FIELD REPORT

REHABILITATING COMMUNITY WATER SYSTEMS: PLANNING FOR SUSTAINABILITY

WASH Field Report No. 397
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WATER AND SANITATION for HEALTH PROJECT

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REHABILITATING COMMUNITY WATER SYSTEMS: PLANNING FOR SUSTAINABILITY

Prepared for the Office of Health, Bureau for Research and Development,
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by

Rick McGowan
Jonathan Hodgkin
Abe Waldstein
and
Paul Kaplan

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Assessment of the Operations and Maintenance Component of Water Supply Projects. Prepared by James K. Jordan, Peter Buijs, and Alan S. Wyatt. Technical Report No. 35. June 1986.

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ABOUT THE AUTHORS

Richard McGowan is Senior Engineer and Senior Associate at Associates in Rural Development, Inc. (ARD), and has 13 years' international development experience working in Asia, Africa, and the Middle East. He has degrees in Mechanical Engineering, Environmental Resources Engineering, and Philosophy. His international experience covers water resources (design and evaluation of community-based water systems) and energy applications (renewable and conventional energy system design, technology assessment, and energy efficiency). His particular interest is the comparative assessment of sustainable water and energy technologies for developing countries. He speaks Nepali.

Jonathan Hodgkin has degrees in mathematics and civil engineering and 10 years' experience working in Africa and the Middle East. He has worked with ARD for eight years. His experiences and interests span the water resources and energy sectors from water pumping and water quality to renewable energy systems. The focus of his recent work has been operations and maintenance, cost analysis, and resource management.

Abe Waldstein is a Rural Development Specialist and Senior Associate with ARD, with degrees in Anthropology and History. He is a specialist in community participation and management of rural development programs, especially in the agricultural marketing and water resources sectors. He has developed and implemented numerous socioeconomic surveys related to enhancing the irrigation management capabilities of communities and local institutions. He has 15 years' experience working in developing countries in Asia, Africa, and Latin America. He speaks French, Spanish, and German.

Paul Kaplan is a Cornell University trained consulting Rural Development Sociologist whose experience has been mainly in South and Southeast Asia. During ten years of work in Nepal, he worked mainly on water-related research, especially regarding water user organizations. As an Associate Sociologist with ARD, he has worked on several WASH proactive tasks over the last three years.

ACRONYMS

GI	galvanized iron (pipes)
IDWSSD	International Drinking Water Supply and Sanitation Decade
LDCs	less developed countries
M&E	Materials and equipment
MLG	Ministry of Local Government
MOH	Ministry of Health
MPW	Ministry of Public Works
NCRWRD	National Corporation for Rural Water Resources Development (Sudan)
NGO	Nongovernmental organization
NRWA	National Rural Water Agency (Sudan)
O&M	Operation and maintenance
PM	Preventive maintenance
PVC	polyvinyl chloride (pipes)
PVO	Private Voluntary Organization
QARQ	Water quality, accessibility, reliability, and quality
RRA	Rapid Rural Appraisal
SHE	Sanitation and hygiene education
VWC	Village water committee
WASH	Water and Sanitation for Health Project
WS&S	Water supply and sanitation

PREFACE

This manual for designing and implementing rural water supply rehabilitation projects is based on Associates in Rural Development, Inc.'s experience working with rural community water systems in Africa, Asia, and the Middle West. It is intended to be used, in conjunction with the many technical references given herein, as a resource by project designers and implementors of rural water supply rehabilitation projects for communities of about 200 to 10,000· people.

Its purpose is to explain the most important technical, institutional, social, and financial factors that determine whether or not the rehabilitation effort will be a long-term, sustainable solution for small community water systems. It assumes that technical and financial assistance for rehabilitation is provided at least in part by an external source (as is the case in most developing countries in Latin America, Africa, Asia, and the Middle East) such as the government, international donors, and local or international private voluntary organizations. This is not a manual dealing with emergency relief situations. In those situations, sustainability would not be of such overriding concern as it is in stable rural communities. Rather, the objective would be to immediately provide people with water of acceptable quantity and quality in the short term, irrespective of whether those supplies are sustainable over the long term. This manual also does not address the different set of problems encountered in rehabilitating a larger urban system.

We would like to acknowledge the considerable help we received in its writing, especially from our friends and colleagues in the WASH Project (particularly Task Manager Phil Roark), the Government of Botswana's Department of Water Affairs, the Government of Sudan's Energy Research Council and the National Water Corporation, CARE/International staff in Sudan and Indonesia, and other private and public sector water specialists we have worked with in Yemen, Oman, Malaysia, and Somalia. We hope that this report will be useful for them the next time they are asked to help rural communities rehabilitate their water systems.

EXECUTIVE SUMMARY

External technical assistance for community water supplies in developing countries, whether provided by governments, donor agencies, or private voluntary organizations (PVOs), used to consist largely of system design and construction. Typically, little time was spent in determining community needs prior to construction. Adequate attention was seldom given to ensuring that proper operation and maintenance (O&M) took place after installation. Where recipient communities were expected to cover O&M and repair costs, few efforts were made to ensure that communities were both willing and able to do so. As a result, water system failures are common, so much so that in some developing countries there are more failed than operating systems. This is coupled with steadily increasing populations and, in many if not all developing countries, increasing demands on limited capital development funds.

There are several options for dealing with failed or inadequate community water systems. Depending on the condition of the existing system, community needs and preferences, and resources available to the project and the community, it may be most appropriate to do the following:

- *Repair*—identify and fix whatever physical component(s) directly caused the existing system to break down, and provide no further assistance.
- *Replace*—replace either major system physical components or the entire system, make any needed minor repairs, and provide no further assistance.
- *Rehabilitate*—repair and replace components as necessary, and provide necessary assistance to strengthen the system support infrastructure (for management, financing, community organization, and technical and logistic support for O&M) so that the system will be sustainable.
- *Expand*—repair, replace, or rehabilitate the existing system as required, and expand its capacity to account for increased demand in the community. This may require additional technical or financial assistance to increase the capacity of the support infrastructure as well.
- *Provide no further assistance.*

The process for deciding which of the above responses is most appropriate is given in the final chapter of this report.

Careful planning of rehabilitation programs means that after the external agency's involvement is over (whether government, donor, or PVO) the beneficiary communities will be capable of properly operating and maintaining their own systems, or they will have the means to hire people who can do so. Planning rehabilitation includes the following:

- Choosing water technologies that are appropriate for the site (in terms of reliability, complexity, and cost);

amount of funding available will determine how many sites can be serviced and to what level of service, within the allotted time frame. This will partially determine site selection and prioritization criteria. (For example, if one project objective is to maximize the number of communities assisted, sites which are very expensive or time-consuming to service may have to be excluded from the list of candidate sites.)

Rehabilitation involves technical, institutional, financial, and social concerns. Technical problems are usually the most obvious symptom of system inadequacy or eventual failure, and are often the most straightforward to deal with. Assessing the system's QARQ (meaning water Quantity, Accessibility, Reliability, and Quality) may indicate that if the system works at all, the water supplied by it may be either inadequate in quantity, lacking in accessibility, unreliable, or of unacceptable quality. Technical problems are best assessed by examining systems component by component, including:

- the water source (open well, spring, borehole, or surface water);
- any mechanical devices used (pumps, engines, or motors);
- conveyances (main pipeline, ditch);
- storage facilities (tanks, cisterns, ponds);
- any treatment devices (slow sand filters, mechanical chlorination, settling ponds); and
- the distribution system (secondary pipes, valves, and water points).

Common problems encountered with each of these components are discussed in this report, and solutions given to deal with those problems. Each type of system and its components have different O&M and repair requirements. It is important to determine whether and how these requirements have ben met (or not met) in the past, and how they will be met after the system has been rehabilitated.

Beneficiary communities (especially those residents most involved with water handling, often women) should be consulted on all background information and decisions related to the use and rehabilitation of their water system. Their opinions and preferences should be taken into account as much as possible in system design and management. By the same token, they should accept as much responsibility for their systems as their technical and management skills and resources permit. This will not only increase the sustainability of their own system, but will also free up project and government resources to permit extending water supply coverage to other deserving communities.

After assessing the suitability of the engineering design and O&M procedures in the RRA, a thorough assessment of all institutional support must be carried out. Typically, support needed for system installation, O&M, financing, and management is provided by more than one group or individual. It may included community water committees, community volunteers, local political leaders, government agencies working in the sector (e.g., from the Ministries of Water Resources, Health, and Rural Development), private voluntary organizations, private contractors, and donor agencies. The institutional assessment will determine who is officially responsible for each system support task, who actually provides that service (if anyone), and which (if any) tasks, left undone, have been important factors in the system not working. The capabilities and constraints of each support group must be assessed, and groups which are unable to carry out their responsibilities must be either institutionally strengthened or that responsibility must be assumed by another more capable group.

Without adequate financial support, systems will fail. Even if an external organization (such as a government agency or a PVO) has paid for the installation of a community water system, the system will require financial support for O&M and periodic repairs over its lifetime. Communities in most developing countries are now routinely expected to cover part (if not all) of the recurrent system O&M support costs after being assisted by various government or private agencies. How the funding for this support is determined, collected, managed, and spent will have a significant impact on the long-term sustainability of the project. Realistic resource mobilization must be provided to ensure that community contributions (including in-kind contributions such as construction materials or income-generating activities) are adequate to keep the system running properly. Beneficiary communities must be appraised of the probable cost of operating their systems, agree to accept responsibility for financial support if external support is unavailable or inadequate, and develop realistic and attainable financial management plans, *before any construction takes place*.

Given the great need in developing countries for adequate, reliable supplies of high-quality water, especially in rural areas, and the limited funding available for building new systems, rehabilitation will likely play an increasingly important role in providing service to rural communities. This manual provides an overview of the complexities of planning and implementing rehabilitation projects, pointing out where projects have succeeded and failed in the past, and why.

Chapter 1

INTRODUCTION

1.1 Background

For many years, foreign development assistance in water supply and sanitation (WS&S) focused primarily on the technical design and construction aspects of water systems. Little attention was paid to community participation, sanitation and hygiene education, operation and maintenance (O&M), and financial management. In many developing countries, external financial and technical assistance support from the national government, international donors and lending agencies, or local or international private voluntary organizations (PVOs) was required for all but the most basic of systems. It was generally assumed that once the water systems were installed, either the appropriate government agencies or the communities themselves could and would properly operate and maintain them.

Systems ran until some component failed, perhaps a pump or motor, a spring catchment or pipeline for a gravity system, or a cylinder on a handpump. While communities might make efforts to repair their systems, lack of money, technical skills, spare parts, fuel, community organization, or simply poor initial design of the system often made it inevitable that the systems would prematurely fail. Government agencies responsible for rural water supplies faced similar problems, and were often unable to carry out their responsibilities for keeping community systems operating. Typically, since little or no training accompanied construction projects, once construction was completed, beneficiary communities were left to their own devices to keep the systems running. So once the systems failed, villagers would revert to their traditional water systems (e.g., unimproved open wells) or available surface water (i.e., *hafirs*, rivers, or irrigation ditches).

The International Drinking Water Supply and Sanitation Decade (1980-1990) focused donor attention on rural water supply issues and led to considerable rethinking of government and donor approaches to rural water supply development. The importance of sustainable O&M practices, community involvement and self-financing, and the use of appropriate water technologies have become more widely recognized and accepted. Due to the large number of failed systems, the high cost of constructing new systems, and the limited amount of funding available to support WS&S system development, interest in water system rehabilitation is increasing.

1.2 Rehabilitation versus New Construction

As used in this report, rehabilitation means more than simple repair. While it may involve repair or replacement of various water system components, it also involves an assessment of the system's support infrastructure (for planning, financing and managing operation, maintenance, and repair), determining why that infrastructure failed to provide adequate support in the past, and developing an infrastructure which will do so in the future. Rehabilitating an existing system generally has the following advantages over new construction:

- generally requires lower capital than new construction;
- often identifies the cause for failure of the existing system which can then be dealt with directly, whether it is technical (a poorly designed or constructed component), financial (water fees are inadequate to support maintenance), institutional (the government agency responsible for maintenance does not comply), or social (water is inequitably distributed in the village, so one group of users has refused to pay water fees);
- allows system designers to draw on experience with existing systems in terms of appropriate level of service and community capability for maintaining and financing the system;
- draws on local communities that are to some extent familiar with the O&M requirements of existing systems, and that are likely to know where to find technicians and sources of spare parts; and
- allows incorporation of more appropriate component designs (e.g., more efficient pumps, or improved spring catchment tank) to complement existing system components without having to replace the system entirely.

Many rehabilitation programs are already underway worldwide, and others are being planned. These activities provide an opportunity to learn from past experience, to design and implement more sustainable rehabilitation projects. Rehabilitation program design and implementation issues differ somewhat from those for new system construction. For example, communities already have expectations about levels of service (e.g., public taps, yard taps, or house connections), responsible community WS&S organizations may already exist, system financing by communities may already be defined and accepted (or the government used to pay for all system costs in the past, but the money no longer exists), the capabilities (and constraints) of government support agencies may be clear, and material and equipment suppliers have probably been identified and used. This is not to say that everything is working well, otherwise the system wouldn't require rehabilitation in the first place.

Expectations, roles, and responsibilities will have been affected by the failure or simple inadequacy of the existing system. There may be community suspicion towards government and/or donor agencies, or a belief that community-contributed labor or money may not produce a water supply system that meets their needs. Government water agencies may feel that involving communities in rehabilitation planning and construction would be troublesome, or that communities will ask for everything and contribute nothing. On the positive side, past experience with improved water systems can provide villagers with a greater appreciation of the obstacles to meeting rural water needs, and can be a source for constructive suggestions during project planning and implementation. Also, donors and government agencies will have a better understanding of communities' willingness and ability to pay for water services if they have had to do so in the past.

Considerable information is available through careful assessment of site conditions to determine what works and what does not (technically, financially, socially, institutionally) in a particular community, region, or country. This is the biggest difference between new construction projects and rehabilitation (apart from the presence of existing structures). Planning rehabilitation of water systems requires not only a technical assessment of the physical system, but also an assessment of financing options, level of local technical and administrative skills for O&M, community social and political traditions, and the roles of institutional players. Although it is usually the need for physical rehabilitation which drives rehabilitation projects, assessing these other issues will help understand why rehabilitation is necessary in the first place.

1.3 The Need for Rehabilitation

The scale of the problem can be illustrated by anecdotal information from several countries. In Sudan, 35 to 40 percent of rural water systems (all of which are formally maintained by the government) are not operating at any given time[1] (see Figures 1 and 2 on the following page). The most common reason given for this situation is a lack of adequate funding. With the exception of war-torn countries such as Somalia, Mozambique, and Cambodia where the proportion of water systems out of commission is extremely high, the situation in Sudan could be considered the typical low end of the developing country scale. The high end of the scale could be represented by Botswana, where about 10 percent of the government-supported village water systems are down at any given time.[2] The most common reason for inoperative systems is lack of spare parts on-site, due in part to transportation difficulties to remote sites. In other areas (e.g., Yemen or Indonesia), community conflict can be a major cause of water system failures, due for example to disagreements about water allocation or fee collection and use. Even in well-designed projects where institutional and social issues are given proper attention, there can be significant levels of individual system failure. Of some 600 communities where CARE/Indonesia has assisted in the construction of rural water and sanitation systems between 1979 and 1992, it is estimated that about 15 to 25 percent are no longer fully functional five years after construction.[3] These are systems that are generally well-designed and constructed, and where communities have received at least some degree of training in system O&M, resource mobilization, and financial

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[1] According to informal discussions with government officials in the National Rural Water Corporation.

[2] Note that this is not necessarily the same 10 percent of government-supported systems which are on the official list for rehabilitation. Some out-of-commission systems may just require a simple repair or component replacement to be put back into operation, and some operating systems may be on their last legs.

[3] On the other hand, system O&M in many communities assisted by CARE has been fully community-financed and successfully managed for 10 years or more. In 1993, CARE/Indonesia will undertake a study to try and determine the factors which are most important to ensuring the sustainability of community water systems.

