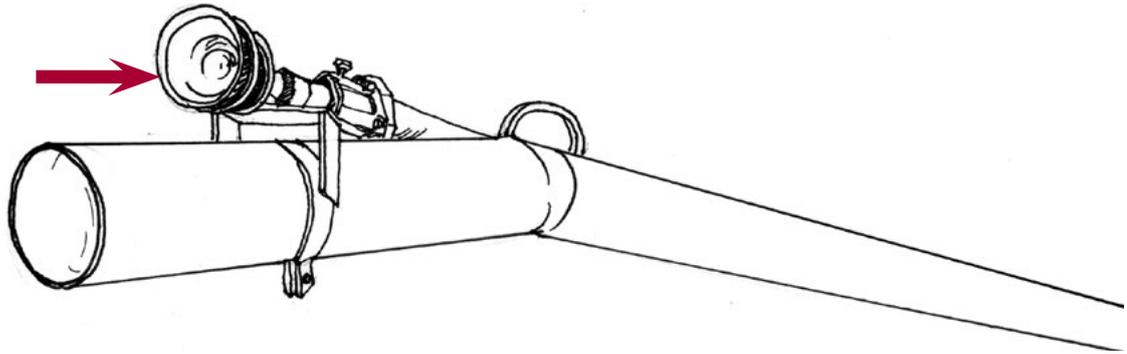
Impeller

Where to get or make/repair spare parts: Purchase a new impeller from a dealer, or have the blade(s) repaired at a local workshop

Tools required:

Dual wrench, adjustable wrench

Problem 5: The pump pulley wears out (1)



Symptoms:

Can be felt by touching the pulley – it will be out of shape or show gouges

Causes:

(1) loose V-belt, (2) rough surface of pulley

Effects:

The V-belt tears

Solution:

Replace the V-belt, or (if the pulley has deteriorated severely) replace the pulley



Problem 5: The pump pulley wears out (2)

Spare parts required:

A new V-belt or a new pulley

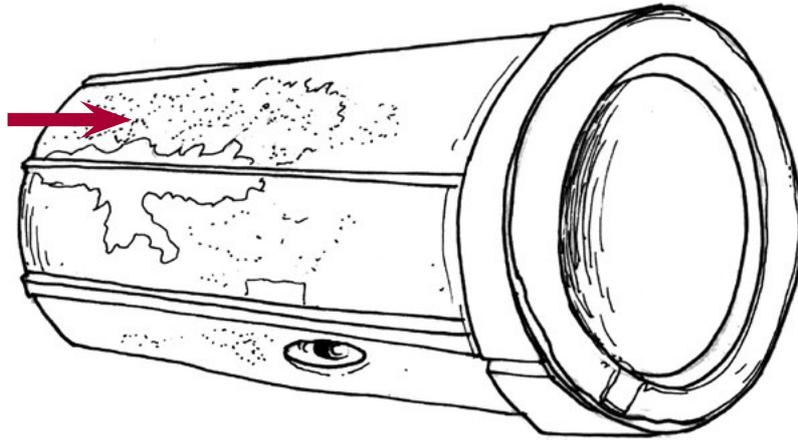
Where to get spare parts:

At a shop dealing in pump/engine spare parts

Tools required:

A file, sand paper or glass paper, wrenches

Problem 6: Damage to shaft bushing due to deposition of sand in the pump (1)



Symptoms:

Excessive vibration of the pump,
faulty shaft

Causes:

(1) the impeller is too close (less than 0.6 m) to the bottom of the canal, pond or river, (2) the pump is running in muddy or sandy water

Effects:

The shaft bends and/or breaks,
the bushing rips

Problem 6: Damage to shaft bushing due to deposition of sand in the pump (2)

Solutions:

