

Operation and Maintenance of rural water supply and sanitation systems

A TRAINING PACKAGE FOR MANAGERS AND PLANNERS

Prepared by
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Contents

Preface	v
Acknowledgements	vi
Part 1: Trainer's guide	1
1. Welcome!	3
2. About the training package	5
3. How to be an effective facilitator	9
4. Getting prepared!	15
5. Evaluation	18
Part 2: Course contents	23
Module 1: Introduction	25
Unit 1: Course introduction	27
Unit 2: Presentations	32
Unit 3: Concepts and trends	35
Unit 4: Linking water, health, sanitation and environmental protection	48
Module 2: Situation analysis	61
Unit 1: Operation and maintenance requirements	63
Unit 2: Analysis of participation	107
Unit 3: Analysis of constraints	110
Unit 4: Analysis of objectives	119
Module 3: Towards sustainable operation and maintenance	125
Unit 1: Linking technology choice with operation and maintenance	127
Unit 2: Institutional set-up	136
Unit 3: Community management	158
Unit 4: Gender awareness	180
Unit 5: Cost recovery	190
Unit 6: Monitoring for effectiveness	214
Unit 7: Working and planning with communities	234
Unit 8: Field visit	264
Module 4: Planning	271
Unit 1: Planning tools	273
Unit 2: Individual assignments	284
Unit 3: Final presentations	287

Preface

The aim of Operation and Maintenance (O&M) programmes, as described in this training package, is to improve the efficiency, effectiveness and sustainability of water supply and sanitation services. Operation and Maintenance activities, which encompass not only technical issues, but also managerial, social, financial and institutional issues, must be directed towards the elimination or reduction of the major constraints which prevent the achievement of sustainability.

This document and the training activities described in it are intended for managers and planners who are concerned with the challenging problem of how to implement effective operation and maintenance of rural water supply and sanitation services in developing countries. In addition to the traditional management aspects of operation and maintenance, this training package highlights the importance of community participation, with a right gender balance, in order to make more efficient use of local human resources for sustainability.

The courses in this training package are based on participatory training methodologies, an important feature of which is to draw on the experiences of all the participants, under the guidance of an experienced facilitator and resource persons. The courses should be adapted to the local situation, and the modules can be modified with additions or deletions according to local needs.

The package is based on material and documentation of global experiences provided by various agencies and institutions in the water supply and sanitation sector. This work was initiated in 1991 at a meeting in Oslo, Norway, which called for an overall effort and the establishment of the Operation and Maintenance Working Group (currently the Operation and Maintenance Network) of the Water Supply and Sanitation Collaborative Council.

We are confident that this document will make an effective and useful contribution to progress in the rural water supply and sanitation sector.

José A. Hueb
Coordinator
Operation and Maintenance Network

Acknowledgements

This training package was first designed in 1991 by Teun Bastemeyer from the IRC International Water and Sanitation Centre, under the guidance and advice of the Operation and Maintenance Working Group of the Water Supply and Sanitation Collaborative Council. Subsequently, François Brikké—with the help of the following staff of IRC: Peter Bury, Christine van Wijk, David Saunders, Jennifer Francis, Jo Smet, Michael Seager, Kathleen Shordt and Ineke van Hooff, and Johnny Rojas of CINARA (Centro Interregional de Abastecimiento y Remoción de Agua) in Colombia—developed it through various stages into the present version.

Professor Harry MacPherson and the staff of the National Directorate of Water of Namibia carried out the first testing of this package in 1993. The staff of ETSHER (Ecole Inter Etats des Techniciens Supérieurs de l'Hydraulique et de l'Équipement Rural) subsequently developed the French version of this course in Burkina Faso, while staff from the Direção Nacional de Águas of Mozambique, together with the Centro de Formação Profissional de Águas y Saneamiento in Maputo, the Swiss Development Cooperation agency, UNICEF, and the Netherlands Embassy in Maputo, helped to develop the Portuguese version. Some elements of the latest version of this package have been tested in Vietnam by the staff of the Centre for Rural Water and Environmental Sanitation in Hanoi and UNICEF.

Members of the Operation and Maintenance Network are thanked for their commitment and contribution to the development of this package, particularly Mr José Hueb, Coordinator of this Network, for his constant support and encouragement. Special thanks are due to Mr Franz Gahwiler from SKAT (Swiss Centre for Development Cooperation in Technology and Management, St Gallen, Switzerland), for his excellent review of this material, which now incorporates most of his comments.

Finally, the World Health Organization supported and promoted the development and use of this training package through the WHO Regional and Country Offices in the world. This has helped to make earlier versions of this document known to the potential beneficiaries through national workshops and training courses.

PART 1

Trainer's guide

1. Welcome!	3
How was this training package prepared?	
Why “management” of operation and maintenance?	
What is the structure of the package?	
2. About the training package	5
What are the objectives?—What is the target group and its size?—What is the duration of the course?—What are the expected outputs?—What is the course methodology?	
What is in the training package?—Proposed time-table	
What are the course contents?	
3. How to be an effective facilitator	9
Profile—Role of the facilitator—Communication	
Facilitating discussions—The use of exercises—Overview of the training tools which can be used by a facilitator	
Role-playing—Brainstorming—Visualization	
Trouble-shooting—Conflict resolution	
4. Getting prepared!	15
Organization—Course contents—Getting started for the session—Leisure and recreation—Some references on participatory training	
5. Evaluation	18
Evaluation form	

1. Welcome!

How was this Training Package prepared?

In response to the shortcomings of the International Drinking Water Supply and Sanitation Decade of the 1980s, a training package was designed in 1991 by a group of sector experts from the Operation and Maintenance Working Group of the Water Supply and Sanitation Collaborative Council. A draft version was developed by the IRC International Water and Sanitation Centre in the Netherlands and tested in 1992 in Namibia. The recommendations resulting from this field-test were then incorporated in the English version, which was subsequently translated into French and Portuguese. The revised version has since been implemented in various countries in Africa and Asia. In 1998 the World Health Organization (WHO) and the IRC decided to update the package.

The present version is therefore the result of seven years of work and experience worldwide. It incorporates recent developments and the latest findings and methodologies, which will help to improve the management of operation and maintenance (O&M) of rural water supply and sanitation services in developing countries.

Why “Management of Operation and Maintenance”?

Operation and Maintenance. These two key words appeared in the answers of many sector professionals and community workers when they were asked about what could be done to improve the performance, efficiency and sustainability of the rural water supply and sanitation services in developing countries. It is well known that O&M has been neglected in the past, or been discussed and introduced only after a project was completed. This neglect or delay in applying proper operation and maintenance has adversely affected the credibility of the investments made, the functioning of the services, the well-being of rural populations, and the development of further projects.

However, the importance of O&M has gained considerable visibility over the past few years, and it appears that policy-makers and project designers are now more conscious of the direct links between improved O&M practices and the sustainability of water supply and sanitation services. There is also greater recognition of the need to approach these projects in a comprehensive way, emphasizing not only the design and construction but also post-construction activities.

Professionals in the sector are realizing that the implementation of **O&M is not just a technical issue**, but has social, community, gender, financial, institutional, political, managerial and environmental aspects as well. This is why the training package focuses on **management** of operations and maintenance. O&M must be organized and planned at both national and local levels, and should be managed at the community level with appropriate support from the local authorities and the private sector. This package looks into these different issues, with the aim of raising awareness and providing guidelines on O&M to project planners, programme managers and community specialists on how to improve the performance, efficiency, and sustainability of their rural water supply and sanitation services.

What is the structure of the package?

The training package is designed as a **guide to facilitators** who will conduct courses or workshops on management of operation and maintenance of rural water supply and sanitation services for working-level managers, as well as engineers, social workers and planners, and other specialists involved in this sector. The structure of the guide is **flexible**, which permits adaptation to local circumstances—e.g. shortening certain sessions, extending others, or adding locally relevant information. The package is divided into two parts: **1) Trainer's guide, 2) Course contents.**

The *Trainer's guide* provides guidelines and hints on how best to facilitate the course sessions. Adult training calls for more than teaching; it should make use of the participants' own experiences in a constructive way in order to effectively transmit basic relevant knowledge and experience. It was therefore considered pertinent to advise trainers and facilitators on how to conduct sessions that would give optimum benefits to the participants. Facilitation is an art, and you are invited to contact the sponsors and authors of this package, or other sector professionals, if your project or organization needs further advice on training-of-trainers sessions.

The *Course contents* focus on the main issues which are relevant today to improve O&M performance—such as the links between water, health, sanitation, and environmental protection; requirements and choice of technologies for operation and maintenance; institutional set-up; community management, including gender awareness and working and planning with communities; cost recovery; and monitoring for effectiveness. The contents demonstrate the use of various managerial techniques, such as analysing participation and constraints, identifying the objectives, setting up a planning matrix and indicators, planning with communities, and presenting a project. Experience has shown that the quality of the course improves if it includes working towards a concrete outcome, supported by awareness-raising which goes on throughout the course. At the end of the course, the participants are asked to prepare an individual assignment based on their experience and situation, and applying the concepts and approaches learned during the course.

We extend a cordial welcome to all who will use this training package. You may contact WHO or IRC, at the addresses given below, if you have any queries or need further information.

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2. About the training package

What are the objectives?

The general objective of the course in this training package is to improve water supply and sanitation programmes and projects by enhancing their ability to sustain adequate O&M activities.

The specific objectives are as follows:

- to update knowledge on the operation and maintenance aspects of rural water supply and sanitation programmes and projects;
- to reinforce management skills with regard to sustainable operation and maintenance;
- to specify approaches for better working and planning with communities;
- to develop the capacity to plan for operation and maintenance in one's own working environment through individual assignments.

What is the target group and its size?

This training package is designed for working-level managers including **engineers, planners, and development and social workers** who are involved in the development and management of water and sanitation projects.

The ideal number of participants, which permits intensive exchange of experiences, is **12 to 15**, but could go up to 20 if the course is guided by experienced trainers and facilitators. Larger groups will need a team of at least two facilitators, because the work will have to be divided frequently into two groups, some presentations and lectures being given to the whole group and participatory exercises to smaller groups. The course includes the preparation of an assignment, individually or by the group, which will require individual and team coaching; the larger the group, the more assistance is required.

What is the duration of the course?

The course is designed for a minimum duration of 80 hours of classes, plus a field visit of one day which is strongly recommended. This is feasible within a period of **two weeks**, including time for any adaptations required by local circumstances and demand.

However, the course duration also depends on the participants' professional level and responsibilities. For example, high-level managers and directors may not be able to afford more than a week away from their normal duties. While the cost per participant increases if the course lasts longer, it can gain in quality if the participants are given more time to reflect on key issues and to prepare their individual assignments.

What are the expected outputs?

Experience has shown that the participants benefit most from a course if they work to produce a result, i.e. they work towards a defined product. Participants are therefore expected to carry out an **individual or group assignment** at the end of the course, based on their own situation and on what they learned during the course.

What is the course methodology?

The course in this package makes use of **participatory learning** methodologies, as far as possible, but also includes background information and overhead sheets for lectures and presentations.

When learning, people remember 20% of what they hear, 40% of what they hear and see, and 80% of what they discover by themselves. This calls for a change in the way of teaching, from typical lecturing to a more participatory approach.

The participatory approach to training is based on the concept that professionals learn more effectively when they are presented with activities which take into account their knowledge and experience and which meet their needs. By **being involved** in this process, both individuals and the group gain a new awareness of their potential, develop greater self-confidence, and see new possibilities. They also become more critically aware of the reasons that underlie their perceptions, attitudes and actions.

The training also proposes the use of a video film, “Prescription for Health”, produced by IDRC¹ from Canada, which can be bought or hired through any Canadian Embassy or High Commission, or by sending an order to the National Film Board of Canada.

What is in the training package?

The training package is divided into two parts:

1. Trainer’s guide
2. Course contents.

The first part includes a welcome note and basic information about the training package. It provides guidelines on how to be an effective facilitator, as well as advice on the preparation of course sessions and the field visit and on evaluation of the course.

The second part is divided into four modules which are subdivided into units, each one linked to a particular theme. The first module is an introduction to concepts and trends, and integration of water, health, sanitation and environmental protection. The second proposes an analysis of the present situation of O&M. The third deals with the main factors which can lead to effective O&M. And the fourth module gives practical guidance on how to plan for effective O&M.

The course follows a **logical sequence of progressive learning**, through raising awareness in Module 1; situation analysis in Module 2; learning in Module 3; and application of tools and knowledge in Module 4.

Each unit is organized in the same way, according to the following format:

<p>1. Outline of session</p> <ul style="list-style-type: none"> ■ Objectives ■ Methodology ■ Materials ■ Handouts 	<p>2. Notes for the facilitator</p> <ul style="list-style-type: none"> ■ Detailed review of each step of the session, with exercises 	<p>3. Overhead sheets</p> <ul style="list-style-type: none"> ■ Proposed text for transparencies to be used during a session 	<p>4. Background information</p> <ul style="list-style-type: none"> ■ Summary of new concepts ■ Content material for presentations ■ References for further reading
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¹ IDRC, P.O. Box 8500, Ottawa ONK1G 3H9, Canada. Tel: +1 (613) 236 6163; e-mail: info@idrc.ca

Proposed time-table

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Session A	Introduction	O&M requirements	Analysis of constraints	Community management	Monitoring for effectiveness
Session B	Presentations	O&M requirements	Analysis of objectives	Community management	Monitoring for effectiveness
Session C	Concepts and trends	Analysis of participation	Linking technology choice with O&M	Cost recovery	Gender awareness
Session D	Linking water, health, sanitation and environmental protection	Analysis of constraints	Institutional set-up	Cost recovery	Preparation of field trip
	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>	

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday
Session A	Field trip	Working with communities	Individual assignments	Preparation of presentations	Presentations
Session B	Field trip	Working with communities	Individual assignments	Preparation of presentations	Presentations
Session C	Lessons learnt from field trip	Planning tools	Individual assignments	Presentations	Evaluation Closing
Session D	Lessons learnt from field trip	Planning tools	Individual assignments	Presentations	
	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>		

Each session is planned to last about two hours, depending on local circumstances and demand. The structure of the course is flexible enough to allow modifications and adaptations. For example, the one-week course in Vietnam turned out to be more of an awareness-raising workshop than a course. While in Burkina Faso, the course was implemented for a period of three weeks, which permitted a longer field study and gave more time for individual assignments.

What are the course contents?

Module 1: Introduction

- Unit 1: Course introduction
- Unit 2: Presentations
- Unit 3: Concepts and trends
- Unit 4: Linking water, health, sanitation and environmental protection

Module 2: Situation analysis

- Unit 1: O&M requirements
- Unit 2: Analysis of participation
- Unit 3: Analysis of constraints
- Unit 4: Analysis of objectives

Module 3: Towards sustainable O&M

Unit 1: Linking technology choice with O&M

Unit 2: Institutional set-up

Unit 3: Community management

Unit 4: Gender awareness

Unit 5: Cost recovery

Unit 6: Monitoring for effectiveness

Unit 7: Working and planning with communities

Unit 8: Field visit

Module 4: Planning

Unit 1: Planning tools

Unit 2: Individual assignments

Unit 3: Final presentations

3. How to be an effective facilitator ¹

Profile

The facilitator should be a professional (resource person or trainer) who is **acquainted with participatory training methodologies**. This is because the course is based on using facilitation techniques rather than “conventional” teaching techniques, although the latter (such as lectures and presentations) are not excluded.

If the facilitator is going to be involved through the whole course, he/she should preferably be knowledgeable about **new developments** in the water and sanitation sector.

It is advisable to have a **team of facilitators** rather than just one because many of the activities require the participants to work in small groups. It is sometimes necessary and useful to have a facilitator to work with each small group, as well as to coach each participant during the individual assignments.

Role of the facilitator

In the conventional teaching methodology, the teacher presents a set of concepts and provides students with exercises for assimilation—in a “top-down” approach. In the participatory approach to training, the role of the facilitator is to facilitate the process of learning, using his/her own experiences and those of the participants in order to raise awareness or transmit knowledge on a particular subject—in a “**sharing**” approach.

Facilitation works best when certain values are accepted and practised not only by the facilitator, but also by the entire group—values such as **democracy** (each person has the opportunity to participate without prejudice), **responsibility** (each person is responsible for his/her experiences and behaviour), and **cooperation** (the facilitator and participants work together to achieve the same collective goal).

As a facilitator, you can influence the group dynamics and discussions by how you present your information, what kind of atmosphere you set within the group, and your attitudes towards the people you are working with.

Many participants will be unfamiliar with facilitation as a leadership style. You should make sure everyone in the group understands what your role is. Your own attitude towards your skills and resources should be a humble one. Demonstrate to the participants that their opinions count, by respecting their ideas as if they were your own.

Communication

Communication is the essential ingredient of any group. Your effectiveness as a facilitator depends on your ability to communicate well with the group and to help the group members to communicate effectively with each other. Some factors will enable you to communicate better, such as:

¹ This section contains extracts from *A manual for group facilitators*, by Brian Auvine et al., published by the Center for Conflict Resolution, 731 State Street, Madison, Wisconsin 53703, USA.

- **Your language** (making sure that the terms you use are easily understood by the group)
- **Your style** (the way you dress and interact with others)
- **The way you listen** (when someone is talking, you are often not really listening but thinking about what you are going to say in answer; therefore, when you listen to someone, try not to immediately evaluate what is being said in terms of how it affects you; instead, try to understand what it means from the other person's perspective)
- **Being aware of what is happening in the group** (restlessness, silence, attention, postures)
- **Giving feedback** (after an exercise, a discussion, or a session, it helps the group to be made aware of the progress made).

Facilitating discussions

Your role as a facilitator in a discussion is also important. Here are some hints which could enhance your work in facilitating discussions:

1. Everyone should know exactly **what the discussion is about**, and what is the reason for having it.
2. **Use questions** to stimulate discussion. The following provocative "open" questions enable the facilitator to encourage a group to find ideas in a creative way: "What is similar? What can be changed? Why? How? Who? When? By which means?". Avoid "closed" questions requiring "yes" or "no" answers, which are unsuitable for group discussions.
3. **Prepare questions in advance.**
4. Relate the discussion to the **participant's experience** (it is difficult for people to feel involved in a discussion which is highly abstract or beyond their own experience; give examples from field experiences).
5. **List ideas on a board** as they are proposed, and regroup or summarize them.
6. Clarify and interpret (you may sometimes rephrase what has been said to make it clearer).
7. **Keep the discussion focused on the subject** (your role may include reminding the group when the discussion strays off the subject or goes into matters not in the agenda that was agreed on at the beginning).
8. **Keep track of time** (it may be your role to make the group aware of how the discussion is proceeding and when it may be time to move on).
9. **Use humour** to break tension and boredom.

The use of exercises

Exercises are group activities, usually designed to aid learning and awareness. Exercises can be used to illustrate a concept or demonstrate a specific point, to promote self-awareness, to stimulate thought and discussion, or to train participants in a certain skill.

Select exercises that fit the group and its goals, and be sure you know why you are using a particular exercise. **Be familiar with the exercise** by previewing it before you use it; indeed, you should know what it will accomplish and how that happens. Do not present participants with a battery of exercises, all designed to make much the same point.

Giving instructions is a very important part of using exercises. The way you introduce an exercise can make a big difference to the group's understanding; you should include an explanation of the objectives, a description of what exactly the participants are supposed to do, and an estimation of how much time the exercise will take.

You should also know **your own role during the exercise**. Are you going to participate, or simply observe, or remove yourself entirely from the scene? At the end of the exercise, it is important for the participants and you to **reflect on the results** and how they relate to the participants' own day-to-day situation.

Overview of training tools which can be used by a facilitator¹

The various tools described in the Table below are training techniques which are most commonly found in adult learning sessions. This course will use most of the techniques described, and it is recommended that facilitators should be familiar with a new technique before using it. Some reference documents are listed at the end of this section.

TRAINING TOOLS	REMARKS
<p>► Group discussion/Conversation A discussion is a free exchange of knowledge, ideas and opinions on a particular subject. A conversation will be more structured and prepared in advance.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to introduce a subject; a structured conversation helps to focus thinking. ■ <i>Advantages:</i> group involvement; starts the thinking process. ■ <i>Disadvantages:</i> risk of unfocused discussions and no change in ideas; time shortage; needs preparation.
<p>► Brainstorming The facilitator or an assistant writes down all the contributions on a board. Quality and substance are evaluated by the group afterwards.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> common method to help group members to think of possible changes or give new orientations. ■ <i>Advantages:</i> stimulates creativity, expands imagination. ■ <i>Disadvantages:</i> answers cannot always be implemented; effort needed can be greater than expected.
<p>► Feedback Informing people what they did in a certain exercise, or role-play or other action in order to let them know how things can be improved</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> for creating awareness on participant's skills and performance. ■ <i>Advantages:</i> participants become eager to learn. ■ <i>Disadvantages:</i> possible distrust without good feedback.
<p>► Lecture An internally consistent, rationally clear presentation, adapted to a specific audience by using visual images, verbal illustrations and other tools.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> for transfer of model, concept or framework. ■ <i>Advantages:</i> opportunity for transfer of knowledge within a short space of time. ■ <i>Disadvantages:</i> monologue; requires good preparation in order to keep attention.
<p>► Demonstration Letting participants go through an event that illustrates the theme of a session. Participants are asked to participate and at the same time observe what is happening.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> start of a session on a topic which needs sensitization or awareness-raising. ■ <i>Advantages:</i> effective way to raise awareness in a short period of time. ■ <i>Disadvantages:</i> can easily fail, if not adapted to the group.
<p>► Field visit Participants are taken out into a real life situation and get the opportunity to observe some elements linked to the course.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to show real life situation. ■ <i>Advantages:</i> helps to clarify concepts and reach a common understanding; excellent for group dynamics. ■ <i>Disadvantages:</i> takes much work and time to organize.
<p>► Reading assignments During the course, participants are asked to read relevant information.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> Creates opportunity to digest written material; can be given for evening reading. ■ <i>Advantages:</i> easy way to cover some material. ■ <i>Disadvantages:</i> slows down dynamics if done in class; participants' understanding may have to be checked.
<p>► Case study A history or example, with relevant details, is examined by the participants. They have to identify the problems and alternative solutions.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to practise analytical skills and reflect on a situation as a group. ■ <i>Advantages:</i> good learning experience when successful; group reaches a common understanding. ■ <i>Disadvantages:</i> difficult to choose or design an appropriate case study; needs preparation, time and experience.

¹ Adapted from *Training of trainers: methods for experiential learning*, by F. Little & J. van de Geer, P.O. Box 4040, 6803 EA Arnhem, Netherlands.

TRAINING TOOLS	REMARKS
<p>► Games Participants are presented with information and rules about a particular situation, and the group tries to go through a simulation of this situation.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to practise and simulate a given situation. ■ <i>Advantages:</i> fun, dynamic. ■ <i>Disadvantages:</i> careful preparation needed with good and clear instructions; unsure outcome; risk of having participants not taking it seriously.
<p>► Exercises Participants are asked to undertake a particular task, following lines laid down by the facilitator, in order to practise skills or test one's knowledge.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to teach complex skills or concepts. ■ <i>Advantages:</i> creates confidence; very practical. ■ <i>Disadvantages:</i> must be realistic, relevant and motivating.
<p>► Role-play Participants assume an identity other than their own to cope with real or hypothetical problems and situations.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to demonstrate or practise a situation which the participants are likely to face. ■ <i>Advantages:</i> strong participation and surprising outcomes. ■ <i>Disadvantages:</i> hiding behind role description; needs "actors" focusing on the subject required.
<p>► Small workshops Participants gather in small groups and come to a conclusion by brainstorming, identifying problems and formulating recommendations.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> to help the group to take decisions or make plans and formulate recommendations at the end of a major event. ■ <i>Advantages:</i> shared vision. ■ <i>Disadvantages:</i> experience needed in using tools and in facilitating.
<p>► Individual assignment Participants are asked to examine in depth their own situation, and to apply what they have learned in an action plan.</p>	<ul style="list-style-type: none"> ■ <i>Optimal use:</i> integrates learning within one's own situation. ■ <i>Advantages:</i> participants analyse their situation and prepare for their return. ■ <i>Disadvantages:</i> takes time and requires coaching.

Role-playing¹

Role-playing is a training technique in which the participants assume an identity other than their own, in order to experience and deal with a real or hypothetical situation or problem. It can be employed in almost any training context, e.g. to broaden a primarily teaching-oriented design.

In playing their roles, the participants **act out behaviour patterns** which they believe are characteristic of those roles in specific social situations. For example, during the course, a role-playing sequence is proposed between two actors, "an engineer" and "a community member", in order to illustrate the process of resistance to change.

This way of simulating reality eliminates many of the risks inherent in real life, while retaining many other aspects of the interaction which are relevant. Role-playing thus permits testing out different ways of behaviour in a given situation.

The role-playing session should start with the facilitator **briefing all participants**—first outlining the situation which is to be acted through role-playing, and then giving a concise description of the characters involved. At the end of the role-playing, the **actors and audience discuss** and draw conclusions from what has taken place.

In planning for a role-playing session, you should discuss with the participants the basic principle of the approach, the problem to be acted, and the message to be conveyed. These points should be kept in mind while **preparing the role-playing with the actors prior to the session**.