Figure 1

Village women drawing water from an open hand-dug well, a traditional water source in North Kordofan, Sudan

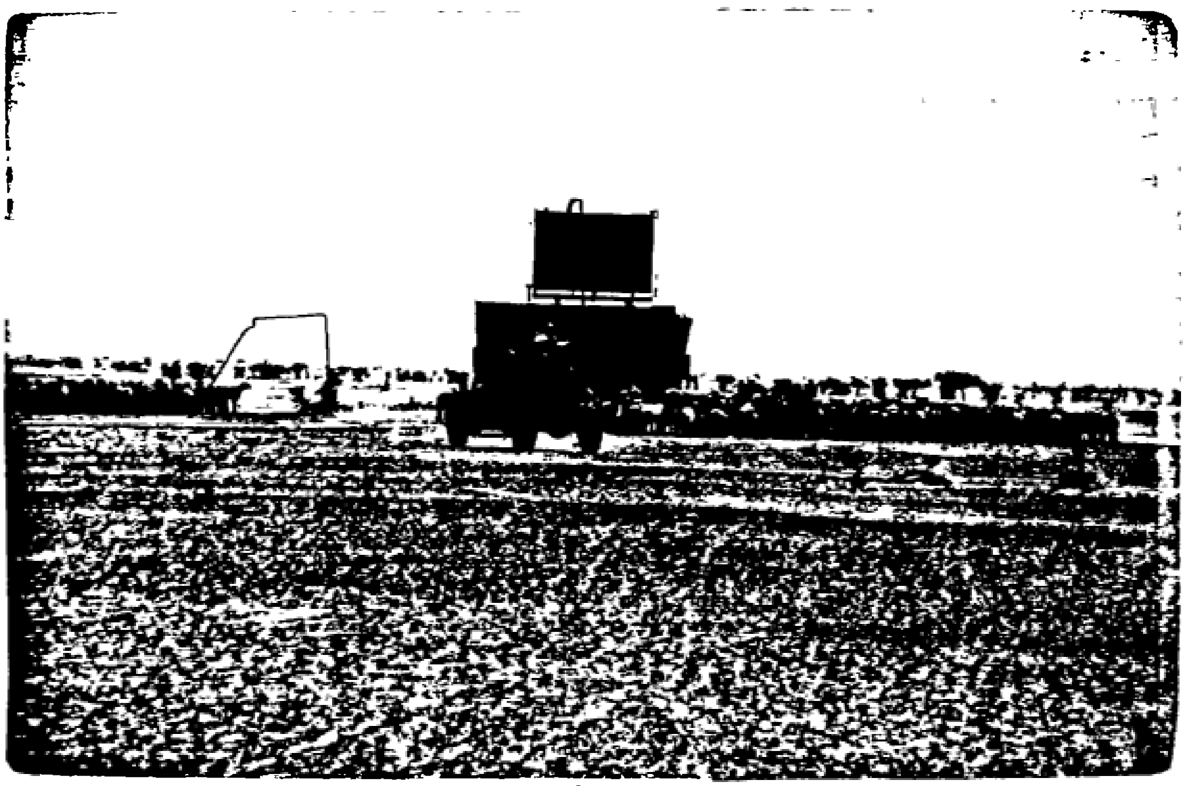

Figure 2

A diesel wateryard in the desert west of Khartoum, Sudan. Regularly supplying necessary materials and equipment to remote sites can be difficult and expensive.

management. Reasons that systems require rehabilitation vary considerably from country to country and even town to town, so generalization about the relative importance of one factor or another is difficult.

1.4 Organization of this Manual

This manual presents a detailed method for planning and implementing rural water system rehabilitation projects. It focuses on identifying the reasons that systems fail, and proposes various solutions. It is intended to be used by project designers and implementors of rural water supply rehabilitation projects for small to medium-sized communities of 200 to 10,000 people. An initial overview of the major issues is given in Chapter 2, helping the reader to define and analyze major assumptions about the goals and objectives of the project, including questions relating to who will take responsibility for what specific actions prior to, during, and after construction is completed. Project identification and preparation are discussed in Chapter 3, including what background information is needed for site selection, initial estimates of procurement needs, and level of effort required to rehabilitate systems in the candidate communities.

Finding out why a particular community water system is either inadequate or has failed and identifying the best approach to rehabilitation with a minimum expenditure of time and money require a quick and reliable method of gathering information at a prospective site. The approach suggested here is Rapid Rural Appraisal (RRA), which is the focus of Chapter 4. RRA can be used by a multidisciplinary team to gather necessary technical, organizational, and socioeconomic information. Checklists of appropriate questions are provided as a starting point for this interactive appraisal methodology.

It is becoming increasingly accepted in development circles that, in lieu of guaranteed and total external financing and management of all costs over the lifetime of the system, community participation and management is a *sine qua non* for sustainability. Chapter 5 discusses roles community members (specifically women) can usefully play in the planning, construction, and long-term O&M of water systems. It also discusses the limits to this approach; the need to recognize the technical, financial, and organizational limitations of communities; and the need to provide appropriate training to expand those limits. Chapter 6 extends the discussion of roles to institutions both internal and external to the beneficiary community (e.g., government water agencies which may from time to time be used to undertake particularly difficult maintenance jobs). It includes a section on agreements between major parties (donors, government agencies, PVOs, and beneficiary communities) to delineate each group's responsibilities in the project. These agreements serve to catalogue responsibilities to make certain that all support functions are addressed, and to ensure that all parties agree to and accept those responsibilities among themselves.

Chapter 7 addresses technical issues related to rehabilitation, referencing many existing technical documents (including a number of WASH reports) useful for planning and implementation. Chapters 8 and 9 cover logistical support and O&M, two areas which are still inadequately addressed in many water resources development projects. Chapter 10 covers system financing, including mobilization of resources to fund all support activities, willingness and ability to pay water user fees, and financial management at the community level.

The last chapter summarizes the important points to consider when deciding whether to repair, rehabilitate, or replace the existing system, or to do nothing further at that particular site, recognizing the limitations of financial and human resources and time.

Chapter 2

REHABILITATION POLICY ISSUES

A water system usually needs to be rehabilitated because it has either failed completely, deteriorated to the point where it no longer meets user needs, or is underutilized or abandoned. Failures are due to the breakdown of one or more physical components of the system—usually the water source (open well, spring, or borehole), main pipeline, engine or pump (if any), or a storage tank or distribution pipe. Repairing the failed component(s) may meet the immediate water needs of villagers, but it may not adequately address the root causes of the problem—nor might it be long before the next failure.

As used here, rehabilitation (as opposed to repair) means not only replacing worn or failed system components, but also making a systematic effort to address the root causes that led to the physical problem. Therefore, the most important information in planning rehabilitation is to find out what went wrong and why.

- *Technical*—component failure, poor design or installation, low-quality construction, water source degradation or failure; alternatively, the system may be underutilized or abandoned because of inconvenient access, poor water quality (taste or contamination), the pump is difficult to operate, or the system support costs are unaffordable because of overdesign of the system.

- *Organizational*—no one takes responsibility for fixing the problem, or the group that has responsibility does not have the necessary resources or training to address the problem successfully.

- *Financial*—there is insufficient money for spare parts, fuel, training, or for hiring a technician to fix the problem; existing water user fees are inadequate to support O&M; or community accounts have been diverted to other uses.

- *Social*—different factions within the community cannot agree on level of service,[4] who should be covered, or how to organize themselves to address the problem.

Analyzing existing system design, O&M, or financing may show that the current system just cannot be supported under the existing conditions. The causes for needing to repair, rehabilitate, or replace a system can be very complex. Examples of some causes and effects include the following:

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[4] Level of service means the degree to which water is distributed, with increased level of service implying greater user convenience. For example, level of service increases from a single source outlet (e.g., a handpump with no distribution), to a tap on the water tank outlet, to distributed groups of taps near the tank, to distribution lines to several centrally located public standpipes in a village, to yard connections for each household, to indoor house taps.

- Community participation in the planning, construction, and operation and maintenance (O&M) of the water supply system were inadequate. The system may not meet community needs in terms of layout, level of service, or increased demand outpacing the supply.

- Existing equipment cannot be maintained by those responsible, due to its complexity, lack of spare parts, or needed skills. This can result in frequent and/or expensive repairs, or require repairs beyond the community's capability.

- User willingness and ability to pay for water were not properly taken into account. This can result in insufficient financial resources to support the system or to purchase new components when existing ones fail.

- Site logistics were not properly taken into account, so that higher than expected transportation costs, variable fuel and parts availability, and poor communications place extreme burdens on remote communities trying to operate and maintain their systems.

- Responsibilities for installing, operating, maintaining, repairing, and replacing the system/components were not clearly delineated and accepted by all involved parties prior to system installation. If responsibilities are not accepted, critical support functions may not receive needed attention.

Any one of the above can be the direct or indirect cause of system failure. Often, a combination of several of these conditions cause problems or failures. For rehabilitation to be sustainable, all contributing reasons for the system deterioration or failure must be examined and addressed.

2.1 Rehabilitation Planning

The key question in developing a rehabilitation strategy is:

What modifications to the existing system are needed to 1) provide coverage to the greatest number of beneficiaries; 2) improve its long-term reliability and sustainability; and 3) increase use of the system up to its design capacity?

Modifications could include repairs, system layout, O&M procedures, financial management, community organization, or abandoning the old system and building a new one. Rehabilitation planning must include discussion with all major players (e.g., communities, government water agencies, donor agencies, and any PVOs involved) about certain policy questions.[5]

- Who should participate in setting goals and objectives for the project, including redesign standards for water quantity, accessibility, reliability, and quality (or QARQ), and decisions about technology choice and level of service?

[5] Most of which are the same questions as those typically considered in any water supply development program.

- What changes in current water system design, construction, and operation practices should be made in order to improve sustainability?
- What are the appropriate contractual and operational relationships among individuals, the community, community water committees, government agencies, NGOs, and the private sector?
- Who has ultimate responsibility for and ownership (i.e., control) of the system, and what obligations does this imply?
- What financial support is expected from communities, the government, and any involved donors or NGOs? How these obligations cover specific costs for equipment, materials, fuel, spare parts, transportation, and labor should be clearly understood and agreed upon.
- What training should be provided, to whom, and who will pay for it?
- What other activities (e.g., sanitation and hygiene education programs) should be included in the overall rehabilitation program?
- How should the progress and success of the project be measured and evaluated.

These discussions must recognize that targeted communities probably have considerable experience with their existing system, and so have in some way already dealt with many of these problems. It is crucial to take advantage of that accumulated experience and not assume that just because the system has failed, the operator or users do not understand how to fix it. They may simply not have the resources to do so.

2.2 Setting Rehabilitation Goals and Objectives

Choosing project goals and objectives must take into account a broad range of issues, including the amount of time and resources available. Different objectives yield very different project results.

- To maximize the number of sites rehabilitated, then only sites where there are no major water source problems should be considered. Redrilling a borehole (drilled well) can be very expensive and time consuming.
- To maximize coverage, then site demand profiles and anticipated demand growth at the larger sites will have to be carefully reviewed.[6]
- To focus the project resources on a certain class of users (e.g., the "poorest of the poor"), it may be necessary to incur greater logistical costs to reach the often remote areas where such people live.

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[6] All else being equal, economies of scale in construction will probably allow more people to be served for a lower per capita cost in larger communities.

- To develop new (higher quality) equipment or design standards or to replace any equipment with a newer model, it may require training people how to operate, maintain, and repair it, and a parts distribution network must also be established.

These objectives should be carefully considered before entering into detailed negotiations with host-country governments or donor agencies, since the mechanisms to reach the objectives can have a significant impact upon project design and implementation.

Decisions which should best be made on a cost, technical, or social basis often have a political side as well. Experience has shown that active community participation is a critical element in the sustainability of rural water systems. Nonetheless, some government officials may feel that since their agency has nominal responsibility for water resources development, communities need not be involved in site selection or planning. In many countries, developing rural water supplies is one of the first (and perhaps only) concrete indications of the benevolent presence of the central government. Consequently, the selection of regions and villages where government or donor-assisted water systems are built or rehabilitated can have a political dimension. National, regional, and local leaders will want to take credit for implementing water supply projects. To minimize the role of politics in site selection, a clearly defined and understandable set of site selection criteria must be developed.[7]

Engineers and technicians play a key role in the planning, design, and construction of water projects. Their expertise is needed to assess site-specific water resource development constraints, review design options, and spell out the technical and cost implications of each. Care should be taken that recommendations made by technical experts include consideration of the many nontechnical issues and constraints involved. Pressures to produce results and meet targets may influence recommendations for standard designs and construction procedures which quickly produce workable systems, but which may not reflect community needs. Therefore, people such as sociologists (or anthropologists) and finance specialists familiar with community development should also be included on project design teams.

Donors have long been aware of the relationship between water quantity, accessibility, reliability, quality, and health, and so are concerned about the health impacts of water system development. Although the immediate objective of a project may be to build a sustainable water system, the long-term goal is usually to improve community health and productivity. Since much of the funding for water system rehabilitation in developing countries is likely to be supplied by donors, they will want to review budget proposals, help set project goals, and establish verifiable indicators of progress to assure that their contributions produce the desired results.

Villagers in communities targeted for rehabilitation are likely to have a well-defined (but not necessarily articulated) set of objectives for their system. Initially, when improved community water supplies were built, they may not have had a clear understanding of all benefits, or

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[7] Discussed in detail in Chapter 3 below.

financial and social costs involved. However, communities in this position are more likely to want to actively contribute to the planning and installation process. It is important to recognize the different (and sometimes conflicting) agendas of individuals and groups involved. In spite of the difficulty of attempting to reach consensus on potentially conflicting agendas, at no time should the attempt be made to avoid this problem by excluding the active participation of all parts of the community, as the entire community will be affected by these decisions.

2.3 Water System Ownership

Ownership and control of rural water supplies varies from country to country, and can reside at the community, district, provincial, or national levels. In countries such as Sudan and Botswana, ownership and (at least) nominal control of water supplies rests with the national water agency. The government view is often that since the system was provided by or through (via a donor) government programs, formal ownership remains in government hands. It may also be argued that rural villagers do not have the skills or capability to take on the responsibilities of ownership, and may mismanage the system and cause it to fail prematurely. In these cases, the water system may be considered a social service provided by the government. Water fees may be levied by government to pay for some or all of the costs of this service, but villagers are likely to look to the government when repair is needed. Taking community responsibility for system upkeep is less likely when ownership is not local.

In other countries such as Indonesia, governments do not always take full responsibility for installation and O&M of rural water supplies, but may nevertheless play some supporting role (e.g., in conjunction with a donor-supported rural water project). In district centers and larger rural towns, the regional water agency takes responsibility for building, operating, and maintaining community water systems. In return, users pay fixed fees to support O&M costs. For smaller and typically more remote systems, the water agency sometimes participates in some regulatory, design, construction supervision, or other backstopping role, and yet not claim formal ownership of the system upon completion. In these situations, the government recognizes that it has a role in water resource management and in technical support, even if it does not have the financial or human resources to support these services in widely dispersed rural areas. Then, communities become de facto owners of their water systems, and must take on system financial and management responsibility themselves (see Figures 3 and 4 on the following page).

Ownership has implications for project planning as well as O&M. From a project planning perspective, if government retains ownership, then the rehabilitation client is the government agency involved. Design standards, equipment choice, and level of service provided must be according to policies and standards set by the national or regional water agency. At project completion, formal transfer of responsibility will be to the agency, not village representatives. This will reduce the community's sense of participation, so it will probably look to government agencies for system O&M and repair when needed.

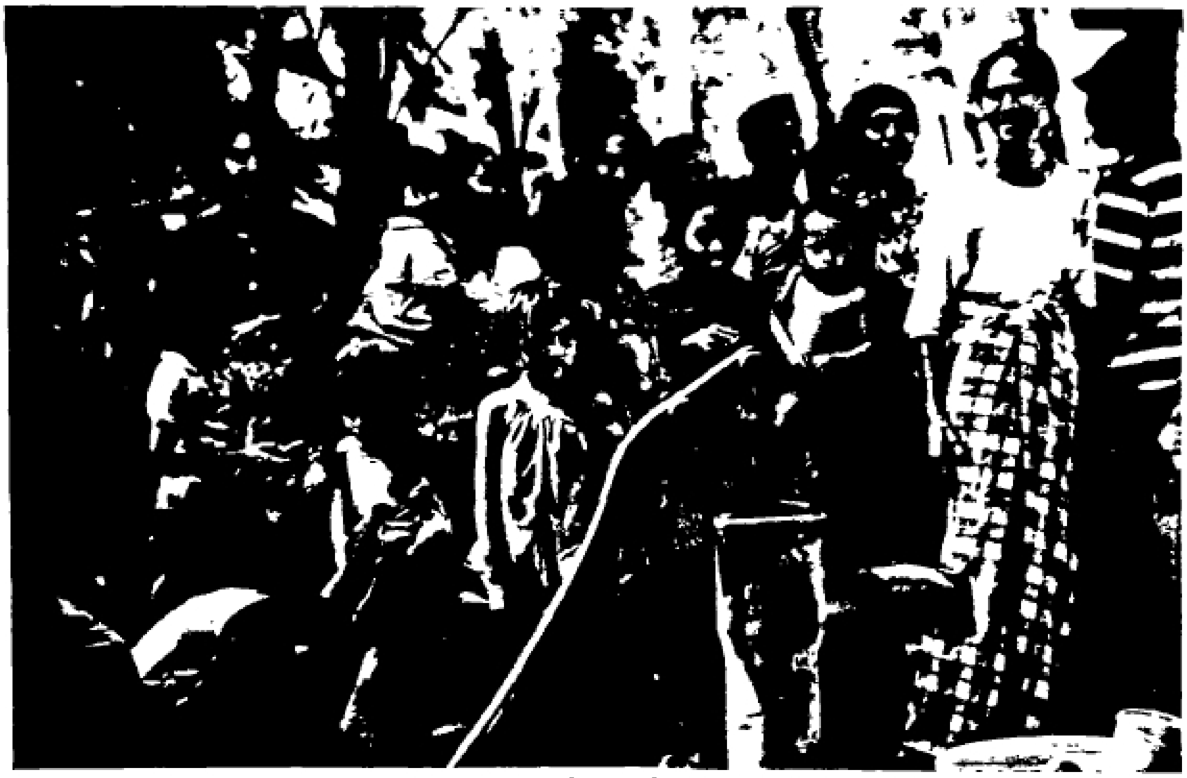

Figure 3

A handpump on Sumbawa Island in Indonesia, rehabiliated with CARE assisance. Villagers have been trained and are now able to deal with most needed repairs themselves.