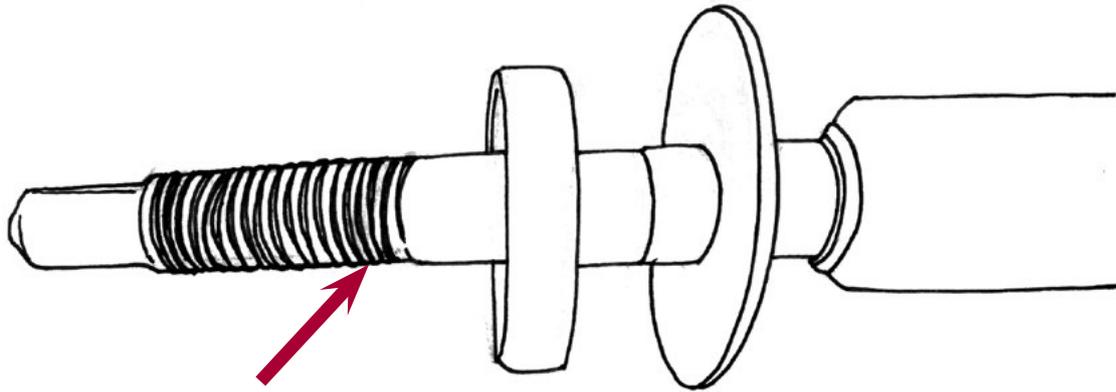
(1) Make sure the impeller is at least 0.2 m (or never less than 0.3 m) above the bottom of the water body being pumped, (2) do not run the pump in muddy or sandy water

Spare part required:
Bushing

Where to get or make/repair spare parts: Purchase new bushing from a dealer or have it repaired/a new one made at a local workshop

Tools required:
Dual wrench, adjustable wrench

Problem 7: Shaft bearing(s) fail (1)



Symptoms:

Noise, overheating bearing(s)

Causes:

(1) misalignment of the shaft, (2) old bearing(s)

Effects:

(1) power loss, (2) reduced discharge

Solution:

Replace faulty bearing(s)



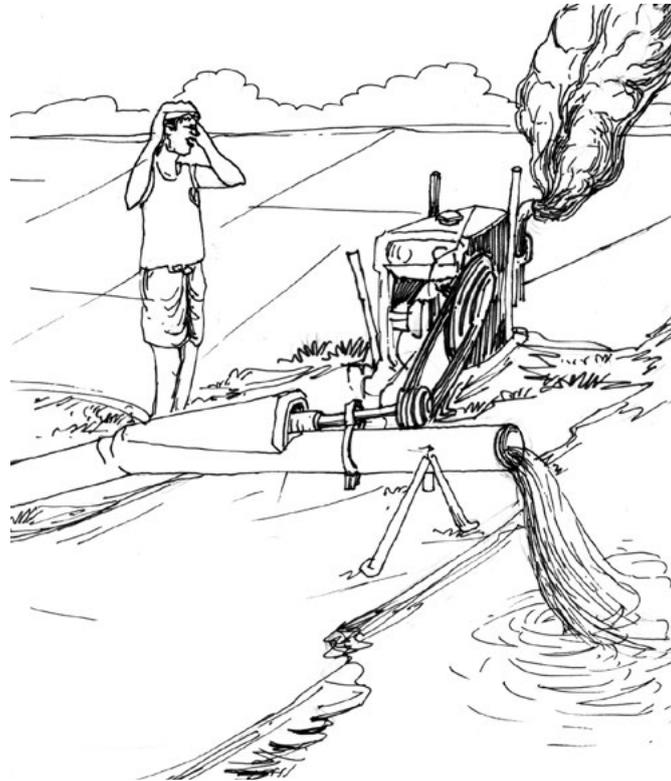
Problem 7: Shaft bearing(s) fail (2)

Spare parts required:
Bearing(s)

Where to get spare parts:
At a shop dealing with pump/engine
spare parts

Tools required:
dual wrench, adjustable wrench,
screwdriver, hammer, puller
and chisel

Problem 8: Too much black smoke in the exhaust (1)



Symptom:

Black smoke comes from the engine during operation

Causes:

- (1) engine speed is too high,**
- (2) water lift height is too high,**
- (3) engine size/horse power is too small for the AFP/MFP being used,**
- (4) engine is old or overloaded**



Problem 8: Too much black smoke in the exhaust (1)

Effect:

Damage can be caused to the engine

Solution:

(1) reduce engine speed, (2) select correct engine or pump, (3) pump water within the suggested range of water lift heights

Maintenance and storage of the AFP/MFP (1)

Every day:

- ◆ **Before starting the machine, move the shaft by hand to check that bearing and bushing are in good working conditions.**
- ◆ **Open inlet cover and check by pulling or pushing the impeller from one side to another to make sure there is no excess movement between shaft and bushing.**
- ◆ **If there is excess movement between shaft and bushing, replace them.**



Maintenance and storage of the AFP/MFP (2)

Every day:

- ◆ Do not run the pump without water. Other than grease, water also helps to keep the impeller and central bushing system cool.
- ◆ Cover the pump inlet with a fishing net so that floating dirt materials are unable to get into the pump inlet.
- ◆ Apply grease to each greasing point.