¹ Adapted from: *Experience with newer techniques for training managers*, by Sidney Mailick & Nancy A. Bord, published by the United Nations Institute for Training and Research (UNITAR).

Brainstorming¹

Brainstorming produces ideas, explanations and interpretations. In an organized “storming of thoughts”, a small group of participants can put forward many possible suggestions on a precisely formulated theme. The method stimulates intuitive seeking and spontaneous creative associations.

Hints on preparation: the topic must be formulated precisely, with a clear statement on who is to participate and the time available. For the actual brainstorming there are some definite rules: no discussion, but note every idea without criticizing, and encourage the development of combinations and associations of ideas. Indeed, no one has a monopoly of good ideas. The contributed suggestions are written on cards and put up on a poster or board, then grouped, analysed and evaluated by a small panel. Some sort of classification is useful, such as “immediately feasible” or “needs more development”.

Visualization

The visualization method uses written cards which are pasted or pinned on posters, pinboards or other surfaces in a specific order. This facilitates a clear structuring of the meeting, discussions, and workshops and the recording of statements in a concise and visible way. Concentration and attention are improved considerably and even shy participants are able to take part actively. Visualization makes the discussion more objective and even enhances the preceding steps. Evaluation and prioritizing of options are much easier when using a visible presentation.

Trouble-shooting

When there is not enough time to do what you had planned. This is the most common problem you are likely to encounter. When your agenda will not fit into the time you have, get the group to assign probable time limits to each section remaining, while prioritizing items on the agenda. Ask one person in the group to be responsible for keeping track of time, and to remind the group when the time limit is close or has been reached. When it is apparent that there is definitely not enough time, discuss alternatives with the group—such as prolonging the meeting, scheduling a later one, etc. Avoid forcing the pace in a limited time, or “stuffing” the participants with all that remains to be covered, or else the session could rapidly deteriorate.

When an exercise flops. The first thing to do is to admit it, point out where your expectations let you down, and find out the reactions of others. You should discuss what could have happened and, in this way, learn a valuable lesson. After this, prepare to switch to something completely different, which will focus everyone’s attention on another subject.

Your session and material are too simple or too complex for the group. If what you are saying is too simple for the group, boredom will result. If what you are saying is too complex, you can expect confusion and blank looks. Unfortunately, blank looks and boredom look remarkably alike, so it is not always easy to figure out which of these you are dealing with. Here are some points which will help you to be alert to the group’s level of comprehension: a) before starting an exercise, ask the participants if they have done anything similar; b) begin a session by asking for an account of the group’s previous experience; c) pause regularly to put questions to the group; d) avoid using “jargon” or technical terms without prior explanation; and e) consider carefully the questions put by the participants because these usually indicate whether they have understood or not.

¹ From: *Cooperation planning—A working aid for beginners and for more experienced planners*, published in 1993 by Swiss Development Cooperation, Evaluation Service, CH 3003 Berne, Switzerland.

Conflict resolution

Conflicts can arise in any group. They should first be treated as **something natural**, and sometimes even useful, because they can force a group to become more aware of the way the group works and thus encourage change and growth. However, conflicts can be destructive, hurt people's feelings, and destroy efforts to reach a common goal, as well as inhibit full participation within the group.

There are many points to consider in seeking solutions to a conflict. The main one is to try to **sort out real disagreements from perceptual disagreements**. Some disagreements could result from a wrong perception of a situation. In this case, clarification and information can help. However, many conflicts are the result of poor communication or misunderstandings about goals and expectations.

Once you have identified a conflict and understood its nature, you will be in a better position to decide what kind of behaviour is appropriate to adopt. If the conflict is serious, **stay calm** and trust your intuition. You may want to intervene as a facilitator, but before attempting to do this, **consider your options carefully**. Beware of your own biases and weaknesses, and be sure that you are not going to overreact. Consider whether the problem can be dealt with by proposing a break (and discussing it later in another place privately), or by exercising restraint and being patient (waiting till the difficult moment passes), or by getting help (from someone with experience who is not involved in the conflict). Does the whole group appear to perceive the problem? During a crisis, people's feelings are especially important. So, allow them to express their feelings, but do not get emotionally involved.

4. Getting prepared!

Organization

A certain amount of preparatory work is required and should begin preferably **six months in advance**, e.g. fixing the dates of the course. This will allow those involved to fit these dates into their work schedule and plans. In setting the dates, account has to be taken of public and religious holidays and important meetings or events which the participants will have to attend.

Secretarial support greatly facilitates the organization of the course. All information and correspondence about the planning, implementation and evaluation of the course should be filed in an orderly manner. During the course, the secretary will be required to make administrative arrangements and contacts, make photocopies, and word-process the work produced by the participants and the facilitator. A record of the work produced throughout the course should be made and kept.

The accommodation should include 1) a large meeting room for the plenary sessions, 2) separate rooms for the working groups, and 3) a place for serving refreshments, as well as lunches, during breaks. Make sure that the meeting room is available for the duration of the whole course and is not noisy, and has adequate ventilation and light, sufficient power points for a video and overhead projector, and enough space on the walls to stick up paper sheets or posters.

All **teaching aids, equipment and stationery** should be ordered well in advance of the course. They will include a) a white or black board; b) sufficient marker pens for white boards, to be used by the facilitator and participants; c) a flip-chart stand and paper; d) masking tape (removable) for sticking cards or paper on a wall; e) large pieces of carton paper (different colours), which can be made into cards by cutting them to the size required; f) an overhead projector with transparencies; g) a screen or white wall for projection; h) a video recorder and monitor; i) access to a photocopy machine; j) note pads, pencils and pens; and k) a pinboard, paper and pins.

A certificate of attendance should be prepared in advance, signed by the relevant authorities or sponsors of the course, which is given to all participants who complete the course.

An invitation should be sent to prospective participants through the appropriate channels of your organization. The invitation should include clear statements on the course's objectives, structure and duration, the importance of full-time attendance, arrangements for accommodating and transporting the participants, insurance and medical coverage, costs, and per diem (if available). The invitation should include a form to be filled in and returned containing information on personal data and education, curriculum vitae, present function and job description, and expectations from the course, as well as a request for financial sponsorship if available.

The **field visit**, which is part of the course, gives the participants an opportunity to look at the operation and maintenance arrangements in a particular community or situation. To be successful the visit has to be planned in advance, so that the local authority and community are given the date and time of arrival as well as details of the programme. Arrangements for transport and food and drink should also be made. The exact pro-

gramme will depend on the distance to be travelled and the local community's size and willingness to be involved in the field visit. If the course group is large, it will have to be divided to make it easier for the participants and the community.

It is suggested that the best time for the field visit is **in the morning**. Many activities associated with rural water supply take place very early in the morning—e.g. the women may traditionally collect water before or at sunrise, and operators will open the valves, start the pumps, and dose the tanks with chlorine, etc. at the start of the day in order to provide sufficient water for early collections. The next peak period for water collection may be in the late afternoon or early evening, which is too late for a field visit. Special arrangements may have to be made to ensure the group's arrival early in the morning at the selected site, and the participants should be ready to make an early start.

For further details about the field visit, see Unit 8 of Module 3, page 264.

Course contents

Facilitators should be thoroughly familiar with all the material in the learning package. In addition, because of the importance of **adaptation to the local circumstances**, it is proposed that the facilitator researches all relevant themes and includes this information (taken from project reports, technical or policy documents, etc.) in the course.

One or more experts with experience in the subject and in new developments could be listed as **resource persons** and invited to give a lecture or make a presentation during the course. It is important that these persons should be fully briefed about the course's objectives, concepts and main messages. The course unit which corresponds to the presentation should also be sent as a reference or example. These arrangements should be made well in advance.

Some countries may have difficulties in gaining **access to relevant additional information**, and in identifying suitable resource persons. Specialized universities or agencies in your country may be consulted. Or contact WHO or IRC, or other sector organizations and external support agencies (ESA) for further information and assistance in organizing a training-of-trainers course.

Getting started for the session

While **planning for your session**, make sure that you know exactly what you want to accomplish and that all the activities relate to that goal. The material you use should be relevant to the objective of the session and properly understood by the participants. Material should be presented in a logical order. After reviewing all the objectives and contents of the session, determine the time needed for each segment and make your agenda flexible. Plan to introduce variety in the pace and methods used. Every session should start with making introductions, discussing plans, and defining expectations, and end with a synthesis and summary of the session.

Before you begin, spend some time alone by yourself and make sure your agenda is clear in your mind. Seating arrangements are important, and you must decide whether the participants will be seated in a U-shape round a long table or in rows without desks, depending on the exercise to be carried out.

As you enter the room, the first few moments will influence your interaction with the group through your mutual perceptions and impressions. It is important to arrive on time, or even early. Besides setting an example by always being punctual, you will be showing courtesy and respect to the group.

Your introduction should include your credentials (justifying your being there!). This is also an opportunity to present yourself not only as an "expert", but also as a "person" and "facilitator". It may be difficult to remember all the participants' names immedi-

ately, so you can have their names written on stiff paper in front of their places, and they could also carry name labels on the front of their clothing.

The first session each day should **begin with a review** of the previous day's work. This can be done in a relaxed way, with some humour, by asking the participants to recall what they did, and what were the main messages conveyed at that time. The facilitator's role will be to explain the link between the previous topic and the new one.

Leisure and recreation

Some thought should be given to the organization of free time, during which the participants will interact and can contribute to team building. Social evenings and excursions are also particularly important for participants who are away from their families during the course.

Some references on participatory training

- CEDPA (1995). *Training trainers for development: conducting a workshop on participatory training techniques*. Washington, DC, USA, Centre for Development and Population Activities.
- Narayan D, Srinivasan L. (1994). *Participatory development tool kit: training materials for agencies and communities*. Washington, DC, World Bank.
- Servaes J, White SA. eds. (1996). *Participatory communication for social change*. New Delhi, India, Sage Publications.
- Thompson J, Pretty JN, Scoones I, Guijt I. (1995). *A trainer's guide for participatory learning and action*. London, International Institute for Environment and Development.

5. Evaluation

Evaluation should be carried out daily, with a final evaluation at the end of the course.

The object of the daily evaluations is to improve the group process by letting **the participants express how they feel about what is going on**. This is often the only time when some participants will feel comfortable enough to express their ideas. It also makes a good ending to the day's work. However, it is not a compulsory activity which has to be done every day; a good idea is to install a "mood barometer", on which each participant can put a sticker on a scale, expressing his/her feelings about the day. Daily evaluations can help to improve the sessions in the future (with regard to facilitation, exercises, contents), as well as to identify possible points which will need to be reinforced during what is left of the course. The daily evaluation can be carried out through 1) an informal discussion, 2) a focused conversation, or 3) a daily evaluation form.

The **informal discussion** will start with questions which you will pose. This gives you the opportunity to ask for comments and make clarifications. This procedure may not reflect the whole group's views because some participants will be silent. Examples of questions are: "What went well in ...?" "What could be improved?" "What specifically do you think you have gained from today's sessions?" "Were your expectations met today?" "Why?" "Why not?"

The **focused conversation** will start with an exercise in which all participants write two "positive" and two "critical" comments about the day's session in general. Each participant is given two cards for the "positive" comments, and two cards for the "critical" comments (cards should be of different colours, e.g. yellow for "negative" and green for "critical"; only one comment per card). All the cards are then pinned or taped on a board, and grouped by categories as they are submitted. The results are discussed with the whole group, who will be asked to make clarifications and comments. This method allows every participant to express him/herself. As this type of evaluation takes considerable time, it might be used once or twice during the course.

A **daily evaluation form** can be prepared, on which each participant ranks the content, relevance and presentation of each session along a scale from 1 to 5 (1 = poor, 2 = limited, 3 = reasonable, 4 = good, 5 = excellent), or another system of grading. If the facilitator adopts this method, he/she will have to share the results of this evaluation before starting the next morning's session.

A **final evaluation form**, which may be anonymous, is proposed in the next pages to evaluate in detail all the different aspects of the course. The results of this evaluation should be included in the final report of the course.

Evaluation form

Management of operation and maintenance in rural drinking water supply and sanitation

Please mark with a tick, where applicable.

1. What do you think about the overall length of the course?

Far too long Too long Just right Too short Far too short

2. During the course, you worked from Monday till Friday from 9.00 a.m. till 5.00 p.m. What is your opinion about this time schedule?

3. What do you think of the allocation of time for the different components of this course?

	Far too much	Too much	Just right	Too little	Far too little
Lectures					
Exercises					
Discussions					
Individual work					
Leisure					

Additional comments:

4. How would you grade the relevance of the course to your country's needs?

Excellent Good Reasonable Poor Not relevant

Comments:

5. What do you think of the balance between theory and practice?

- Far too much theory Too much theory Just right
 Too much practice Far too much practice

6. How did you find this course in general?

- Too difficult Difficult Just right Easy Too easy

7. Have your expectations, which you had when you applied to join the course, been realized?

- Completely Largely Partly To some degree Not at all

8. To what extent, in your opinion, did this course achieve its objectives?

Objectives	Completely	Largely	Partly	Hardly	Not at all
1. Upgrade knowledge on the O&M aspects of RWS&S					
2. Reinforce management skills with regard to O&M					
3. Specify approaches to working and planning with communities					
4. Develop the capacity to plan for O&M in one's own project					

9. How useful has this course been to the specific requirements of your own job?

- Very useful Useful Of some use Of limited use Not useful

10. Please name any technique or method from this course which you would like to introduce or apply in your own organization.

11. How relevant, on average, were the handouts and reading material provided, most of which you have probably examined?

- Highly relevant Quite relevant Of some relevance Of limited relevance Not relevant

12. In the list below, please give a mark for each topic or session dealt with during the course, with regard to its relevance and quality. Make additional remarks, if necessary.

(1 = poor, 2 = limited, 3 = reasonable, 4 = good, 5 = excellent)

Topic or session	Relevance (from 1 to 5)	Quality (from 1 to 5)	Remarks
Course introduction			
Presentations			
Concepts and trends			
Links between W, H, S, E*			
O&M technical requirements			
Analysis of participation			
Analysis of constraints			
Institutional set-up			
Community management			
Gender awareness			
Cost recovery			
Monitoring for effectiveness			
Working with communities			
Field visit			
Capacity-building			
Setting up objectives			
Planning tools			
Individual assignments			
Final presentations			

* Water, Health, Sanitation and Environment

13. What are the major professional problems in your work, if there are any, which were NOT discussed sufficiently in this training course?

14. What was your experience of working relations with the following:

Main facilitator(s)	Other training staff	Administration	Participants
<input type="checkbox"/> Stimulating	<input type="checkbox"/> Stimulating	<input type="checkbox"/> Stimulating	<input type="checkbox"/> Stimulating
<input type="checkbox"/> Cooperative	<input type="checkbox"/> Cooperative	<input type="checkbox"/> Cooperative	<input type="checkbox"/> Cooperative
<input type="checkbox"/> Neutral	<input type="checkbox"/> Neutral	<input type="checkbox"/> Neutral	<input type="checkbox"/> Neutral
<input type="checkbox"/> Distant	<input type="checkbox"/> Distant	<input type="checkbox"/> Distant	<input type="checkbox"/> Distant
<input type="checkbox"/> Difficult	<input type="checkbox"/> Difficult	<input type="checkbox"/> Difficult	<input type="checkbox"/> Difficult

Comments:

15. How do you rate the internal organization and logistical support during the course?

Excellent Good Reasonable Poor Not applicable

Comments:

16. How satisfied were you with the accommodation (classroom, etc.)?

Very much Much Reasonable Not much Not at all

Comments:

17. Please write down any suggestions for improving this course.

PART 2

Course contents

Module 1: Introduction	25
Unit 1: Course introduction	27
Unit 2: Presentations	32
Unit 3: Concepts and trends	35
Unit 4: Linking water, health, sanitation and environmental protection	48
Module 2: Situation analysis	61
Unit 1: Operation and maintenance requirements	63
Unit 2: Analysis of participation	107
Unit 3: Analysis of constraints	110
Unit 4: Analysis of objectives	119
Module 3: Towards sustainable operation and maintenance	125
Unit 1: Linking technology choice with operation and maintenance	127
Unit 2: Institutional set-up	136
Unit 3: Community management	158
Unit 4: Gender awareness	180
Unit 5: Cost recovery	190
Unit 6: Monitoring for effectiveness	214
Unit 7: Working and planning with communities	234
Unit 8: Field visit	264
Module 4: Planning	271
Unit 1: Planning tools	273
Unit 2: Individual assignments	284
Unit 3: Final presentations	287

MODULE 1

Introduction

Unit 1: Course introduction	27
1. Outline of session	27
2. Notes for the facilitator	27
3. Overhead sheet	29
Unit 2: Presentations	32
1. Outline of session	32
2. Notes for the facilitator	32
3. Exercise sheet	34
Unit 3: Concepts and trends	35
1. Outline of session	35
2. Notes for the facilitator	35
3. Overhead and exercise sheets	38
4. Background information	45
4.1 Operation and maintenance in the context of sustainability	45
4.2 Factors which contribute to sustainability and to effective operation and maintenance	45
4.3 Processes which influence sustainable operation and maintenance	46
Unit 4: Linking water, health, sanitation and environmental protection	48
1. Outline of session	48
2. Notes for the facilitator	48
3. Overhead and exercise sheets	51
4. Background information	55
4.1 Why is behaviour not changed by conventional hygiene education?	55
4.2 What motivates people to improve their hygiene?	55
4.3 Experiences in better water resource management	56

Unit 1: Course introduction

1. Outline of session

► Objectives

- To introduce the participants to one another
- To review the participants' fears and expectations
- To reach a common understanding of the course's objectives and structure

► Methodology

1. Welcome address
2. Exercise for group interaction
3. Group discussion on expectations and fears
4. Interactive presentation on course objectives, methodology and programme

► Materials

- ✓ Transparencies on the course's objectives and programme
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall
- ✓ Stationery for each participant, including note pad, binder, pencil, eraser, pen and marker
- ✓ The binder should contain the following: the course's objectives and programme, full list of participants, and practical information concerning food, lodging, transport, recreation areas, access to telephone, medical help, and contact person for information and emergencies.

► Handouts

- ✓ Information on the place where the course is being held (optional)

2. Notes for the facilitator

Welcome address and introduction

The welcome address can be given by the Director of the Institute where the course is being held, or by a well-known specialist. The facilitator's introduction must clearly state his/her credentials and role, including some personal facts that would interest the participants, and he/she presents the team who will be working with the participants through the whole course. This is followed by an explanation of how the session will proceed, its objectives, and the methodology.

Interactive exercise

One way of making introductions is to ask the participants to pair up and spend a few minutes introducing themselves to each other. The facilitator then goes to each pair and, in turn, one of them will introduce the other, giving his/her name, nationality,

place of residence, education, professional function, and one or two personal facts. In a course where the participants are meeting for the first time, this approach allows everyone to get acquainted with at least one person very quickly, and helps the participants to be relaxed and informal. At the end of this exercise, the participants are asked to write the name by which they would like to be called during the course on a folded sheet of paper, which will be placed in front of their respective places.

Expectations and fears

A group discussion can be started by asking the participants, “What are your expectations from this course?”, or “What did you think you would get out of this course at the time when you registered for it?” If no one volunteers to speak, the facilitator chooses someone with whom to start developing ideas, which are written on the flip chart. If any statement is not expressed clearly, these persons should be helped so that it becomes clear. Once the group’s views have been stated, the facilitator summarizes the participants’ expectations and relates them to the objectives of the course.

The same procedure is followed with regard to anxieties within the group concerning the course’s content, logistics, follow-up, etc., which can be started by asking the participants, “Have you any worries about this course?” Removal of such fears is important and allows the facilitator to get to know the group’s strengths and weaknesses, and to help the participants with any problems or difficulties that may arise.

Course’s objectives, structure, methodology and programme

The facilitator describes the course’s objectives, structure, methodology and programme, using the overhead projector and transparencies (see Part 1, Trainer’s Guide, in the section “About the training package”, page 5). In this process the participants’ expectations, which were discussed earlier (see above), should be related to the programme’s objectives. Time must be set aside for questions and clarifications, so that the objectives will be clear to all and any doubts can be dispelled. However, some of the expectations may not be met, and some concerns may remain. These matters should be discussed with the group, and the facilitator should help to clear up any misunderstandings. Questions on technical matters, e.g. a maintenance plan for diesel engines, could be deferred, if feasible, till the appropriate session during the course. If any concerns still remain, the matter should be referred to the course organizers and administration.

3. Overhead sheets: Sheet 1

Course objectives

General objective

- To contribute to the sustainability of water supply and sanitation programmes and projects in rural areas

Specific objectives

- To update knowledge on O&M issues
- To reinforce management skills on sustainable O&M
- To create specific approaches for better work and planning with communities
- To develop individual assignments based on the lessons learnt and each participant's workplace

Overhead sheet 2

Course outline

Module 1: Introduction

- Unit 1: Course introduction
- Unit 2: Presentations
- Unit 3: Concepts and trends
- Unit 4: Links between water, health, sanitation and environment

Module 2: Situation analysis

- Unit 1: O&M requirements
- Unit 2: Analysis of participation
- Unit 3: Analysis of constraints
- Unit 4: Analysis of objectives

Module 3: Towards sustainable O&M

- Unit 1: Linking technology choice with O&M
- Unit 2: Institutional set-up
- Unit 3: Community management
- Unit 4: Gender awareness
- Unit 5: Cost recovery
- Unit 6: Monitoring for effectiveness
- Unit 7: Working and planning with communities
- Unit 8: Field visit

Module 4: Planning

- Unit 1: Planning tools
- Unit 2: Individual assignments
- Unit 3: Final presentations

Overhead sheet 3

Proposed timetable

Week 1	Monday	Tuesday	Wednesday	Thursday	Friday
Session A	Introduction	O&M requirements	Analysis of constraints	Community management	Monitoring for effectiveness
Session B	Presentations	O&M requirements	Analysis of objectives	Community management	Monitoring for effectiveness
Session C	Concepts and trends	Analysis of participation	Linking technology choice with O&M	Cost recovery	Gender awareness
Session D	Linking water, health, sanitation and environmental protection	Analysis of constraints	Institutional set-up	Cost recovery	Preparation of field trip
	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>

Week 2	Monday	Tuesday	Wednesday	Thursday	Friday
Session A	Field trip	Working with communities	Individual assignments	Preparation of presentations	Presentations
Session B	Field trip	Working with communities	Individual assignments	Preparation of presentations	Presentations
Session C	Lessons learnt from field trip	Planning tools	Individual assignments	Presentations	Evaluation Closing
Session D	Lessons learnt from field trip	Planning tools	Individual assignments	Presentations	
	<i>Daily evaluation</i>	<i>Daily evaluation</i>	<i>Daily evaluation</i>		

Unit 2: Presentations

1. Outline of session

► Objectives

- To enable the participants to present their personal experiences with operation and maintenance

► Methodology

1. Individual or group exercise
2. Presentations by the participants

► Materials

- ✓ Transparencies on the forms to be filled in
- ✓ Flip chart and masking tape
- ✓ Large sheets of paper
- ✓ Overhead projector, screen or white wall

► Handouts

- ✓ Information about operation and maintenance services in the host country
- ✓ Forms for the exercise on initial presentations

2. Notes for the facilitator

The presentations allow the participants to share their personal experiences in different backgrounds with the group, and to give an overview of the problems which they have encountered or are likely to encounter in their professional life. This approach will help the facilitator to plan future sessions, taking into account these problems and the distinctive features of each group.

The facilitator will explain the object of the presentations and distribute a prepared form for each participant to fill in (see exercise sheet, page 34). Participants from the same department, region or project could be asked to join together and prepare a single presentation.

The group is given a maximum of 20 minutes to prepare the presentations. Each presentation is allowed 3 minutes, plus 2 minutes for questions or clarifications. Long discussions are not permitted at this stage since time will be given later during the course.

Each presentation should be written on large sheets, which will be put up on the wall during the presentation. If possible, a secretary should type out the main points and results of the presentations after the session is over, and distribute this information to all the participants.

One problem frequently encountered in this exercise is the tendency to exceed the time allocated. The facilitator must therefore be prepared to warn the participants when their time is nearly over. This responsibility could be shared with one of the participants.

Different presentations often tend to be repetitive as regards the problems or experi-

ences that are described. One way of overcoming this is to organize the presentations by subject, taking all the participants who work on similar projects (e.g. gravity systems, or small piped systems with motorized water lifting, etc.) and grouping them together. Questions will be allowed only after all the participants in the subject area have completed their presentations.