Figure 4

A handpump installed in a small village north of Kathmandu, Nepal. Poor design, especially lack of proper drainage, is undermiing the foundation, which will soon have to be replaced. Villagers must rely on outside technical help to keep this pump running.

Ownership tends to generate responsibility, and lack of ownership (or at least control) tends to lessen a community's willingness to support its water system (see the examples in the box below). It is unlikely that one rehabilitation project in a given country will enable a donor agency or PVO to leverage major policy changes to shift system ownership from government agencies to communities. In fact, community ownership may not be the best solution in all cases. However, if the government retains ownership of a system, it is important at the project design stage to clearly define what roles the government will play in protecting its investment by providing O&M support over the long term, and what responsibilities can and will be shifted to the beneficiary communities.

2.4 Financial Management and Cost Recovery

Most donor-supported rural water supply projects require a minimum contribution by communities in terms of labor, local materials, cash, or other contributions. Water users are often required to pay fees to support system O&M, sometimes supplemented by government funds or other sources. Government agencies (usually in concert with donors or NGOs) often cover initial construction costs, particularly in the least developed countries. In some cases, donors or NGOs provide an O&M fund to support those costs for a specified time (one to two years is typical), after which the communities themselves assume all responsibility for future costs.

User willingness and ability to pay for new or rehabilitated water systems are critical issues affecting sustainability. The questions of who should pay for what and how much are important ones in project design. In planning rehabilitation projects, the following questions must be addressed:

- How much should a community reasonably be expected to pay toward the installation, O&M, and eventual replacement of system components?
- What payment mechanism (per capita or family tariff, general tax) should be established to ensure that the system will be adequately supported?
- How will community resources (including in-kind contributions) be mobilized and managed?

Historically, water tariff design all too often underestimated actual O&M costs. For rehabilitated systems, existing tariff structures may need to be substantially revamped after estimating O&M costs. This should be done before final site selection, so that community contributions (for construction) and user fees (for O&M) are clearly understood and accepted by community members before construction begins. An assessment should be made of the community's actual ability to pay these costs. Because system cost is directly tied to level of service, community willingness and ability to pay may limit level of service options. Relying only on community resources to support O&M may also mean that some poorer communities will be unable to support even low-cost systems. If so, it may be necessary to develop a set of criteria under which rehabilitation efforts are partially subsidized (or not undertaken) in very poor

How Community Ownership Can Support or Destroy a Water System

In Sudan, the National Rural Water Agency (NRWA) built many community water systems in rural villages, usually with donor funding. NRWA owned and controlled the systems. A typical system included a deep borehole with a diesel-driven piston pump, requiring regular and costly supplies of fuel, spare parts, and materials. Communities received no training in system operation, maintenance, or repair from NRWA. The systems were operated by NRWA field staff. Water fees were collected by the resident NRWA agent on a per capita basis for people and animals. These fees were nominally to be used to operate, maintain, and repair the community's water system. What actually happened was that the fees were passed back to the regional NRWA, then to the national level, then to the undifferentiated general government revenue account. The funding allocated by the Ministry of Finance back to the national NRWA, then on down to the community level, had little to do with either the community fee payments or their system's financial support requirements. Without adequate funding, many of the systems ceased to operate. Some more resourceful communities, faced with having no water, established a second fee collection with which they could directly purchase black market parts and fuel to keep their systems running. Once this parallel collection was established, local NRWA agents in many cases returned less (or even none) of the locally collected fees, since communities had demonstrated the ability to support the systems themselves.

In contrast, in CARE-assisted water systems built in Indonesia, the source of much (and in some cases all) of the system financing was communities themselves. The communities owned and controlled their own systems. Other than being a conduit for international donor assistance (in this case, USAID), the government had little formal involvement in constructing or maintaining these mostly remote rural systems. In some cases, communities took out loans from banks or from equipment suppliers. Water fees were collected on a regular basis, and managed and dispersed by community water committees. Many of these systems are still operating successfully after as much as 10 years, with O&M funded ***solely*** from contributions within the community. Communities were motivated not only by the need for water, but also by the fact that they had directly contributed labor, local materials, and in many cases cash to build their own systems. They had also received the training necessary to manage and maintain the systems with little or no external support.

communities.[8] There is no point in rehabilitating a system which will simply fail again. If a system cannot be supported it should not be built.

[8] For example, in communities where incomes are only half of that typically found in the area, perhaps 50 percent of recurrent costs could be provided out of a fund established by the donor or government agency.

2.5 Human Resources Development

Training should be a key component of rehabilitation. Lack of technical, financial, and management skills often leads to the early failure of water systems. Sanitation and hygiene education programs should always accompany rehabilitation. For the modest increase in funding needed to support such programs (compared to typical physical rehabilitation costs), significant health benefits may occur. Training should include the following components.

- *Water system operators*—upgrading operation and minor maintenance skills, and learning the importance of preventive maintenance measures;
- *Village water committee members and other community leaders*—water system management, including financial planning, fee collection, accounting, maintenance operations, and planning;
- *Fee collectors/treasurers*—accounting and disbursement procedures;
- *Water users*—hygiene education, sanitation practices, and water conservation;
- *Village water technicians*—pipeline repair, tank and valve maintenance and repair; and
- *Engine/pump mechanics*—although rehabilitation programs do not usually include technical training for mechanics, the capabilities of local private sector and/or government agency mechanics should be assessed to determine if existing skills are adequate to meet project demands for skilled labor.

It is important to consider whether the purpose of the project is to physically rehabilitate a fixed number of sites in a region (i.e., focus more directly on immediate water needs), or whether the focus is on sustainability, so that it will not be necessary to come back three years later and do the job over again. If the latter, the project should include a strong training component. For a given amount of available funding, this will inevitably reduce the number of sites which can be rehabilitated. However, if proper training is provided, it will greatly increase the sustainability of those fewer sites. Training should be a major project focus except in circumstances such as refugee relief work. Implementation plans, organizational responsibilities, and funding sources for training programs should be formulated during project design. Physical rehabilitation work can then include on-the-job training for community members. Besides the actual number of sites rehabilitated, indicators of project progress should include improvements in community management/technical skills, well-maintained systems, and changes in hygiene and sanitation practices.

2.6 Organizational Relationships

Relationships among different groups (communities, government agencies, PVOs, donors, private contractors) in the project will be dependent in part upon government policy on water system ownership and support responsibilities. In countries such as Sudan and Mozambique where civil unrest is a major problem, government agencies may be unwilling or simply unable to assist rural communities beyond helping with system design and installation. This may be due to financial constraints, more pressing priorities for government revenues, or an inability of government agencies to retain enough qualified technicians and managers with self-initiative to work unsupervised in remote areas.

In such cases, rural communities must take on greater responsibility for operating and maintaining their own systems. This requires governments to recognize the legitimacy of community organizations such as village water committees, allowing them to collect water fees and make decisions about O&M. This may involve interceding with policy-makers to modify the mandates of government water agencies, either implicitly (to ensure that planned project activities will not be undermined) or explicitly (so that role modifications formally become a part of government policy). By making project implementation contingent upon the government's acceptance of the transfer of certain responsibilities from government agencies to communities and/or the private sector, considerable leverage can be applied to change certain policies.

Complementary Public and Private Sector Roles in O&M

In addition to government agencies and communities, the private sector can also play an important role in rural water system O&M. In the mountainous areas of Yemen, community water systems are initially built with cooperation from the government, usually through donor-funded development projects. The systems are designed and constructed by private sector contractors. Boreholes are usually drilled by the government's Rural Water Supply Department, or subcontracted out to the private sector. However, responsibility for O&M lies with the communities themselves. Except in poor areas in the Tehama lowlands (where O&M is subsidized by government local councils), the systems are privately operated and maintained by beneficiary communities. Water user fees are collected by community representatives, based on consumption as measured by metered connections whenever possible, or flat rate for unmetered connections. Since one system will typically cover six or eight communities, the system is jointly financed by fees contributed by all participating communities (see Figures 5 and 6).

Varying from country to country, the roles of the private sector may be limited simply to providing materials and spare parts, or may include other responsibilities such as system design, installation, maintenance, and repair as well. This does not mean that government agencies do not have a legitimate role in rural water system O&M. Rather, this role may be more appropriately in monitoring and policy rather than direct support. For example, government agencies may be able to provide skilled labor for system design, engine overhaul services, repairs requiring expensive or specialized tools, technical and management training, or consulting services when system design changes or expansion are needed. It must be determined which of these roles might be more efficiently assumed by other groups.

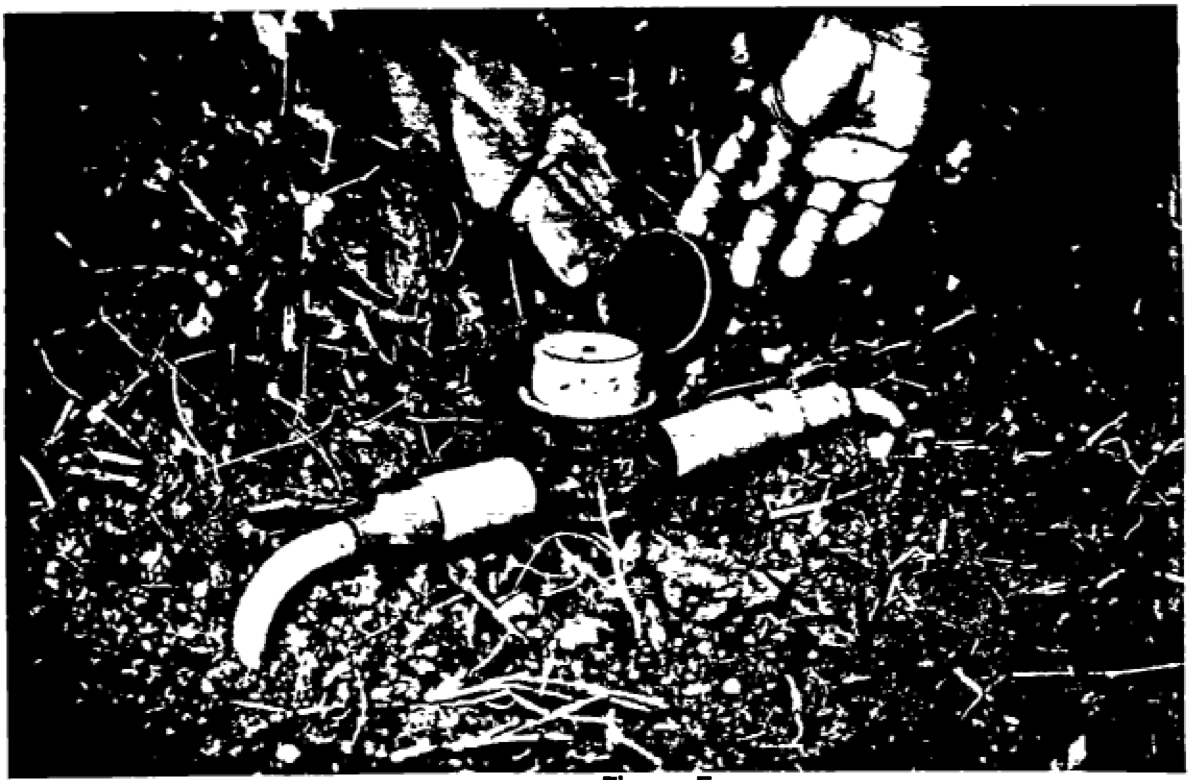

Figure 5

A single-residence water meter used in a rural community water supply in Kalutara, Sri Lanka.

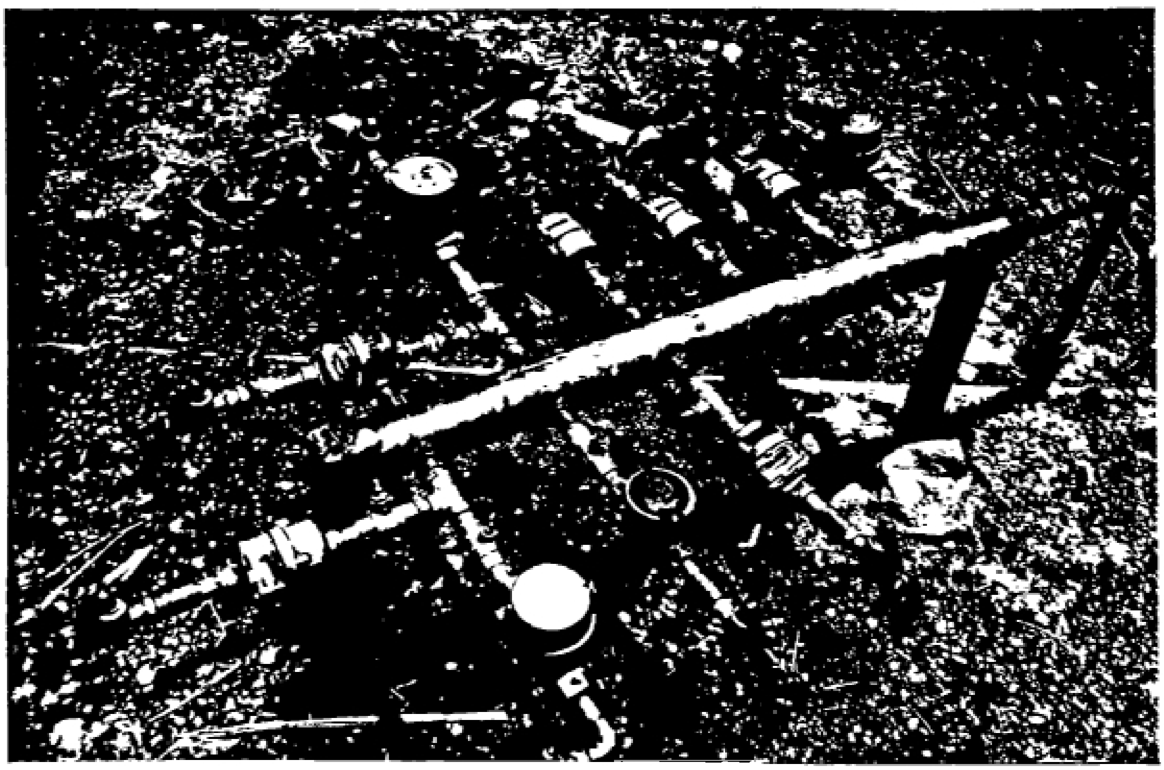

Figure 6

A water point with meters and locked taps for individual families in Turba, Yemen. Individual metering coupled with progressive tariffs are crucial to controlling demand and recovering costs, especially for household connections.

Assessing the capability of the private sector and government agencies is important in determining organizational responsibilities. Government policy may limit options. Since responsibility without authority is useless, to assign responsibility for a task to a group that does not also have authority to make necessary decisions (e.g., a village water committee) will greatly impair its ability to carry out the task, or may sabotage the project completely. Similarly, without access to adequate resources (human, financial, and material), even government water agencies with both the responsibility for implementing actions and the authority to make appropriate decisions will get nowhere.

2.7 Project Monitoring and Evaluation

Monitoring of project activities takes place during construction and training at a given community site, as well as during periodic follow-up visits after site activities are largely completed. It typically includes periodic reviews by project staff of progress through:

- ***project staff meetings***—the purpose of which is to:
  - review progress thus far, and compare it to the planned schedule of activities in the project implementation plan;
  - assess whether ongoing activities appear to be meeting the project's objectives and achieving its goals;
  - lay out workplans for the upcoming period;
  - assess what staff training needs have been identified, and plan human resource development activities accordingly; and
  - note problems which have arisen in project implementation, and identify solutions;
- ***quality control inspections***—to make certain that one construction activity is properly completed before proceeding on to the next, for example, inspecting the pipeline ditch prior to backfilling, or inspecting forms and rebar installation before pouring the foundation for the pumphouse and engine mounting block;
- ***assessment of training activities***—(for community organization, technical skills, hygiene and sanitation, etc.) to review community response to training programs, their absorption of required skills, and to redirect training as other needs are identified; and
- ***reviews of resource mobilization efforts***—including collection of agreed-upon community contributions, and status of loan and grant application and approval.