Maintenance and storage of the AFP/MFP (3)

Every day:

- ◆ Check whether the grease pot and grease nipple on the impeller, shaft bushing and pulley bearing are in good conditions, as they are often damaged during transportation.
- ◆ Check the inlet screen daily or at one-hour intervals and clean.
- ◆ To ensure maximum pump capacity, check for any cracks or damage on the screen and impeller whenever the machine stops.



Maintenance and storage of the AFP/MFP (4)

Long-term storage:

- ◆ **The pump should be kept carefully so that it does not rust by touching the ground.**
- ◆ **It is better to keep the pump above the roof or hanging from the roof beam.**
- ◆ **The open ends of the pump should be kept covered so that children cannot put hard materials inside the pump.**

Session 6

Starting an AFP/MFP service business

**Axial and mixed flow pump
one-day training flipchart**





What do we mean by a 'business'?

Most farmers who buy an axial or mixed flow pump use it to provide irrigation or pump water to other farmers growing crops or managing fish and shrimp ponds.

A business is the activity of making, buying or selling goods or providing a service in exchange for money or other goods and services. Any activity or occupation run by an individual or group to obtain a profit and satisfy customer needs is a business – this includes businesses run by farmers!

Common types of businesses include:

- ◆ manufacturing
- ◆ trading
- ◆ a store – such as one selling agricultural inputs to farmers
- ◆ farming
- ◆ providing agricultural machinery services to farmers

What is a business plan?

A business plan is a marketing and sales strategy, which includes possible profits and losses. It helps the person running the business predict whether it is going to be a success, and helps him/her plan for the busy and not-so-busy times of year. An AFP/MFP business plan should consider the following questions:

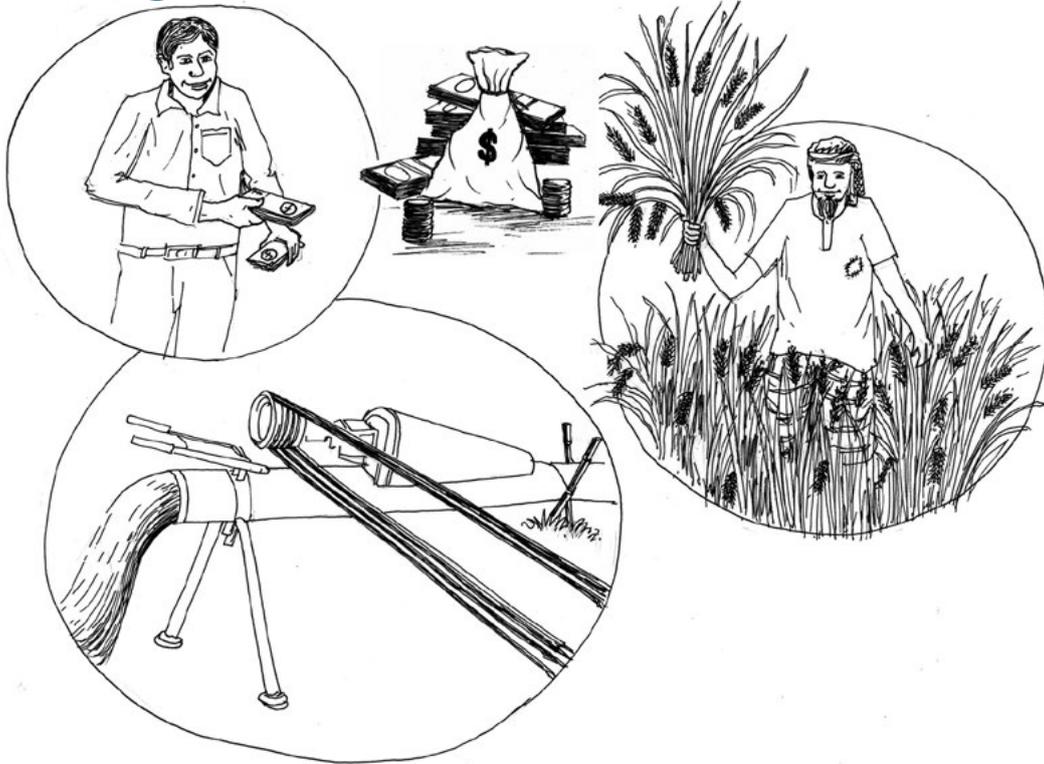
- ◆ Where there is a market for AFP/MFP services? Where will farmers pay for irrigation with an AFP/MFP?**
- ◆ What crops or enterprises are best suited for an AFP/MFP?**
- ◆ What is the demand for an AFP/MFP service in my area? Other areas?**