3. Exercise sheet

Form for initial presentations

1. Personal data

Name: _____

Nationality: _____

Location of professional activity: _____

Profession and education: _____

Present function: _____

2. Programme / project

Name of programme / project: _____

Main components of the project (point by point and briefly):

3. Main O&M and management problems

Unit 3: Concepts and trends

1. Outline of session

► Objectives

- To specify the importance of O&M and management
- To analyse O&M in a wider perspective of sustainability. To define the concepts of operation, maintenance and management
- To raise awareness on present trends

► Methodology

1. Introductory note
2. Focused discussion on the importance of O&M
3. Interactive presentation of the factors and process dealing with sustainability
4. Group exercise on definition of concepts
5. Exercise on the attributes of good management
6. Focused discussion on what is rural

► Materials

- ✓ Transparencies on the forms for exercises
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall

► Handouts

- ✓ Forms for exercises
- ✓ Copies of selected parts of background information
- ✓ Copies of all transparencies

2. Notes for the facilitator

Introductory note

The aim of this session is to clarify and define the key concepts around which the course has been designed. It is important for all participants to understand that the issues relating to O&M are not only technical, but also social, managerial, institutional, financial and environmental. Recent advances in water supply and sanitation projects reflect these concepts, which are the result of trials and experiences during the past 20 years. The session will also serve to introduce the group to a participatory teaching methodology, which does not exclude presentations and lectures. It is recommended that the group should be reminded, from time to time during the course, of these concepts which are the cornerstone of the whole approach.

Focused discussion on the importance of O&M

After reminding the participants that their decision to attend this course was because they believed O&M was an important issue in their profession, the facilitator asks them, “Why is O&M important?” The group’s answers to this question are written on the flip chart or board by the facilitator or one of the participants. If an answer is not clear, the facilitator helps this person and, in addition, may ask the participants to illustrate their answers with an example from personal experience in order to improve comprehension. The facilitator should ensure that the following ideas are mentioned and discussed by the group: proper functioning, user’s satisfaction, sustainability, quality of life, health standards, and credibility of investments. After the session, the results of the discussion may be typed out and distributed. The facilitator should not forget to keep track of time.

Interactive presentation of the factors and process dealing with sustainability

In an interactive presentation the facilitator, from time to time during the presentation, poses questions so that the group can interact, e.g. by explaining the situation in their own words or by experiencing or proposing new ideas. The presentation starts by reminding the participants of the close links between operation and maintenance and sustainability. The first message to be conveyed is that sustainability is a process which starts right from the planning stage, and that O&M is not simply what happens after the system has been constructed. The first overhead sheet, representing a graphic of sustainability (see page 38), may now be presented. More details are provided below in the section on background information. The second message deals with the factors that influence sustainability. The facilitator can refer to the second overhead sheet and to the content details under background information (see page 45). Another effective way to help the participants’ comprehension is to explain the drawing with sustainability circles (see page 39), step by step.

Group exercise on definition of concepts

The facilitator asks the group to define the following terms: 1) sustainability, 2) operation, and 3) maintenance. Key words suggested by the participants are then written on the board, and from these a definition is gradually formulated for each term. At this stage, full phrases may not be required for the definitions.

A set of overhead sheets provides definitions for this course (pages 41–43), which are compared with what the participants proposed. Any difficulties in understanding should be discussed until the whole group reaches a consensus.

Exercise on the attributes of good management

Management is one of the key terms in this course. It is therefore important to have a common understanding about what it entails. There are no right or wrong answers, but the objective is to highlight the participants’ perception of management and to compare this with what the course will provide in terms of management tools.

The facilitator divides the participants into three or four groups and gives them an envelope containing labels, each representing a major attribute generally connected with management (see exercise sheet, page 44). Each group must choose five major attributes, which they think are needed for the proper management of projects. Some 15 to 20 minutes are required for this exercise.

Each group puts up their labels on the board and explains briefly (in five minutes) the reasons for their choice. The facilitator then presents the group with a definition of

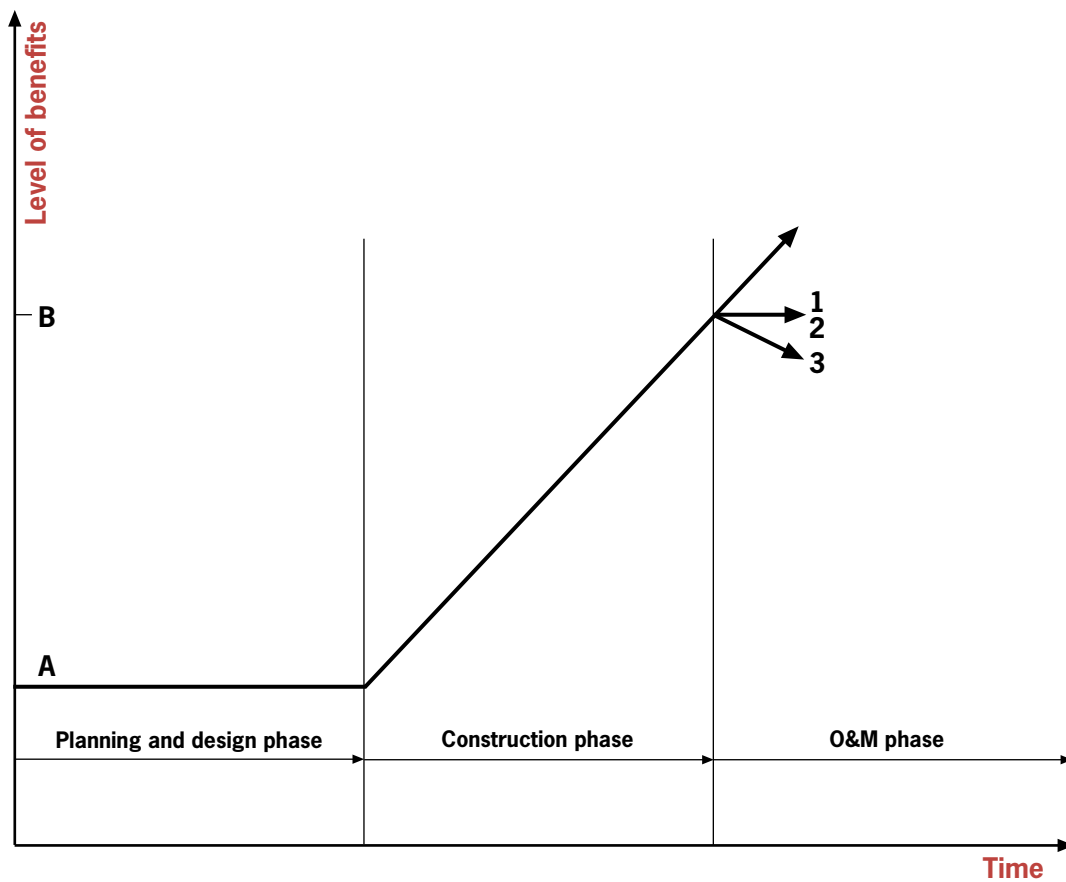
management and highlights some issues on management, which will be worked upon in the course. Time should be set aside for discussion and questions to promote clarification.

Focused discussion on what is rural

To end the session, the facilitator asks the group to reflect on this key term in the title of the course, i.e. what do they understand by “rural”? The participants’ answers may cause some difficulty because countries vary in their rural situations and characteristics. To facilitate consensus it can be proposed that, in the present context, the focus must be on low-cost technologies, including small piped-water supply systems. The aim here is not to give a precise definition of what is rural, but to provide a framework for improving rural water supply and sanitation, and to give an overview of the size and socioeconomic conditions of human settlements in the rural areas. Water supply and sanitation technologies will be reviewed during the session on “O&M requirements” (see Module 2, Unit 1, page 63).

3. Overhead and exercise sheets: Sheet 1

Sustainability in the project phases

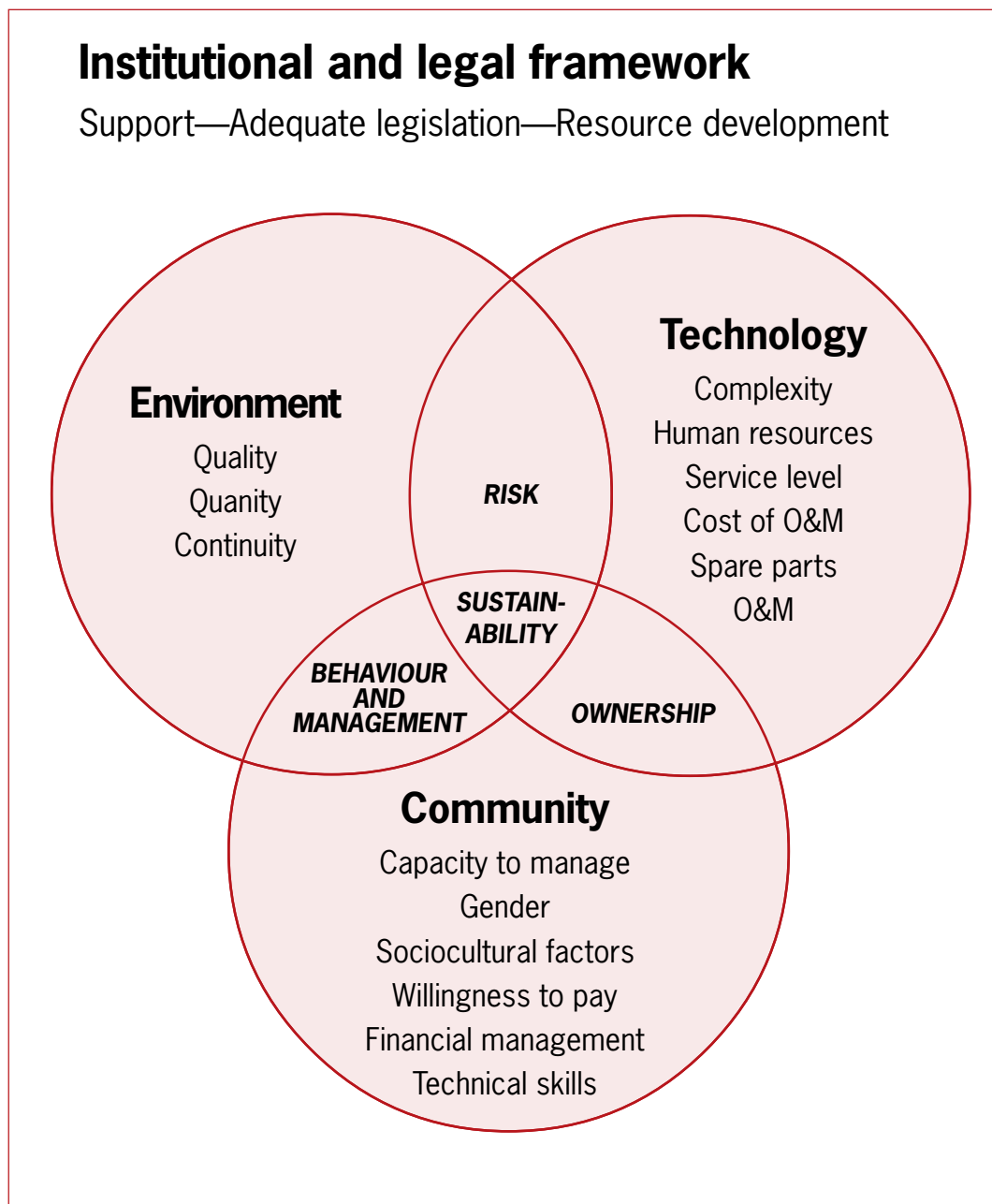


1 & 2: Development reaches sustainability
3: Unsustainable development

- Careful planning and design of O&M must already be completed during the planning and design phase
- Sustainability starts at the planning phase
- What are the factors that influence sustainability?

Overhead sheet 2

Factors which influence sustainability¹



¹ From CINARA-IRC course material: *Gestión para la sostenibilidad en programas de agua potable y saneamiento* (Management of sustainability in drinking-water and sanitation programmes), 1994–98.

Overhead sheet 3

Processes which influence sustainability

- Demand from the community
- Responsiveness from the supporting institutions
- Participation of the community throughout the project phases
- Linking technology choice with operation and maintenance
- Integrated planning (sanitation, water, hygiene, environment)
- Planning with a gender perspective
- Decentralization and transfer of responsibilities and resources
- Capacity-building at all levels
- Communication among stakeholders
- Public-private partnership
- Co-responsibility between communities and municipalities

Overhead sheet 4

Definitions

Sustainability

A service is sustainable when:

- it functions and is being used
- it is able to deliver an appropriate level of benefits (quality, quantity, convenience, comfort, continuity, affordability, efficiency, equity, reliability, health)
- it continues over a prolonged period of time (which goes beyond the life-cycle of the equipment)
- its management is institutionalized (community management, gender perspective, partnership with local authorities, involvement of formal/informal private sector)
- its operation, maintenance, administrative and replacement costs are covered at local level (through user fees, or alternative financial mechanisms)
- it can be operated and maintained at local level with limited but feasible external support (technical assistance, training, monitoring)
- it does not affect the environment negatively.

Overhead sheet 5

Definitions

Operation

Operation deals with the actual running of a service (e.g. provision of fuel, starting or handling of pumps, control of water collection points, general mechanical or water treatment procedures, hygienic handling, etc.).

Maintenance

Maintenance deals with the activities that keep the system in proper working condition, including management, cost recovery, repairs and preventive maintenance.

- **Crisis maintenance:** maintenance undertaken only in response to breakdowns and/or public complaints, leading to poor service level, high O&M costs, faster wear and tear of equipment, and user's dissatisfaction.
- **Preventive maintenance:** maintenance activities undertaken in response to pre-scheduled systematic inspection, repair and replacement, leading to continuity in service level, O&M costs spread over time, extension of life-span of equipment, user's satisfaction and willingness to pay.

Overhead sheet 6

Definitions

Management

Management deals with the control and organization of a service and encompasses the following main functions:

- Development of a vision and strategy
- Planning
- Organization and mobilization of resources
- Administration
- Accounting
- Leadership, motivation of personnel
- Supervision, monitoring and evaluation
- Promotion of external relationships.

This course focuses on the following managerial issues:

- Strategy development
- Planning skills
- Skills in problem-solving
- Integration of technical and social issues
- Communication (efficient presentation technique)
- Monitoring
- Human resource development
- Planning with communities.

Exercise sheet

Management attributes ¹

Prepare in advance an envelope containing the following labels which describe a possible management attribute. Each group will have to choose the five most important attributes for managing O&M (see notes on page 36).

Sense of responsibility

Willingness to
take risks

Skill in problem-solving

Capability to generate
new ideas

Planning with
communities

Promotion of external
relations

Strategy development

Integration:
technical/social

Mobilizing resources

Human resource
development

Skills in planning

Staff supervision

Sense of humour

Communication

Enthusiasm

Monitoring

Initiative

Technical skills

Ability to work in groups

Stimulating leadership

¹ Adapted from: Srinivasan L. *Exercise in tools for community participation—A manual for training trainers in participatory techniques* (PROWESS/UNDP Technical Series). PROWESS/UNDP—World Bank Water and Sanitation Program, New York, 1993.

4. Background information

4.1 Operation and maintenance in the context of sustainability

Sustainability depends to a large extent on effective and efficient operation and maintenance. Many factors and processes that contribute to sustainability have a direct influence on operation and maintenance.

Sustainability can be analysed in time, as shown in the Figure on project phases (see page 38). A service is sustainable when:

a) it is functioning and being used; b) it is able to deliver an appropriate level of benefits (*quality, quantity, convenience, comfort, continuity, affordability, efficiency, equity, reliability, health*); c) it continues over a prolonged period of time (*which goes beyond the life-cycle of the equipment*); d) its management is institutionalized (*community management, gender perspective, partnership with local authorities, involvement of formal/informal private sector*); f) its operation, maintenance, administrative and replacement costs are covered at local level (*through user fees, or alternative financial mechanisms*); g) it can be operated and maintained at local level with limited but feasible external support (*technical assistance, training, monitoring*); and h) it does not affect the environment negatively.

Proper operation and maintenance activities will contribute to the sustainability of a service after its construction, depending on a series of factors and processes which will have to be developed during the design and planning phase, and consolidated during the construction phase. In other words, the sustainability of operation and maintenance starts right from the planning stage.

4.2 Factors which contribute to sustainability and to effective operation and maintenance

As described in the chart with circles (see page 39), sustainability relies on four interrelated factors (adapted from CINARA—IRC course material, 1994 to 1998): a) technical factors, b) community factors, c) environmental factors, and d) the legal and institutional framework.

The **technical factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: technology selection; complexity of technology; its capacity to respond to a demand and a desired service level; its impact on the environment; the technical skills needed to operate and maintain a system; the availability, accessibility and costs of spare parts; and the cost of maintenance.

The **community factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: availability of technical skills to operate and maintain a service, and implement preventive maintenance activities and small and big repairs; capacity and willingness to pay; participation of all social groups in the community and both men and women; financial and administrative management carried out by a legitimate and organized community structure; the felt need for an improved service; socio-cultural aspects related to water; and individual, domestic and collective behaviour regarding hygiene and sanitation.

The intersection between the technical circle and the community circle (see chart on page 39) indicates the level of ownership and responsibility of communities towards the service. Ownership and responsibility are the key prerequisites for sustainable operation and maintenance.

The **environmental factors** which are likely to influence operation and maintenance as well as sustainability as a whole are: the quality of the water source (which will in turn influence the technology choice, and its need for treatment); and its quantity and continuity.

The intersection between the environmental circle and the community circle (see page 39) represents the way the community will manage water resources and especially

the impact on the environment of community behaviour in terms of sanitation and management of used waters. Water resources management, pollution control, hygienic behaviour, and proper wastewater management are all crucial components for sustaining a water supply service, to which operation and maintenance must contribute.

All these factors evolve within a **legal and institutional framework**. At the national level there must be clear policies and strategies towards operation and maintenance, which can be implemented. Support activities, such as technical assistance, training, monitoring, water quality control, and the setting up of alternative financing mechanisms are all likely to influence operation and maintenance activities.

Financial factors are key components inherent in all the above factors (technical, community, environment and institutional).

4.3 Processes which influence sustainable operation and maintenance

Processes differ from factors since they focus on the approach and the methodology of working. In the past, it was thought that the development or consolidation of factors alone could contribute to greater efficiency, effectiveness and sustainability. Now, however, it is realized that processes also have an important role to play. Among the processes can be listed the following: demand from the communities; responsiveness from supporting institutions and agencies; participation of communities (men and women) through the whole project cycle; linking technology choice with operation and maintenance; integration of water, sanitation, health and environment; planning with a gender perspective; effective decentralization; communication among all stakeholders; public/private partnership; co-responsibility between community and municipality; and capacity-building at all levels.

Demand for an improved service by the communities is a prerequisite for sustainability. It is an expression of their commitment, and a way to make communities responsible for their choices and future tasks. However, demand should be promoted because communities must be made aware of the different technology options available, and of their financial consequences. The concrete expression of demand varies from one country to another and from one development agency to another. Demand can be manifested in the form of an initial contribution in cash or in kind to the capital costs, or in the form of a written solicitation from an organized community group to the municipality.

Responsiveness of support institutions and agencies is the capacity of municipalities, nongovernmental organizations (NGOs), and other institutions and agencies to respond adequately to the needs and demand of communities. In many countries, municipalities need to be consolidated in their ability to deal with rural communities.

Participation of communities (men and women) throughout the whole project cycle is essential since it is a way to motivate, make responsible and build the capacities of communities in their new tasks and functions.

Linking technology choice with operation and maintenance at the planning stage is the key in the technology selection process. Indeed, communities must be able and willing to operate, maintain, administrate and finance the new service.

Planning with a gender perspective implies that the roles and functions of both men and women are clearly defined for management, operation and maintenance, since these might also highlight the need for specific capacity-building activities.

The **decentralization process**, which is underway in most developing countries, has a definite impact on the way institutions deal with the provision of water supply services. The main trend is for municipalities to be responsible, while the private sector (formal and informal) can contribute actively in the maintenance of systems.

Communication from central to local level and vice versa, and between private agencies and development agencies can enhance the coordination of activities and

implementation of policies. Furthermore, a proper information and monitoring system relies on effective communication channels.

Public / private partnership can have an important role in the operation and maintenance of improved water supply and sanitation services, where the private sector can operate, maintain, and manage the service under contractual agreements.

Co-responsibility between communities and municipalities implies that the tasks, responsibilities and functions of both parties are clearly defined. This is especially true now that municipalities are increasingly being given the legal and constitutional responsibility for the provision of public services. At the same time, community management is being promoted as a key element of sustainability. Efficient dialogue and a clear definition of roles need to be worked out, developed and consolidated.

Capacity-building at all levels is needed, especially in an environment of changing roles and responsibilities induced by the decentralization process.

Unit 4: Linking water, health, sanitation and environmental protection

1. Outline of session

► Objectives

- To raise awareness on the need to link water, health, sanitation and environmental protection
- To show that adequate operation and maintenance of water supply and sanitation will contribute to health and environmental protection

► Methodology

1. Introductory note
2. Video presentation followed by a discussion
3. Interactive presentation on the links between major health preventive measures and environmental protection
4. Focused discussion on behavioural change
5. Exercise in plenary using a behavioural change matrix

► Materials

- ✓ Overhead transparencies
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall
- ✓ Video projector
- ✓ Video: "Prescription for Health"

► Handouts

- ✓ Copies of all transparencies
- ✓ Selected extracts from background information

2. Notes for the facilitator

Introductory note

It was mentioned in a previous session that there is a trend to link water supply, health, sanitation and environmental protection activities because an adequate water supply by itself cannot solve all health problems. Proper handling and hygienic use of water, hygienic maintenance of water points and water sources, protection of the environment, safe sanitation disposal and cleaning of hands all contribute to the improvement of health. The facilitator must therefore focus on the importance of linking water supply, health, sanitation and environmental protection, and help all participants to see the need for such integration.

Video presentation followed by a discussion

A 23-minute video film, “Prescription for Health”, was produced by the IDRC (International Development Research Centre), P.O. Box 8500, Ottawa K1G 3H9, Canada, and is suitable for audiences of diverse cultural backgrounds. It was filmed in Bangladesh, Kenya, Philippines, Sri Lanka and Thailand, with extensive animation sequences to illustrate clearly the contamination path. The video promotes personal hygiene and community practices linked to water supply and sanitation, which can help to break the cycle of infection. Produced in collaboration with the World Health Organization and OXFAM, the video is primarily aimed at health care workers and water and sanitation engineers. It is a source of information for planners and policy-makers, and particularly strong in raising awareness.

After viewing the video, the participants are asked by the facilitator to comment on the key messages brought up in the film. Their main ideas are written on the board, together with statements from the video which are added by the facilitator who must be thoroughly familiar with the film. The facilitator then asks the participants how far this type of approach has been or could be utilized in their own working environment, and encourages them to discuss freely based on their personal experiences.

Identification of obstacles that inhibit the link between water supply, health, sanitation and environmental protection is discussed in a plenary session. The aim of this exercise is to show the constraints that must be overcome in order to reach integration. Such issues as no priority, not our mandate, no knowledge about it, poor financial resources, and poor inter-sectoral cooperation might come out during the discussion. The course does not try to solve these problems, but tries to show how O&M activities can contribute to this integration.

Interactive presentation on major preventive measures and environmental protection

Using the overhead sheets provided, the facilitator shows the major preventive measures for reducing the transmission of diseases related to water and sanitation. Some explanations are available in the background information and supporting material.

The topic of environmental protection is dealt with in the same way. In both cases, it is important to show how these issues are related to O&M and its management. After an overhead sheet is presented, the group is asked, “How can a better O&M contribute to this situation?”

Focused discussion on behavioural change

Since hygiene practices and environmental protection activities are linked to specific individual, domestic or collective behaviours, the facilitator initiates a discussion with the group by asking the following questions: “Can you give examples from your professional experience of activities that aimed at changing behaviour, or specific outcomes which depended on behaviour change?” “Were they successful?” “What made them successful or not successful?” The facilitator then discusses with the group some basic aspects which make behavioural change not always successful (see background information, page 55).

Exercise in plenary using a behavioural change matrix

Key criteria for activities to promote behavioural change have been developed in a matrix by UNICEF, which can be presented to the whole group as an exercise in a plenary session. The matrix is given in an exercise sheet (see page 54).

The facilitator asks the group for examples of behavioural change which all participants are familiar with, such as “Use of chlorine tablets to disinfect water at household level”. The facilitator goes through the whole matrix with the participants, analysing the chosen behaviour change, and scores the total number of points. The final result is evaluated according to the ranges given in the exercise.

3. Overhead and exercise sheets: Sheet 1

Prevention of diseases related to water and sanitation

Major preventive measures

1. Safe human excreta disposal*
2. Personal hygiene
3. Domestic hygiene
4. Food hygiene
5. Water hygiene*
6. Safe wastewater disposal and drainage*

* Link with Operation and Maintenance.

Overhead sheet 2

Relationship between infection and preventive measures¹

Infection	Safe human excreta disposal*	Personal hygiene*	Domestic hygiene	Food hygiene	Water hygiene*	Drainage*
Diarrhoea Dysentery Typhoid Cholera						
Roundworm (ascariasis) Whipworm (trichuriasis)						
Hookworm						
Beef and pork tapeworms						
Schistosomiasis (bilharzia)						
Guinea worm (dracunculiasis)						
Scabies Ringworm Yaws						
Trachoma Conjunctivitis						
Louse-borne typhus Louse-borne relapsing fever						
Malaria Yellow fever Dengue						
Bancroftian filariasis						

* Can be influenced by adequate operation and maintenance.

¹ From: Boot M, Cairncross S. *Action speaks: the study of hygiene behaviour in water and sanitation projects*. The Hague, IRC (and London School of Hygiene and Tropical Medicine), 1993.