Post-construction monitoring usually entails periodic visits to each site (typically every three to six months) to inspect the physical system, meet with the community to discuss use of the system, assist with any problems which may have arisen, and identify any further training needs. This is important to make sure that:

- systems have been properly constructed;

- the design and operation meets community needs; and
- communities have been provided suitable technical and management training to undertake all of their O&M responsibilities.

Project assistance with initial post-construction O&M can help develop a community's confidence in its own ability to take full responsibility (in conjunction with other external agencies as appropriate) for maintaining its system over the long term. Project staff can also act as meditators to assist with conflict resolution as the community becomes more directly involved in system management.

Accurate documentation of project activities at each site needs to be kept, including:

- summary descriptions of the site and the community:
  - the physical system description and layout;
  - relevant community organizations, including VWC members;
  - description of other groups (local NGOs, government agencies) and individuals with O&M responsibilities and their skills;
  - any plans for future expansion; and
- a site log of the following:
  - all construction, O&M, and repair activities undertaken;
  - visits from outsiders connected with system; and
  - all training activities undertaken;
- financial bookkeeping:
  - all cash, labor or in-kind inputs (including loans, grants, and periodic collection of water fees);
  - disbursements for O&M, repairs or other associated activities; and
  - loan repayment status (if any).

Evaluation requirements vary from one donor or government organization to the next, but typically, development projects are evaluated at midterm and at their conclusion. External teams of expatriate and local consultants are often brought in to evaluate the project, and follow specific prescribed guidelines for doing so.[9] Increasingly, communities themselves are involved in "participatory" evaluations to increase their understanding of the system, and to make them more self-reliant in maintaining it.

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[9] *Evaluation Guidelines for Community-Based Water and Sanitation Projects*, P. Roark. WASH Technical Report No. 64, May 1990.

To evaluate the success of the project and the approaches taken to water system rehabilitation, it can be very worthwhile to assemble a database to analyze important information about each community where the project has provided assistance. Analysis of this data may provide insights into what site conditions or project activities have been indicators of success and failure. It can provide quantitative analysis of project achievements (e.g., per capita system development costs) as well as potential correlations of specific project interventions (e.g., types of training provided to beneficiary communities) to observed impacts (e.g., reduced incidence of diarrheal disease, or low O&M costs). This information could be quite valuable not only in redirecting ongoing project activities, but also in planning future project activities.

Chapter 3

PROJECT INITIATION

Project initiation includes project preparation (i.e., gathering initial background information and negotiating with major institutional players), developing site selection criteria, identifying rehabilitation needs in particular areas, appraising the feasibility and scope of project activities based on those criteria, and preliminary identification of procurement needs.

3.1 Project Identification

The first stage in rehabilitation is project identification. A rehabilitation project may be initiated by:

- *Government agencies*—which may find it increasingly difficult and costly to support water systems in poor condition;
- *Donors*—who identify a need for more reliable rural water supplies;
- *Local or international NGOs*—working in the sector; or
- *Communities*—that find that existing systems no longer meet their needs.

Targeting a particular group of beneficiaries is often more difficult than it may first appear. Determining a project area may have little to do with technical, social, or institutional selection criteria. It is usually easier to implement projects in areas or regions which are well-known to the funding agency. Logistical considerations (and consequently reduced costs and more rapid project progress) strongly argue for carrying out projects in less remote regions of a country. Also, the selection of a project area can be driven by government (or individual) political concerns. The government may wish to reward a group for its political support, or perhaps win over an out-of-favor group. In some countries or regions, another consideration may be political or security concerns.[10]

3.2 Project Preparation

After a project area is identified, the second step is preparing a detailed implementation plan. Developing this plan begins with defining and agreeing upon specific objectives with major players, including the host-country government, the donor (if there is one), the project implementing agency (perhaps an NGO), and potential beneficiary communities. The implementation plan must consider all technical, institutional, social, financial, and economic

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[10] An excellent discussion of how many communities are de-selected from development projects because it is more convenient to do so is given in Robert Chambers book, *Rural Development: Putting the Last First.*

aspects of the project. Project success (as judged by the long-term sustainability of sites rehabilitated by the project) is contingent upon a series of technical and nontechnical indicators which include the following:

- *Institutional arrangements*—Responsibilities for all aspects of system support (provision of skilled and unskilled labor, management, materials, equipment, transportation, and communications) must be delineated. What other logistical support is needed during and after project completion? Can all support functions be readily addressed?

- *Financial responsibilities*—Financial responsibilities of all institutional players (government, donor, any NGO, and the community) must be clear. Is the community willing and able to provide support (financial, human resources, materials) during construction? To what extent? Is it able to support the system's recurrent costs long after the donor's departure? If not, who will?

- *Physical resources*—Water demand must be carefully matched against hydrogeological conditions. At some sites, it may be necessary to develop additional water sources (develop new springs, or drill new boreholes). At others, it simply may not be possible to meet anticipated demand from readily available water resources.[11] Is there likely to be adequate high-quality water to meet demand?

- *Technology choice*—Technologies that are appropriate from social, technical, cost, standardization, and supportability (O&M) perspectives must be identified. If the physical situation demands complex technologies (e.g., drilled boreholes with engine-driven pumps and distribution systems), can the system be locally supported?

- *Human resources*—A wide variety of technical and management skills must be available to operate and maintain a water system successfully. A rapid assessment is needed of human resources available (in the community itself and the local district) to support project activities, factoring the cost of training needs into rehabilitation cost. Are required skills locally available?

- *Political environment*—Project design must take account of the political environment in which the project is to take place. Stable, well-organized communities increase the probability of successful rehabilitation efforts. Are there any obvious institutional, political, or social problems which may make it difficult to operate and maintain the system?

Assigning (and accepting) institutional and financial responsibilities can be a very complex and time-consuming task. Willingness-to-pay criteria must be based on a realistic assessment of recurrent costs (including future component replacement) and the community's ability to bear these costs. Villagers must be well aware of the cost of installation and O&M, and be able to

[11] For example, it may be necessary to truck in water from a central source, or to build treatment systems for otherwise unusable water from irrigation ditches or other potentially polluted surface water sources.

meet the unsubsidized portion of those costs. Many development specialists feel that if recurrent cost subsidies are required (especially in LDCs), the system is probably not sustainable. If O&M subsidies are required, it is important to identify both the level of subsidy and its source.

The viability and appropriateness of different water technologies must be judged not only on being able to meet water demand, but also on system complexity, the ability of local personnel to do maintenance and repairs, the availability of fuel and spare parts, and the cost for these functions.

3.3 Site Selection Criteria

Site selection is a multistage activity which, to some extent, will continue throughout the project. First, there should be a general assessment of the geographical area to get a good sense of the factors discussed in Section 3.2. A list of candidate villages should be assembled, larger than the actual number of sites to be serviced, to allow for de-selection. Candidate sites may be suggested by government water agencies (or related areas such as health services), NGOs working in that area, communities themselves, or other sources. Candidates should be chosen based first on their inclusion in the target group identified during project preparation, and then on the extent they are suitable according to the indicators listed in Section 3.2. Once the list of candidate villages is developed, specific sites must be identified and prioritized by applying site selection criteria reflecting the project's goals and objectives.

If enough information is known about village water supplies in the designated project area during project preparation, it may be advisable to establish site selection criteria at that time. This would allow the donor or implementing agency to help cooperating agencies better focus on specific project objectives. The criteria should cover the entire range of issues important to project success, including technical, social, institutional, financial, and economic parameters. These criteria vary somewhat from project to project, depending upon the types of systems being considered. They may also be re-configured to reflect characteristics of different beneficiary groups. The following site selection criteria[12] assume that a fixed amount of money is available to provide water to the greatest number of beneficiaries:

Technical Criteria

- The community must have an established water source reasonably nearby which can be cleaned or expanded (if necessary) to meet anticipated demand and water quality requirements.

[12] Assembled from different lists of selection criteria used on several CARE and Save the Children water rehabilitation projects. Some of these criteria are clearly controversial. If the objective is to maximize coverage and the probability of sustainable systems, however, none of these criteria should be arbitrarily dismissed as unworkable.

- Rehabilitating the site should not require extraordinary expenditures (such as the cost of developing a new borehole, or laying a 10 kilometer gravity pipeline, unless all sites would require this level of expense), since this would greatly reduce the funds available for other sites.
- Communities whose water requires extensive treatment (even if only slow sand filters) should receive lower priority than those whose sources do not require treatment.
- The water source should be the only reliable high-quality water source accessible to people in that area. No site should be considered for rehabilitation that is close to an existing functioning water point (since this would be a matter of greater convenience not necessity).
- For selection, system breakdowns must have occurred more than three times during the previous year.[13] Alternatively, sites considered, although with functioning systems, were unable to meet basic water demand criteria of 30 liters per person per day.
- Where possible, sites should be chosen at communities where other development projects have been or are being successfully undertaken.
- Rehabilitation of the site (either in isolation or in conjunction with other sites in the area) should not cause significant environmental degradation.
- Sites with in-house connections should receive lower priority than those with public taps.[14] Alternatively, rehabilitation projects may proceed with the understanding that in-house connections will not be a part of physical system rehabilitation, and will be financed only by the beneficiaries themselves.

Social and Institutional Criteria

- The community should express an active and broadly supported interest in having its system rehabilitated.
- The community must either have an existing and active water committee, or show evidence that community members have the initiative to support one.
- Communities which have a relatively stable population with relatively homogeneous religious and tribal affiliations[15] should receive priority.

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[13] Three breakdowns per year is a fairly typical number for well-maintained developing country rural water systems. Any less than that suggests that the system is working fairly well.

[14] In-house connections cost much more than public taps and typically have much higher water consumption rates.

[15] Intergroup conflict can take a heavy toll on community projects such as water systems, wasting considerable time, effort, and money if not quickly resolved.

- The project implementing agency should give priority to sites which can be completely rehabilitated with minimum active cooperation from other external agencies (governmental or otherwise). This reduces the probability that potentially conflicting agendas will bog down the project.
- Communities with a history of successful self-help projects should be assigned higher priority, since successful rehabilitation is more likely at such sites.
- Communities must agree to relatively equitable distribution of public taps so that water accessibility is assured to all.

Financial and Economic Criteria

- The community must be willing to commit an agreed-upon percent of cash funds (and/or in-kind contributions) in addition to unskilled labor for construction activities.[16] The higher the community contribution, the greater the number of community systems that can be rehabilitated by the project, and the greater the probability that the community will successfully support the system over the long term.
- The community must have access to transportation (public or private) which will be suitable for logistical support for the water system, or the community must accept responsibility for all maintenance and repair locally.
- The community must have a stable base of income-generating activities to generate support funds.
- It is well to consider a maximum limit on the projected per capita cost of rehabilitating any given site. If a particular site is likely to cost more than the limit, serious reservations should be raised about its inclusion. Otherwise, the objective of maximizing coverage with a fixed budget will be compromised.[17]
- Communities must be willing to participate in community organization and financial management training, and agree to regularly collect user fees of a minimum fixed amount (contingent upon the availability of any subsidies) to insure that adequate funds will be available for O&M and repairs.

Other criteria should be added to this list from past experience. These criteria can be easily applied by assigning each an "importance value" from one to three, depending upon which are considered to be most relevant given the project's goals and objectives. The next step is to set up a matrix of all candidate sites. Each criteria is applied to the site, assigning a value

[16] Depending upon the number of available candidate communities, this percentage of self-financing may be as high as 100 percent (not including the cost of technical assistance or donor logistical support).

[17] Alternatively, this criteria might be formulated in terms of physical quantities (e.g., for gravity systems, that no site will be selected whose source is more than 6 kilometers away, or no site will be chosen where borehole drilling depth is greater than 100 meters).

of zero to each negative answer (no established water source, no expressed interest in having their system rehabilitated), and a value of one to each positive answer. Multiply the "importance value" by one if it applies to that site. Add up all points accrued for each site. Sites can then be easily prioritized according to the number of points they have been assigned.

Rather than trying to apply such a large set of criteria at one time, consider a three-step site selection process. Say that during project preparation you have estimated that there is sufficient funding to rehabilitate about 30 systems, based on preliminary estimates of water needs and typical system costs. The first step is to assemble a list of about twice that many (60) potential candidate communities. An extension team trained to identify social, institutional, and financial/economic criteria can then be sent to each of the 60 candidate communities to determine which best meet those criteria, and make an initial screening of those communities.[18] After the list is suitably reduced and prioritized, a group of technicians then visits each of the remaining communities and applies the technical selection criteria. Identifying technical rehabilitation needs at this stage allows a much better determination of likely site rehabilitation costs. With that information, the remaining qualified communities can then be re-prioritized to compose the initial set of project sites. Of course, the numbers of sites suggested above can be adjusted to reflect resources available to the project.

Site selection for the entire project *should not* be undertaken at the beginning of the project. For example, for a multiyear project, site selection can be done annually, with the first year's sites identified as discussed above. Each year, as the current set of community sites are rehabilitated, a new site selection process occurs. This has the following advantages:

- It allows for evolving changes in site status (some sites may be rehabilitated by some other group, or dropped off the priority list for other reasons).
- It allows better estimation of individual and aggregate site costs, so that a better determination of the extent of project resources can be made.
- Growing experience with the results of the site selection criteria may suggest modifying those criteria as the project progresses.
- Site selection teams (extension and technical) have their work more evenly spread out over the project. Also, as they work with extension activities at the first set of chosen sites, their understanding of the importance of various site selection criteria improves, allowing for better future site selection.

Some projects (such as CARE/Indonesia's Community Self-Financing Water Supply and Sanitation Project) use selection criteria based in part on communities identifying themselves and approaching the project for assistance. Sites are selected largely on a community's ability to organize itself, mobilize resources for project use, and argue effectively that it needs the external assistance to complete the project. This approach has the advantage that preliminary

[18] See Chapter 4 for more detail on Rapid Rural Appraisal techniques.

site selection is effectively made by the communities themselves, since they are responsible for initiating contact with the implementing agency. By mobilizing funds and other resources, they demonstrate a capacity to organize themselves for their own benefit, indicating an increased probability for project success. The above selection criteria are then applied as before.

In some circumstances, the selection of certain communities may be politically motivated, as may the selection of the project area. If political pressure arises to include certain communities or regions in the rehabilitation program, it may not be possible to refuse to include them. However, the selection of communities for political rather than technical reasons may have an impact on the level of cooperation and contributions expected from them.

Chapter 4

RAPID RURAL APPRAISAL

It is important that adequate and precise background information on each site be gathered and reviewed before undertaking any site work. It is equally important that this information gathering be only a supplemental activity supporting the main project objectives. The information must be gathered quickly, at minimum expense, and yet accurately reflect site conditions. One method of accomplishing this task is Rapid Rural Appraisal (RRA).[19]

RRA is a method of field investigation designed to quickly appraise the management of rural resources. It enables surveyors to determine villagers' needs and circumstances quickly and cost-effectively to develop better approaches to water resource management. Its emphasis on participatory and interactive data collection makes it an appropriate tool for increasing community involvement in project design. The RRA approach is described in this chapter as it applies to collecting data on community participation, institutional issues, system design and construction, logistics, O&M and repair, and financial management. Detailed discussion of each of these areas is given in Chapters 5 through 10 of this manual. A discussion of the mechanics of RRAs is given in Appendix A.

4.1 Specific Information Needs

The RRA team is typically composed of at least a social scientist and a technician or engineer. Other specialists[20] can be used as the situation requires. They need not be foreign consultants, and using a local social scientist is strongly advised. In many cases local engineers and technicians may have a better understanding and appreciation of local hydrological conditions and construction techniques. If the project is funded by an international donor or PVO, one of the team members should be an expatriate to act as a conduit of information to the funding agency.

Before visiting a field site, a list of key village respondents (categories or positions, not names) should be developed with the help of project extension workers. A project extension worker is then sent out to determine who these people are and to ensure that they will be available when the survey team arrives. The team should plan which team members will participate in which interviews. It is useful to begin the visit with a general introductory session, including

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[19] Much of the RRA approach given in this chapter comes from "Short Cut Methods of Gathering Social Information for Rural Development Projects," by Robert Chambers, a chapter in the 1985 book *Putting People First: Sociological Variables in Rural Development*, Michael M. Cernea (Ed.), Oxford University Press, New York; and from the report, *Training Notes for Agro-Ecosystem Analysis and Rapid Rural Appraisal*, Conway, Gordon E., et al., 1987, International Institute for Environment and Development, London.

[20] Specialists in rural credit, women in development, health and sanitation, etc.

all key respondents as well as other villagers. The team leader should explain the purpose of the village visit, and raise questions and issues of interest to the group. Later, the team may visit key elements of the water system while interviewing key informants, including:

1. the system caretaker/operator;
2. the village leader;
3. water committee members;
4. a nurse or village health worker (if available);
5. several village women;
6. any technically skilled villagers;
7. merchants and traders; and
8. the heads or leaders of schools, health facilities, and religious organizations.