What is a business plan? (continued)

- ◆ **What is my capacity to provide an AFP/MFP service?**
- ◆ **What machinery and equipment do I need to start up and run an AFP/MFP service?**
- ◆ **How can I afford to buy an AFP/MFP?**
- ◆ **What profits will I obtain from my future AFP/MFP business service?**
- ◆ **How can I get as many farmer-clients as possible to pay for using the AFP/MFP, so I can maximize my profits?**
- ◆ **Would it help to combine the use of the AFP/MFP with other machinery services, for example, bed planting or the PTOS? What about self-propelled multi-crop reapers?**

Service provider experience sharing



Do you know any successful service providers who use an AFP or MFP? Ask them some questions!

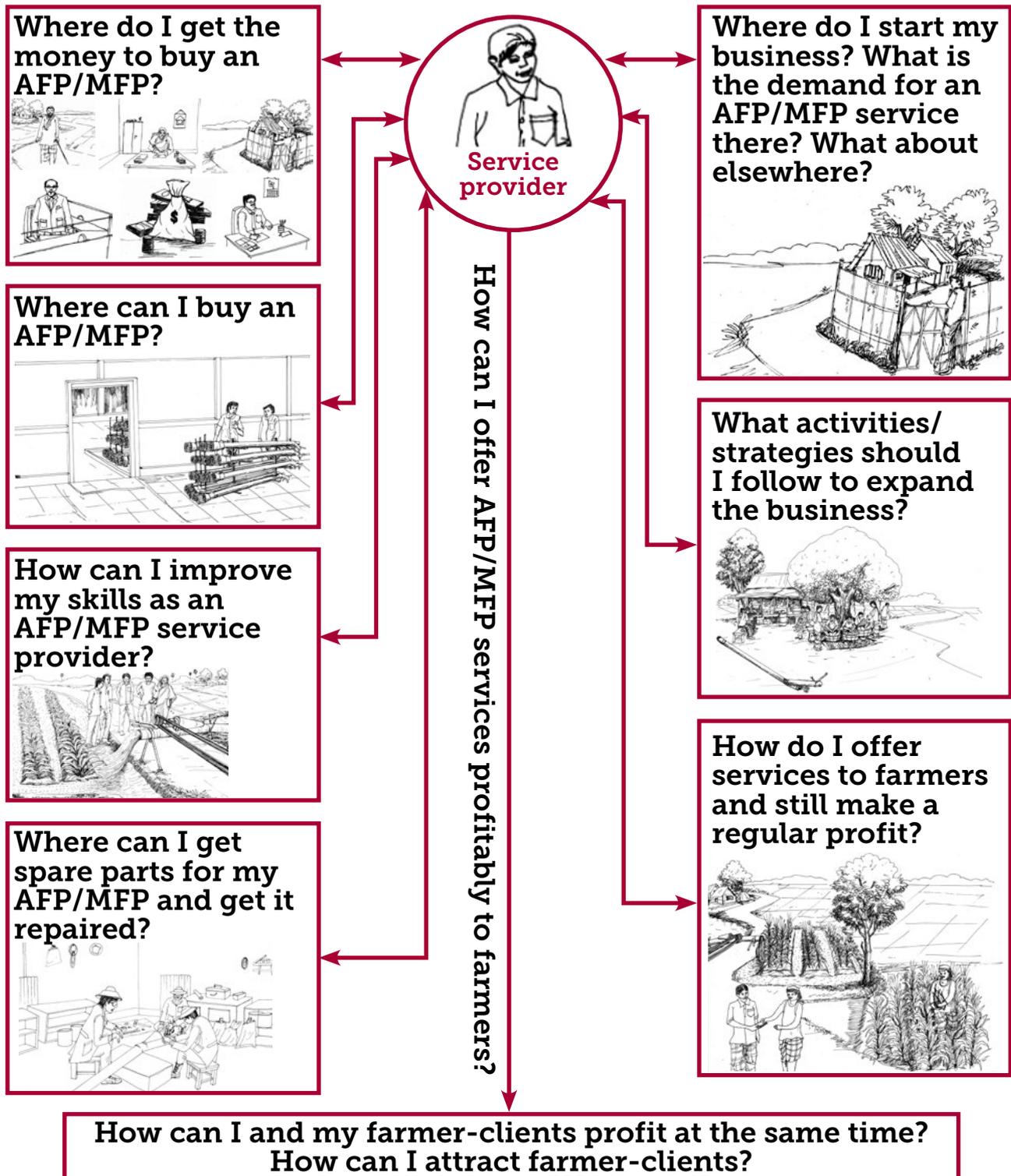
- ◆ **Why did they start an AFP/MFP business?**
- ◆ **How did they start up their business?**
- ◆ **What are the costs and benefits of an AFP business?**