Overhead sheet 3

Drinking water source protection¹

- Appropriate source selection and intake
- Catchment protection*
- Sanitary surveying of water point*
- Improvement of sanitation practices*
- Physical protection of wells and intakes*
- Soil and water conservation techniques*
- Wastewater treatment*
- Wastewater recycling*
- Artificial recharge
- Reforestation
- Community motivation and awareness*
- Partnership between communities and authorities
- Legislation and enforcement

* Can be influenced by adequate operation and maintenance practices.

¹ From: Bastemeyer TF, Lee MD. *Drinking water source protection*. The Hague, IRC, 1991.

Exercise sheet

Behavioural change matrix

Criteria for evaluating the likelihood of behavioural change

(Source: van Wijk C, Murre T, Esrey S. *Motivating for better hygiene and behaviour*. New York, UNICEF—IRC, 1996)

<p>Health impact of behavioural change</p> <ol style="list-style-type: none"> 0. No impact on health 1. Minor impact 2. Some impact 3. Significant impact 4. Very significant impact 5. Eliminates the problem 	<p>Complexity of behavioural change</p> <ol style="list-style-type: none"> 0. Unrealistic 1. Involves too many actions 2. Involves many actions 3. Involves few actions 4. Involves two actions 5. Involves one action 	<p>Direct consequences of behavioural change</p> <ol style="list-style-type: none"> 0. No consequences 1. Minor consequences 2. Some consequences 3. Significant consequences 4. Major consequences 5. Consequences guaranteed
<p>Frequency of behaviour</p> <ol style="list-style-type: none"> 0. Too cumbersome 1. Must be done hourly 2. Must be done once a day 3. May be done every few days 4. May be done once a week 5. May be done occasionally 	<p>Cost and effort of engaging behavioural change</p> <ol style="list-style-type: none"> 0. Unrealistic 1. Requires important resources and effort 2. Requires significant resources and effort 3. Requires some resources and effort 4. Few resources or effort 5. Requires only existing resources 	<p>Persistence needed to induce behavioural change</p> <ol style="list-style-type: none"> 0. Unrealistic 1. Requires compliance for several weeks 2. Compliance for a week 3. Compliance for several days 4. Compliance for a day 5. Very brief compliance
<p>Compatibility with existing activities</p> <ol style="list-style-type: none"> 0. Totally incompatible 1. Significantly incompatible 2. Some incompatibility 3. Little incompatibility 4. Easy to incorporate in existing activities 5. Type of activity already widely practised 	<p>Observability</p> <ol style="list-style-type: none"> 0. Cannot be observed by an outsider 1. Very difficult to observe 2. Difficult to observe 3. Is observable with attention 4. Observable 5. Cannot be missed 	<p>Similar practices</p> <ol style="list-style-type: none"> 0. Nothing like this is done 1. Slightly similar 2. Existing practice similar 3. Several similar practices 4. Many similar practices 5. Similar practices widely existing

For each proposed behavioural change, score 0 to 5 for each of the nine boxes. Aggregate the total score for each behavioural change. If the score is less than 20, it is highly unlikely that the audience will make the change. Different goals must be set. If the score is over 36, it is highly likely that the goal will be achieved.

4. Background information

4.1 Why is behaviour not changed by conventional hygiene education?¹

Planners of hygiene programmes and practitioners often believe that it is possible to give universal hygiene messages to the population. Such messages are based on the assumption that the knowledge of health educators is superior to local insights and practices. The fact that people have adapted their lifestyle to local circumstances and developed their insights and knowledge over years of trial and error is overlooked. General hygiene messages can therefore be irrelevant, incomplete or unrealistic.

The methods used to get the information across are often not suitable to create behavioural change. Many health messages are given in the form of lectures at health clinics, talks in meetings and gatherings, and through the mass media (e.g. posters, radio talks, brochures and booklets). Even if the educators succeed in reaching the intended audiences using the media, the people are only “told what to do”, and often do not get the chance to relate the message to their own experiences. It is important to realize that people can make sense of new information only in the light of their own experiences, perceptions and cultural backgrounds.

Many health education programmes teach people about water and sanitation-related diseases—what they are, how they are caused, and how they are prevented. But education does not, by itself, reduce the risks of transmitting these diseases. Only action can do this; knowledge is useful but not sufficient. Reviews of hygiene programmes show that appropriate settings to promote particular changes are rare.

4.2 What motivates people to improve their hygiene?

If general messages and information on disease transmission do not change people’s behaviour, what is it that can bring people to take action on the risky practices and conditions in their own environment?

An individual will adopt new behaviour when he or she believes that the practice has clear benefits—for health or other reasons—and considers these benefits as important. Change of behaviour is also considerably influenced by convenience, comfort, and status. The individual will then develop a positive attitude to the change. Positive or negative views on the environment from others can also influence a person’s decision to try the new practice. Thus, an individual’s attitude and situation will determine if the practice is taken up, and when this is found to be beneficial, it is continued.

What hygiene education programmes can do is to support water and sanitation projects, which are planning to install new facilities for the community’s use:

a) by assessing if water, sanitation and hygiene have a high priority among the various groups in the community, and by promoting their understanding of the implications of the existing conditions and proposed technical options for both community and family health;

b) by following up people’s use of the newly installed facilities and their hygiene practices in order to provide feedback to planners who will be better prepared to reduce other disease transmission risks, which prevent the realization of health improvements in the communities concerned.

Certain practices cannot produce results by individual change alone, but require concerted action by larger groups and the whole community. Making choices together, assigning responsibilities, and monitoring action will increase the people’s commitment to put into practice the agreed changes. Communal change is only possible when the com-

¹ From: van Wijk C, Murre T, Esrey S. *Motivating better hygiene behaviour: importance for public health—Mechanisms of change*. New York, UNICEF—IRC, 1996.

munity members themselves feel there is a problem and jointly undertake action that will permanently improve the conditions and their practices.

When learning, people remember 20% of what they hear, 40% of what they hear and see, and 80% of what they discover for themselves. This calls for a change in the way teaching is carried out—from a didactic to a more participatory and growth-centred education.

Four major factors stimulate people to change their behaviour: 1) facilitation (convenience, making life easier); 2) practical understanding; 3) influence of others; 4) capacity to change.

4.3 Experiences in better water resource management¹

Source selection and siting of intakes

Field experience shows that good source selection and adequate siting of intakes contribute to the reliability of the water supply system. For the selection of groundwater sources, in particular for small point source supplies, procedures could be more systematic, both in terms of locating high-yielding sites and in terms of avoiding sites with a high potential for contamination by seepage from the surface.

For the siting of shallow drilled and hand-dug wells, the risk associated with faecal contamination from on-site sanitation are poorly understood and quantified. Where water supply points are located within or adjacent to settlements, two elements have not been adequately addressed with respect to possible contamination by existing sanitation units and/or waste disposal practices. The first element concerns the risk of contamination of drinking-water sources from waste. The second is the lack of criteria for the establishment of safe distances between water source and possible contamination points.

With increasing population pressures and expansion of human activities into previously undisturbed catchment areas, risk assessment must take into account both current and projected activities within the catchment area.

Catchment protection

More active protection of catchment areas is needed, which involves a systematic appraisal of catchment areas for surface or groundwater sources and the identification of environmental factors related to land use. There is a need for practical experience to develop checklists for small sources to be effectively managed and maintained by local communities.

The groundwater pollution risk is the product of the contaminant load applied to the subsurface by human actions and the natural pollution vulnerability of the aquifer. To protect aquifers, it must be clear which pollutants and pollution sources affect them most. This knowledge forms the basis for delimiting protection zones within which human activities must be regulated.

Protection zones are important for the design, prioritization and distribution of water resources protection measures. The zones can be delimited with respect to the level and nature of the risk, resulting in more coherent and incisive protection strategies. The effectiveness of protection zones depends on the commitment of the local population to observe established protection measures. Protected areas are obviously increasingly vulnerable as population density increases.

¹ Extracts from: Bastemeyer T. *Drinking-water source protection*. The Hague, IRC, 1991.

Sanitary surveying

Sanitary surveys are a form of risk assessment in which the bacteriological, physical and chemical quality of a water source, the technical quality of the water supply point, the way it will be used by the communities, the surrounding environmental hygiene conditions, and the potential causes for contamination are examined. Their purpose is to minimize the level of risks of on-site contamination by identifying remedial measures which can quickly and easily be undertaken.

Improvement in sanitation

The problem of contamination of the water supply by users through poor sanitation and hygiene is widespread. Use of latrines and other sanitary systems reduces the risk of faecal pollution by excluding contamination of the topsoil or ground surface so that excreta are not washed into the surface water or transported by animals. The design of latrines should in principle ensure that there is no direct sub-surface link between the excreta and the groundwater supply, which involves taking into consideration the site, soil type and depth, and seasonal and daily water levels.

Physical protection of wells and intakes

Users pollute their water sources due to the lack of awareness about ways and means to ensure adequate physical protection of the water supply point. Community water supply projects, which are engaged in groundwater development through construction of wells, recognize the importance of simple site protection against pollution. The addition of well-aprons, soakway drains, covers and handpumps protect the water's quality by preventing the inflow of contaminated water back into the well.

Soil and water conservation techniques

Soil and water conservation activities can decrease turbidity by preventing sediment transport, increasing groundwater recharge, and decreasing surface flow peaks by increasing infiltration. A full range of erosion control techniques and strategies has been pioneered for developing countries and applied with considerable success.

However, soil erosion has expanded at a faster pace than most national governments have been able to cope with. A large proportion of soil erosion problems resulted from the expansion of shifting cultivation techniques into marginal areas. Additionally, they result from the settling of previously semi-nomadic people who have little history of terrace building or other traditional forms of soil stabilization.

Wastewater treatment

Both industrial effluent and domestic sewage should be treated to minimize pollution risks. For domestic sewage, different on-site and off-site technical options are available, but they are not always applied. In the developing countries, sewage lagoons and oxidation ditches are among the most economical methods. There is little experience in the use of simple and effective, low-cost treatment technologies for small-scale industrial polluters, especially for small rural agro-industries. There are no feasible treatment possibilities to deal with the many toxic elements originating from industries and the misapplication of fertilizers. Preventive measures against contamination from industrial and agricultural activities are therefore crucial.

Wastewater recycling

Wastewater treatment is complementary to wastewater recycling. As such, sewage waste may only need partial treatment in order to be used on farmland for irrigation or in a range of industrial processes where water quality standards are not critical. Wastewater recycling, if carried out correctly, can be a form of water source protection as well as conservation. The risk of contamination of water sources is decreased through proper recycling and increases the efficient use of the water source. In this way, water is treated by less expensive methods, since treatment requires mainly the removal of coliforms and helminths (e.g. wastewater treatment ponds).

Artificial recharge

Ground-water resources can be managed in order to decrease water table recession and saltwater intrusion, by artificial recharge. On the small and medium scale, recharge is predominantly performed from infiltration ditches, ponds and basins, retention of river underflow (using sub-surface dams), and through the retention of river floodwater. Sand storage dams can also be used to increase the dimensions of the shallow ground-water reservoir.

Reforestation

Reforestation programmes coupled with anti-erosion, soil and water conservation techniques are considered essential for the improvement of many water source problems. However, at the present time many more trees are cut down than planted.

Community motivation and awareness

Many water pollution problems are due to a lack of awareness of the causes of health problems among communities. The link between water, hygiene and illness is not strongly perceived since water is assumed to be beneficial and cleansing rather than a potential source of infection.

Partnership between communities and government agencies

A reliable and functioning water supply system may greatly contribute to the protection of water sources, and vice versa. Community-based maintenance and management of water supply systems is a good starting point for a more integrated approach to water source protection and environmental conservation. Although community water management strategies are possible, there must generally be direct links between the community and the water source. Communities must be the users of the water source or derive some other benefit from the protective action such as commercial benefits from tree planting or increased crop production following soil conservation. Conflict of interest between upstream and downstream users is a serious problem worldwide. That is why a sound legal basis for community water supply systems is very important. Government institutions and local authorities should support community efforts to manage and protect their drinking-water sources.

Legislation and enforcement

At the present time, water resource and environmental legislation in most developing countries has evolved over the years in response to specific water management problems, which were associated with economic and demographic growth. The legislation has usually been directed towards controlling the use of water from major rivers or lakes, which

are of economic significance, and currently does not provide a good basis for the protection of drinking-water sources.

WHO has listed the following legal issues which require attention:

- regulations are needed to ensure that the source exploited for community water supply is the most favourable in terms of quality, quantity, and access;
- regulations are needed to ensure health and environmental protection for wastewater use since there are obvious public health hazards;
- legal provisions are required to ensure that potential water sources are adequately protected from the harmful effects of wastewater infiltration;
- legislation and regulations are needed to ensure that the costs of community water supply and sanitation are recovered from all water source users.

MODULE 2

Situation analysis

Unit 1: Operation and maintenance requirements	63
1. Outline of session	63
2. Notes for the facilitator	63
3. Overhead and exercise sheets	65
4. Background information	70
4.1 What is sanitation?	70
4.2 Water supply and sanitation O&M fact sheets	70
Rooftop water harvesting—Spring water captation—	
Drilled well—Rope and bucket: loose, through a pulley or	
on a windlass—Direct-action handpump—Deep-well piston	
handpump—Diesel engine—Chlorination in piped water	
supply systems—Slow sand filtration—Public standpost—	
Ventilated improved pit latrine—Double-vault compost	
latrine—Septic tank and aqua-privy—Drainage field—	
Small-bore or settled sewerage	
4.3 Spare parts provision in general	103
4.4 Towards sustainable spare parts provision	103
Unit 2: Analysis of participation	107
1. Outline of session	107
2. Notes for the facilitator	107
3. Overhead sheets	109
4. Background information	109
Unit 3: Analysis of constraints	110
1. Outline of session	110
2. Notes for the facilitator	110
3. Overhead sheets	112
4. Background information	116
4.1 The importance of problem analysis	116
4.2 What is a problem?	116
4.3 The OOPP methodology	117
4.4 How to analyse problems	117
Unit 4: Analysis of objectives	119
1. Outline of session	119
2. Notes for the facilitator	119
3. Overhead sheets	121
4. Background information	123
4.1 Discussion on alternatives: identifying potential alternative	
solutions	123

Unit 1: Operation and maintenance requirements

1. Outline of session

► Objectives

- To identify the rural water supply and sanitation technologies which are most frequently used in the participants' projects
- To identify the operation and maintenance requirements of both water supply and sanitation technologies
- To review problems in spare parts availability.

► Methodology

1. Introductory note
2. Focused discussion on rural water supply and sanitation technologies most frequently used in the participants' projects
3. Group assessment of operation and maintenance requirements and problems most frequently encountered
4. Presentation on spare parts availability.

► Materials

- ✓ Overhead transparencies
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall

► Handouts

- ✓ Copies of all transparencies
- ✓ Selected extracts from background information
- ✓ Forms for the exercise

2. Notes for the facilitator

Introductory note

Situation analysis starts by reviewing the main technical activities for the operation and maintenance of rural water supply and sanitation services. It allows the participants to understand and be familiar with the various technologies presented in the course.

Focused discussion on rural water supply and sanitation technologies

The facilitator asks the participants what types of technologies are being promoted in their rural water supply and sanitation projects. These are listed on the board and, with the aid of the transparencies (see overhead sheets, pages 65–67), compared with the technologies presented in the course.

The course deals with only human excreta disposal systems, which is the basic sanitation option in many projects. This does not mean that other aspects of sanitation, such as

wastewater disposal, solid waste disposal, and drainage of surface (rain) water, are not important because they are all important.

All water supply and sanitation project planners should, as if automatically, be able to integrate their basic and simple wastewater disposal services with water supply services. However, the course does not advocate systems which cannot be sustained by rural communities.

Group assessment of basic O&M requirements

The aim of this exercise is to assess the basic O&M activities in a particular system which will be chosen by the groups, including their frequency, human resources and skills, and requirements for tools, equipment, materials and spare parts. The participants are divided into groups corresponding to the main technologies, including sanitation. All participants are asked to fill in a form (see exercise sheet on “Assessment of basic O&M requirements”, page 68). Each group then rapidly presents their work, with an emphasis on the problems encountered which will be considered throughout the course. The present session deals with the problem of spare parts availability.

Interactive presentation on spare parts availability

Problems in the availability of spare parts are often encountered in the operation and maintenance of water supply and sanitation projects. This session reviews the main characteristics of the problem, which must be taken into account in planning for spare parts. The overhead sheets and background information (see below) will be useful in preparing the presentations, in which the participants will describe their experiences. In addition, a spare parts supplier could be invited to share his experience and perceptions during the session.

3. Overhead and exercise sheets: Sheet 1

Water sources for low-cost water supply technologies

Rain water

- Rooftop water harvesting
- Catchment and storage dams

Groundwater

- Spring water captation
- Dug well
- Drilled well
- Subsurface harvesting

Surface water

- Protected side intake
- Bottom river intake
- Floating intake
- Sump intake

Water-lifting technologies

- Rope and bucket: loose, through a pulley, or on a windlass
- Bucket pump
- Rope pump
- Suction plunger handpump
- Direct action pump
- Deep-well piston pump
- Deep-well diaphragm pump
- Centrifugal pump
- Electrical submersible pump
- Axial flow pump
- Hydraulic ram

Overhead sheet 2

Power systems

Human power

Animal traction

Windmill

Photovoltaic systems

Electric engines

Diesel engines

Water treatment devices

At the household level

Heating

Solar disinfection

Household slow sand filter

Domestic chlorination

At the community level

Pot chlorination in well

Storage and sedimentation

Upflow roughing filters

Slow sand filtration

Chlorination in piped water supply systems

Overhead sheet 3

Low-cost sanitation technologies

Dry systems

- Basic improved traditional latrine
- Ventilated improved pit latrine
- Double-vault compost latrine

Wet systems

- Pour-flush latrine with leaching pits
- Aqua-privy
- Pour- or full-flush latrine with septic tank

Pit-emptying techniques

- Vacuum tanker
- Vacutug
- Manual latrine pit-emptying technology

Liquid effluent disposal systems

- Soakaway
- Drainage field
- Small-bore sewerage

Assessment of basic Operation and Maintenance requirements

Technology choice (Fill in when applicable)

Type:	Power system:	Distribution system:	Water treatment:
Major O&M activities	Frequency	Tools, materials, spare parts	Skills and human resources

Conclusion

Tools, materials and spare parts needed:

Skills and human resources needed:

Main problems:

Overhead sheet 4

Sustainable provision of spare parts depends on:

1. The demand for spare parts

- Spare parts needs
- Spare parts costs
- Spare parts accessibility

2. The supply of spare parts

- Use of local materials and manufacture
- Marketing and sales points
- Perspective on profits

3. Strategic issues

- Efficient planning
- Quality of spare parts
- Whether to standardize
- Approaches to reduction of spare parts needs
- Appropriate pricing policy
- Private sector involvement
- Capacity-building

4. Background information

4.1 What is sanitation?

Sanitation encompasses the following: 1) human excreta disposal systems, 2) wastewater disposal devices, 3) solid waste disposal, and 4) drainage of surface (rain) water. This course focuses mainly on human excreta disposal, which is considered to be the basic sanitation option. The other three areas are also important and some comments on them are given below.

Wastewater is either sullage (greywater), which is wastewater from kitchens and bathrooms, or sewage (blackwater), which includes sullage and is settled wastewater containing parts of human excreta, and water-borne waste. Problems are mainly encountered in areas with a high density of houses and people, where the wastewater is liable to flooding if there is no proper drainage, or can be a source of smells, rodents and contamination (see Module 1, Unit 4, page 48). Wastewater can contaminate drinking-water supplies through broken pipes or the spread of stagnant water, depending on the absorption capacity of the soil. The problem with water-borne disposal is its high rate of water consumption, regular blockage in the drainage system, and high O&M costs.

Plans for simple wastewater disposal and drainage devices should be made during the initial technical design phase. Proper maintenance of small gutters, drainage devices, or areas surrounding water points is essential, and communities should actively participate to prevent blockages and stagnant water forming around the water points.

Solid waste generally includes household refuse, waste from institutions, industrial waste and hospital waste. Rural areas are mainly concerned with the first two of these, but can be contaminated indirectly by pollution from industrial waste. Populations in developing countries produce different wastes from those in industrialized countries; there is a similar difference in wastes between urban and rural areas. Vegetable waste accounts for, on average, 30% of the total waste in industrialized countries and 75% in developing countries; the possibilities for composting and recycling depend on the composition. Improper solid waste disposal can present a public health risk, and is often the cause of drainage blocks and aesthetic problems. Unplanned and uncontrolled dumpsites can generate ground and groundwater pollution, as well as lead to air pollution and proliferation of rodents.

Maintenance activities linked to wastewater and solid waste disposal in rural areas are to a large extent a matter of preventive maintenance by the active involvement of users. Behavioural changes in communities to improve the operation and maintenance of basic sanitation systems can be induced by effective awareness campaigns, together with participatory sanitary problem assessment (see Module 1, Unit 4, page 48).

4.2 Water supply and sanitation O&M fact sheets

The fact sheets given below are extracted from: *Linking technology choice with operation and maintenance, in the context of low-income water supply and sanitation*, by F. Brikké et al. Published by the Operation and Maintenance Network of the Water Supply and Sanitation Collaborative Council, 1997, and available from WHO headquarters (contact Mr J. Hueb) or from IRC.

O&M FACT SHEET

Rooftop water harvesting

a. Brief description of technology

Rooftop catchment systems gather rainwater caught on the roof of a house, school, etc. using gutters and downpipes (made of local wood, bamboo, galvanized iron or PVC) and lead it to one or more storage containers ranging from simple pots to large ferrocement tanks. If properly designed, a foul flush device or detachable downpipe is fitted for exclusion of the first 20 litres of runoff during a rainstorm, which is mostly contaminated with dust, leaves, insects and bird droppings. Sometimes runoff water is led through a small filter consisting of gravel, sand and charcoal before entering the storage tank. Water may be abstracted from the tank by a tap, handpump or a bucket and rope system.

Initial cost: In Southern Africa, US\$ 320 for a system with 11 m galvanized iron gutter, 1.3 m³ galvanized iron tank, downpiping, tap and filters, excluding transport (Erskine, 1991). Where the roof is not suitable for water harvesting, the cost of improving the roof and gutters will have to be added to the cost of the tank. Such costs were found to vary between about US\$ 4 (in Kenya, subsidized) and US\$ 12 (in Togo) per m² (Lee & Visscher, 1992). Total capital costs for rooftop rainwater catchment systems are usually higher than for other water supply systems.

Yield: Potentially almost 1 litre per horizontal square metre per mm rainfall. The quantities usually are only sufficient for drinking purposes.

Area of use: Most developing countries with one or two rainy seasons (especially in arid and semi-arid zones, with average annual rainfall ranging from 250 to 750 mm) and where other improved water supply systems are difficult to realize.

Construction: Systems are usually produced locally.

b. Description of O&M activities

In case there is no foul flush device, the user or caretaker has to divert away the first 20 litres or so of every rainstorm. Fully automatic foul flush devices are often not very reliable. Water is taken from the storage tank by tapping, pumping, or using a bucket and rope. For reasons of hygiene, the first two methods are preferred. Just before the start of the rainy season, the complete system has to be checked for holes and broken parts and repaired if necessary. Taps or handpumps have to be serviced. During the rainy season the system is checked regularly, and cleaned when dirty and after every dry period of more than a month. Filters should be cleaned every few months, filter sand should be washed at least every six months, and the outside of metal tanks may be painted about once a year. Leaks have to be repaired throughout the year, especially leaking tanks and taps, as they present health risks. Chlorination of the water may be necessary. All operation and maintenance activities can normally be executed by the users of the system. Major repairs, such as a broken roof or tank, can usually be executed by a local craftsman using locally available tools and materials. Maintenance is simple but should be given ample attention.

Organizational aspects

The organization of O&M of communally shared roof or ground tank supplies is considerably more difficult than for privately owned systems. Rooftop harvesting systems at schools, for instance, may suffer water losses from a tap left dripping, and padlocks are often needed to ensure careful control over the supply. Ideally, one person should be responsible for overseeing the regular cleaning and occasional repair of the system, control of water use, etc. Selling the water is an option to ensure income for O&M and to restrict water use. Where several households have installed a communal system, e.g. where several roofs are connected to one tank, the users may want to establish a water committee to manage O&M activities, which may include collection of fees, control of the caretaker's work, and control of water use by each family. External agents can play an important role in monitoring the condition of the system and the water quality, in providing access to credit facilities to buy or replace a system, in training of users/caretakers for management and execution of O&M, and training of local craftsmen for larger repairs.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean the system	1–3 times per year	Local	Chlorine	Broom, brush, bucket
Divert foul flush	Every storm	Local		
Clean the filters	Twice a year	Local	Sand, charcoal, plastic mesh	
Disinfect the reservoir	Occasionally	Local	Chlorine	Bucket
Repair roof, gutters and piping	Occasionally	Local	Tiles, metal sheet, asbestos cement sheet etc., bamboo or PVC pipes, nails, wire	Hammer, saw, pliers, tin cutter
Repair tap or pump	Occasionally	Local or area	Washers, cupseals etc.	Spanner, screwdriver
Paint outside of metal reservoir	Annually	Local	Anticorrosive paint	Steelbrush, paintbrush
Repair ferro-cement reservoir	Occasionally	Local	Cement, sand, gravel, metal mesh, wire	Trowel, bucket, pliers

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Close taps after taking water, keep the system clean	No special skills
Caretaker	Check functioning, divert first flush, clean the filters and rest of the system, perform small repairs	Basic skills
Water committee	Supervise caretaker, collect fees	Organizational skills
Local craftsman	Repair roof, piping and tank	Basic plumbing and masonry
External support	Check water quality, stimulate and guide local organization, train the users	Microbial analysis, extension work

e. Recurrent costs

Recurrent costs for materials and spare parts are very low. In most cases these costs are even considered negligible. However, the recurrent costs for personnel—in cash or kind (for caretakers, committee members and craftsmen)—will need to be added.

f. Problems, limitations and remarks

Frequent problems. Corrosion of metal roofs, gutters, etc. Failure of functioning of the foul flush devices due to neglect of maintenance. Leaking taps at the reservoir and problems with handpumps. Contamination of uncovered tanks, especially where water is abstracted with a rope and bucket. Tanks may provide a breeding place for mosquitos, which may increase the risk of diseases like malaria.