During the interview process, the RRA team will develop an understanding of the system's O&M history, the roles of the villagers and other outside support groups, identify any design flaws (mechanical or organizational), and any other information necessary to explain why the system now needs to be rehabilitated. Areas of inquiry include general background, community organization and participation, institutional arrangements and responsibilities, financial management, logistics, technical description of the system, and operating history. Sample questions and suggestions for key informants (number coded from the list above) on each of these topics is given below.

4.2 General Background (all respondents, in group setting)

General background information may be available from secondary sources such as other project and government reports and staff, and NGOs working in the area. To establish general community characteristics, topics best covered in field visits in a group meeting include the following:

- village name and estimated population, including areas of possible future expansion;
- other donor/government-supported development activities within the village, including schools, health posts, etc.;
- economic activities and general income levels;
- the cultural background and diversity in the area;
- distance to the nearest market town where marketable items from the village are sold and where fuel, spare parts, and skilled mechanics are available;
- social/religious attitudes about water and water supply, including willingness and ability to pay, or a history of group cooperation (or not) in achieving common goals; and

- traditional water sources or means of obtaining water when the main water system is out of order, and the reasons for using these other sources (convenience, health, taste, etc.).

4.3 Community Participation (respondents 1, 2, 3, and 5)

Objectives here include determining the level of community participation in water system planning and installation, the present level of this participation and its form, and the level of participation that can be expected of villagers during and after system rehabilitation. Key questions include:

- Is there an active water committee, what do they do, who is on it, and how are they selected?
- In what ways did the community contribute to original water system installation (labor, cash, in-kind contributions)?
- Were villagers consulted about the location of water points, the level of service, or their longer-term obligations for O&M support (if any)?
- How does the village contribute now? Are contributions made to pay operators or technicians, or for fuel, spare parts, and repair labor? Were contribution levels clearly understood and agreed upon when the system was installed?
- When was the system first installed? What expectations did villagers have concerning level of service and reliability? Have these expectations been met? If not, why not?

4.4 Institutional Arrangements (respondents 1, 2, 3, and 7)

The RRA may confirm or bring into question secondary information sources about the participation of the village and/or other organizations in the ownership, O&M, and repair of the water system. Discussions of these issues may reveal major sources of problems from outside the village. Questions should include the following:

- What are present roles of government agencies and other groups or individuals in the construction, operation and maintenance, and repair of the system?
- What organization(s), if any, assisted in the planning, design, and installation of the existing system?
- Who formally owns the water system, who is supposed to be responsible for its O&M, and who actually does it?
- How does the community communicate with those responsible for maintenance and repair and get them to respond? How long does the response typically take?
- How many times has the system broken down this year? How long was it out of service each time? Who repairs it when this becomes necessary?

- What supplier/distributor networks exist for equipment, materials, fuel, spare parts, and other related mechanical services? Who pays for these when needed?
- What procedures are used to fix the problem when breakdowns occur? Are different procedures used depending on the seriousness or probable source of the problem?
- Are there villagers who have the technical skills and tools needed to attend to some breakdowns? What kinds of breakdowns can they handle? Are they paid for this service? If so, how?

4.5 Financial Management (respondents 1, 3, 6, and 7)

Adequate and well-managed financial resources are crucial for sustainable water supply systems. The purpose of this line of questioning is to determine who is responsible for and how funds are collected and managed for system O&M.

- What community-level financial practices exist and what are their characteristics, such as general access to credit, formal or informal loans, loan rates, financial management practices for community resources, and accountability?
- Who paid for the system originally? In general, how is the system now supported financially? Does some external agency (e.g., the government) fund O&M? If user fees are collected, who is responsible for their collection and disbursement?
- How are user fees collected? Is payment made per container, by household unit, per capita or some combination thereof? Is payment received in a regular manner? Are running accounts kept? What is the typical running balance? How much is available now?
- Is there a sliding scale or some other means to assure that poorer residents have access to water? Is there a different tariff for businesses that consume larger quantities of water?
- What costs are user fees intended to cover (operation, fuel and lubricants, the operator's salary, minor and major repairs, component replacement, eventual system replacement)?
- Are user fees or other funds collected sufficient to cover all system costs? If not, how are additional funds collected?
- How was the payment method and level initially set and agreed upon? Has this changed? If so, how and why?

4.6 Logistics (respondents 1, 3, 6, and 7)

Logistics are important not only for project planning, but also for the long-term sustainability of the system. Key questions include:

- How do villagers travel to market towns and what facilities are available to transport goods to and from the village? Are there times of the year when travel is difficult due to periodic fuel shortages, rainy season, etc.?
- What is the condition of roads and other transportation, and are there seasonal limitations in their use?
- What if any vehicles are owned by village members? Have and can they be used to support the water system?
- Are there any skilled laborers living in the village? What unskilled labor is available in the village, and are there any seasonal constraints to its availability (e.g., conflicting demands due to agricultural labor demand for planting or harvesting)?

4.7 Technical Issues (respondents 1, 3, and 6)

This is the last item on the question list not because it is the least important. Rather, it is far too easy to focus exclusively on the technical side of rehabilitation, since a technical issue (e.g., the main pipeline in a gravity system has failed) is probably the most obvious reason for the system needing attention. Before proceeding with any rehabilitation activity, a full technical description of the site must be completed, including a list of necessary rehabilitation tasks. Discussions with villagers about the site's O&M history and a review of any available records may bring up possible problems. The site technical review falls into the two broad categories of system description and history.

For the system description, it is important to visit all elements of the water system and review with key respondents (most likely the system operator) the condition of each component (see Figure 7 on the following page). The major components will be the water source (e.g., borehole, spring, open well, river, irrigation ditch), the pipeline, the pump and engine (if any), water storage tank(s), distribution system, and valves and taps. Some information may be available at national or regional government water agency offices, but it should be confirmed on site.[21] This would include such items as:

- typical designs and types of components (spring catchments, storage tanks, pumps and engines) of local water systems;
- the hydrogeological conditions in the proposed project area, average spring yields, typical well depths and yields, seasonal variability; and

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[21] It is not safe to assume that the actual system is the same as the engineering plans. Things are not always built according to design plans.

Figure 7

WASH consultant working with local water technicians to plan a site monitoring and evaluation methodology in Khartoum, Sudan.

- the existence of drilling and water system installation records at the appropriate regional or national offices.

Even if the information is available from secondary sources, it is best to ask villagers directly and to inspect equipment personally. Take full advantage of villagers' knowledge. The extent of their knowledge and understanding reflects their involvement with the water system, so their information may be more accurate than that found elsewhere. Include a sketch of the water system layout and measurements. Important questions to ask respondents are:

- *Water Source*—What is the location of the water source or well, its yield, depth (if known), age, if it has ever gone dry at any time during the life of the water system (and if it is dry now, when did this occur), and what efforts have been made to clean, deepen, or develop a new source? Is the source protected and sanitary? If a spring catchment, are there cracks or leaks? If a spring, is there any change in its physical surroundings which might affect water yield or quality?[22]

- *Pipeline*—What is the main pipeline made of? What are its length and dimensions? For any pipeline, is it properly buried under roads? If PVC, is it properly buried along its entire length? Is it properly supported crossing creeks or other obstructions? Is there obvious leakage anywhere? Are there cleanouts and air relief valves in the appropriate spots?

- *Pump*—What (if any) type of pump is installed in the well, the make or model (if known), the depth setting and the diameter of the rising main. Since the pump is sometimes not visible, this information may be hard to obtain. Villagers may know how many drop pipe sections are in the well, and from this a pump setting level can be calculated. Note any obvious wear on bearings, bushings, or other moving parts.

- *Engine*—What (if any) is its make and model? Record the serial number, number of cylinders and the information on the engine identification plate. Note how it is connected to the pump (e.g., belts, transmission, etc.). Observe the condition of the engine, note its cleanliness, any wires and rags holding it together, and missing parts (common missing parts are the exhaust system, air and oil filters, and factory spec fuel tanks). Is the engine operating or could it be operated? If the engine is operating, note the color of the exhaust and any unusual engine vibration.

- *Surroundings*—Other items of importance to note at pumping sites are how fuel is stored, what tools are available, what old or new spare parts are lying about, the condition of the pump-house or shelter (if any), and how the well is protected from contamination from spilled fuel, oil, or water leaks and puddles. Is there a "soak-away" apron, drains, or other means of disposing spilled wastewater from around taps or other areas?

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[22] For example, have any trees around the spring been cut down? Has the area been converted over to agricultural use, including the application of fertilizers or pesticides?

- *Storage Tank*—Examine the water storage tank and stand (if any) and describe its construction, volume, location, elevation, and any observable rusting, leaks, or evidence of such. If possible, examine the inside of the tank. Note how full it is, how clean it is, and what means are used to keep debris and small animals out of the tank. Are there any controls (float valves, overflows)? Is the tank filled from the top or bottom, and is there a way to drain the tank for cleaning? Is there a water meter on the tank? Does it work? Have readings been recorded in any water committee or other records?

- *Distribution System*—Do villagers know where the distribution pipes are (if they are buried)? Walk along the water distribution system and observe any obvious leaks. If the system has not operated in some time, it may not be possible to locate leaks. Draw a diagram of the distribution system. Note the location of all valves and other fittings, and ask the operator what each is for. Note any places where the distribution system is exposed and note the pipe material and diameter. Note pipe material, lengths and diameters, and where they change.

- *Water Quality and Treatment*—Taste the water. Does the water taste pleasing? Is there any provision for water treatment such as slow sand filters, or chemical or other kind of treatment? If so, are they regularly maintained? If possible, have a water quality analysis performed on samples from the source and taps to compare it with WHO standards.

- *Layout*—Are there separate areas for human and animal watering? Is there a separate area for water vendors (if any) to fill their bags or tanks? Are there public latrines near the water points? Are fees collected at the site? What is the flow of traffic (human and otherwise) into and out of the area around the water taps?

- *Level of Service*—Visit each public tap and a selection of house or yard taps (if any). How many public taps are there, and how many private connections? Who is responsible for maintaining private connections, and who installs them? Is there an additional charge for house connections? Note the types of taps being used (e.g., self-closing, T-handle, etc.). Are they all in place and working? Are any broken or missing? Make a note of how standpipes and taps are constructed, where they are located, and what provision is made for water spillage and wastewater drainage. Are there long lines of people waiting around the water points?[23]

- *Water Demand and Uses*—Get some estimate of how much water families typically use in a day. How does this vary over the year? How many and what kind of animals do they water? Do they water small gardens or orchards from the village water supply (and if so, what time of the year)? Is any use being made of wastewater (such as for

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[23] Often this is only apparent early in the morning or in the late afternoon as people collect water for cooking and washing for the day.

nearby gardens)? Is any significant portion of the water being used for other than drinking, cooking, washing, animal watering, and small gardening? Are there any disagreements about inappropriate uses of the water?

In completing the operational history, look for patterns of repair problems and responses. Some of the general history can and should be covered in a general village meeting. A more detailed history is likely to be available from the operator and/or water committee members. The focus of this questioning is to establish what common problems have occurred and what approaches were taken to solving those problems, and to try and identify more appropriate solutions. Questioning should work from the present backward and include the following:

- If the system is currently out of order:
    - How long has it been out of service?
    - What is the problem—source, spare parts, money, skills?
    - What efforts are being made to make repairs?
- What are the most common problems with the water supply system? How have they been addressed in the past?
- What is meant when the village says the water system is out of order? Is it not delivering enough water, or is it completely out of commission? Do they distinguish between minor and major repairs? Are these distinctions based on who can make the repairs, how much the repair costs, how long the system is out of service, or some combination thereof? How are each of these cases handled?
- How many hours per day is the system typically running now (or when it works)? Does this vary much seasonally? Is it ever necessary to rotate supply between the different water points due to insufficient pressure or water?
- For pumped systems, how much fuel is used each day in each season? Who actually provides the fuel? If the village does, is it purchased at an official rate or black market rate?
- When was the engine last replaced? Was the replacement a brand new engine or a rebuilt one? Why was the engine replaced at that time? Who paid for the replacement, and who did the actual work? Ask the same questions about the pump.
- When was the engine or pump last overhauled, who performed the work, and how much did it cost?

- How many breakdowns were there during the last year (or the last year that the system operated)[24], what was the problem in each case, and how long was the water system out of service each time?

If all of the above information can be successfully obtained about each site, there should be more than enough data to make reasonable choices about which sites should be rehabilitated. For sites which clearly fit the selection criteria, choose their approximate order of priority by evaluating which sites can initially be done with relative ease. This will not only enable the technician and extension crews to gain valuable project experience on less logistically or technically complex sites, but it will give them confidence in their ability to successfully undertake work at the more difficult sites. *Avoid starting out with the hardest sites.*

During the technical assessment component of the RRA, it is useful to make a preliminary list of materials and equipment (M&E) which will need to be procured or used, including most or all of the following:

- *civil works*—spring catchment, main pipeline, pump house, well casing, distribution piping, concrete for well aprons, engine pads and filling benches (tap mounts), storage tanks, valves, taps and troughs for human and animal watering, and fencing;

- *mechanical system* (if any)—pump, engine, valves, fuel tanks, cooling systems, tools, and spare parts;

- *heavy equipment*—vehicles, vehicle fuel and spare parts, drilling rigs, and borehole cleaning equipment (if required); and

- *extension activities and training support equipment*—audio/visual materials, copiers, computers, and training manuals.

This will help to develop a rough estimate of what it would cost to rehabilitate each site, a piece of information necessary to make the final selection and prioritization of sites to work with.

[24] Three or less breakdowns a year implies that the system is running fairly well, depending on how long it took to get the system back in operation. As mentioned in Chapter 2 if 90 percent of systems are typically operational (as is the case in Botswana), things are going well.

Chapter 5

COMMUNITY PARTICIPATION

The WASH Project has undertaken many field studies in this area. Rather than repeat what exists elsewhere,[25] this chapter summarizes the most important aspects of community participation in rural water supplies, and provides illustrations and lessons learned from the authors' own experience.

5.1 The Traditional Approach to Community Involvement

In the past, rural water systems in developing countries were often funded by donors and/or governments, with design and installation undertaken by national or regional water agencies, PVOs, or private contractors. In many cases, O&M was to be handled by district water agencies that had the skills and funds to fulfill this role. Local communities were largely dependent on these agencies, and formally had few (if any) responsibilities for managing their water systems. During the past decade, it has become clear that this approach has not produced sustainable water systems. In fact, central to the rural water supply development approach which has evolved over the past decade is the concept that ordinary people can be trusted to solve their own problems if they are given the chance and have the resources, and no policy or program is likely to succeed without these elements.[26]

Donor and government interest in increasing water system sustainability (and minimizing the need for government intervention) has resulted in an increased focus on community participation and management approaches.[27] Community participation does not simply mean providing unskilled labor, housing, and food for technicians from outside the community during system construction. Some national water development agencies see expanded community participation as helping their agency perform its assigned tasks less expensively and more quickly, but with no real transfer of responsibility or control to the communities or their village water committees (VWC). Water agencies may feel that communities do not have the

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[25] *Tech Pack: Steps for Implementing Rural Water Supply and Sanitation Projects*, May Yacoob and Phil Roark, WASH Technical Report No. 62, the WASH Project, Washington, DC, August 1990. This manual contains many useful checklists for important tasks to be carried out during all of the important phases of water system development (or rehabilitation), including site identification, community organizing, system design, construction, and operation and maintenance of community water supplies. Another useful reference is *Evaluating Community Participation*, May Yacoob and Tom Cook, a WASH Working Paper No. 98. March 1991

[26] *Lessons Learned from the WASH Project*, WASH Project Staff, 1990.

[27] *A Workshop Design for Community Participation, Volume I—Starting Work with Communities*, and *Volume II—Planning and Implementing Sustainable Projects*, Ray Isley and David Yohalem, WASH Technical Report No. 33, December 1988.

skills or knowledge to operate and maintain their water systems properly, so it most be done for them by a government agency. This view is often counterproductive, since it is in the community's own interest to help design and learn to manage their water system. In fact, villagers may already manage their system in the absence of adequate support from government agencies. Communities often have informal water or health committees that are charged with overseeing certain aspects of the water system, such as collecting water user fees, summoning assistance when the system breaks down, or monitoring water use and wastage. These committees sometimes expand their responsibilities as the situation requires, up to the limit of their capabilities, sometimes taking on *de facto* full responsibility for system management.

Candidate villages for water system rehabilitation usually have a strong incentive to cooperate with external donors or government agencies providing technical assistance simply because they need the water. Having come to depend on their improved water systems, traditional (undeveloped) sources may no longer be adequate. The failure or inadequacy of their improved system is likely a major inconvenience. In this situation, the communities will probably be willing to work with external groups financing rehabilitation of their system, and would welcome more active community participation in system management. However, if they expect the government to provide them with free water with no responsibility on their part, they may feel that they bear no responsibility for any improvements. This may occur even if the government has not helped them for years.