Service provider experience sharing (continued)

- ◆ **How long did it take them to break even (make a profit that is equal to the cost of an AFP/MFP) on the cost of buying an AFP/MFP, or when do they expect to break even?**
- ◆ **What activities make their AFP/MFP business profitable? What makes it not profitable, and what would they advise avoiding?**
- ◆ **Do they face any challenges when using the AFP/MFP?**
- ◆ **What benefits are their farmer-clients getting from the AFP/MFP business?**

Questions to ask before becoming an AFP/MFP service provider (group exercise)



To attract farmer-clients to your AFP/MFP business, it is important to advertise the benefits of the AFP/MFP to farmers in your own and nearby villages



**Remember the benefits of
an AFP/MFP?**

- ◆ **For low lifting (to a height less than 3 m), fuel consumption of AFP is significantly (21–50%) lower than that of a traditional centrifugal pump, saving money for irrigation service providers.**
- ◆ **These fuel savings mean that it is possible to lower irrigation and water pumping prices for farmers – so they benefit too.**
- ◆ **More farmers can be served to make even more money.**



AFP or MFP Cost-Benefit Analysis (group exercise)

Centrifugal pump	Axial or mixed flow pump			
<p>A- Irrigation cost for maize: Area = Oil-fuel cost = Canal making cost in fields= ----- Total=</p>	<p>B- Capital cost AFP/MFP cost = Cost of an engine (new buyers only) =</p>	<p>C- Maize Oil-fuel cost = Cost of canal-making (labor) =</p>	<p>D- Maize (Opportunity cost of service provider's labor) =</p>	<p>E- Maize AFP/MFP service charge to farmer for irrigation =</p>
	<p>F- Service provider's profit (maize) = $E - (C + D) =$</p>	<p>G- Farmer's savings (maize) = $(A - E) =$</p>		
<p>H- Irrigation cost for dry season boro rice: Area = Oil-fuel cost = Canal making cost in fields= ----- Total=</p>	<p>I- Boro rice Oil-fuel cost = Cost of canal-making (labor) $K - (I + J) =$</p>	<p>J- Boro rice (Opportunity cost of service provider's labor) =</p>	<p>K- Boro rice AFP/MFP service charge to farmer for irrigation = $(M - K) =$</p>	
	<p>L- Service provider's profit (dry season boro rice) =</p>	<p>M- Farmer's savings (dry season boro rice) =</p>		
<p>N- Irrigation cost for other crops: Area = Oil-fuel cost = Canal making cost in fields= ----- Total=</p>	<p>O- Other crops Oil-fuel cost = Cost for canal-making (labor) =</p>	<p>P- Other crops (opportunity cost of service provider's labor) =</p>	<p>Q- Other crops AFP/MFP service charge to farmer for irrigation =</p>	
	<p>R- Service provider's profit (Other crops) $Q - (O + P) =$</p>	<p>S- Farmer's savings (Other crops) = $(N - Q) =$</p>		
<p>W- To break even: Time (year) required $= \frac{B}{(AG + AH + AI)}$</p>	<p>T- Area you can irrigate in 1 day Maize (AA) = Boro rice (AB) = Other crops (AC) =</p>	<p>U- No. of days you can irrigate in 1 year Maize (AD) = Boro rice (AE) = Other crops (AF) =</p>		
<p>V – Service provider's yearly profit</p> <p>Maize: $AG = [AA \times AD \times (E - C + D)]$ Dry season rice: $AH = [AB \times AE \times (K - (I + J))]$ Other crops: $AI = [AC \times AF \times (Q - (O + P))]$</p>				
<p>X- 1 bigha = 0.33 decimal/acre = 0.134 hectare</p>				



Review of key messages (1)

After learning about AFP and MFP business plans, can you answer the following questions?