Limitations. The water may be insufficient to fulfil the drinking-water needs at certain times in the year, making it necessary to develop other sources or go back to traditional sources during these periods. The investment needed for the construction of a tank and suitable roofing is often beyond the financial capacity of households or communities.

Remarks. Tiled or metal roofs give the cleanest water. Thatched roofs yield less water which is more contaminated. The acceptance of rooftop water harvesting as a suitable system may depend on the users' views on the water's taste.

O&M FACT SHEET

Spring water captation

a. Brief description of technology

Spring water captation systems abduct and protect groundwater flows at the points where these arrive at the surface to facilitate their abstraction. Spring water is usually fed from a sand or gravel water-bearing ground formation (aquifer), or a water flow through fissured rock. Where solid or clay layers block the underground flow of water, it is forced upward and can come to the surface. The water may emerge either in the open as a spring, or invisibly as an outflow into a river, stream, lake or the sea. The main parts of a spring water captation are a drain under the lowest natural water level, a protective structure providing stability and a seal to prevent surface water from leaking in. The drain is usually placed in a gravel pack covered with sand and may lead to a conduit or a reservoir. The protective structure may be made of concrete or masonry and the seal is usually made of puddled clay and sometimes plastic. A screened overflow pipe guarantees that the water can flow freely out of the spring at all times. To prevent contamination infiltrating from the surface, a ditch (known as the interceptor drain) diverts surface water away from the spring box and a fence keeps animals out of the spring area. There are many types of spring captations, ranging from a simple headwall with backfill to more complicated structures like tunnel systems for collecting water from a larger area.

Initial cost: Capital costs vary considerably and depend on a large number of factors. In Nepal, a relatively large spring box serving 150 households including facilities for clothes washing was constructed for about US\$ 1000 (1989 data, Rienstra 1990), including costs for unskilled labour. In Kenya, minor structures for an average of 110 persons were constructed for US\$ 200, including a headwall, backfill, fencing, and labour and transportation costs. Major spring structures for an average of 350 persons cost about US\$ 400, including a spring box (1986 data, Nyangeri 1986).

Dimensions: From 0.5 m² to many square metres.

Yield: From many litres per second to less than 0.1 l/s .

Area of use: In areas where groundwater arrives at the surface, usually at hillsides or mountainsides.

Construction: Spring water captation systems are constructed on-site, often by local craftsmen.

b. Description of O&M activities

Operation

Water should be permitted to flow out freely all the time so that it will not find another way out of the aquifer. Operation may include activities such as opening or closing valves to divert the water to a reservoir, a conduit or a drain. The spring and surroundings must be kept clean.

Maintenance

Prevent contamination (e.g. from open defecation, latrines, cattle-gathering places, use of pesticides, chemicals, etc.) both in the area where the spring water infiltrates into the ground (if possible) and in the immediate surroundings of the spring. Check the surface drains, the animal-proof fence and gate, and repair if necessary. Protect from vegetative growth both in the area where the spring water infiltrates into the ground (if possible) and in the immediate surroundings of the spring (prevent clogging of the aquifer by growth of roots). Check the water flow from the spring box. If there is an increase in turbidity or flow after a rain storm, surface run-off has to be identified and the protection of the spring improved. If the water flow decreases, it has to be suspected that the collection system is clogged. It may then be necessary to take out the gravel and replace with new gravel or, in case a seep collection system is used, to clean the collection pipes. Regular water samples must be taken and analysed to check for evidence of faecal contamination. Annually, open the washout and remove all accumulated silt. Check all screens; if damaged or blocked, replace with non-rusting materials, e.g. copper or plastic screening, and clean if dirty. After cleaning, make sure to close the washout valve thoroughly and replace and seal the manhole cover. Disinfect the spring box every time a person enters to clean or repair it, or when there is bacteriological contamination. Leaks in the protective seal, undermining of the headwall, and damage caused by erosion or settlement of soil must be repaired.

Organizational aspects

In many cases, springs are communally owned. Users may need to establish an association which can effectively deal with issues such as control and supervision of water use, prevention of contamination of water, execution of O&M activities, financing of O&M, monitoring of water quality and the system's performance, etc. Proper management may also prevent conflicts over these and other matters. For the execution of O&M tasks at the spring site, a person who lives or farms near the site could be appointed. This person could also be made responsible for water allocation to users at or near the site, and be involved in monitoring activities. His or her authority should be clear and accepted by all users.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean well surroundings	Weekly	Local		Broom, bucket, hoe, machete
Check turbidity	After each flood	Local		
Check water quantity	Occasionally	Local		Bucket, watch
Repair fence and clean surface drains	Occasionally	Local	Wood, rope, wire	Machete, axe, knife, hoe, spade, pickaxe
Check water quality	Regularly	Area	Laboratory reagents	Laboratory equipment
Wash and disinfect the spring	Annually	Local	Chlorine	Bucket, wrench, brush
Repair piping and valves	Occasionally	Local or area	Spare pipes and valves, cement, sand, gravel	Bucket, trowel, wrench, flat spanners
Repair cracks	Annually	Local	Cement, sand, gravel, clay	Bucket, trowel, hoe, spade, wheelbarrow

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Use water, report malfunctioning, keep site clean, assist in major repairs	No special skills
Caretaker	Keep site clean, check for damage, perform small repairs	Basic skills
Water committee	Organize bigger repairs, control caretaker's work	Organizational skills
Mason	Repair masonry or concrete	Masonry
External support	Check water quality, guide and stimulate local organization	Microbial analysis, extension work

e. Recurrent costs

Recurrent material costs are usually very low. The recurrent personnel costs, in cash or kind (for caretakers, watchmen, labourers, committee members and craftsmen), will need to be added but will also usually be low. Total recurrent costs are usually less than US\$ 1 per year per capita, which often includes O&M costs for the water transport system. Several sources report that "O&M costs are minimal and, for this reason, spring water technology is the technology of choice wherever the sites permit it." However, problems may arise when a sudden large investment is needed for a large repair or replacement of the system.

f. Problems, limitations and remarks

Frequent problems. Erosion or collapse of the spring box due to wrong design, construction errors, large surface runoff flows, and damage caused by people or animals. Leaks in the box or leaking taps and valves. Contamination of the spring water due to cracks in the seal or to people's behaviour. Damaged piping because of faulty construction, abuse or corrosion. Improper drainage of surface runoff, outflow and wastewater. Clogged pipes because of siltation or plant roots. Poor accessibility for water users.

Limitations. Springs may not deliver enough water or become dry during certain seasons of the year. Not all springs produce clean water of acceptable taste. Springs may be sited too far from households or on privately owned land. In some cases, the cost of construction, large repairs or replacements may be beyond the capacity of communities. Some spring water is very corrosive.

Remarks. Usually spring water is of good quality but this should be checked; examples exist where the water was fed from a polluted stream which had gone underground or where the catchment area was contaminated. Unprotected springs are almost always contaminated at the outlet.

O&M FACT SHEET

Drilled well

a. Brief description of technology

Drilled wells, tubewells or boreholes give access to groundwater in an aquifer and facilitate its abstraction. They differ from dug wells in the small diameter, generally varying between 0.10 m and 0.25 m for the casing, which does not allow a person to enter for cleaning or deepening. The well is usually the most expensive part of a handpump drinking-water supply project. Boreholes can be constructed by machine or by hand-operated equipment and usually consist of three main parts:

- At ground level, a concrete apron around the borehole with an outlet adapted to the water abstraction method prevents surface water from seeping down the sides of the well, provides a hard standing, and directs wastewater away from the well to a drainage channel.
- Below ground but not in the desired aquifer(s), these parts are usually lined with pipe material (mostly PVC and sometimes galvanized iron) to prevent it from collapsing, especially in unconsolidated formations. In consolidated formations, a lining may not be required.
- Below water level in the aquifer sections, the pipe material is slotted to allow groundwater to enter the well. A gravel filter layer surrounding this part facilitates groundwater movement towards the slotted pipes and, at the same time, prevents ground material from entering the well. In consolidated formations this gravel may not be required.

A proper combination of slot size, gravel filter and aquifer material, and extensive sand pumping before the well is brought into production (well development) can considerably improve long-term performance.

Initial cost: Capital costs vary considerably and depend on a large number of factors. According to Arlosoroff et al. (1987), the initial cost for a 50 m deep hand-drilled well in the alluvial plains in South Asia could be as low as US\$ 200. More recent data state that typical costs for a 50 m drilled well in India were US\$ 770 and in Mozambique US\$ 10 000 (Wurzel & Rooy, 1993).

Range of depth: From a few metres to over 200 metres.

Yield: From less than 0.3 litre to over 10 litres per second.

Expected life: Over 25 years.

Area of use: In areas with suitable aquifers.

Construction: In most countries, drilled wells are constructed by public or private sector drilling companies.

b. Description of O&M activities

Operation

Operation of the well itself is usually not required. When the production capacity of the well is lower than the demand, daily monitoring of the water level may be necessary. Abstraction of the water from the well is usually done by the users, often women and children, or by a caretaker.

Maintenance

Apart from cleaning the apron daily and occasionally cleaning the drain and repairing the fence, if there is one, there are hardly any maintenance activities. Rarely, when a well has to be desilted or rehabilitated, all appliances have to be removed and a specialized company will have to come and do the job. There are various rehabilitation techniques such as forced air and water pumping, brushing, and treatment with chemicals. It is very difficult to deepen an existing drilled well.

Organizational aspects

Users may need to establish an organization that can effectively deal with issues such as the control or supervision of water use, prevention of water contamination, execution of O&M activities, financing of O&M, and monitoring of water quality. Although the number of O&M activities required is limited and they usually cost very little, they should be given ample attention, as many wells have been abandoned because they were contaminated or had collapsed as a result of lack of maintenance.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean well site	Daily	Local		Broom, bucket
Clean drain	Occasionally	Local		Hoe, spade, wheelbarrow
Repair fence	Occasionally	Local	Wood, nails, wire etc.	Saw, machete, axe, hammer, pliers, etc.
Repair apron	Annually	Local	Cement, sand, gravel	Trowel, bucket
Rehabilitate well	Very rarely	National	Gravel, pipe material etc.	Various special equipment

d. Actors implied and skills required in O&M

Actor	Role	Skills
Water user	Use water, keep site clean, assist with major maintenance tasks	No special skills
Caretaker	Monitor water use, keep site clean	Basic skills for cleaning and disinfection
Water committee	Supervise caretaker, organize major maintenance, collect fees	Organizational skills
Specialized well company	Rehabilitate the well	Very special skills
External support	Check water quality, stimulate and guide users' organization	Microbial analysis, extension work

e. Recurrent costs

Recurrent material costs are usually low. The recurrent personnel costs, in cash or kind (for caretakers, watchmen, labourers, committee members and craftsmen), will need to be added but will also usually be low. Occasional large maintenance activities such as rehabilitation of the well may require a high investment, which may pose problems if this has to be financed by the community. The life expectancy of a good well is over twenty years but after a few years the yield may diminish drastically and rehabilitation may be necessary. In Ghana (Baumann, 1993), rehabilitation costs were estimated at US\$ 750 once every ten years.

f. Problems, limitations and remarks

Frequent problems. Bad water quality or collapse due to corrosion of the galvanized iron lining, poor water inflow because of inadequately developed well, entrance of ground particles in the well because of wrong screens or wrong development, contamination due to wrong apron design or construction or neglect of maintenance, collapsing of borehole where no lining is applied or where the lining is not strong enough.

Limitations. Well construction depends on geohydrological conditions like presence, depth and yield of aquifers and presence of rock formations above them. Wells constructed at locations which are too far from the users' households, or which are too difficult to reach, will not be sufficiently used or maintained. Wells should not be drilled near places with latrines or where cattle gather and vice versa. The usually recommended minimum distance is 30 metres, although this is no guarantee that contamination will not occur. The investment in labour, cash or kind needed for the construction of an improved dug well may be beyond the capacity of the community. It may be impossible to transport the heavy equipment and materials needed to the drilling site.

Remarks. In many cases, wells are not only used for drinking-water supply but also for irrigation. When assessing the development potential of wells with the community, it is important to place this in a wider context, including all water uses and their effect on water availability.

O&M FACT SHEET**Rope and bucket: loose, through a pulley or on a windlass****a. Brief description of technology**

Mostly used with hand-dug wells. A bucket on a rope is lowered into the water. When hitting the water, the bucket dips and fills itself and is pulled up with the rope. The rope might be held only with the hands, run through a pulley or be wound on a windlass. Sometimes animal traction is used in combination with a pulley. Improved systems use a rope through a pulley and two buckets, one on each end of the rope. For water depths of less than 10 metres, one can use a windlass with a hose running from the bottom of the bucket to a spout at the side of the well. Even with this system and a protected well, hygiene is poorer than with a bucket pump.

Initial cost: US\$ 6 for a plastic bucket and 5-metre rope to US\$ 150 for a windlass, hose and closed superstructure in Liberia (Milkov 1987).

Range of depth: 0–15 m (greater depths are possible).

Yield: 0.25 litre per sec at 10 m.

Area of use: All over the world, mainly in rural areas.

Construction: Buckets, ropes, pulleys and windlasses are manufactured locally; buckets and ropes also by larger industries.

b. Description of O&M activities**Operation**

Lower and raise the bucket by paying out and pulling in the rope or rotating the windlass. One must be careful not to dirty the rope or bucket.

Maintenance

Preventive maintenance consists of greasing the bearings of the windlass or pulley. Small repairs are limited to patching of holes in bucket and hose, reconnecting the bucket hinge and fixing the windlass bearings or handle. All repairs can be done by local people and with tools and materials available in the community or area. Other repairs and replacements mainly consist of replacing a bucket, hose, rope or part or all of the windlass. Woven nylon ropes may last two years, twined nylon or sisal ropes only last a couple of months. A good quality hose may last over two years and buckets, depending on material and quality, may last a year.

Organizational aspects

When people use their own rope and bucket, no extra organization is required. For community wells, usually a committee organizes the maintenance and cleaning of the well, maintenance of the windlass, etc. Most repairs can be paid with ad hoc fund-raising.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Grease axles of windlass or pulley	Every two weeks	Local	Grease or oil	Lubricator
Replace bucket	Each year	Local	Bucket, wire	Knife
Replace rope	Every two years	Local	Rope, wire	Knife
Replace hose	Every two years	Local	Hose, wire, rubber straps from tyres	Knife, tongs

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Lower and lift the bucket Keep site clean Warn in case of malfunctioning	No special skills
Caretaker	Keep site clean, do small repairs	Basic maintenance
Water committee	Organize well cleaning, collect fees	Organizing skills
Local artisan	Repair of bucket, windlass, well cover, etc.	Tinkering, carpentry
Shopkeeper/trader	Sale of rope, bucket, etc.	No special skills
External support	Check water quality, stimulate and guide local organization	Microbial analysis, extension work

e. Recurrent costs

These consist in occasional purchase of rope, bucket, hose, wire, etc. Occasional windlass repair costs are low. Annual per capita costs for rope and bucket in Upper Volta were reported to range from US\$ 0.56 to 1.36 (Hofkes, 1983). These costs varied with the depth of the well and family size.

f. Problems and limitations

Frequent problems. Fast deterioration of bad quality rope. Sisal rope only lasts for a few months. Bucket falls into the well. To prevent this, communities can keep a spare bucket available and fit the bucket in a protective cage, for instance like the design described by D. Carty (1990). In windlass with hose systems the hose breaks frequently.

Limitations. Very poor hygiene, especially when the rope and bucket touch the hands or ground. Communal wells often tend to get more contaminated than family-owned wells. Therefore the latter should be aimed for where possible. Only suitable for limited depths, although examples are known of rope and bucket systems exceeding 50 metres.

O&M FACT SHEET

Direct-action handpump

a. Brief description of technology

Direct-action handpumps are usually made of PVC and other plastics and installed on boreholes of limited depth. The user at the pumpstand directly moves the pump rod in an up-and-down motion, holding a T-bar handle. The plunger at the lower end of the pump rod is located under the groundwater level. On the up-stroke, the plunger lifts water into the rising main and replacement water is drawn into the cylinder through the foot valve.

On the down-stroke, the foot valve closes, and water passes the plunger to be lifted on the next up-stroke. The elimination of the mechanical advantage (which, for example, deep-well handpumps have through a lever or flywheel) restricts the application of direct-action pumps to the depth from which an individual can physically lift the column of water (about 12 m). The mechanical simplicity and the potential for low-cost, lightweight construction makes these pumps well equipped to meet VLOM (Village Level Operation and Maintenance) objectives.

Initial cost: Varying from about US\$ 100 to over US\$ 900 (1985 prices, Arlosoroff et al., 1987). Models that are particularly suitable for village level O&M cost less than US\$ 150.

Range of depth: 0–12 metres.

Yield: 0.25–0.42 litre per sec at 12 m.

Area of use: Rural and low-income peri-urban areas where groundwater tables are within 12 m from the surface.

Construction: Blair, Ethiopia BP50, Malawi Mark V, Nira AF85, Tara, Wavin.

b. Description of O&M activities

Operation

The pump is operated by moving the handle up and down. As the plunger is located under water, no priming is needed. Adults and even children can pump, although if the water table is more than 5 metres it may be difficult for children. Pumpstand and site must be kept clean.

Maintenance

Maintenance of direct-action pumps is relatively simple and can be taught to users or caretakers, sometimes within a few hours. For preventive maintenance, usually only one or two persons are needed. Activities consist in checking pump performance and appearance of the water daily (if the water is cloudy with silt, the borehole must be cleaned). The pump should be taken apart and checked annually. Small repairs are the replacement of worn cupseals and washers, straightening of bent pump rods, and replacement of corroded lock nuts. For major repairs (e.g. broken pump rod or rising main, cracks in welding of metal parts), more highly skilled persons may be needed.

Organizational aspects

O&M can very well be organized at community level. As maintenance is relatively simple, good organization will result in a reliable service.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean pump and site	Daily	Local		Broom
Check performance	Daily	Local		
Check whole pump	Annually	Local		Spanners, screw-driver
Replace cupseals and washers	Occasionally	Local	Cupseals, washers	Spanners, screw-driver
Replace pump rod and/or pump handle	Occasionally	Local	Pump rod, pump handle	Spanners, wrench
Replace cylinder and/or plunger and/or foot valve	Occasionally	Local or area	Cylinder, plunger, foot valve	Spanners, wrench, screwdriver
Repair rising mains	Occasionally	Local or area	PVC tubing, PVC solvent and sandpaper or galvanized iron tubing, teflon or hemp	Saw and file or two pipe wrenches
Repair pump platform	Annually	Local	Cement, sand, gravel	Bucket, trowel

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Pump water Keep site clean Warn in case of malfunctioning	No special skills required
Caretaker	Keep site clean Do small repairs Check pump annually	Basic maintenance skills
Water committee	Organize maintenance collect fees	Basic organizational skills
Local merchant	Sell spare parts	No special skills
Local or area mechanic	Perform more major repairs	Welding
External support	Check water quality Stimulate and guide local organization	Microbial analysis, extension work

e. Recurrent costs

Apart from personnel costs, recurrent costs mainly consist in expenses for spare parts. In Ghana the annual costs recently were found to be US\$ 3.35 per capita per year or US\$ 0.61 per m³, based on 15 litres/capita/day, including capital amortization and other costs at an interest rate of 10% (Baumann 1993a). According to Reynolds (1992), a Tara handpump can be sustained for about US\$ 0.10 per user per year.

f. Problems, limitations and remarks

Frequent problems. Worn washers, plungers and footvalve parts. Abrasion of the seal on the PVC cylinder and between the pump rod and rising main (nitrile rubber seals have proven substantially better). Broken or damaged handles.

Limitations. The maximum lift is limited to about 12 m. The forces required at the handle to pump the water may be too high for children, especially when the water table is deeper than 5 m.

Remarks. At least a moderate industrial base is recommended for manufacturing these pumps, because good quality PVC is needed. Some designs have a relatively low discharge (Peter. 1990).

O&M FACT SHEET

Deep-well piston handpump

a. Brief description of technology

In a deep-well piston handpump, the piston is placed in a cylinder below the water level which is usually in the range of 15 to 45 metres below the ground. The pumping motion by the user at the pumpstand is transferred to the piston by means of a series of connected pumping rods inside the rising main. On the up-stroke, the plunger lifts water into the rising main and replacement water is drawn into the cylinder through the footvalve. On the down-stroke, the footvalve closes, and water passes the plunger to be lifted on the next up-stroke. The pumping height is limited only by the effort needed to lift water to the surface. Nowadays most cylinders have an open top, which allows the piston and footvalve to be removed through the rising main for servicing and repairs while the rising main and cylinder can stay in place. The pump rods have special connectors allowing for assembly and dismantling with no or only very simple tools. The joints incorporate pump rod centralizers that prevent wear of the rising main. To a large extent improved models can be maintained at village level.

Initial cost: For well depths of 25–35 m, prices vary from about US\$ 40 for a cylinder, plunger and footvalve set, to be installed under a locally made pump head, to over US\$ 2300 for a complete pump with many stainless steel parts (1985 prices, Arlosoroff et al.). Most good pumps cost US\$ 300–500.

Range of depth: 15–45 metres, depths up to about 100 m are possible

Yield: 0.25–0.36 litre per sec at 25 m and 0.18–0.28 litre per sec at 45 m depth

Useful life: 6 to 12 years

Area of use: Rural and low-income peri-urban areas where groundwater tables are within 100 m, but preferably within 45 m from the surface

Construction: Afridev/Aquadev, Bestobell Micro, Bush pump, Blair pump, India Mark II and III, Kardia, Tropic (Duba), UPM, Volanta, etc.

b. Description of O&M activities

Operation

Operation of the pump is done by moving a handle up and down or by rotating the handle of a flywheel. This can be done by adults and even children. Handle forces are usually kept within acceptable limits (depending on brand and lifting heights). Pump and site must be kept clean.

Maintenance

Preventive maintenance usually consists in checking pump functioning and cleaning the pump and site daily, greasing weekly, checking all parts of the pump stand monthly, and taking the whole pump apart for a check, cleaning the parts with clean water and painting the pump stand annually. Pump rods that show bad corrosion must be replaced. Under normal conditions, a galvanized steel pump rod needs replacement every five to six years. Rising mains consisting of galvanized iron have to be removed and checked and pipes with badly corroded threads must be replaced. Small repairs are the replacement of bearings, cupseals and washers, straightening bent pumping rods, etc. Major repairs may involve the replacement of the plunger, footvalve, cylinder, pump rods, rising main, pump handle, fulcrum, etc. With open-top cylinder pumps, all preventive maintenance activities can normally be executed by a village pump caretaker. For major repairs and problems, external support may be needed. Closed-top cylinder pumps often need special lifting equipment to pull up the rising main and cylinder for maintenance of parts down in the hole.

Organizational aspects

Most deep well pumps are too expensive for family use and will have to be used at communal level. The price of these pumps also means extra effort in fund-raising. Communities have to organize themselves in order to maintain the pump in good working condition. Often a caretaker is appointed and a pump committee coordinates activities. External support is often provided by state or nongovernmental organizations but becomes costly. In some cases small private enterprises, paid directly by the communities, are now doing this job very satisfactorily.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean pump and site	Daily	Local		Broom, brush
Grease bearings	Weekly	Local	Grease or oil	Lubricator
Check pump stand parts	Monthly	Local		Spanner
Replace pump stand parts	Occasionally	Local	Nuts and bolts, bearings, pump handle	Spanners, screw-driver
Replace cupseals	Annually or less	Local or area	Cupseals	Spanners, wrench, knife, screwdriver etc.
Redo threads in pump rod or main	Occasionally	Local or area	Oil	Pipe threader, tackle
Replace footvalve, plunger or cylinder	Occasionally	Area	Footvalve, plunger or cylinder	Spanners, wrench
Replace pump rod or main	Occasionally	Area	Pump rods or main tubing	Spanners, wrench, pipe threader
Repair platform	Annually	Local	Gravel sand, cement	Bucket, trowel

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Pump water Keep site clean Warn in case of malfunctioning	No special skills
Caretaker	Keep site clean Regularly check pump Do small repairs	Basic maintenance
Water committee	Supervise caretaker Collect fees	Organizing skills
Area mechanic	Perform more major repairs	Some special skills, depending on brand
External support	Check water quality, stimulate and guide local organization	Microbial analysis, extension work

e. Recurrent costs

The costs for preventive maintenance may range between US\$ 12 and US\$ 60 per pump per year for spare parts and materials (based on price indications from several brands). The recurrent personnel costs, in cash or kind (for caretakers, committee members, and, in case larger repairs are needed, mechanics or other skilled people), will need to be added.

f. Problems, limitations and remarks

Frequent problems. Replacement of plunger seals is the most common repair needed. Problems with local manufacture, centring mostly around quality control, are often reported, especially in African countries. Hook and eye connections of pump rods tend to break more often than conventional connections. Rods also reportedly get disconnected or bend spontaneously sometimes. Especially where groundwater is corrosive, corrosion has been reported to affect the pump rods (if not made of stainless steel), the rising main (if galvanized iron), the cylinder, and the pump head bearing housing and other pump stand parts. Broken or shaky handles, mainly due to worn-out or otherwise affected bearings.