In this situation, it is best to help communities realize that whatever the formal commitments of the government, if they want to improve their water systems anytime soon, they must take on some responsibility themselves. If communities are not willing to take on any responsibility, then any outside assistance would probably just result in having to come back two or three years later and do it all again. Therefore, it is recommended that no help be given to communities that refuse to take any responsibility for system improvement and upkeep. As there are usually enough deserving communities that *are willing* to help themselves, scarce resources should not be wasted on those who are not.

5.2 Opportunities for Community Involvement

Beyond merely providing unskilled labor, there is a broad range of activities in which active community involvement is not only helpful but essential to the long-term sustainability of the project. This section lists where communities could and should be involved in the entire rehabilitation process. From initial contacts to community identification through training, construction, and follow-on extension activities, the process typically takes six months to two years.[28]

[28] Based on recent experience in Indonesia and Sudan.

During site selection, project field staff or extension agents make initial contact with a community to discuss the purpose and goals of the project, and to conduct the RRA to gather technical, social, institutional, and financial information used to evaluate candidate communities. These field staff provide continuity for project activities during what may well become a multiyear activity. They often have supervisory, training, and technical responsibilities in project activities at their sites. Their social skills in dealing with and motivating communities are at least as important as their technical skills. During implementation, it is important that they not be assigned responsibility for too many sites, which might force them to cut back on crucial supervisory or monitoring activities and adversely affect quality control.

From the RRA information for all candidate communities, project staff develop a prioritized list of acceptable sites by applying site selection criteria such as those discussed in Chapter 3. Next, project extension agents visit the selected communities to discuss basic system design parameters in more detail,[29] survey the physical system, and make more detailed estimates of system cost (see Figures 8 through 11 on the following page). The level and type of community contributions to the project are discussed with village representatives, and formal agreements for assistance are concluded (see Chapter 6).

Depending on the cultural context, it may be important to identify and work closely with both formal (government-designated) and informal (traditional) leaders within the community to obtain their support for the project. Without at least their passive cooperation, the project may become a source of political controversy and never get started. Before any site construction gets underway, a series of village training activities are initiated. When project extension agents begin training in village organization, they typically assist the community in first establishing a Village Water Committee (VWC) which will be the project's primary village counterpart organization throughout the project. If an appropriate organization serving the function of a VWC already exists in the village, that organization is used and strengthened. The extension agents train the VWC (and other community members and leaders as appropriate) in resource mobilization and management issues such as:

- identifying potential sources of funding, labor, materials, and equipment;
- estimating recurrent costs of operating and maintaining the system; and
- collecting user fees and financial management (bookkeeping and disbursement of funds, see Chapter 10 for details).

Resource mobilization training often takes place in conjunction with technical assistance in water system design by project engineers or technicians. With the active participation of the VWC and other community members, detailed system design and layout (location of taps, tanks, pipes, and water sources) is completed. This allows for a better overall estimate for the system's capital and recurrent costs. If community members are to take an active role in system

[29] Such as the placement of water points and size of storage tanks.

Figure 8/9

Discussing water needs with local women and children, and discussing spring catchment tank design with villagers after measuring spring yield in West Kalimantan, Indonesia.

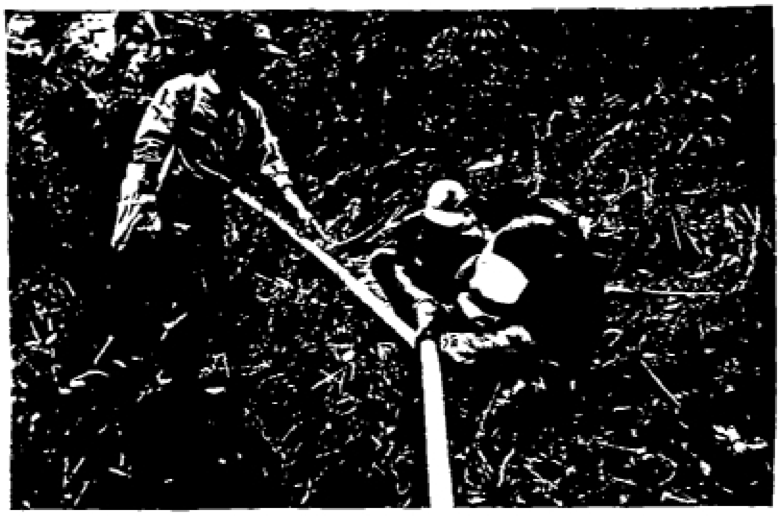

Figure 10/11

Villagers digging ditch and assembling main pipeline for their gravity-fed piped water supply system, under the direction of CARE/Indonesia field technicians in West Java.

construction (and we recommend that they do to the extent possible), technical training in construction planning and techniques takes place next.

Construction training will occur largely during construction itself. For example, a cadre of workers (whether villagers themselves or hired laborers) can be trained to build a ferrocement water tank by actually building one under the close supervision of project technical staff. Members of this cadre might then individually or collectively supervise the building of the remaining storage tanks throughout the system by themselves, with periodic inspections by project technical staff to assure that strict quality control standards are maintained. If, for cultural or other reasons, community members themselves do not take skilled labor roles in project construction, they will probably at least provide unskilled labor (e.g, digging ditches, carrying materials, or providing logistical support such as food and lodging for hired workers) for which little training is required.

As the system approaches completion, training will begin to focus on operation, maintenance, and repair skills which are necessary to keep the system running properly over the long term. Depending on the site, these services may be provided by community members themselves, technical staff from a government agency, or technicians hired from the private sector. If the basic O&M responsibilities fall to community members, they will have to be trained by project staff in the necessary skills. It is strongly recommended that enough villagers be trained to provide multiple redundancy in case the primary system operator becomes unavailable for whatever reason. In any event, these operators should be paid for carrying out their duties to help ensure that they will be properly undertaken. If a number of systems are being rehabilitated simultaneously, O&M training could be given to operators and their assistants at central locations. Particularly for pumped systems, complete tool kits could be provided during training, and provision made for their safe storage on-site. *Regular monitoring and periodic inspection by project staff of ongoing construction is critical to ensure that the system was properly built and is being properly maintained.* Besides periodic inspections (every six months) of the physical system after construction is completed, visits to communities can also be used to monitor maintenance, bookkeeping, and to make sure that any loans are being paid on schedule.

After rehabilitation of the main system, project staff and the VWC may want to review various options for later expansion of the system to other nearby hamlets or portions of the community not serviced thus far. If all of the training discussed above has taken place, villagers should be in a position to undertake such expansion themselves, perhaps requiring some technical assistance for subsystem design. A modest amount of technical assistance at this point may save them a lot of trouble later by focusing on important constraints by making them well aware of the following:

- the maximum sustainable yield of their water source (and the capacity of their main pipeline for gravity systems), and the limits this places on expanding coverage to new areas or increasing the level of service;

- the need to ensure quality control of any further construction undertaken;[30] and
- the importance of thoroughly understanding how the system and its components work together, so that any expansion plans fit within the overall physical limitations of the system design.

Water system development often includes installing public and/or private sanitation facilities to maximize the health benefits of these projects. While the construction of sanitation facilities and promotion of hygiene education is not specifically a focus of this report,[31] whenever possible they should be included in system rehabilitation efforts to maximize the project's health impact. Even if construction of sanitation facilities is not a major focus in a particular rehabilitation project, a community training program on sanitation and hygiene education (SHE) should definitely be included. SHE activities can be undertaken simultaneously with the other training discussed above. Wherever possible, this training should take full advantage of existing local health resources such as community- or district-based health clinics. Project-provided SHE should be integrated into existing SHE promotional activities, such as radio or television health broadcasts, and government or donor-sponsored primary and maternal health care programs.

Finally, communities working with the rehabilitation project should be encouraged to discuss the program with other communities that may be included in later phases of the project. Often the most successful dissemination of such programs happens on a word-of-mouth basis. When communities that have successfully participated in the program share their impression of its results with neighboring communities, those new communities can then directly approach project staff for assistance. Some projects also promote the practice of cross visits by representatives of communities (that have not yet been involved in the project) to sites which have been successfully rehabilitated. This gives those representatives an opportunity to speak at length with people whose systems have been rehabilitated, and to learn about the potential opportunities and constraints involved.

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[30] One problem which has arisen in community self-financed water systems when proper attention is not paid to quality control is a tendency for villagers to try to cut costs by using poor quality construction practices, such as not using enough cement in their masonry work, reducing critical dimensions of structures such as water tanks, or using cheap materials such as substandard quality PVC pipe. All of these can lead to disastrous results, and subsequently much higher costs over the long run.

[31] There are a number of excellent WASH reports covering the construction and use of appropriate sanitation facilities, including the WASH Technical Report No. 25, *A Workshop Design for Latrine Construction: A Training Guide*, Maria Le Clerc and Keith Shere, June 1984. In addition, a very useful reference in this area is *Appropriate Sanitation Alternatives - A Planning and Design Manual*, the World Bank Studies in Water Supply and Sanitation, Report Two, John Kalbermatten, et al., Johns Hopkins University Press, Baltimore, 1982.

5.3 What Works and What May Not in Community Participation

While active community participation is known to be a crucial component of sustainability, complaints that it slows down the project or makes it more complex are not completely without foundation. The process described in the last section is a generally accepted description of how water system development (and rehabilitation) should proceed. However, problems can and often do arise during that process. This section is intended to point out some of those problems, and make some suggestions on how to deal with them.

Communities often have very different perspectives and agendas from rehabilitation project managers.

The primary concern of a community is to get the water system back in working order, usually at least cost, with minimum controversy, and in the shortest time possible. Sustainability may be of little immediate concern, since poor people cannot often afford a long-term perspective. They may share traditional views that government officials or village leaders know best what communities need, and that there is no need to involve water users (or perhaps, women in general) in the planning process. They may feel that they cannot afford to pay water fees, and that the government should provide all necessary financial support, whether or not it actually does.

Government water agencies may not always consider community participation all that desirable, especially if it involves relinquishing control over operation, maintenance, system design, and perhaps most importantly, revenue.

In most if not all cases, the community's formal or informal leaders have tried a variety of ways to get the system operating, usually involving entreating one or more local or district government officials for financial and technical assistance. Since these leaders have come to the project for help, they were clearly not successful going through the traditional channels. Depending on the extent of their problem (often a problem of water scarcity or difficult access, rather than water quality), the project may be in a position to leverage the project's potential involvement in that community by firmly insisting on certain provisions. Those provisions might include the following, as well as a wide range of others as required by specific site conditions:

- a VWC, equitably representing all major social and economic divisions within the community (including women), will be established and will actively participate in all project planning, construction, management, and O&M activities;
- the opinions of common villagers will be actively solicited and incorporated in decisions involving location of public taps and sanitation facilities (if a part of the project) and decisions about water tariffs;
- an acceptable forum for dealing with conflict resolution involving water allocation and accessibility will be established, if a suitable one does not yet exist; and
- guarantees that agree upon minimum contributions from the community will go to support rehabilitation efforts and subsequent recurrent costs of O&M.

Community self-financing can help insure system sustainability because the people who use the system are the same people who (at least in part) pay for it.

While not a completely new concept in many developing countries, community self-financing of water supply may nonetheless be resisted in some areas due to the government's formal responsibility for providing free water to rural communities. The reality of the situation may be that due to severely limited human or financial resources, government agencies are unable to meet these responsibilities in all communities under their jurisdiction. This can lead to village leaders having to resort to political in-fighting to gain special favors such as water system installation or service. Invariably, not everyone gets served. Some communities in Java, Indonesia, for example, have been waiting for over 10 years for the government to build improved water systems. Inevitably, communities come to accept that their systems will never be built unless they take the initiative themselves. If necessary, a willingness to pay (in cash or in-kind contributions) can be used as one of the site selection criteria for rehabilitation projects. To avoid completely eliminating poor communities from consideration, where clear evidence of a community's inability to pay the minimum standard contribution exists, provision could be made to set aside a certain percentage of project funds (no more than 10 percent of the total) to subsidize their systems.

Communities should be consulted on all issues related to the rehabilitation of their system, and their opinions and preferences should be taken into account whenever possible.

While community participation to some extent implies community management, community members often do not have the technical training necessary to make all important decisions related to system design, financing, or project management. Therefore, project staff should not relinquish control over the project by providing only technical assistance in response to the community's wishes. This is particularly true with respect to engineering and financial issues. Construction must be done right the first time. Legitimate community desires for cost-minimization must not be allowed to interfere with proper construction practices. A cheaply built system which fails prematurely will benefit no one. Similarly, a realistic financial plan must be developed which reflects both true system costs (capital *and* recurrent) as well as a reasonable evaluation of the community's ability to cover at least some of these costs. Unrealistic financial plans could lead to system failure and the need to rehabilitate the system again in five years' time (or less).

A preconceived community participation/management framework need not be forced upon reluctant communities.

It is unlikely that any single community participation/management model can provide the required flexibility and adaptability to meet the needs of diverse communities in all circumstances. For example, smaller villages may traditionally be able to manage by consensus, whereas larger villages may require election or appointment of VWC representatives from different family groups, user groups from around each public tap, or village elders. The underlying criteria of acceptability for a management framework is that it is supported by villagers who will invest energy and resources to ensure sustainability of the water system.

Proper financial management at the community level is essential to system sustainability.

While one individual may be trusted to collect and manage funds to operate and maintain the water system, it is still recommended to have financial controls as discussed in Chapter 10. System finances should also be monitored and periodically carefully reviewed by VWCs to minimize diversion of funds. After receiving proper training in resource mobilization and bookkeeping, VWCs should be periodically visited by project personnel to review the books and make suggestions for improving accounting and management practices.

Cultural and religious traditions may conflict with the community management and responsibility approach.

Where communities perceive water as a commodity, it will be easier to get them to accept the necessity for paying for water. According to some cultural beliefs or interpretations of certain religious teachings, it is inappropriate or even forbidden to charge people for water. However, water vending is common throughout the world, and people who are not willing to pay for water *per se* may be willing to pay for access to water. Simple things such as taste may make it difficult to convince people to invest in water quality improvements. If they are used to the taste of water from a particular well, even if it is determined that the well is contaminated, they may not be willing to use another source (especially if an additional cost or inconvenience is involved) simply because water from the alternative source "doesn't taste right."

People must be informed about the impact of their personal behavior upon the operation of the system, and enforcement mechanisms devised to promote communal and individual responsibility for the system.

Behavioral problems such as water wastage or illegal taps may arise. It may be quite difficult to convince water users on one subsystem that by not closing their taps regularly, they are disturbing the system's water pressure balance so that users on another subsystem or water point cannot get water. A similar result may occur if people illegally install hoses on public water points to bring water directly to their own homes, thereby increasing consumption and reducing water availability to other water consumers. Where user groups differ by economic status, ethnicity, or religion, they simply may not care about causing any such adverse impact. To deal with problems such as these, forums for resolving conflicts must be established within existing community institutions.

The role of women in water supply must be recognized; women must be included in system design and management to the extent possible.

In many traditional societies, the role of women is very well-defined, and they are not encouraged (or, in some societies, even allowed) to step outside these roles. In much of the developing world, women are the primary water gatherers and users, but they frequently have little or no say in water system planning or operation. One of the objectives of the project may be to encourage and, if necessary, to leverage for women's greater involvement in water system planning and management. While there is no particular reason to exclude them from any project-related activities discussed above, if it is considered culturally inappropriate for women to participate (e.g., in construction itself), they could still play increased roles in areas such as the following:

- acting as members of VWCs;
- providing financial management, such as collecting, managing, and disbursing water fees;
- participating in resource mobilization efforts;
- organizing income-generating activities;
- operating and maintaining the system and its components, especially public water taps, tanks, and sanitation facilities;
- providing secretarial support;
- controlling distribution and consumption of water;
- providing environmental sanitation, health, education, and other extension services; and
- acting as information dissemination specialists, interacting with representatives from other villages who are interested in developing their own water systems.

Whenever possible, it is advantageous to work through and strengthen the capabilities of existing community or local organizations.

Rather than creating new institutions (at the village, district, or national level) to deal with rehabilitation projects, it is preferable to link project activities with appropriate existing institutions (if there are any) which will be able to support post-project activities after the rehabilitation project is completed. There are several reasons for this. First, institutions created specifically for one development project are less likely to be sustainable after project funding is terminated. Second, establishing new institutions which wholly or partially infringe on the turf of established government or private sector institutions is sure to create unnecessary conflicts which may have adverse impacts upon the project itself. Where logistically possible, skilled technical workers (e.g., water system mechanics, health and hygiene educators) hired during the project should be able to make the transition into those existing institutions so that their skills are not wasted, and they have some incentive to remain working in this field after the project is over.