- ◆ Where is the market for an irrigation service business?**
- ◆ What is the market demand for an irrigation service?**
- ◆ What is my capacity to provide an irrigation service?**
- ◆ What machinery and equipment do I need to start an AFP/MFP business?**

Review of key messages (2)

- ◆ What does it mean to 'break even' on an investment?
- ◆ What profit can I hope to obtain from my proposed AFP/MFP business?
- ◆ Which crops are likely to be the most profitable to irrigate with an AFP/MFP – or is it best to service farmers with fish or shrimp ponds?
- ◆ How much time do I need to break even?

Session 7

Review of key messages, post-training evaluation and close of training

**Axial and mixed flow pump
one-day training flipchart**

Review of key messages, post-training evaluation and close of training (1)

- ◆ What are the significant differences between the axial flow pump, the mixed flow pump and the centrifugal pump?
- ◆ What are the advantages of an axial or mixed flow pump over a traditional centrifugal pump?
- ◆ In which environments (in terms of saline or non-saline water) and at what water lift heights can the axial or mixed flow pump be used profitably?
- ◆ What are the main functional parts of an AFP/MFP?
- ◆ What are the important considerations for starting and safely operating an AFP/MFP?



Review of key messages, post-training evaluation and close of training (2)

- ◆ **What are the main causes of failure or breakdown of the AFP/MFP? What are their solutions?**
- ◆ **What do we mean by a 'business'?**
- ◆ **How long does it take to break even after buying an AFP/MFP and starting a business providing irrigation services to farmers?**
- ◆ **How can you make an AFP/MFP service profitable, while benefiting farmers at the same time?**
- ◆ **Why is financial record-keeping important?**

Annexes

Annex 1

Evaluation questionnaires and answers

Pre-training evaluation questionnaire

Venue:
(to be completed by the facilitator)

Batch:

Date:

Name: _____

Please check (√) or circle the correct answer **Total time: 10 minutes**

Question	Answer		
1. In which year was the AFP introduced into Southeast Asia?	1955	1960	1970
2. Why are both the AFP and the MFP called propeller pumps?	Because the impeller works much like a boat propeller	Because the impeller works much like an airplane propeller	Because the impeller works much like a car propeller
3. What kind of tractor is needed to run an AFP?	4-wheeled tractor	2-wheeled tractor	Both types of tractor
4. What is the function of an impeller?	Drives the impeller, which pushes water up the pump	Blocks dirt and other stray materials from getting into the pump from the canal, pond or river that the water is pumped from	Pumps/pushes water upward through the pipe or conduit
5. What is the function of a bushing?	Holds the impeller and shaft in place	Drives the shaft that rotates the impeller (powered by an engine)	Straightens the water after it is transferred by the impeller into the conduit pipe
6. What is the fuel consumption of the AFP/MFP compared to that of a centrifugal pump?	High	Low	Very high
7. What should you consider when setting the inlet of the pump in the water?	The inlet needs to be at least 0.1 m below the water surface and at least 0.4 m above the bottom of the river, pond or canal	The inlet needs to be at least 0.2 m below the water surface and at least 0.5 m above the bottom of the river, pond or canal	The inlet needs to be at least 0.3 m below the water surface and at least 0.6 m above the bottom of the river, pond or canal
8. What are the causes of water leaking during pumping due to a faulty oil seal?	-tearing or loosening of the oil seal -loosening of nuts and bolts, -bent shaft	- Water leakage from the base of the oil seal	-water gets into the bearing and causes bearing damage -reduced water discharge/efficiency -increased fuel cost

(Continued on page 94)

(continued from page 93)

Question	Answer		
9. What is the solution, when there is too much black smoke in the exhaust?	black smoke comes from the engine during operation	- reduce engine speed - select correct engine or pump	- engine speed is too high - engine is old or overloaded
10. What are the safety net must necessary of the operator during the operation of bed planter in the field?	Wear tight clothing and shoes	Wear shoes and loose fitting clothing	Wear loose fitting clothing and go barefooted
Overall training feedback from the participants			
Did you understand all the messages delivered by the facilitator(s)?	Yes/No	Partly	Fully
How do you rate the training?	Not very useful	Useful	Very useful
Do you feel confident that you can use the AFP/MFP profitably while also saving money for your farmer-clients?	Yes	Partially	Unsure

Post-training evaluation questionnaire

Venue:
(to be completed by the facilitator)

Batch:

Date:

Name: _____

Please check (✓) or circle the correct answer Total time: 10 minutes

Question	Answer		
In which year was the AFP introduced into Southeast Asia?	1955	1960	1970
2. Why are both the AFP and the MFP called propeller pumps?	Because the impeller works much like a boat propeller	Because the impeller works much like an airplane propeller	Because the impeller works much like a car propeller
3. What kind of tractor is needed to run an AFP?	4-wheeled tractor	2-wheeled tractor	Both Both types of tractor
4. What is the function of an impeller?	Drives the impeller, which pushes water up the pump	Blocks dirt and other stray materials from getting into the pump from the canal, pond or river that the water is pumped from	Pumps/pushes water upward through the pipe or conduit
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6. What is the fuel consumption of the AFP/MFP compared to that of a centrifugal pump?	High	Low	Very high
7. What should you consider when setting the inlet of the pump in the water?	The inlet needs to be at least 0.1 m below the water surface and at least 0.4 m above the bottom of the river, pond or canal	The inlet needs to be at least 0.2 m below the water surface and at least 0.5 m above the bottom of the river, pond or canal	The inlet needs to be at least 0.3 m below the water surface and at least 0.6 m above the bottom of the river, pond or canal
8. What are the causes of water leaking during pumping due to a faulty oil seal?	<ul style="list-style-type: none"> - tearing or loosening of the oil seal - loosening of nuts and bolts, - bent shaft 	<ul style="list-style-type: none"> - Water leakage from the base of the oil seal 	<ul style="list-style-type: none"> - water gets into the bearing and causes bearing damage - reduced water discharge/efficiency - increased fuel cost
9. What is the solution, when there is too much black smoke in the exhaust?	black smoke comes from the engine during operation	<ul style="list-style-type: none"> -reduce engine speed -select correct engine or pump 	<ul style="list-style-type: none"> -engine speed is too high -engine is old or overloaded
10. What are the safety net must necessary of the operator during the operation of bed planter in the field?	Wear tight clothing and shoes	Wear shoes and loose fitting clothing	Wear loose fitting clothing and go barefooted
Overall training feedback from the participants			
Did you understand all the messages delivered by the facilitator(s)?	Yes/No	Partly	Fully
How do you rate the training?	Not very useful	Useful	Very useful
Do you feel confident that you can use the AFP/MFP profitably while also saving money for your farmer-clients?	Yes	Partially	Unsure

Answers to questions 1 to 10

- 1. 1960**
- 2. Because the impeller works much like a boat propeller**
- 3. 2-wheeled tractor**
- 4. Pumps/pushes water upward through the pipe or conduit**
- 5. Holds the impeller and shaft in place**
- 6. Low**
- 7. The inlet needs to be at least 0.3 m below the water surface and at least 0.6 m above the bottom of the river, pond or canal**
- 8. Tearing or loosening of the oil seal, loosening of nuts and bolts, bent shaft**
- 9. Reduce engine speed, select correct engine or pump**
- 10. Wear tight clothing and shoes**

Annex 2

Video resources

Several training videos are included in this compendium of experiential learning and modular training resources. We encourage their use as an audiovisual learning aid to improve the quality of training. The appropriate video for a specific module is indicated in each chapter and module. Descriptions of the videos can be found below.

<https://www.youtube.com/watch?v=VnV79S9ROTg>

Annex 3

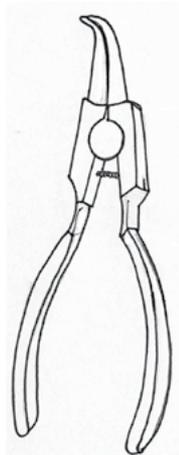
Common tools used to repair the axial and mixed flow pumps (1)



Adjustable wrench: An adjustable tool for gripping hexagonal nuts with an adjusting screw.



Hammer: A hand tool with a heavy head used for striking objects.

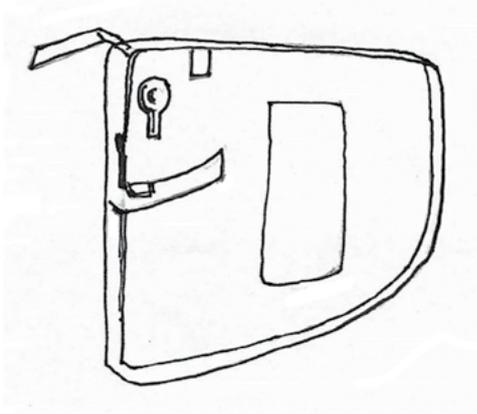


Pliers/cutting pliers: Used to grasp small objects, and to insert/extract or turn them. Pliers often have small cutting blades that can also be used to cut wire or other materials.