Limitations. The maximum lift differs by brand, varying between about 45 and 100 metres. The forces required to turn the handle of the pump may be high in certain cases, depending on the brand and on the depth of the well.

Remarks. The quality of the material used for the rising main should be as high as possible to reduce the number of repairs needed on this part. Many of these pumps can be produced in developing countries. Rigorous quality control is needed. Piston pumps may be driven by a windmill but often rotary pumps are preferred because of their lower starting torque.

O&M FACT SHEET

Diesel engine

a. Brief description of technology

Diesel engines are very often used as a stationary power source. The main parts of the engine are the cylinders, pistons, valves, and crankshaft. The number of cylinders may vary from one to more than six. When air is heavily compressed by a piston inside a cylinder and diesel fuel is injected to it, this mixture comes to a controlled explosion that moves the piston. This movement is transferred to the crankshaft and from there it can be put to use, for example to drive a pump or an electricity generator. Valves in the cylinder regulate the inflow of fuel and air and the outflow of exhaust gasses. A high pressure pump forces the diesel fuel into the cylinder at the right moment. Diesel engines differ from petrol engines in that they use a different fuel, do not have spark ignition plugs and work at much higher pressures. Efficiency of diesel engines is higher and they need less maintenance than petrol engines. Engines can differ in size, speed (revolutions per minute), cycle (two-stroke and four-stroke cycles), cooling system (water or air), etc. Generally, low-speed four-stroke engines last longer and high speed two-stroke engines produce more power per kg of engine weight. Water-cooled engines generally need less maintenance than air-cooled engines.

Initial cost: From US\$ 200 per kW for 25 kW engines to US\$ 600 per kW for 2 kW engines (1990 data, McGowan and Hodgkin, 1992); installation and other costs not included.

Range of power: Commonly starting at 2 kW

Life cycle: Average 20 000 hours of operation ranging from less than 5000 to 50 000 hours, depending on the quality of the engine, installation and O&M.

Area of use: All over the world, especially for high-power needs and where no grid electricity is available.

Trademarks: Kubota, Lister-Petter, Lambardini and many others.

b. Description of O&M activities

Operation

The engine must be operated by a trained caretaker. Every engine has its own typical operating instructions. Before starting it, the levels of fuel, oil and cooling water (if not air-cooled) are checked. If these levels are low, extra fuel, oil or water has to be added. During operation, the fuel level, oil pressure, and engine speed are checked and also the functioning of the pump or generator. Some moving parts may need manual lubrication. When the engine is operated at very low speeds, its efficiency is low and carbon builds up rapidly in the engine, increasing the need for servicing. All data on liquid levels and running hours are written down in a log book.

Maintenance

Every day the outside of the engine must be cleaned, and in dusty conditions the air filter must be checked and cleaned. Some parts may need manual lubrication. In moderately dusty conditions, oil-bath air filters are cleaned once a week, dry-paper air filters a little less frequently. The engine is serviced for preventive maintenance according to the number of hours it has run. Every 50 hours, the clutch (if present) must be greased. Every 250 hours, clean all filters (replace if necessary), change oil, check nuts and bolts and exhaust pipe. Every 1500 hours, major service overhaul with decarbonizing, adjusting valve clearance, etc. If the engine is connected to a pump or generator with a V-belt, this will regularly need replacement. Once a year the engine house must be painted and occasionally repaired. If a generator is present it will have its own maintenance needs. The Table below shows only the most important O&M activities.

Organizational aspects

Diesel engines require a lot of simple maintenance and, if this is done well, they can have a long service life. Therefore training and supervision of the caretaker are important. More complicated maintenance tasks and repairs have to be done by a well-trained mechanic with access to sufficient spare parts. Good organization will guarantee scheduled services at the right times and a quick response in case of breakdown.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Check liquid levels and add if necessary	Daily	Local	Fuel, engine oil, cooling liquid	Funnels, containers for liquids
Start and stop engine	Daily	Local		
Keep logbook	Daily	Local	Paper, pen	
Check air filter, clean or replace if necessary	Daily or weekly	Local	New dry paper filter, or kerosene and engine oil	Wrench
Check for oil and fuel leaks	Weekly	Local		
Tighten nuts and bolts	Weekly	Local		Spanners
Change engine oil	Every 250 hours	Local	Engine oil	Spanners
Clean or replace filters	Regularly	Local	Oil filter, fuel filter	Spanners, special tools
Decarbonize, clean injector nozzles, adjust valves, etc.	Every 500 to 2000 hours	Specialist		Spanners, brass wire brush, special tools
Replace drive belt	Regularly	Local	Drive belt	Spanners
Replace engine parts	Occasionally	Specialist	Nozzles, injectors, gaskets, bearings, fuel pump, etc.	Depending on part to be replaced
Repair engine mounting and housing	Occasionally	Local or area	Cement, sand, gravel, nuts and bolts, nails, galvanized corrugated iron sheets, wood, etc.	Trowel, bucket, hammer, chisel, saw, spanners, etc.

d. Actors implied and skills required in O&M

Actor	Role	Skills
Caretaker	Operate engine, keep logbook, perform minor service, warn in case of irregularities	Special training is needed for basic diesel O&M
Water committee	Supervise caretaker, collect fees, organize major service and repairs	Organizational skills
Area mechanic	Perform major service and repairs	Special training needed
External support	Train caretaker and area mechanics	Training and technical skills

e. Recurrent costs

Where fuel and spare parts are scarce, the costs for these may amount to 50% of the annual system capital cost (McGowan and Hodgkin, 1992).

f. Problems, limitations and remarks

Frequent problems. Excessive wear due to wrong O&M, neglect or misunderstanding. Rapid carbon buildup and low efficiency due to running the engine under full loading. Broken drive belts.

Limitations. Frequent maintenance. High fuel costs and difficulty to get fuel. From time to time a specialist mechanic is needed for service and repairs.

Remarks. Diesel engines are especially suited for high stationary power output. With good maintenance they are dependable energy sources. It is very important to select a brand of good reputation and locally available service and spare parts.

O&M FACT SHEET

Chlorination in piped water supply systems

a. Brief description of technology

Chlorination is a chemical method for disinfecting water which kills nearly all pathogens and provides a barrier against reinfection. It can be applied as the last stage in a drinking-water treatment process or as the only measure when the water quality is already reasonably good. The most frequently used low technology methods are batch chlorination and flow chlorination.

For batch chlorination a concentrated chlorine solution is added to the water in a reservoir with inlets and outlets closed. The water is stirred and the chlorine is left to react for at least 30 minutes. After that, the outlets can be opened. When the reservoir is empty the outlets are closed, the reservoir is refilled and a new batch is disinfected. This method will not be discussed further in this fact sheet.

Flow chlorinators continuously feed small quantities of weakly concentrated chlorine solution to a flow of fresh water, often at the instream of a clear water reservoir. Usually a small reservoir containing the chlorine solution is placed on top of the water reservoir and the solution is administered close to the point where the fresh water comes in and turbulence guarantees good mixing. A special device like the floating bowl chlorinator enables precise dosage. Sometimes a special electric pump is used for this purpose. For on-site chlorine production, electrical devices can be bought that convert a solution of kitchen salt to a chlorine solution (Oliveira, Tavares and Meyers, 1995).

Chlorine doses must be monitored and adjusted to the water quality and quantity. For this purpose, small test kits are available. Chlorine-producing chemicals must be stored and prepared with care.

Initial cost: A chlorinator and hoses can cost as little as US\$ 15. This excludes the cost of the tank for the concentrated solution and the construction costs of a protective shelter.

Yield: Generally 350 to 1400 m³ of treated water per kg of 70% chlorine compound.

Area of use: Where drinking-water needs extra disinfection and chlorine is available.

Trademarks: Chlorine compounds have many trademarks.

b. Description of O&M activities

Operation

The chlorine tank has to be refilled with a freshly prepared solution once or twice a week. The flow rate has to be checked and adjusted if necessary. Operators must be very careful to avoid contact of chlorine compounds or solutions with eyes or clothes. In some cases, a logbook is kept with data on the amounts of chlorine applied and residual chlorine levels measured. Chlorination can easily be learnt.

Maintenance

Chlorinators regularly have to be adjusted and cleaned of chlorine salts. When hoses get affected by chlorine they have to be replaced. If a steel chlorine tank is used, it must be painted and checked for corrosion annually. Protective gloves and utensils used for the preparation of the chlorine solution occasionally need replacement, and the shelter of the chlorine solution tank needs maintenance.

Organizational aspects

Usually the water committee appoints a caretaker who is trained for the job. The chlorine compound has to be obtained through a merchant or the health department and an adequate supply of chlorine compound must be kept in stock. An external organization like a governmental health or water department will have to provide training for caretakers and monitoring.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Refill chlorine tank	Once or twice a week	Local	Chlorine compound, water	Spoon, scale, bucket, stirring rod
Adjust and clean chlorinator	Regularly	Local	Water	Measuring cup, stopwatch
Replace hose or chlorinator	Occasionally	Local	Hose, small tubes of plastic, glass etc., plug, bowl	Knife, nail
Paint steel tank	Annually	Local	Latex paint	Steel brush, paint brush
Check and adjust doses	Regularly	Area	Test medium, water sample	Test kit

d. Actors implied and skills required in O&M

Actor	Role	Skills
Caretaker	Refill chlorine tank and prepare solution, clean and adjust chlorinator, perform small repairs	Basic skills
Water committee	Supervise caretaker, collect fees	Organizational skills
Local health worker, shopkeeper or merchant	Provide or sell chlorine compound	No special skills
External support	Check residual chlorine in water and adjust doses, train caretaker	Basic testing and calculation, training skills

e. Recurrent costs

Recurrent costs for chlorine-producing chemicals in the USA are about US\$ 7 per kg of available chlorine. In other countries this figure may differ substantially. One kg of available chlorine (1.4 to 4 kg of compound) is needed for disinfection of 500–2000 m³ of water. Cost of rubber gloves, hoses and other spare parts is generally low. Apart from this, there will be recurrent costs for the caretaker's fee, monitoring and training.

f. Problems, limitations and remarks

Frequent problems. Bad quality hoses wear quickly. Some chlorine compounds are very sensitive to storage conditions and rapidly lose strength. If the chlorinator gets clogged or residual chlorine is not monitored, disinfection may not be sufficient.

Limitations. Chlorination does not kill all pathogenic organisms but is generally very effective. In alkaline water, pH above 8, chlorination is less effective. When the water contains a lot of organic matter or suspended material, pretreatment will be needed. High cost and unavailability of the chlorine compound can be serious limitations.

Remarks. Chlorination affects the taste of water and for that reason may be rejected by consumers. On the other hand, sometimes a chlorine taste is appreciated. The taste of chlorine in water is no proof of proper disinfection. Often a chlorine taste is caused by the application of too little chlorine.

O&M FACT SHEET

Slow sand filtration

a. Brief description of technology

Slow sand filter water purification is a combination of biological, chemical and physical processes occurring when water slowly passes downwards through a bed of sand. Fine particles are filtered out, and in the sand and on top of the filterbed a population of micro-organisms develops which feed on bacteria, viruses and organic matter in the water. The filter reservoirs have drains on the bottom, covered with gravel and the filter sand. An inlet provides for smooth entrance of the raw water and an outlet structure leads the clean water from the drains to the clean water mains. During operation the filter sand is covered with a water layer of 0.3 to 1.0 m. For good functioning there must be a continuous flow in the range of 0.1 to 0.3 m/hour. For community use, filter reservoirs can be made of concrete, bricks, ferrocement etc. At least two filters are needed to provide continuous operation.

It is recommended to combine slow sand filters with a dynamic roughing filter pretreatment unit. When raw water quality is low, adding upflow roughing filters is recommended. Sometimes the water is chlorinated afterwards to prevent recontamination. For small-scale application, see also the fact sheet on household slow sand filter. With good operation and maintenance a slow sand filter produces water virtually free from harmful organisms.

Initial cost: Data from rural India, in 1983, indicated US\$ 60–130 per m² of filter area. In Colombia, this was US\$ 105–215 per m² in 1987.

Yield: 0.1–0.3 m/hour or 0.028–0.083 litres per sec per m².

Area of use: All over the world.

Manufacturers: Slow sand filters can be built by experienced building contractors or even by communities, with external technical assistance.

b. Description of O&M activities

Operation

Operation of a slow sand filter is crucial to its effectiveness. The flow of water must be maintained in the range of 0.1–0.3 m per hour to provide the organisms in the filter with a stable flow of nutrients and oxygen and give them time to purify the water. After several weeks to a few months the population of micro-organisms gets too dense and starts to clog the filter. Depending on the filter design, flow rates may have to be adjusted accordingly or the layer of supernatant water on the filter will get too high. The caretaker of a slow sand filter keeps a logbook with flow rates and operation and maintenance activities. Slow sand filters can be operated and even monitored by communities, provided caretakers are trained well. It takes less than one hour a day for a caretaker to check the functioning and adjust the flow rates. Cleaning the site and other activities may take more time.

Maintenance

When flow velocities get too low the filter is drained and the top layer of the sand is scraped off, washed, dried in the sun and stored. After several scrapings the sand is restored, together with new sand to make up for losses during washing. It takes one day for several people to clean a filter unit. Hygienic measures must be taken every time someone enters a filter unit for maintenance or inspection. Valves must be opened and closed every two months to keep them from getting stuck. Any leaks must be repaired immediately. If well-designed and constructed, hardly any repairs of the filter tanks and drainage system will be needed, although valves and metal tubing may need occasional attention. Test kits are available which only require some basic training to monitor water quality.

Organizational aspects

A slow sand filter for community use requires some organization in order to have enough workers for scraping and resanding the filter units. A local caretaker will have to be trained and some other people may need training for water quality testing and to be able to replace the caretaker. It may take some time for people to get to trust that a green and slimy filter is capable of producing safe water. Apart from extra sand, some chlorine and test materials very few external inputs are needed. With proper external assistance, water organizations can become very independent in managing their water treatment.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Check inflow	Daily	Local		
Regulate flow	Daily	Local		
Keep logbook	Daily	Local	Logbook, pen	
Clean site	Daily	Local	Broom	
Scrape off sand, wash, dry and store	About every six weeks	Local	Water, disinfectant for tools, boots or feet	Wheelbarrow, hoe, rake, spade, rope, bucket, ladder, planks, broom, wash basin
Resand filter	About every 18 months	Local	Recycled and new sand, water, disinfectant for tools, boots or feet	Sieve, wheelbarrow, hoe, rake, spade, rope, bucket, ladder, planks
Repair valve	Occasionally	Local	Washers, spare valve	Spanners, screwdriver, wrench
Replace metal tubing	Occasionally	Local or area	Nipples and accessories, plumbing sealant or teflon, cement, sand	Steel saw, wrench, pipe threader, hammer, chisel, trowel, bucket
Disinfect filter outlets	Occasionally	Local	Chlorine	Bucket, brush
Analyse water quality	Regularly	Local or area	Water sample, test media	Test kit

d. Actors implied and skills required in O&M

Actor	Role	Skills
Local caretaker	Regulate flow, keep site clean, scraping and resanding	Fair understanding of filter process and hygiene, organizational skills
Water user or paid worker	Assist in scraping and resanding of filter units	No special skills
Water committee	Supervise caretaker, monitor water quality, collect fees, organize scraping and resanding	Organizational skills, basic water quality testing
Local plumber	Repair valves and piping	Basic plumbing
External support	Train caretaker, monitor water quality	Training and microbial testing skills

e. Recurrent costs

The caretaker's fee and the cost of additional sand are the main recurrent costs, assuming that the users occasionally do some of the work free of charge.

f. Problems, limitations and remarks

Frequent problems. If flow rates through the filter are too high, water quality drops. Excessive turbidity (>30 NTU) in the raw water can cause the filter to clog rapidly; in this case a prefilter may be needed. When water quality is very bad, harmful and badly tasting products like NH_3 and H_2NO_3 may be formed in the lower layers of the filter. If water flow is interrupted for more than a few hours, beneficial micro-organisms in the filter may die and filter action is disturbed. Smooth vertical surfaces can cause short circuits in the water flow, producing poor quality water.

Limitations. In some regions, sand is expensive or difficult to get. Slow sand filters require a substantial initial investment and dedicated operation and maintenance.

Remarks. After re-sanding a filter it takes a few days to ripen; in this period water quality is lower.

O&M FACT SHEET**Public standpost****a. Brief description of technology**

At a public standpost or tapstand people from several households can take water from one or more taps. Because they are used by many people and are often not so well taken care of, their design and construction must be sturdy compared with domestic connections. The standpost includes a service connection to the supplying water conduit, a supporting column or wall, and one or more 0.5-inch (or 1.25-cm) taps protruding far enough from this column or wall to enable easy filling of the water containers.

The taps can be a globe or a self-closing type. The column or wall may be of wood, brickwork, dry stone masonry, concrete, etc. Some standposts have a regulating valve in the connection to the mains, which can be set and locked to limit maximum flow. A water meter may also be included. A solid stone or concrete slab or apron under the tap and a drainage system must lead spilled water away and prevent the formation of muddy pools. A fence may be needed to keep cattle away. The residual pressure head of the water at the tapstand should preferably be between 10 and 30 metres and should never be under 7 or over 56 metres. The location and design of public standposts have to be determined in close collaboration with the future users.

Initial cost: In 1995, the cost of a self-closing tap for 0.5 to 1-inch pipes was US\$ 12 (UNDP/APSO, 1995). Cheaper taps can be found. Other costs depend largely on the standpost design.

Number of taps: Usually 1 to 3, or more.

Users per tap: Maximum 200 people.

Yield: 0.2–0.4 litres per sec per tap.

Area of use: Piped public water systems.

b. Description of O&M activities**Operation**

Users clean and fill their containers at the tap. Bathing and washing of clothes is usually not permitted at the standpost itself. The tap site has to be cleaned daily and the drain inspected.

Maintenance

The drain must be cleaned at least once a month. Formation of pools must be prevented at all times. Occasionally, a rubber washer or other part of a tap may have to be replaced. The fence may need repair too. Serious cracks in the structure must also be repaired, and when wood rots it must be treated or replaced. Occasionally the tubing may leak or need replacement.

Organizational aspects

A caretaker or tap committee may be appointed to keep the tap functioning and the surroundings clean, and to regulate the amounts of water used. The committee may also collect the fees for water use. Sometimes water vendors fill their tanks at public tapstands at special rates for resale to people living far away.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Tap water	Daily	Local		Jar, bucket, can, etc.
Clean site	Daily	Local		Broom or brush
Inspect and clean drain	Daily	Local		Hoe, spade
Repair or replace valve	Occasionally	Local	Rubber or leather washer, gland seal, Teflon, flax, spare valve	Spanners, screw-driver, pipe wrench
Repair fence	Occasionally	Local	Wood, steel wire, nails	Machete, pliers, hammer
Repair valve stand, apron or drain	Occasionally	Local	Wood, nails, cement, sand, water, etc.	Hammer, saw, trowel, bucket, etc.
Repair piping	Occasionally	Local	Pipe nipples, connectors, elbows etc., oil, Teflon, flax or plumbing putty	Pipe wrench, pipe cutter, saw, file, pipe threader

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Tap water, keep site clean	No special skills
Caretaker or tap committee	Clean site, perform small repairs, collect fees	Basic skills
Communal water committee	Organize more major repairs, collect fees	Organizing and bookkeeping skills
Mason	Repair tapstand and apron	Masonry
Plumber	Repair piping and taps	Basic plumbing
External support	Monitor hygiene, train committee members	Training skills and microbial testing

e. Recurrent costs

Recurrent costs for a tapstand comprise a few minor repairs to the taps every year and occasional repairs to the pipes, column, wall, apron or drain.

f. Problems, limitations and remarks

Frequent problems. Tampering, insufficient maintenance, and conflicts over use due to bad location of tapstand or unsolved social problems. Poor drainage. Often taps are not closed after use and even left open on purpose to irrigate a nearby plot. Tapstands at the tail end of a piped system often have insufficient water pressure.

Limitations. If people are willing to organize communal use and maintenance, the only limitation is the cost.

Remarks. Special attention should be given to how the water is handled after collection at the tapstand in order to prevent subsequent contamination.

O&M FACT SHEET

Ventilated improved pit latrine

a. Brief description of technology

Ventilated improved pit (VIP) latrines are designed to reduce two problems frequently encountered by traditional latrine systems—smells and flies or other insects. A VIP latrine differs from a traditional latrine in having a vent pipe covered with a fly screen. Wind blowing across the top of the vent pipe creates a flow of air which sucks out the foul-smelling gases from the pit. As a result, fresh air is drawn into the pit through the drop hole and the superstructure is kept free from smells. The vent pipe also has an important role to play in fly control. Flies are attracted to light and if the latrine is suitably dark inside, they will fly up the vent pipe to the light. They cannot escape because of the fly screen, so they are trapped at the top of the pipe until they dehydrate and die. Female flies, searching for an egg-laying site, are attracted by the odours from the vent pipe but are prevented from flying down the pipe by the fly screen at its top.

VIP latrines can also be constructed with a double pit. The latrine has two shallow pits, each with its own vent pipe but only one superstructure. The cover slab has two drop holes, one over each pit. Only one pit is used at a time. When this becomes full, its drop hole is covered and the second pit is used. After a period of at least one year, the contents of the first pit can be removed safely and used as soil conditioner. The pit can be used again when the second pit has filled up. This alternating cycle can be repeated indefinitely.

Initial cost: Single-pit VIP family latrine: about US\$ 70–400.

Double-pit VIP family latrine: about US\$ 200–600. Prices include the cost of materials (60–80%), transport (5–30%), and local labour (10–25%). Prices depend on the pit volume; quality of the lining, slab and superstructure; extent to which locally available materials are used; and the country or region.

Area of use: Rural or peri-urban areas, household and public use.

b. Description of O&M activities

Operation

Operation of pit latrines is quite simple and consists in regularly cleaning the slab with water (and a little disinfectant if available) to remove any excreta and urine. The door must always be closed so the superstructure remains dark inside. The drop hole should never be covered as this would impede the airflow. Appropriate anal cleaning materials should be available in or near the latrine. Stones, glass, plastic, rags, and other non-biodegradable materials should not be thrown in the pit as they reduce the effective volume of the pit and hinder mechanical emptying.

Maintenance

Every month the floor slab has to be checked for cracks and the vent pipe and fly screen must be inspected to ensure they are not corroded or damaged. Rainwater should drain away from the latrine. Any damage should be repaired. Repair of the superstructure (especially light leaks) may be necessary too. When the contents of the pit reach the level of 0.5 metre below the slab, a new pit has to be dug and the old pit covered with soil. Another possibility is to empty the pit mechanically. With double-pit systems, the second pit is used when the first is full. The full pit can be emptied safely by hand after a period of a year or longer and is then ready for use again.

