

## MODULE 2

# Situation analysis

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# 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:
<b>Major O&amp;M activities</b>	<b>Frequency</b>	<b>Tools, materials, spare parts</b>	<b>Skills and human resources</b>

### 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 m<sup>3</sup> 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 m<sup>2</sup> (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 m<sup>2</sup> 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 m<sup>3</sup>, 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&amp;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 m<sup>3</sup> 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 m<sup>3</sup> 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 m<sup>2</sup> of filter area. In Colombia, this was US\$ 105–215 per m<sup>2</sup> in 1987.

**Yield:** 0.1–0.3 m/hour or 0.028–0.083 litres per sec per m<sup>2</sup>.

**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  $\text{NH}_3$  and  $\text{H}_2\text{NO}_3$  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 m<sup>3</sup> 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"> <li>■ Wide use of the same item of equipment encourages agents and shopkeepers to store and supply these spare parts because of the “guaranteed demand”</li> <li>■ Proliferation of brands and technology makes it difficult to organize spare parts availability</li> <li>■ Prices and markets can be more easily researched</li> <li>■ Users become familiar with one type of product or technology</li> <li>■ Training of personnel can be standardized.</li> </ul>	<ul style="list-style-type: none"> <li>■ The chosen technology does not respond totally to the needs and preference of the users</li> <li>■ The market is closed for new, innovative and cheaper technologies</li> <li>■ Poor incentive for involvement of the private and research sectors</li> <li>■ Possible conflict with donor policies on technology choice</li> <li>■ Competition between different brands can bring down prices and lead to improvements.</li> </ul>

### 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

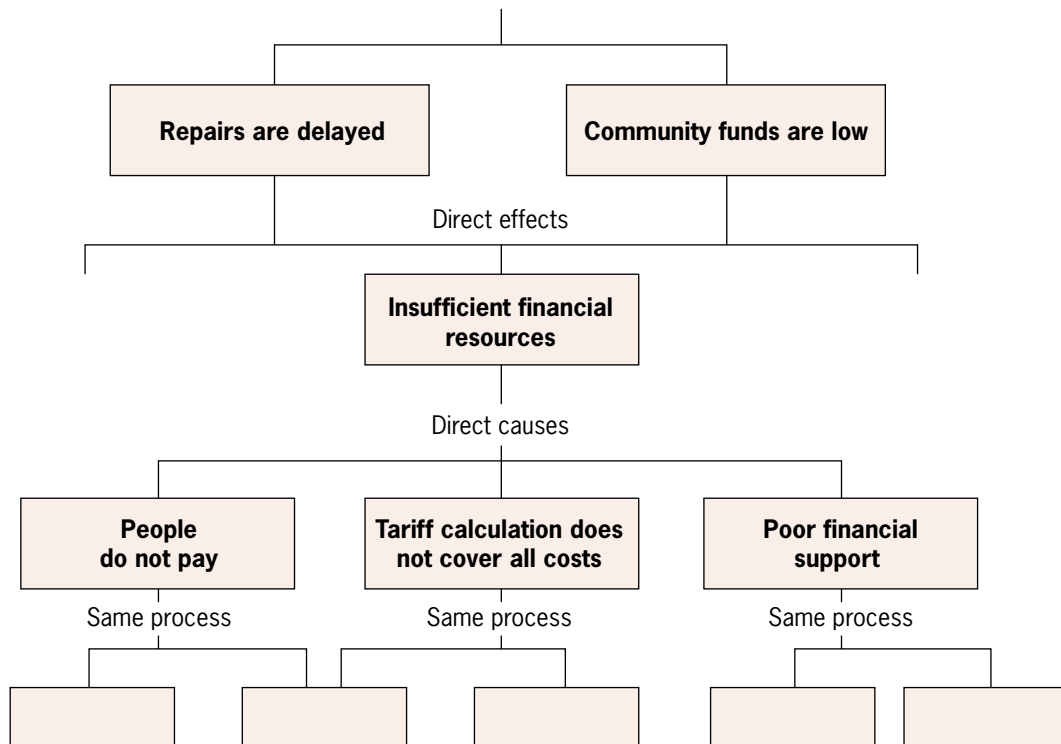
Overhead sheet 3

# 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.

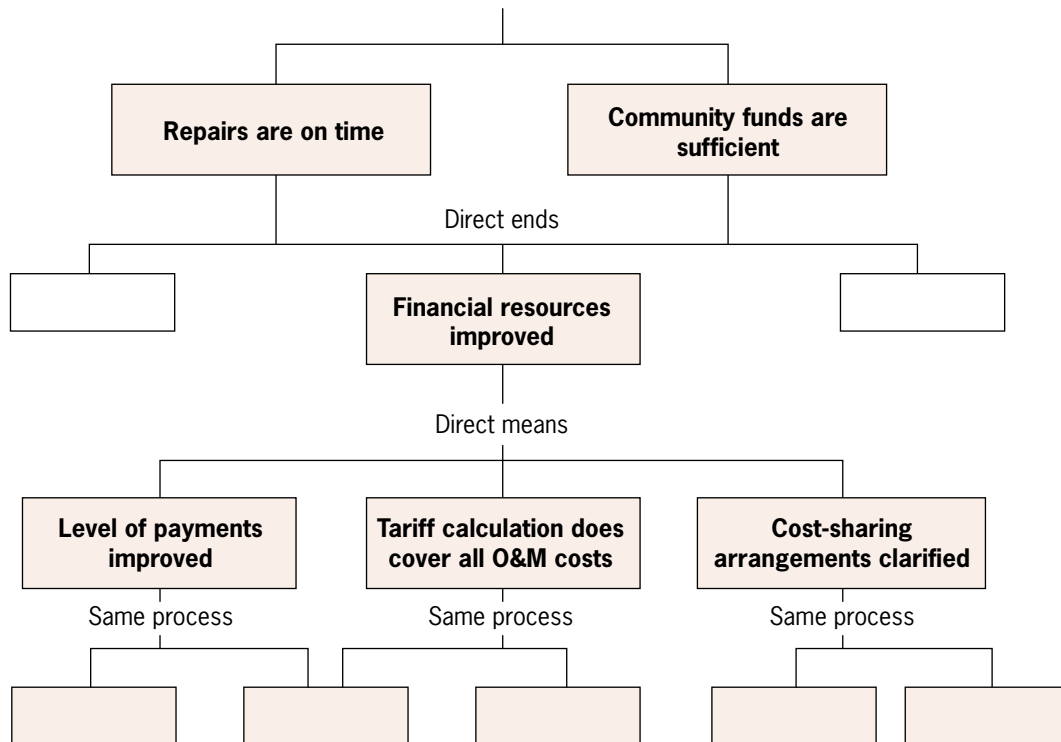
### 3. Overhead sheets: Sheet 1

## 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.