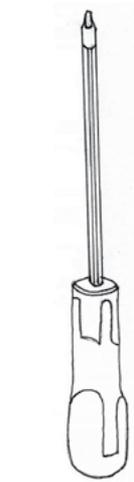


Grease gun: A common workshop and garage tool used to apply lubricant to machinery.

Common tools used to repair axial and mixed flow pumps (2)



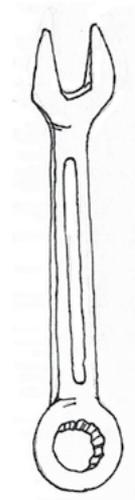
Measuring tape: A flexible scale used as a common measuring tool.



Screwdriver (star/Phillips head): Used to screw in or out screws with a + shape at the head of the screw.



Screwdriver (flat head): used to screw in or out screws with a – shape at the head of the screw.

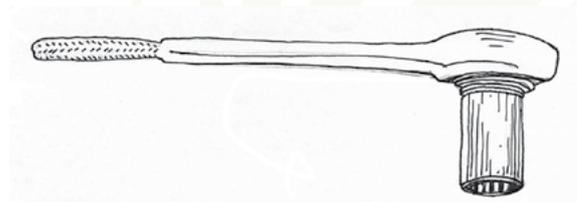


Dull wrench: Used to turn bolt heads to the left or right. This one has two ends, the circular one has the best grip.

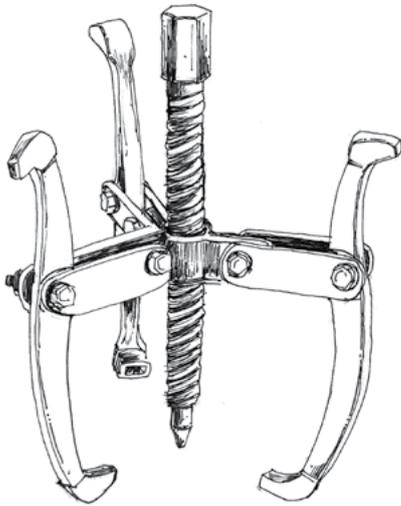
Common tools used to repair axial and mixed flow pumps (3)



L-dull wrench: Used to grip bolt heads. This one has two gripping areas at each end.



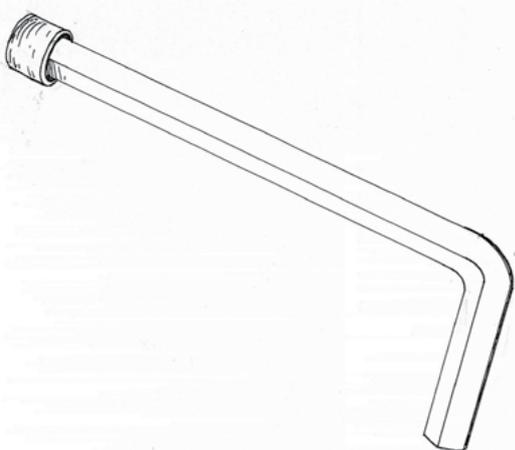
Ratchet: Used to turn the head of a bolt in one direction but not the other. It makes it easy to tighten or loosen bolts without having to take off the tool each time (as with pliers or wrenches).



Three-jaw puller: Useful for removing components such as a gears, pulleys or bearings from a shaft.



Files (flat and round): Used to grind or file different metal parts to the shape required. They can be useful in difficult repair jobs.



Allen key (hex key) wrench set: Used to tighten or loosen bolts that have an 8-sided hex shape at the head of the bolt.



This set of training modules focuses on ensuring that local service providers are able to make repairs to axial flow pumps and mixed flow pumps efficiently and correctly. This booklet is designed so that anybody who uses these materials can easily conduct training – even those with a limited background in and understanding of agricultural engineering or machinery. This training uses an experiential and hands-on modular format. It is based on a foundation of experiential and hands-on work, combined with discussion and reflection among participants.

This means that although the facilitator is instructed on how to carry out the training and how to present the materials, the format in which this is done should be horizontal and participatory, with room for adaptation and modification.

The technical materials included in this document should therefore be seen as a guide to supplement the in-depth knowledge that the trainee farmers and agricultural machinery service providers already have. By the conclusion of the training module, participant service providers will be well-equipped to repair axial flow pumps and mixed flow pumps as part of their ongoing agricultural machinery service business. Nonetheless, users of this booklet should carefully read all the instructions on how to implement the training effectively in order to ensure the best learning experience possible for the participants.

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