Organizational aspects

Where latrines are used by a single household, O&M tasks are implemented by the household itself or by hired workers. If two or more households use the latrine, arrangements for rotation of cleaning tasks have to be made and agreed upon to avoid conflict. Pits can only be emptied manually if their contents have been left to decompose for at least a year. In all other cases, either new pits have to be dug when a pit is full or the pit has to be emptied mechanically. If double-pit latrines are used, the users must fully understand the concept of the system in order to be able to operate it properly. User education has to cover aspects such as the reasons for switching after using only one pit at a time, use of excreta as manure, and the need to leave the full pit for at least a year before emptying. The users also need to know how to switch pits and how to empty the pit, even when they do not do these tasks themselves. Where these tasks are carried out by privately hired labourers, the latter must also be educated in the operational requirements of the system.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean drop hole, seat and superstructure	Daily	Household	Water, soap	Brush, bucket
Inspect floor slab, vent pipe and fly screen	Monthly	Household		
Clean fly screen and vent inside	Every one to six months	Household	Water	Twig or long bendable brush
Repair slab, seat, vent pipe, fly screen or superstructure	Occasionally	Household or local workers	Cement, sand, water, nails local building materials	Bucket or bowl, trowel, saw, hammer, knife
Dig new pit and transfer latrine slab and superstructure (if applicable)	Depending on size and number of users	Household or local workers	Sand, possibly cement, bricks, nails and other local building materials	Shovels, picks, buckets, hammer, saw, etc.
Switch to other pit when pit is full	Depending on size and number of users	Household or local workers		Shovels, buckets, wheelbarrow, etc.
Empty pit (if applicable)	Depending on size and number of users	By hand: household or local workers (not recommended)	By hand: water	By hand: shovel, bucket
		By mechanical means: specialized service	By mechanical means: water, spare parts for machinery	By mechanical means: pit-emptying equipment

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Use latrine, keep clean, inspect and perform small repairs, empty full pit and switch over, dig new pit and replace latrine	Understanding of hygiene
Local unskilled workers (sweepers/scavengers)	Dig pits, transfer structures, empty full pits in double-pit systems, small repairs, solving small problems	Knowledge about the concept of a double-pit system (when working with such systems), knowing how to solve simple problems.
Local mason	Build and repair or transfer latrines	Basic masonry, latrine building
Health department	Monitor latrines and hygienic behaviour of users, train users	Training skills and knowledge on sanitation

e. Recurrent costs

These costs are usually very low, maximum about US\$ 1 to 2 per capita per year, as normally maintenance activities are few (mainly cleaning) and can be done by the households themselves. Even if local labour has to be hired for digging a new pit, the recurrent costs per time unit and user are low although paying in full may pose a problem. The same applies to the cost of mechanical emptying of the pit. Emptying a double VIP latrine can be done by hand, either by the household itself or by hired workers. Sometimes the humus can be sold to farmers.

f. Problems, limitations and remarks

Frequent problems. Bad quality of the floor slab due to inappropriate materials or improper curing of concrete. Inferior quality fly screens get damaged easily by the effects of solar radiation and foul gases. Improperly sited latrines can get flooded or undermined. Children may be afraid to use the latrine because of the dark or because of fear of falling into the pit. If the superstructure allows too much light to come in, flies will be attracted by the light coming through the squat hole and may fly out into the superstructure; this may jeopardize the whole VIP concept. Odour problems may occur during the night and early morning hours in latrines relying more on solar radiation for the air flow in the vent pipe than on wind speed. Leakages between pits can occur because the dividing wall is not impermeable or the soil is too permeable.

Limitations. In hard soils it may be impossible to dig a proper pit. Pits should preferably not reach groundwater level and latrines must be 15 to 30 metres away from ground and surface water sources. VIP latrines cannot prevent mosquitos from breeding in the pits. Families may not be able to bear the much higher costs for construction of a VIP latrine in comparison to a simple pit latrine.

Remarks. Cultural resistance to handling human waste may prevent some households from emptying their double pits themselves. Usually local workers can be hired to do the job.

O&M FACT SHEET

Double-vault compost latrine

a. Brief description of technology

The double-vault compost latrine consists of two watertight chambers (vaults) to collect faeces. Urine is collected separately as the contents of the vault have to be kept relatively dry. Initially, a layer of absorbent organic material is put in the vault and after each use, the faeces is covered with ash (or sawdust, shredded leaves or vegetable matter) to deodorize the faeces, soak up excessive moisture and improve the C/N ratio, which ensures that sufficient nitrogen is retained to make a good fertilizer. When the first vault is three-quarters full, it is completely filled with dry powdered earth and sealed so that the contents can decompose anaerobically. The second vault is used until it is three-quarters full and the first vault is emptied by hand, the contents being used as fertilizer. The vaults have to be large enough to keep faeces for at least a year in order to become pathogen-free. A superstructure is built over both vaults with a squat hole over each vault which can be sealed off. The latrine can be built in any place as there is no risk of pollution from the watertight chambers to the surroundings. Where there is rock or a high watertable, the vaults can be placed above the ground.

Initial cost: US\$ 35–70 (in 1978 US\$) in Guatemala (Winblad & Kilama, 1985). Prices include the cost of materials and local labour, construction with vaults of 0.3 m³ each above the ground and a movable raised seat.

Area of use: Areas where people are motivated to handle and use humus or human excreta as a fertilizer and where no water is used for anal cleansing.

b. Description of O&M activities

Operation

Initially some absorbent organic material is put in the empty vault after each use and, whenever available, wood ash and organic material are added. When urine is collected separately it is often diluted with 3–6 parts of water and utilized as fertilizer. This may cause a health hazard and should be avoided. Adding lime or ash may help, but there is no guarantee that the urine will then be safe. Water used for cleaning should not be allowed to go into the latrine as it will make the contents too wet.

Maintenance

When the vault is three-quarters full, the contents are levelled with a stick, after which dry powdered earth is added till the vault is full. The squat hole is then sealed and the other vault emptied with a spade and bucket, after which it is ready for use. The removed contents can be used safely as a fertilizer. Householders may grow insect-repelling plants like citronella around the latrine.

Organizational aspects

Extensive investigation among potential users is needed to find out if the system is culturally acceptable and if they are motivated and capable of operating and maintaining the system properly. Prolonged support by the agency is needed to ensure that users understand the system and operate it properly.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean toilet and super structure, empty urine collection pot	Daily	Household	Water, lime, ashes	Brush, water container
Add ashes or other organic material	After each defecation and whenever available	Household	Wood ashes and organic material,	Pot to contain the material, small shovel
Inspect floor, super-structure and vaults	Monthly	Household		
Repair floor, super-structure or vaults	When necessary	Household or local	Cement, sand, water, nails, local building materials	Bucket or bowl, trowel, saw, hammer, knife
Close full vault after levelling and adding soil, empty other vault, open its squat hole and add absorbent organic material before starting to use, store humus (or use directly)	Depending on size and number of users	Household or local pit emptier	Water, absorbent organic material	Shovel and bucket
Use humus as fertilizer	When needed	Household or other users	Humus	Shovel, bucket, wheelbarrow

d. Actors implied and skills required in O&M

Actor	Role	Skills
User, householder	Use latrine, remove urine, keep clean, inspect and perform small repairs, empty pit and switch	Understanding of hygiene, understanding of system and its O&M
Local mason	Build and repair latrines	Basic masonry, latrine building skills
Local pit emptier	Empty pit and switch, check system and perform small repairs	Understanding of hygiene, understanding of system and its O&M
External support organization	Investigate applicability, monitor users' O&M and hygienic behaviour and provide feedback, train users and local artisans	Research and surveying skills, training skills, knowledge of the system, organizational skills, communicative skills

e. Recurrent costs

When the system is well designed and constructed and O&M is done properly, the recurrent costs will be limited to the costs of small repairs and emptying of a vault when full. Sometimes the humus can be sold to farmers.

f. Problems, limitations and remarks

Frequent problems. Proper operation needs full understanding of the concept. This is often lacking and, as a result, the contents are left too wet, making the vault malodorous and difficult to empty. Where people are eager to use the contents as fertilizer, they may not allow sufficient time for the excreta to become pathogen-free.

Limitations. Only to be used where people are motivated to use human excreta as a fertilizer. The system is not appropriate where water is used for anal cleansing.

Remarks. Double-vault latrines have been successfully used in Vietnam and Central America (Guatemala, Honduras, Nicaragua, El Salvador). When tried elsewhere they have usually been unsatisfactory.

O&M FACT SHEET

Septic tank and aqua-privy

a. Brief description of technology

Septic tanks and aqua-privies have a water-tight settling tank with one or two compartments, to which waste is carried by water flushing down a pipe connected to the toilet. If there is a tank immediately under the latrine, excreta drop directly into the tank through a pipe submerged in the liquid layer (aqua-privy). If the tank is located away from the latrine (septic tank) the toilet usually has a U-trap. The systems do not dispose of wastes; they only help to separate the solid matter from the liquid. Some of the solids float on the surface, where they are known as scum, while others sink to the bottom where they are broken down by bacteria to form a deposit called sludge. The liquid effluent flowing out of the tank is, from a health point of view, as dangerous as raw sewage and remains to be disposed of, normally by soaking into the ground through a soakaway or with a connection to small-bore sewers. The sludge accumulating in the tank must be removed regularly, usually once every 1–5 years, depending on size, number of users and kind of use. When sullage disposal is also in the tank, a larger capacity is required for both the tank and the liquid effluent disposal system. Connection to small-bore sewers may then be needed. Where high groundwater tables or rocky or impermeable undergrounds occur, this may also be the case. Every tank must have a ventilation system to allow escape of explosive methane and malodorous gases (generated when bacteria decompose some of the sewage constituents) from the tank. Septic tanks are more expensive than other on-site sanitation systems and require sufficient piped water. Aqua-privies are slightly less expensive and need less water for flushing.

Initial cost: US\$ 90–375, including cost of labour and materials

Area of use: Rural or peri-urban areas where water is available.

Amount of water needed per toilet flushing: About 2 to 5 litres if a pour-flush pan or aqua-privy system is used.

b. Description of O&M activities

Operation

Regular cleaning of the toilet with soap in normal amounts is unlikely to be harmful, but the use of large amounts of detergents or chemicals may disturb the biochemical process in a tank. In aqua-privies the amount of liquid in the tank should be kept high enough to keep the bottom of the drop pipe at least 75 mm below the liquid level. A bucket of water should be poured down the drop pipe daily in order to clear scum (in which flies may breed) from the bottom of the drop pipe and to maintain the water seal. When starting with a new tank, adding some sludge from another tank will ensure the presence of micro-organisms so that the anaerobic digestion process can start directly and more completely.

Maintenance

Routine inspection is necessary to check whether desludging is needed and to ensure that there are no blockages at the inlet or outlet. The tank should be emptied when solids occupy between one-half and two-thirds of the total depth between the water level and the bottom of the tank.

Organizational aspects

Organizational aspects revolve around the reliability of the emptying services, the availability of skilled contractors for construction and repair, and the control of sludge disposal.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean squatting pan or seat and shelter	Daily	Household	Water	Brush, water container
Unblock U-trap when blocked	Occasionally	Household	Water	Flexible brush or other flexible material
Inspect if entry pipe is still submerged (for aqua-privies)	Regularly	Household	Water	Stick
Inspect floor, squatting pan or seat and U-trap	Monthly	Household		
Repair squatting pan or seat, U-trap or shelter	Occasionally	Household or local artisan	Cement, sand, water, nails, local building materials	Bucket or bowl, trowel, saw, hammer, knife
Control vents	Annually	Household	Rope or wire, screen material, pipe parts	Scissors or wire-cutting tool, pliers, saw
Empty tank	Every 1–5 years	Service crew	Water, fuel, lubricants, etc.	Vacuum tanker (large or mini) or MAPET equipment, if possible

d. Actors implied and skills required in O&M

Actor	Role	Skills
User	Flush, keep clean, inspect vents, keep record of emptying dates, control contents in tank and contact municipality or other organization for emptying when necessary	Understanding of hygiene, basic bookkeeping, measuring skills
Sanitation service	Empty tank, control tank and vents, repair if needed	Skills to work with vacuum tanker or MAPET, basic masonry
Agency	Monitor tank performance, and tank emptying by emptying teams, train emptying teams	Training skills, monitoring skills, organizational skills and technical knowledge

e. Recurrent costs

The main cost involved is the emptying of the tank. The frequency of emptying depends on the amount of solids and liquids entering into the tank. The average annual O&M cost per capita measured over 39 countries was US\$ 3.09, while in Brazil this cost was only US\$ 0.67 (World Bank studies, quoted in Wilson H., 1988 (in 1987 US\$)).

f. Problems, limitations and remarks

Frequent problems. Many problems are due to inadequate consideration being given to liquid effluent disposal. Large surges of flow entering the tank may cause a temporarily high concentration of suspended solids in the effluent owing to disturbance of the solids which have already settled out. Leaking tanks may cause insect and odour problems in aqua-privies because the water seal is not maintained.

Limitations. Unsuitable for areas where water is scarce, where financial resources are insufficient for construction of the system, or where safe tank emptying cannot be done or afforded. Where not enough space is available for soakaways or drainage fields, small-bore sewers will have to be installed. Aqua-privies only function properly when they are very well designed and constructed and operated.

Remarks. Septic tank additives—such as yeast, bacteria, and enzymes—which are often sold for “digesting scum and sludge” and “avoiding expensive pumping” have not proved to be effective.

O&M FACT SHEET**Drainage field****a. Brief description of technology**

Drainage fields consist of gravel-filled underground trenches called leachlines or drainage trenches, into which the liquid effluents coming from a septic tank are led through open-jointed (stoneware) or perforated (PVC) pipes, allowing the effluents to infiltrate into the ground. Initially the infiltration into the ground may be high, but after several years the soil clogs and an equilibrium infiltration rate is reached. If the sewage flow exceeds the equilibrium rate of the soil, eventually the sewage will surface over the drainage field..

Trenches are usually 0.3–0.5 m wide with a depth of 0.6–1.0 m below the top of the pipes. They are laid with a 0.2–0.3% gradient and contain 20–50 mm diameter gravel with 0.3–0.5 m of soil on top, with a barrier of straw or plastic sheets to prevent soil from washing down. They should be laid in series so that as each trench fills, it overflows to the next one. This ensures that each trench is used either fully or not at all. Trenches should be 2 m apart, or twice the trench depth if this is greater than 1 m. The bottom of a trench should be at least 0.5–1 m above groundwater, bedrock or impermeable soil, and land slope should not exceed 10%. An equal area of land should be kept in reserve for possible extension or replacement of the drain field if it becomes clogged.

Compared to soakaways, drainage fields are often used where larger quantities of liquid effluents are produced.

Initial cost: No data found.

Area of use: Rural or peri-urban areas where sufficient water and space are available and the soil is permeable.

b. Description of O&M activities**Operation**

Hardly any activities for operation are required, except observing if there are overflows and switching to a second drainage field every 6 to 12 months and fixing the dates of switching (if applicable).

Maintenance

Clean the tank outflow and check if it is still in order (if not, it should be cleaned or repaired). Deblocking of the delivery pipe may be necessary occasionally. Diversion boxes have to be cleaned from time to time. Control plant growth to prevent the roots from entering the pipes or trenches.

Organizational aspects

Minor O&M and bookkeeping are organized and executed by households, groups of households or a community organization. The government department needs to monitor the performance of drainage fields and train users (and their organizations), artisans and caretakers on the technical aspects of O&M.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Control plant growth	Regularly	Household or caretaker		Shovel, bucket, panga, etc.
Switch to other drainage field	Once every 6–12 months	Household or caretaker	Bricks or other material to block pipes	Tools to open diversion box
Deblock delivery pipe	Occasionally	Household, caretaker or local artisan	Water, piece of pipe, glue	Brush, shovel, long stick or flexible brush, knife, saw
Clean diversion boxes	Every month	Household or caretaker	Water	Shovel, brush
Check outflow of tank and clean	Once a month	Household or caretaker	Water	Brush, tools to open access hole

d. Actors implied and skills required in O&M

Actor	Role	Skills
Household user or local caretaker	Check outflow tank and performance of drainage field and control plant growth	Understanding of hygiene, some technical knowledge of tank and field
Local artisan	Repair parts if broken, remove obstructions in delivery pipes	Basic masonry, piping techniques, knowledge of system techniques and functioning
Agency	Monitor performance of systems, train users, caretakers and local artisans, provide assistance with big problems	Training skills, technical skills for repair and maintenance of drainage fields, monitoring skills

e. Recurrent costs

If the system is well designed, repairs are needed only very occasionally and the recurrent costs are therefore low.

f. Problems, limitations and remarks

Frequent problems. Overflowing leachlines, unpleasant odour, groundwater contamination, and social conflict (over siting of the drainage fields, odour, etc.).

Limitations. Unsuitable where the available space, water or financial resources for construction are insufficient, where the permeability of the soil is poor, or where bedrock or groundwater are at a shallow depth.

Remarks. Pressure can be taken off drainage fields by reducing the amount of water and solids flowing into the solids interceptor tank, e.g. by improved design of toilets which use less water or by preventing sillage from entering the tank.

O&M FACT SHEET

Small-bore or settled sewerage

a. Brief description of technology

Small-bore sewerage (or settled sewerage) is a sewerage system that is designed to receive only the liquid fraction of household wastewater. The solid components of the waste, which settle, are kept in an interceptor tank (basically a single-compartment septic tank) which needs periodic desludging. Because the sewers only receive the liquid sewage, they are designed differently from conventional sewers and have the following advantages:

- the system needs less water because solids are not transported;
- excavation costs are reduced because the pipes can be laid at shallow depths and do not need to maintain self-cleansing velocity;
- material costs are reduced because the diameter of the pipes can be small (peak flow is attenuated by the interceptor tanks) and there is no need for large manholes;
- treatment requirements are reduced because the solids are kept in the interceptor tanks.

The small-bore sewer system consists of a house connection, an interceptor tank, sewers, cleanouts/manholes, vents, sewage treatment plant, and lift stations (if there is no gravity flow). The system is most appropriate in areas that already have septic tanks but where the soil cannot (or can no longer) absorb the effluent or where densities are such that there is no room for soakaways. It also provides an economical way to upgrade existing sanitation facilities to a level more comparable to conventional sewers.

Initial cost: No recent data available, but the cost of the system in Brotas (Brazil) was calculated to be 78% cheaper than conventional sewerage; in Australia and the USA there were 25–35% savings on the construction cost, but this excluded the cost of the interceptor tanks.

Area of use: Areas where individual soakaways are not appropriate (soil conditions or densities), or areas where pour-flush latrines with soakpits can be upgraded to a small-bore sewer system.

b. Description of O&M activities

Operation

The main operational requirement is for the household to ensure that no solids can enter the system and that the interceptor tank functions properly.

Maintenance

Regular removal of the sludge in the interceptor tank. This has to be checked by the local sewerage authority because the system will be at risk if solids can enter. Also, removal of blockages, regular control of sewage pipes, and periodic flushing. The performance of accessories in the pipeline system such as cleanouts, manholes, (possible) lift stations, and ventilation points should be regularly checked and maintained.

Organizational aspects

These are mainly the organization of desludging services for the interceptor tanks. The principal problems related to desludging revolve around responsibility. Normally this lies with the property owners since the interceptor tank is on their property. Residents who are not owners have no incentive to desludge regularly. Desludging costs money and is inconvenient; sludge overflowing in the sewerage system will not directly affect the resident but will affect the communal sewer system downstream. If the sewer system is to work effectively, the responsibility for tank desludging must fall on the organization which is responsible for maintenance of communal sewers. This organization must therefore bear the responsibility for treatment of the liquid from the sewers and the sludge from the interceptor tanks.

c. O&M requirements

Activity	Frequency	Human resources	Materials and spare parts	Tools and equipment
Clean grease trap	Daily/weekly	Household	Water	
Repairs and removal of blockages	When needed	Local workers or mechanic	Water, specialized materials and spare parts	Rodding tool, mechanic's tool set
Check inspection chambers, appurtenances such as pumps and controls, vacuum and surge chambers, check valves	At least annually	Household or mechanic	Water	Basic tool set
Inspect street sewers	Regularly	Staff sewerage department	Specialized spare parts and materials	Specialized tools and equipment

d. Actors implied and skills required in O&M

Actor	Role	Skills
Householder	Check appurtenances within plot, assist community organization in maintenance of inspection chambers and common block sewer line	Understanding of system, some technical skills to check appurtenances
Local workers/mechanic	Check on-site appurtenances, perform small repairs, removal of blocks	Mechanical skills
Community organization	Organize regular checking of block sewer, notify agency of problems that cannot be solved, collect sewer charges	Understanding of system and bookkeeping skills, organizational skills, monitoring skills, communicative skills
Agency	Monitor system's performance; keep regular contacts with community organizations and monitor their performance; train teams, mechanics, organization staff and community organization members, operate and maintain collector sewer, pumping station and treatment plant	Technical skills, administrative skills, organizational skills, monitoring skills, communicative skills, training skills

e. Recurrent costs

The main recurrent cost is the emptying of the interceptor tanks, which varies by country and city. Other recurrent costs are for occasional flushing of the system, and repairs to maintain the system.

f. Problems, limitations and remarks

Frequent problems. Overflowing interceptor tanks because they have not been desludged in time. Blockages due to illegal connections bypassing the interceptor tank.

Limitations. Basically only suitable where septic tanks or other on-site systems are already in existence. If a new system needs to be installed, the shallow sewer system is more appropriate as it does not need an interceptor tank. The need for regular desludging of the interceptor tank calls for a well-organized sewerage department.

Remarks. The small-bore sewerage system needs a regular lay-out along back lanes or streets and a regular (even if limited) water supply system. These are absent in many low-income urban areas so that this system is not appropriate. So far, positive experiences with the system have all been in developed countries.

4.3 Spare parts provision in general

Instead of being one of the principal items on a check-list for sustainability, spare parts are often considered long after the technical and operational designs of a water supply or sanitation project have been decided. Spare parts provision should therefore be one of the deciding factors in technology selection, and not merely an unplanned consequence.

Spare parts can be defined as all the materials and items needed for the efficient and sustainable operation and maintenance of a water supply or sanitation system. They include:

- Mechanical, hydraulic, electrical and electronic parts
- Tools
- Seals and washers
- Fuel, lubricants
- Paint
- Chemicals and other consumables
- Parts for essential transport and communication equipment
- Stationery

4.4 Towards sustainable spare parts provision

Spare parts provision should be viewed as much from the demand side as from the supply side. Furthermore, sustainable spare parts provision depends also on strategic issues.

Such elements as the need for spare parts, their cost, and accessibility to spare parts are likely to influence the **demand for spare parts**. The following items should be considered in analysing this demand.

Need for spare parts

- Assessment of the spare parts needed for a particular technical option, based on the technical characteristics and experience;
- Identification and inventory of the spare parts required, based on an accurate diagnosis of the problems most likely to occur, and their periodicity;
- Estimate of the spare parts needed for emergency repairs, accidents, or scheduled replacement;
- Variations in the frequency of this need, which communities should be aware of;
- Determination of proper timing for initiating repairs or replacement, in addition to the activities needed for simple maintenance of the system;
- Proper operation and maintenance, including effective preventive maintenance, in order to decrease the need for spare parts and their frequency;
- Interchangeability of some spare parts with other brands or technologies.

Cost of spare parts

- Can the cost of spare parts be met according to the tariff in place?
- Are the transport costs to obtain the spare parts included in the tariff? If not, how may these be met?
- What financial mechanisms are available in case the budget cannot cover the cost of spare parts?
- How does the cost of imported spare parts compare with similar parts produced locally or in neighbouring countries?
- How significant are exchange rate fluctuations on the cost of spare parts?

Accessibility to spare parts

- The distance between the village and the location of the shop which is selling the spare parts could be a factor influencing the demand for spare parts;
- This demand can be divided into three categories: 1) *frequently needed* spare parts, for which the sales outlet or mechanic should be in the village or as close as possible to it; 2) *occasionally needed* spare parts (every six months to a year), for which the distance should not be too far; 3) spare parts for *major repairs or replacement*, which may be ordered only from the regional or state capital.

Factors likely to have an influence on the **supply side** are the availability and use of local materials and locally manufactured parts, location of marketing and sales points, and the profit perspective. The following items should be reviewed.

Use of local materials and locally manufactured parts

- Making better use of materials from sustainable local sources;
- Having options for recycling and re-use or restoration of worn-out parts;
- Improving the reliability of the products (quality control) and the guarantees;
- Improving compliance with delivery deadlines through bonuses or other mechanisms, including penalties for delay;
- Encouraging local entrepreneurs or cooperatives to undertake the manufacture of spare parts;
- Making sure that the parts are guaranteed to remain available over a period of time;
- Learning from the experience of local manufacturers in other sectors;
- Balancing the proportion of imported spare parts with those manufactured locally;
- Offering incentives to local entrepreneurs (e.g. tax breaks, subsidies, preferential consideration against foreign suppliers, etc.).

Quality of spare parts

- Type of material used;
- Quality of manufacture, quality control;
- Interchangeability.

Marketing and sales points

- Encouraging local entrepreneurs, mechanics and shops to undertake the distribution and supply of spare parts, making them aware of the market potential and of the three categories of spare parts, as described above under “accessibility”;
- Installing, where possible, a revolving fund for spare parts which is managed by a cooperative of users or mechanics;
- Making sure that the provision of spare parts through donor assistance or government channels is only temporary, and promoting the development of the private sector;
- Creating better links between the supplier and the user;
- Ensuring stock control, warehousing and sustainable outlet options.

Perspective on profits

- Involving local manufacturers, entrepreneurs, mechanics and shops by offering them some kind of benefits or profit (e.g. a defined profit margin, percentage of sales as own income, free stock for first sales, etc.);

- Making sure that donor-assisted or heavily subsidized prices do not “kill” the market, which means that market prices should be realistic right from the start in order to keep the system sustainable.

Strategic issues for improving spare parts provision include efficient planning, whether to standardize or not, approaches to reducing the need for spare parts, appropriate pricing policy, private sector involvement, and capacity-building.

Efficient planning

- Planning for spare parts provision should start as early as possible in the project cycle.
- During a feasibility study, the project should assess the following: types of spare parts currently available locally or in neighbouring countries; the distribution network; type of equipment used in other projects and regions; the possibility of interchangeability; the possibility of local manufacture (in steel works and plastic works); the cost of spare parts to the customer; the level of import taxes; and national policy regarding spare parts provision.
- Implementation of the project should ensure the sustainability of spare parts provision on a long-term basis.
- After the construction phase, regular monitoring and evaluation of the equipment will help to determine the right time for repairs and rehabilitation within the economic life-span of the scheme; feed-back to the manufacturers on any weakness in the manufacturing of the equipment can help them.