Rehabilitation takes place within a government policy framework that may limit community participation. For example, in Sudan, the National Corporation for Rural Water Resources Development continues to insist that it alone has responsibility for the operation and maintenance of rural water supplies in Darfur and Kordofan Regions, even though they are clearly unable to operate these systems on even a remotely sustainable basis. However, in

Botswana, district governments have been providing effective maintenance and repair for rural systems for many years. In some cases (e.g., Sudan), informal, politically and legally unrecognized community management systems have arisen to try to meet community needs where formal government mechanisms have failed. Rehabilitation projects should try to integrate their efforts with these informal groups where they exist and are effective.

Chapter 6

INSTITUTIONAL ISSUES

Responsibility for providing different kinds of support for rural water systems is often divided among several institutions. Failure to carry out these institutional responsibilities (especially for O&M) is a common cause of system failure, and the subsequent need to rehabilitate rural water supplies. Problems include the inability of an institution to fulfill its own responsibilities, misunderstandings within the same or among different institutions about their own or others' roles, and conflicting objectives and agendas. Institutions responsible for rural water supplies often include the following:

- *Communities*—community leaders, villagers involved in community development and self-help programs, health or water committees, and individuals (e.g., influential merchants, technically trained people, or others within the community);
- *Governments*—provincial, regional, or district rural development or rural water agencies, the Ministries of Agriculture, Water Resources, Health, Rural Development, and other ministries or agencies with water-related responsibilities;
- *The private sector*—local merchants of materials and equipment, engine and pump rebuilding shops, equipment manufacturers, private mechanics, water vendors, and local and international/expatriate contractors;
- *Donors*—multilateral and bilateral donor organizations which can act as project funding and/or executing agencies, or as sources of information and coordination; and
- *Private voluntary organizations*—both international and local PVOs working in water resources development or related fields such as primary health care, agriculture, and integrated rural development.

Responsibilities for all project inputs and outputs should be clearly identified in the project preparation documents. All major players should be involved in the planning and assignment of those responsibilities during project preparation. Many physical inputs and short-term management skills required during construction are typically supplied through consultants or external agencies who may not be involved in O&M. In the past, donor-funded projects usually have not funded recurrent costs, and local government agencies often have not allocated sufficient funds for O&M. Inadequacies in local institutions responsible for long-term O&M may surface only as systems age and O&M needs increase, possibly overwhelming those responsible for them. These inadequacies may not be identified during the initial assessment of institutional capabilities, and externally supplied inputs (e.g., of equipment, materials, and consultants) in the early phase of the project can generate enough momentum to temporarily obscure existing weaknesses in local support institutions.

Rehabilitation implies that water systems are already in place, perhaps operating only marginally or not at all. As such, rehabilitation projects have two major advantages over new construction projects:

- Communities are at least somewhat familiar with what is required to operate and maintain their system, and what kinds and amounts of resources are needed to support the system over the long term.
- Institutional players (whether government water agencies, private groups, or individuals providing some necessary services, NGOs, or others) who are nominally or actually responsible for installing, operating, and maintaining a water system which has failed can be an excellent source of information on what works (technically, financially, organizationally) *and, more importantly, what doesn't.*

These are distinct advantages to rehabilitation planners and implementing agencies since project designers can learn much from communities and support institutions because of their previous experience with existing systems. Taking maximum advantage of this experience in project planning will help prevent making the same mistakes over again.

6.1 Common Institutional Responsibility Problems

This section suggests solutions for many common problems in the institutional support of water supply projects, and emphasizes the importance of careful assessment of the capabilities of all support institutions to improve project sustainability.

6.1.1 Failure to Meet Responsibilities

Failure to meet support responsibilities may stem from lack of any or all of the following:

- *Physical resources*—equipment, materials, financing, transportation;
- *Human resources*—skilled labor (e.g., mechanics, well-drillers, truck drivers), professionals (engineers, managers, accountants), and trainers;
- *Institutional stability*—which may, as the project evolves, affect staffing levels, funding, political support, or simply the willingness or ability to continue to shoulder project responsibilities;

- *Unclear or overlapping mandates*—it is common for more than one agency to be responsible for various aspects of community water supply.[33] Failure of one institution to carry out its responsibilities can have a direct impact upon another institution's ability to carry out its own responsibilities.

Constraints can be internal or external. Internal constraints can include a lack of available community financing to cover O&M costs, or lack of sufficiently trained or experienced local people who can manage, operate, and maintain their systems. External constraints outside the direct influence of the project may include deteriorating transportation or communication infrastructure. Transportation can be a major logistical problem for government agencies, communities, and individuals. This may stem from a simple lack of vehicles, spare parts, or fuel, or may be due to the government's assigning available vehicles to higher priority activities. Lack of adequate public or private transportation can limit the ability of communities to obtain spare parts, fuel, or skilled repair services in a timely fashion. Availability and cost of needed physical resources may vary seasonally, sometimes due to impassable roads during rainy seasons or to fluctuations in imports. Dramatic changes in prices of needed commodities (especially fuel and lubricants, or pipes) may hinder the ability of otherwise responsible organizations to meet their responsibilities.

Some limitations only apply to certain organizations and not others. For example, government agencies may be allowed to obtain spare parts only from government stores, and may not be allowed to purchase them on the open market. The same may be true for fuel and lubricants, which may be available on the black market (at an inflated price) but not in official government reserves.

Shortages of trained and experienced people often plague developing countries. Professional and skilled labor shortages affect less developed countries even more because typically, low government wages cause human resource drains to the local private sector as well as to other countries (such as the brain drain from Northeast Africa to the Gulf). Further compounding this problem is a common disinclination of qualified regional government staff to accept positions in rural or remote areas.

Institutional instability can be a significant constraint to development in some countries or regions. Institutions whose mandate and influence depend heavily upon one individual are especially vulnerable. Project design (and agreement to accept specific responsibilities) which is dependent upon the active intervention of particular government officials may completely fall apart if that official loses influence, or if there is a change of government resulting in policy changes in conflict with project goals.

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[33] For example, the Ministry of Public Works may build a water system, the Ministry of Local Government may manage it, and the Ministry of Health may be responsible for hygiene and sanitation training. The quality (and cost) of construction has a large impact upon the ease and cost of O&M. So, if MPW decides to save money by building a cheap system, O&M costs provided by MLG increase (perhaps beyond existing allocations). If lack of O&M results in a deteriorating drainage system, this will have an adverse impact upon community hygiene and sanitation.

6.1.2 Misunderstandings about Responsibilities

Although the primary responsibility for a water supply system may be clearly shouldered by one or two organizations, other institutions may play supporting roles in the system's O&M such as the following:

- choosing, training, and paying a system operator;
- collecting, managing, and disbursing funds;
- purchasing, collecting, and storing spare parts;
- supplying consumables such as fuel, lubricants, and filters;
- providing skilled and unskilled labor for construction;
- making major and minor repairs, and replacing major water system components such as pipelines, pumps, engines, and taps;
- providing transportation, temporary lodging, and/or food for workers;
- organizing and training members of village water committees;
- working with health and sanitation specialists for hygiene education programs;
- maintaining formal or informal communication networks so that problems are rapidly reported to and addressed by those responsible;
- allocating management responsibilities at the local, regional, and national levels; and
- being the appeal of last resort in disputes, when all else fails.

Each of these roles must be filled by one of the groups or agencies involved in supporting community water systems. Confusion about responsibilities can be minimized by making it clear to each of these organizations which of the tasks listed above (and any others required) they are directly responsible for, and making sure that they willingly accept those responsibilities. Sometimes, when one organization is unable to fulfill a nominal responsibility, it may be taken on by another group, either temporarily or permanently. For example, official government fuel allocations may not always be available when needed, forcing a VWC to purchase fuel on the black market to keep its system running. If this happens repeatedly, it may give rise to different nominal and actual responsibilities. It is important to assess this possibility when examining institutional responsibilities.

Nominal responsibilities may not coincide with actual responsibilities. Communities themselves can become caught in a predicament where a government agency is ostensibly responsible for assuring their water supply, yet is unable or unwilling to do so. Since communities must have water, they may first try to exert what political pressure they have to influence the government water agency. If this does not work, they will then find themselves in a dilemma. For example, suppose that the government agency which is supposed to provide them with diesel fuel for their engine does not do so (this is common in Sudan). Since there is no private fuel allocation, communities are forced to mobilize their own resources to purchase fuel (or parts, or materials) on the black market to keep their pump running.

In some countries (e.g., Indonesia or Sudan) the government water agency typically builds and owns community water systems. They have the mandate to collect water fees, which are nominally allocated to cover O&M and repair. Fee collection in Sudan goes from individual communities to the regional and then to the national office of the water corporation, which then has to remit its revenues to the Ministry of Finance and Planning for later redistribution as part of general government revenues. Fund disbursements for O&M go back to the national water corporation, then to regional offices, then to individual community systems. The amount actually returning to the communities may or may not cover local support costs. If not, the responsibility for financing system O&M falls directly on the communities. Only major policy reform can address such a situation. Depending on the size of the proposed rehabilitation project and the government's interest in seeing it proceed, there may be adequate leverage to institutionalize some needed reforms so that O&M costs are covered at the community level.

Depending on the country, the private sector may play an active role in water system construction or O&M support. If a need exists, and they are not legally (or otherwise) prevented from addressing that need, they usually respond on a fee-for-service basis. The private sector can be divided into formal and informal players. The formal sector includes organizations which work under contract as would any firm in developed countries. The informal sector is exactly that—usually individuals (such as village mechanics) or unofficial organizations which typically provide services in return for cash and do not pay taxes. In many countries, government employees (e.g., engineers, mechanics, drivers, surveyors) have a second job, moonlighting in their spare time to cover their family's income needs. Private-sector enterprises are often undercapitalized and depend on the management and technical skills of one key individual. Where government agencies cannot meet the support needs of rural water systems, there may be considerable demand for private sector services. Bilateral donors such as USAID are increasingly focusing their efforts on developing the private sector in the belief that free markets are the most efficient and cost-effective way of providing a wide variety of services, including technical support for community water systems.

Organizational responsibility problems stem from different expectations, agendas (hidden or otherwise), and assessments of organizational capability between communities, government water or planning agencies, PVOs, and donors about project goals and objectives. Expectations of everybody involved should be carefully reviewed and discussed. Local individuals or agencies may have unrealistic expectations about the donor or PVO's involvement in the project. They may be unaware of limits on available funding and time, or equipment source requirements and cumbersome procurement processes for imported system components. Donor responsibilities in rehabilitation projects are typically limited to planning and construction, and usually end with a formal transfer of the system (to either local government or beneficiary communities) after it is operating once again. Donors may also finance extension and training activities (e.g., health and hygiene education) after construction is completed, but these are often limited to a certain period of time (the end of the project, at best). If possible, project-supported extension activities should be coordinated with institutions (public or private) which will exist after the project is over, so that some continuity is maintained. To make sure these activities continue, a source of follow-on financing must be arranged.

6.1.3 Conflicting Objectives

During project planning or implementation, some institutional players have or develop conflicting objectives. For example, communities may want provision for livestock water and small-scale irrigation included in the rehabilitation of their potable water system. If government water system design standards do not have consumption levels which include these secondary demands, water demand may outstrip the supply. When estimating the demand for a particular community, all interested parties must understand and agree on what the water is to be used for *and what it is not*. For example, public water points typically result in lower per capita consumption than do house connections. If some people establish house connections on an ad hoc basis, they may overtax the system's capabilities, even to the point where others do not get enough water. Appropriate enforcement mechanisms such as fines should be established in each community to deal with such situations should they occur.

While water allocation is the most frequent source of problems, other problems may arise. For example, government staff may be motivated by objectives such as concern for job security, maintaining positions of influence, and keeping jobs in more desirable urban areas. Villagers tend to be more focused on immediate needs. They, their families, and their livestock cannot wait long for government agencies to respond to their immediate water needs. If this response is not forthcoming, villagers must take responsibility themselves within or without formal channels. Similarly, donors' project objectives are formally directed at helping villagers meet their water needs on a sustainable basis, while at the same time strengthening government water agencies. Nonetheless, donors are sometimes driven by internal project evaluation criteria which compel them to focus on short-term successes, as indicated by quickly completing installations and meeting scheduling targets. Focusing primarily on installation targets can adversely affect individual system sustainability, since it is always more difficult and time-consuming (over the short term) to develop systems which are sustainable over the long term.

Conflicting objectives can sometimes be avoided by minimizing overlap of responsibilities. If responsibility problems arise, it may become necessary to reassess institutional capabilities based on project activities thus far, and either re-delegate responsibilities, work to revise government policies, or both. System sustainability will be enhanced if overlapping responsibilities for each supporting role (listed in the previous section) are minimized. However, responsibility without authority is meaningless. Government policies must be devised which allow responsible groups to perform their roles without unnecessary hindrance. Policy reform should legitimize actual institutional responsibilities as a way to recognize and support existing institutional capabilities, rather than as a way to retain centralized authority. Development project designs are shifting away from centralized government responsibility toward greater community responsibility, sometimes with an expanded private sector role. Any reassignment of organizational responsibilities must take into account constraints in funding, skills, and access to materials and spare parts supplies of each supporting institution.

6.2 Successful Planning of Institutional Roles

The best general institutional approach to successful rehabilitation projects is to ensure the following:

- All institutional responsibilities are clearly delineated and agreed upon, as evidenced by formal project agreements.
- All players are institutionally and individually willing and able to accept those responsibilities.
- Any institutional problems which led to the failure of the system in the first place have been successfully addressed.

Agreements between all relevant parties (see Section 6.3 below) should be made which:

- delineate precise responsibilities for each party;
- specify the quantity and approximate scheduling of each party's inputs to the project;
- establish an accepted procedure for conflict resolution; and
- specifically address all financial issues which will arise (what financial inputs are required, from whom, when, how it is managed and spent), and plan ways to assure system financial support after the project's conclusion.

6.2.1 Community Responsibility

Regardless of who has nominal responsibility for maintenance, it is the system users who are most affected. In many instances, it is the community itself which ultimately has actual responsibility for system upkeep, including the tasks listed in Section 6.1.2 above. This has several important implications for sustainability.

First, communities, although they may have established a formal procedure for obtaining maintenance and repair services, are likely to make O&M decisions based on their evaluation of immediate costs and benefits. Misunderstandings about the long-run effect of short-term decisions (e.g., avoiding expenditures necessary for proper O&M) can have a major effect on water system sustainability. For example, villagers may be tempted to avoid what they view as unnecessary near-term repairs, and unknowingly incur greater O&M costs over the long term. The importance of preventive maintenance measures as simple as regularly changing oil and filters in an engine, or fixing leaky pipes before the leaks become catastrophic, can have a dramatic impact upon O&M costs and system reliability. This needs to be made clear to system operators and community decision-makers.

Second, communities need to take responsibility for finding solutions to problems they cannot resolve through official channels with outside help. When communities take responsibility, they can usually deal successfully with minor O&M problems on their own. However, when major problems occur, they are usually compelled to first seek outside help (trained technicians) through official channels. If that assistance is not forthcoming, they then must seek alternative methods of meeting their needs, such as taking up spot collections to either hire technicians or to buy fuel or spare parts on the black market. A means for accessing equipment, materials, and technical skills outside the village must be established if one is not already in place. This should include establishing ways for communities to access *short-term* loans (privately or commercially) and/or *specialized skills* (e.g., skilled mechanics who can do engine overhauls, or surveyors who can lay out a pipeline), tools, and vehicles (e.g., drilling rigs for cleaning boreholes) either through government or private organizations to which communities typically do not have access. Project planning should include not only assigning responsibilities to communities, but making sure that the communities have the necessary resources (financial, human, material) to successfully carry out those responsibilities.

Third, assignment of system support responsibilities varies considerably from one situation to the next. There are many possible divisions of responsibility between total government and total community responsibility. For example, while the government water agency may not be able to meet all of the system's support needs, it may be that when combined with community resources, the private sector, donors, and PVOs together can provide assistance which put a system into operation again. Community technical resources may be sufficient to cover minor repairs, private technicians can be hired with locally collected water tariffs, and local financial institutions (formal or informal) may be able to provide short- or medium-term loans to replace major system components. It is not always necessary to look to donor support for rehabilitation.

6.2.2 Training

Institutional strengthening and training are both important components of rehabilitation projects. However, these are likely to be secondary objectives for a community that is primarily interested in getting its water system up and running. Institutional strengthening is a somewhat different objective than rehabilitation, in that the goal is longer term, not so tangible, and requires different project support skills than the largely mechanical process of redeveloping water sources, installing equipment, or repairing pipelines. Training components of rehabilitation projects should focus not only on technical training for operators and technicians, but also on increasing the community's participation and sense of responsibility for the water system by training village water committees in organizational skills such as management and bookkeeping. Training needs assessments should identify community needs for

- training the system operator and any assistants in proper operation and care of all system components (spring catchments, pipelines, any mechanical components, water tanks, valves and filters, etc.);

- improving the financial management and budgeting capabilities of village water committee members;
- improving management of spare parts inventories and logistical support needs;
- raising village awareness of the system's technical requirements, capacity, and costs, as well as the rationale (and cost implications) of proper care of system components;
- maximizing benefits from system rehabilitation by including health and hygiene education extension work;
- improving government agencies' ability to collaborate with rather than obstruct community wishes, by paying more attention to village priorities regarding system design and support needs; and
- developing an improved capacity within government water agencies to act as technical consultants and project managers.