Whether to standardize

Several countries have chosen to standardize their choice of technology. There are positive as well as negative aspects which should be carefully considered (see Table below) before making a decision. Whatever the choice, it could be for a certain number of years only.

FOR STANDARDIZATION	AGAINST STANDARDIZATION
<ul style="list-style-type: none"> ■ Wide use of the same item of equipment encourages agents and shopkeepers to store and supply these spare parts because of the “guaranteed demand” ■ Proliferation of brands and technology makes it difficult to organize spare parts availability ■ Prices and markets can be more easily researched ■ Users become familiar with one type of product or technology ■ Training of personnel can be standardized. 	<ul style="list-style-type: none"> ■ The chosen technology does not respond totally to the needs and preference of the users ■ The market is closed for new, innovative and cheaper technologies ■ Poor incentive for involvement of the private and research sectors ■ Possible conflict with donor policies on technology choice ■ Competition between different brands can bring down prices and lead to improvements.

Approaches to reducing the need for spare parts

- Better design of equipment to make them last longer.
- Better engineering to reduce operation and maintenance requirements.
- Better use and operation, by instructing the users on how to reduce wear and tear in the equipment.
- Introduction of a **maintenance “culture”** that promotes prevention rather than cure.

Appropriate pricing policy

- At the outset, donor assistance often includes subsidized prices for spare parts, which can have a negative effect later on. While this type of pricing by donors may be an incentive to local distributors initially, it raises false expectations and does not help to stabilize the market.
- Highly subsidized prices may not be sustainable over a long period.
- Pricing policy could include an agreed margin of benefits for the intermediaries up to the final outlet point, with prices which the users can afford and are willing to pay.
- Free price policies could open up the market for spare parts and their distribution, but will result in higher prices for consumers initially; however, competition between various brands could lead to a fall in prices.
- High taxes on imported foreign equipment for water supply could be reduced.
- Appropriate pricing of spare parts should be one of the key elements in the technology selection process.

Private sector involvement

- Is there a policy towards private sector incentives and promotion?
- Are there manufacturers of spare parts in other sectors, from whom lessons can be learnt and with whom resources and experiences can be shared?
- What are the opportunities for interregional cooperation in terms of shared markets, marketing, agreements on prices, or division of specialization?
- What are the possibilities for joint ventures with firms and manufacturers in developed countries, which will provide technical, entrepreneurial and managerial training?
- Can the links between manufacturers be strengthened?
- How can the informal private sector at local level contribute to the manufacture and provision of spare parts?

Capacity-building

- Assessment of training needs in the private sector for stock management, as well as manufacture, distribution, supply and use of spare parts.
- Opportunities for learning from the experiences in neighbouring countries and from partners.

Unit 2: Analysis of participation

1. Outline of session

► Objectives

- To identify all the actors involved in the operation, maintenance and management of rural water supply and sanitation systems
- To identify their roles, interest, problems and degree of participation

► Methodology

1. Introductory note
2. Interactive group exercise
3. Concluding remark

► Materials

- ✓ Overhead transparencies
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall

► Handouts

- ✓ Background information

2. Notes for the facilitator

Introductory note

The object of operation and maintenance is to deal with people and institutions on technical issues. This session aims to identify all the actors who are directly and indirectly involved in the operation and maintenance of water systems, their roles and interests (interests can be contradictory or complementary between different actors), and their major problems.

The work in this session and the next will involve the whole group. Different seating arrangements should be made, because the participants will not have to take down notes or carry out any special exercises. Tables are not required, and the chairs should be placed in a semi-circle facing a wall. The results of the two sessions, when completed, should be distributed to the participants.

Analysis by participation is an integral part of the OOPP (Objective Oriented Project Planning) analytical method. A full explanation of the methodology is given in the supporting material below. Some elements have been adapted especially for this course.

Before the session, the facilitator puts up sheets of paper (craft paper or flip chart sheets) on the wall and draws the framework of a Table for the participation analysis (see page 109). Participants will only need their marker pens.

Group exercise on analysis of participation

Once the framework has been explained, the facilitator will proceed in three steps:

Step 1: Ask the group what actors are involved in the operation, maintenance and management of rural water supply and sanitation systems. The analysis can be carried out for either water supply or sanitation services, or both. The choice depends on the previously identified demand and needs of the group. All contributions are made on cards, on which the name of an actor is written down, and these are placed within the Table on the wall. The participants may assist the facilitator in writing down the names of the actors. Some of the cards can be grouped if necessary.

Step 2: The group is asked to give the main roles of each major actor and follows the same procedure as in Step 1. See background information (below) for further details.

Step 3: The participants are divided into groups corresponding to the major groups of actors (national level, provincial/district level, local level, etc.) that have been identified. They then describe the interests and problems of each group. All the results are written down on the cards which are placed within the Table. Each group then presents its cards and explains the meaning behind each one. Some rules about how to write the statements on the cards are given below:

Rule 1:

**CARDS SHOULD BE WRITTEN
WITH CAPITAL LETTERS**

Rule 2:

**CARDS SHOULD BE WRITTEN
IN A LEGIBLE WAY**

Rule 3:

**CARDS SHOULD DESCRIBE
ONLY ONE IDEA**

Rule 4:

**CARDS SHOULD HAVE
NOT MORE
THAN THREE LINES**

The next session will describe how to present the statement of problems in an appropriate way. The facilitator should accept the statements given on the cards; however, if their formulation should be unclear, he could ask for clarification or reformulation.

Concluding remark

The facilitator goes over the whole Table, highlighting the main roles, interests and problems that have arisen. The last column (“Present degree of involvement”) can be filled in at the same time, following discussions with the group.

The facilitator will point out that this analysis has shown that O&M is concerned with a large number of actors and that it is important to see how all of them can cooperate in an optimal and effective way. The initial identification of problems is the starting point for the next session, which deals with the analysis of constraints.

3. Overhead sheets

There are no overhead sheets because the Table for the analysis of participation should be prepared on a large sheet of paper which is put up on a wall. For details, see below.

4. Background information

An analysis of participation can rapidly show that various actors are involved in the operation and maintenance of rural water supply and sanitation systems. The analysis consists in listing all the actors involved at various levels, highlighting their roles in operation, maintenance and management, their interests, the main constraints each actor is facing, and their degree of involvement, as shown in the Table below.

Actors/group	Role in O&M of actors	Interest	Problems	Degree of involvement*	
				Present	Future
National level					
Provincial/district level					
Local and community level					

* Three degrees: 1, little involvement; 2, medium involvement; 3, major involvement. Future involvement should be filled in after the decentralization policies have been reviewed.

Roles usually include policy-making for maintenance; sector planning and programming for maintenance; coordination; budget allocations; follow-up and monitoring; normative control; regulation; training; technical assistance; tariff setting; payment of services; day-to-day operation of the system; preventive maintenance; small repairs; major repairs; rehabilitation; manufacture of spare parts; provision of spare parts.

This analysis can be summarized in the Table below, which gives an overview of the degree of involvement of the major actors in the operation and maintenance of water supply and sanitation systems.

Major actors	Degree of involvement		
	Little	Medium	Major
National institutions			
Provincial institutions			
Local authorities			
Community organizations			
Users			
Private sector and NGOs			
External support agencies			

The above analysis can also be done in a more detailed way by analysing the degree of involvement of each actor for each role, as identified in the first Table.

Unit 3: Analysis of constraints

1. Outline of session

► Objectives

- To further identify problems linked to O&M
- To analyse these problems in a logical way
- To draw a problem tree

► Methodology

1. Introductory note
2. Focused discussion
3. Interactive group exercise

► Materials

- ✓ Overhead transparencies
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall
- ✓ Large sheet of paper (craft paper), hung on the wall for the problem tree exercise
- ✓ Cards of various colours (code is important: for example, yellow for problems)

► Handouts

- ✓ Copies of transparencies, background information

2. Notes for the facilitator

Introductory note

The present session is directly linked to the previous one. The OOPP (Objective Oriented Project Planning) methodology will now be introduced for application in this course (see below, background information and overhead sheets). This adaptation of the original methodology provides a flexible management and analytical tool. The session deals with problem analysis in the context of operation and maintenance of water supply and sanitation systems; other activities will be developed later in the course. It should be noted that the full use of the methodology is not essential, especially in a training session to work on a situation analysis. OOPP is not an end in itself, it is just a tool.

Focused discussion

Before starting with the OOPP methodology, the participants will be asked to indicate the planning tools which are being used in their professional setting. This list of tools will be written on the board by the facilitator, who will ask for comments from the participants.

Interactive group exercise

The group should have the same informal seating arrangements as in the last session. The facilitator will proceed in the following way:

- Problems which are linked to operation and maintenance of water supply and sanitation systems are formulated. For this exercise, a large group can be divided into smaller subgroups, who will have to prioritize the problems and produce a maximum of seven cards; some of these problems could come from the analysis in the previous session, with others added.
- All the subgroups should clearly understand each problem; the facilitator may have to rewrite some of the cards.
- All the identified problems are put up on one side of the sheet on the wall in order to leave enough space for the actual analysis.
- The analysis starts by asking the participants which of the problems could be direct causes of the main problem for “poor O&M”, until all the problems have been examined and linked to form a tree.
- The analysis also examines the effects of poor O&M; if some problems have not been highlighted, the group can do so now.
- The whole logic of the tree can be checked in terms of cause-effect relationships.
- At the end of the analysis, lines should be drawn linking the cards in order to visualize the relationship between problems, thereby building an objective tree.

This session is highly participatory and the facilitator should be careful to keep good track of the time. The aim is not unanimous agreement on a hypothetical situation, but an acceptable compromise by the group. At this stage, the object is to examine the main problems in order to see how they are interrelated. The participants will have the opportunity to develop this in more detail during their individual assignments later in the course.

3. Overhead sheets: Sheet 1

OOPP

Objective Oriented Project Planning



1. Analytical phase



2. Planning phase

Overhead sheet 2

1. Analytical phase

- a. Analysis of participation
- b. Analysis of problems
- c. Analysis of objectives
- d. Analysis of alternatives

2. Planning phase

- a. Development of planning matrix
- b. Identification of assumptions
- c. Identification of activities
- d. Formulation of indicators
- e. Estimation of costs and human resources needs
- f. Time planning

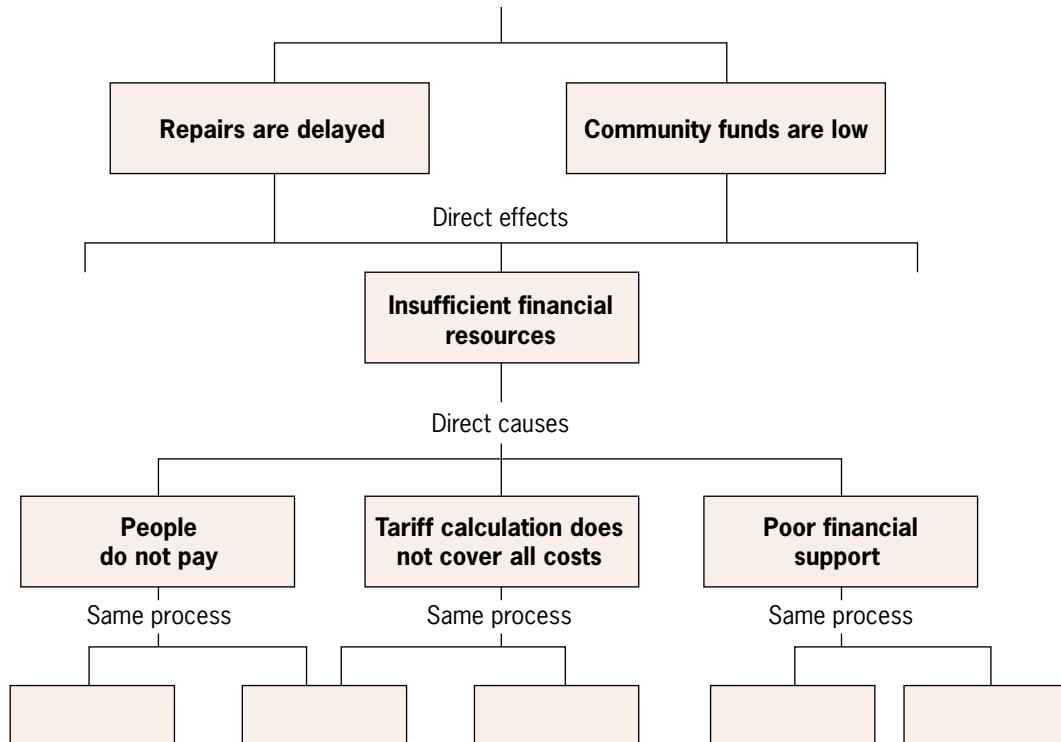
Overhead sheet 3

Problem analysis

- 1 Identification and formulation of problems
- 2 Selection of an “essential” problem
- 3 Identification of the direct causes of this problem
- 4 Identification of the direct effects of this problem
- 5 Continuation of the identification of cause-effect relationships
- 6 Control of global coherence
- 7 Drawing of lines to create a problem tree

Overhead sheet 4

Cause-effect relationships



4. Background information

4.1 The importance of problem analysis

One of the first tasks for a manager or a group of persons is to understand and assess the present situation. There are many different ways to go about this—reading reports and studies which have been written on a particular project; holding a series of interviews and meetings, and asking staff about their perceptions on the situation; making field visits in order to visualize the situation; deciding to analyse successes and focus on them only.

Experience has shown that good plans are based on an appropriate understanding of a situation, which is based not only on an analysis of successes, but also of constraints and problems. However, many managers will limit themselves only to the identification of problems, and omit their analysis. Furthermore, there are often as many interpretations of a problem as there are professionals.

Without denying the positive aspects of other working methodologies, this methodology proposes to assess a situation on the basis of a common understanding of the problems. It is simple, participatory, democratic and motivating. It allows a group of professionals at different levels, from different departments or sectors, to reach consensus on the situation, which is vital for the effective implementation of a plan. The logical sequential analysis shows that problems are interrelated and cannot be isolated.

4.2 What is a problem?

According to the Collins Cobuild English Language Dictionary, a problem is *a situation or a state of affairs that causes difficulties for people, so that they try to think of a way to deal with it.*

People do not always have the same perceptions and vision of a problem, since they belong to different cultures and have different priorities in their working or living environments. However, the above definition helps to focus our vision on what is a problem.

It causes difficulties for people, so that they try to think of a way to deal with it. A problem is based on a real, existing situation, which becomes troublesome in a way that one has to react to it. Therefore, a problem is **not an interpretation** of a situation, it is a fact, a reality. Furthermore, it is **significant** enough that people do want to react to it, thus avoiding minor troubles which life is usually filled with anyway.

Many people will identify a problem in terms of a desired situation which they do not have, visualizing a problem as an absent solution. For example, some will say that “no equipment”, “no vehicle” or “no money” are problems while analysing a situation of long delays for repairs. This could be hiding the fact that there is poor planning, that villages are far away, that tools and equipment are obsolete, that the project is understaffed, that spare parts are not available, etc. However, lack of equipment or poor budget allocations could also be a reality.

In this course, we will consider problems with a negative formulation, since this helps to raise an issue, a challenge to be met. A formulation just stating “spare parts” does not raise an issue, and does not say what is wrong, although spare parts can be a problem. This could be formulated as “poor availability of spare parts”, or “high cost of spare parts”, etc., depending the situation.

In summary, we will define a problem as :

1. A real, existing situation
2. Significant
3. Preferably not an absent solution
4. A negative formulation

4.3 The OOPP methodology

This methodology was first developed in 1983 by the German Organization for Development Cooperation (GTZ). It combines the logical framework tool with new communication techniques (Metaplan) into an analytical and planning tool called Objective Oriented Project Planning (OOPP, or ZOPP in German). This is now being used as a major planning tool by the great majority of agencies involved in development cooperation. Other planning tools are also proposed in this course.

OOPP is based on a logical sequence of reflection, and the team work approach is its essential feature. It uses a strong visualization tool, i.e. cards, in order to see what would otherwise be abstract. The result of the thinking process is accepted by the group. The analytical method is based on the analysis of a logical sequence of cause-effect relationships between various problems as will be exposed later.

OOPP is composed of two phases: an analytical phase and a planning phase.

The **analytical phase** comprises participation analysis, problem analysis, objective analysis, and an analysis of alternatives.

The **planning phase** consists in the development of a planning matrix, determination of assumptions and conditions, determination of activities, formulation of indicators, estimation of financial and human resources needed, and the development of a chronogram (for timing of activities).

What are the advantages of the methodology?

- Reaches a common understanding of problems
- Clarifies cause-effect relationships
- Provides clear planning documents
- Allows the participation of various staff and professionals, as well as beneficiaries of the project
- Establishes a consensus
- Easier to implement because of broad acceptance.

What are the limitations of the methodology?

- Truth is not only rational and logical; the methodology puts aside all intuition, contradictions and feelings.
- Can lead to a simplified “linear” representation of reality.
- The whole planning depends on an adequate and accurate problem analysis.
- Creative thinking only done for the problem analysis, but gets lost in the mechanical sequences afterwards.
- The emphasis on problems can put a shadow on the perception of existing potentials and successes.
- Certain groups are not familiar with an abstract and logical analytical sequence of thinking, which can create problems in its application.
- Needs a good and experienced facilitator.

4.4 How to analyse problems

After the problems have been identified and listed by all the participants, the group is asked to select one problem as essential, which will be used to start the analysis. Criteria of selection can be: most pressing problem, or most frequently occurring problem. As an example for illustration, we have chosen the problem of “insufficient financial resources”.

From the listed problems, the group then identifies those that are the main causes for this essential problem, and are directly linked to it. It is possible to formulate additional problems if they are not all present yet. It is also possible to reformulate some cards, which appear to be too vague. It is also possible to eliminate cards that appear to be

totally out of context. The question to be asked in order to find the direct causes, is **WHY?**

In a second step, it is now proposed to select from among the list of identified problems, those that can be the effects of the essential problem, and are directly linked to it. Problems can be added, or eliminated as shown above. The question to be asked in order to find the direct effects, is **WHAT** are the direct consequences of this essential problem? What will it lead to? This process is then repeated for each cause. What are the causes of this problem? Same applies for the effects, until all the cards have been placed. Lines are then drawn showing the relationship between each card. The final result is a problem tree. There is no perfect problem tree. All problem trees are different, since all groups are different. It just represents the consensus and understanding of a particular situation for a given group, at a given time, in a given context.

Unit 4: Analysis of objectives

1. Outline of session

► Objectives

- To identify objectives linked to O&M
- To analyse these objectives in a logical way
- To draw a problem tree

► Methodology

1. Introductory note
2. Interactive group exercise
3. Concluding remark

► Materials

- ✓ Overhead transparencies
- ✓ Flip chart and masking tape
- ✓ Overhead projector, screen or white wall
- ✓ Large sheet of paper (craft paper), hung on the wall for the problem tree exercise
- ✓ Cards of various colours (code is important: for example, green for problems)

► Handouts

- ✓ Copies of transparencies and background information

2. Notes for the facilitator

Introduction

This session is the immediate follow-up of the problem analysis. It looks into the future on the basis of an analysis of the present situation, the problem analysis.

Interactive group exercise

The group exercise is in two parts: 1) construction of the objective tree; 2) selection of a strategy.

1) Using the problem tree, the facilitator asks the participants to restate the negatively formulated problems into objectives which are positive and achievable. Avoid statements of objectives with an ultimate or long-term improvement, but indicate, on the basis of the problem analysis, an improved situation. For example, do not indicate the problem of lack of funds as plenty of funds, but rather as improved financial situation, etc.

It may be that some problems cannot be changed into objectives, because the project will not be able to solve them, e.g. "corruption". These cards in the exercise will remain as problems, even in the objective tree.

It is important to use cards of two different colours for objectives and problems.

The facilitator, with the help of the participants, can rebuild an objective tree, similar to the structure of the problem tree. However, they will have to look at the means-end relationship (as opposed to cause-effect for problems). It can very well be that the logic is not always the same and that some analyses need to be examined again; also, other objectives may have to be added in order to complete the analysis.

The end product is an objective tree, in which the facilitator can circle the various entities that appear, such as “community”, “technical aspects”, “institutional support”, etc.

2) The selection of a strategy consists in the selection of objectives. It would be impossible for a project to tackle all the objectives which are formulated in the objective tree, mainly for the following reasons:

- All the objectives are not within the mandate and responsibility of a project.
- There are not enough financial and human resources to work on all objectives.
- The project has to respond to some priority or urgent issues first.

The management and staff will therefore have to choose and prioritize in a participatory way. The selection process can be performed in the following way:

- Identify those objectives which are not within the mandate and the responsibility of the project (in this case, it might be difficult because the project is hypothetical).
- Identify key objectives (maximum seven) which can greatly influence the main objective, i.e. “Improved O&M”. These objectives should generate a maximum impact for a minimum input of resources, which are limited; it could be that the main objective is not completely resolved, but the chosen objectives will greatly contribute to it.

Procedure. The facilitator asks the participants to form small groups of three persons. Each group will have the task of identifying a maximum of seven objectives which will contribute to the main objective. They will also have to give a priority to each objective.

After the objectives have been chosen, the facilitator draws the following Table on the board:

Selected objectives	Number of groups who selected this objective	Priority given by the group
1.		
2.		
3.		
4.		
5.		
6.		
7.		

This Table, when filled in, will allow a participatory decision to be made on which objectives to choose. The final selection will correspond to the objectives which obtained the best score, taking into account the priority as well.

Conclusion

The project has now selected precise objectives to work on, which are based on an analysis of a real situation.

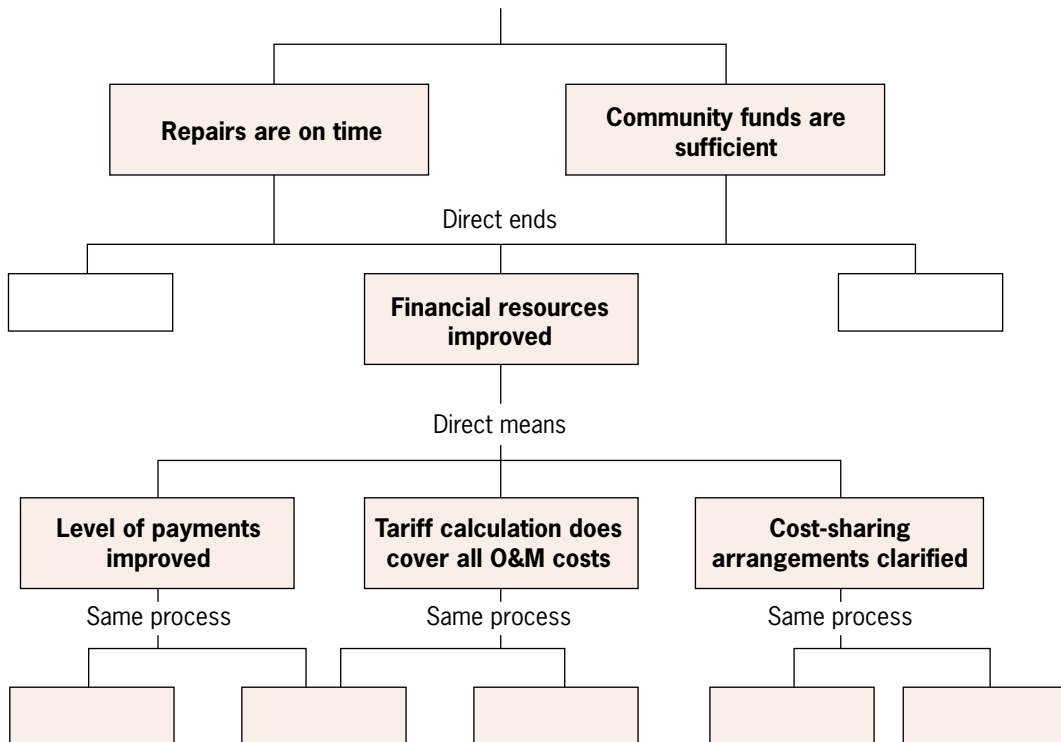
3. Overhead sheets: Sheet 1

How to do an objective tree

- Step 1:** Reformulate all negative conditions into positive attainable conditions
- Step 2:** Check whether rewording has led to unrealistic or ethically questionable statements
- Step 3:** Examine the “means–ends” relationships, thus derived to assure the validity and completeness of the tree; add cards if necessary
- Step 4:** Draw lines between all objectives showing relationships and finalize the objective tree
- Step 5:** Circle different groups or entities which appear within the objective tree and give them a name

Overhead sheet 2

Example of an objective tree



4. Background information

4.1 Discussion on alternatives: identifying potential alternative solutions

The chief criterion when evaluating and selecting alternatives is whether the project is realistic and more beneficial than problematic. The following aspects can be significant:

- Priorities in policy development
- Specific conditions in the country
- Suitability of the chosen project to the donor agency and the national departments which support it
- Availability of funding
- Project's experience in the region or sector
- Available manpower
- Complementary or competitive activities of other projects.

The choice between alternatives will be determined by cost-benefit analyses, additional analysis of various interest groups, and management discussions and decisions.