In most instances, rehabilitation projects require that executing agencies (contractors or PVOs) work closely with the government institutions responsible for rural water supplies. Those institutions can often provide technical assistance in system design, source rehabilitation or drilling, and equipment installation. Training needs assessments should therefore include a review of training needs for these support institutions. Training programs should be designed to complement, not duplicate, existing skills of local organizations (communities, government agencies, and the local private sector).

The supporting institutions should reach a consensus on roles which the government plays and will continue to play. Once consensus is reached, training programs can be tailored for these roles. Some groups may not be interested in (or may actively hinder) proposed institutional or human resources development which they feel could change the status quo, affect personal positions and power bases, suggest mistrust of subordinates or those outside the agency, or expose previous failures or lack of accomplishment. Effective institutional strengthening and human resources development programs concentrate on on-the-job training, focused seminars, and courses based on specific local needs. Field visits and study tours by trainees to other communities ("cross-visits") can also be a very effective way to share experiences and learn new ways to approach problems. To improve specific technical or management skills, out-of-country training may be necessary.

6.3 Project Agreements

Institutional responsibilities and linkages should be formalized in project agreements. Lines of communication should be specified, and who makes decisions and how should be clearly understood by all parties. It is neither necessary nor usually advisable to start from scratch here. During project negotiations, clearly stating current linkages and discussing ways for improvement are usually enough. Existing arrangements were probably developed for good practical and personal reasons, some of which may not be immediately apparent. Noting any limitations of current arrangements may prove to be a starting point for discussion of alternatives.

Project agreements vary considerably among different donors, countries, executing agencies (NGOs, contractors, or multilaterals such as UNDP), and communities. Separate agreements can be made between the donor and the government, between the donor and the executing agency (a contractor or PVO), and (sometimes) between PVOs (as executing agencies) and communities. Depending upon social and cultural tradition, communities themselves may not actually have signed agreements with the other major players. Nonetheless, carefully conceived, well-understood, and jointly developed project agreements are often the best way to formalize the institutional arrangements among project participants. Depending on the project, agreements include those between

- a donor and host-country government agencies;
- a donor and an implementing agency such as a contractor or an NGO;
- one government agency and another;
- communities/organizations and private sector firms or individuals (to provide goods or services);
- government agencies and communities (usually through their chosen representatives such as village water, development, or self-help committees); and
- an implementing agency (often a contractor or NGO) and a beneficiary community.

Agreements should reflect the overall purpose and immediate objectives of the project, and recognize the capabilities and limitations of each party to the agreement. Where they exist, it is best to review the original construction project agreements, compare them to what actually happened, and determine what did and did not work. With that in mind, rehabilitation project agreements can be better formulated to address institutional shortcomings.

6.3.1 With Donors

Agreement between donors and other parties can be contracts or cooperative agreements to perform specified tasks over a particular time period for a certain amount of money. Project goals, objectives, and a general implementation approach should be stated. Typically, the goal is to rehabilitate a target number of sites by a specific time. Other items which should be in donor agreements include

- task-specific responsibilities for all parties involved;

- required inputs from each party, such as money, labor, equipment,[34] materials, and logistical support (including vehicles, drivers, fuel, and parts);
- financial management requirements, including how funds are collected, managed, and disbursed;[35]
- a summary of important project management procedures such as the approval process, monitoring and evaluation; and
- procedures for turn-over of systems after completion (either to communities or government agencies), and post-project responsibilities.

Indicators of project progress should also include less tangible objectives which can significantly increase the positive impact of the project, such as

- improvements in water quantity, accessibility, reliability, and quality;
- sustainability of the rehabilitated systems; and
- benefits such as technical training, health and hygiene education, and anticipated economic benefits.

These indicators reflect the fact that simply putting a system back into operation is usually much simpler than ensuring that it will still be operating two years after the project is over. Project monitoring and evaluation which relies primarily on determining how many sites were "rehabilitated" within a given time period can force the implementing agency to ignore the very issues (organizational, financial, managerial, technical training, and increased awareness through health and hygiene education) most likely to ensure system operation in the future.

6.3.2 With Communities

Not all projects use formal agreements with beneficiary communities. However, this is a good way to make sure all commitments and responsibilities are clearly understood on all sides *before construction starts*, so we recommend that they be used.[36] Such agreements should specify community obligations (financial and resource contributions) and project obligations (tasks to be performed and services to be provided). Any deadlines and the penalties for

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[34] If any specific constraints such as source origin limitations (meaning that equipment can only be purchased from certain countries or suppliers) exist, they should be included in the agreement.

[35] Or other funding limitations, such as if any funds are to be earmarked for specific purposes (e.g., if only local funds are to be used for local procurement, local per diem, and overtime pay).

[36] Save the Children Federation (USA) has successfully used a variety of agreements with communities in past water supply rehabilitation projects in Nepal. Types of agreements have included Village Maintenance Agreements, Plumber Contract and Job Descriptions, Handover Agreements, and Village Maintenance Worker Contract and Job Descriptions.

missing them should be spelled out.[37] Project scheduling should be realistic, as unforeseen delays are commonplace when transportation, weather, equipment delivery, and other uncertainties intervene. It is unwise to promise precisely scheduled delivery of goods or services over which the implementing agency has no control. Conversely, it is important to be realistic about community commitments and constraints which may affect villagers' ability to keep those commitments.

It is important to have a realistic plan for system O&M after project completion. This may be a separate document (called a handover agreement) from that in which the community agrees to participate in the project. The plan should include an estimate of the funding requirements, how these requirements will be met, financial management procedures, and a strategy for handling system O&M and repair needs. Any government agency which is expected to play a supporting role should be a party to this agreement.

6.3.3 With Government Agencies

Negotiated agreements with the government provide an opportunity for the donors or PVOs to propose policy changes to improve sustainability in the water sector. For example, where system management has historically been very centralized, agreement might encourage policy reforms to give more autonomy to communities for fee collection and management or responsibility for O&M. Government agencies which are particularly constrained financially could be encouraged to take a more supportive role, providing expertise and services not available from other available sources such as the private sector. The smaller the project, the less leverage it is likely to have for influencing existing policies. Governments may or may not be at all disposed toward others trying to influence their policies, particularly in sensitive areas such as cost-recovery or decentralization of system responsibilities.

Agreement with governments should include lists of project goals and objectives, and government project obligations (e.g., local currency, technical and logistics support). It is important to recognize financial, human resource, logistic, and managerial constraints in providing agreed-upon project inputs. Where there is little or no direct government support of the project's efforts, the agreement may simply consist of its consent for the project to take place within a country or region. Encouraging the government to commit even modest resources to the project (e.g., providing personnel to monitor project activities) is a way of securing government endorsement of the project's goals.

Agreements should include issues such as import duties (e.g., are they to be completely or partially waived), special customs arrangements (e.g., who is responsible for clearing project

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[37] For example, if the community agrees to provide 50 percent of construction M&E costs up front by a particular date, it is useful to specify what will happen if that doesn't occur. It may be necessary to state that if community contributions are not available after a certain time, then the community will be dropped from the list of assisted sites. Such statements need not be draconian. Flexibility is important in community participation projects.

equipment) and related questions. When agreements are with a national organization and the executing agency is regional or local, the regional or local entity should also be a signatory to the agreement.

Establishing a good working relationship with government agencies responsible for rural water supplies is crucial. There may be disagreements about system design, equipment selection and standardization, fee collection and management, community participation, or system ownership and responsibility. It is best to avoid trying to encourage policy reform in too many areas, but rather to work toward change in stages. Trying to force reform may jeopardize project completion, increase frustrations on all sides, and develop confrontational rather than cooperative attitudes on the part of the government (or other parties).

6.3.4 With the Private Sector or NGOs

Contracts with individuals or firms in the private sector can be effective for meeting certain support needs. Contracting for services such as well cleaning and drilling, equipment procurement and delivery, tank construction, and installation of distribution systems has been used effectively in rehabilitation projects. Any contract should include a clear description of the work to be completed, a timetable for completion, activity supervision responsibility, a method for verification of completion and acceptance of the work undertaken, and the amount of money and payment schedule involved. Where completion of tasks requires specific materials and equipment, contracts should specify who is responsible for obtaining these items.[38]

It is common for funding agencies to provide some working capital to contractors. This should not exceed 20 percent of the contract value. Since nonperformance or late completion of contracts can cause difficulty and delays in overall project completion, consider inserting a bonus clause into the contract for ahead-of-schedule completion. Bonuses for on-time work are generally much stronger incentives than penalties (which are often difficult to enforce) for late or unacceptable work.

[38] For example, if a contract is for drilling a well, someone must provide drilling mud (bentonite), well casing, as well as forms, sand, aggregate, and cement for concrete work, and two or more laborers (perhaps supplied by the village) to help the drillers. The contract should specify who is to provide all of these items and when.

Chapter 7

SYSTEM DESIGN AND TECHNICAL ASPECTS

This chapter describes working with the community to pinpoint the source(s) of any technical problems related to system design, installation, O&M, and repair which may have contributed to the failure of the existing system. After identifying these sources, suggestions are given on how to deal with the technical problem(s) related to rehabilitation planning—specifically why the system is not delivering enough (or any) water, or not satisfying the community in some other way. Physical deterioration is the most common cause for systems requiring rehabilitation. Although the RRA approach (see Chapter 4) may disclose other more critical reasons for system deterioration (e.g., financial, organizational, managerial), in our experience technical problems are nearly always the principal focus of rehabilitation projects.

The information in this chapter applies to all types of water systems (including pumped boreholes and surface water sources, spring-fed gravity flow systems, handpumps, and open wells). Excellent technical references exist for gravity systems[39,40] and handpumps[41,42], so their particular problems will not be addressed in detail here. Technical problems are categorized according to the following basic system components:

- water source(s);
- pumps, engines, or motors (for pumped systems);
- water storage facilities; and
- water distribution system (including pipeline).

During the RRA and the later detailed assessment of a community's water system after it is selected for project assistance, these components should all be examined to determine whether they need to be redesigned, repaired, or replaced. Rehabilitation planning must take into account each component's O&M requirements and costs, as well as the community's (and any

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[39] *A Handbook of Gravity-Flow Water Systems for Small Communities*, T. Jordan, Intermediate Technology Publications, London, 1984.

[40] *Community Piped Water Supplies in Developing Countries - A Planning Manual*, D. Okun and W. Ernst, World Bank Technical Paper No. 60, The World Bank, Washington, 1987.

[41] *Community Water Supply - The Handpump Option*, S. Arlosoroff et al., UNDP/World Bank Rural Water Supply Handpumps Project, The World Bank, Washington, 1987.

[42] *A Workshop Design for Handpump Installation and Maintenance: A Training Guide*, P. A. Pashkevitch and C. Liebler, WASH Technical Report No. 26, June 1984.

other groups which have support responsibilities) ability to access all necessary materials and equipment (M&E), technical assistance, and to raise funds to pay for them.

7.1 Water Sources

Problems with water sources, which can be very difficult and costly to deal with, usually have to do with one or more of the following:

- *Source depletion*—the yield of the source has declined over time due to problems such as drought, over-pumping, spring siltation, or well screen encrustation;
- *Source contamination*—groundwater wells or springs can become contaminated to the point where they are no longer usable. When using surface water (from rivers, lakes, irrigation ditches), assume that the source is already contaminated;
- *Structural failures*—for boreholes, collapse of the well, or plugging of the casing. For spring sources, poorly designed or constructed spring capping which has failed or leaks badly, or ground shifting (landslides, earthquakes, or subsidence) which has altered the source or the capping structures;[43] and
- *Increased demand*—while the source yield may not necessarily have declined, increased community demand for water has exceeded the available supply or system capacity.

The cost of dealing with those problems varies greatly depending on whether the source is a borehole, capped spring, open well, or a surface water source such as a river, lake, or an irrigation ditch. After calculating the anticipated demand at the site, the source yield and water quality must be measured to determine whether it can meet community needs.

7.1.1 Boreholes

Some rehabilitation projects assume that source development will be necessary at some or all sites, so they plan and budget for drilling wells wherever necessary. Other projects have as one selection criteria that an adequately developed source of safe water must already exist. Rehabilitation is likely to be less expensive and time-consuming if existing water sources are used, but many otherwise deserving communities might not be helped.[44] Where new wells need to be drilled or existing ones rehabilitated, well yields may be low, aquifers may be small and confined, water quality may be poor or unacceptable, or it may be necessary to drill

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[43] *Workshop Design for Spring Capping: A Training Guide*, W. Gormley, D. Goff, and C. Johnson, WASH Technical Report No. 28, September 1984.

[44] Eighty-five percent of rehabilitation costs for pumped water systems using boreholes are for underground components, according to *Water Supply and Sanitation Systems: Advantages of Rehabilitation vs. Replacement or New Investments*, B. Shore and D. Young, consultants to the Water Supply Division, Asian Development Bank, September 1990.

several wells before a suitable one is located. Do not rely only on drilling success rates according to local drillers or geological survey departments.[45] Although sophisticated techniques to increase the odds of locating a good water source are available, considerable time, effort, and money may be spent using them. It can be more cost-effective to test-pump and clean existing wells before developing new water sources.

Source options should be discussed with project participants when identifying potential water sources for development. Beyond technical difficulties in locating and developing suitable sources, issues of water rights, land tenure, and distance from the source to the village are important matters to consider. Villagers or their leaders may insist that the well be drilled in a particular place as people may believe, for example, that good water traditionally comes from the east of the village, or an influential villager wants the well on or near his land. Such problems must be resolved well in advance of any formal commitment to rehabilitate the site, otherwise major delays may be encountered. If the site selection criteria specify that an adequate source of safe water for the village must already exist, its quality and yield should be measured during the dry season if at all possible. Wells should be properly test pumped to verify adequate yields. If the community's only water source is to be rehabilitated, there must be a plan for what the community will use for water during construction if its flow must be interrupted.

Where necessary to rehabilitate or clean existing wells as part of system rehabilitation, be cautious—particularly if the well is old and has steel casing.[46] The cleaning process of bailing or jetting the existing well can cause well failure or collapse because of rusting. If this happens, the project must be prepared to commit the necessary resources to drill another well, otherwise the community may be left completely without water. This is not to say that sites which require well rehabilitation should not be included, but rather that planning should include worst-case scenarios (i.e., drilling a new borehole).

Source rehabilitation, especially for drilled wells, can easily become the most time-consuming and expensive aspect of rehabilitation. When sources are rehabilitated, their yield may be insufficient to meet existing or planned future water needs of the village. There are six problems that can cause well output to degrade over time:[47]

- *Incrustation*—due to chemical deposition from calcium (usually calcium carbonate), iron, or manganese compounds;

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[45] *The Selection of Drilling Rigs for Rural Water Supply*, by R. Preble and P. Roark, WASH Technical Report No. 42, April 1988, discusses the important issues related to well drilling in developing countries.

[46] The life expectancy of steel casing is about 20 years, but steel quality, thickness, and water quality (especially acidity) may reduce its lifetime. PVC casing has a much longer life expectancy than steel.

[47] *Groundwater and Wells*, edited by F. Driscoll, the Johnson Well Company, St. Paul, Minnesota, 1986, is one of the best and most comprehensive references for groundwater resources development.

- *Biofouling of steel well screens*—often by iron bacteria, the well screen can become so clogged that water flow through it is greatly inhibited;
- *Plugging of the geologic formation around the well screen*—-small particles loosened by constant pump cycling or improper well design can clog the cracks and fissures around the well through which water is drawn, eventually choking off the well;
- *Sand pumping*—inadequate well development or local geologic conditions can cause pumping of sand which can slowly grind away well screens, and degrade or destroy pump impellers, impeller housings, and pump shafts;
- *Corrosion*—electrolytic corrosion (particularly in acidic water) can cause structural collapse of the well casing, or pitting; and
- *Poor pump design*—can cause cavitation and subsequent pitting and eventual destruction of the impeller and pump bearings.

Chemical incrustation depends on water quality and the presence or absence of incrustation-causing chemicals and bacteria. There are several methods for cleaning incrusted wells, including various acid treatments (muriatic, sulfamic, and hydroxyacetic) and mechanical methods (brushing, scraping, and blasting). Careful well development can minimize the introduction of iron bacteria into a well and subsequent biofouling. If they are either inadvertently introduced during drilling or occur naturally and become a problem, they can be treated by various chemical (chlorine, acid, or ammonia, then agitation with a jetting tool) or other methods (pasteurization, precipitating out iron and manganese—the Vyredox method). Physical plugging of the well can be minimized by proper well design, screen selection, and development. If well formations do become clogged with silt or clay, various chemical treatments (using polysulfates and surfactants or wetting agents) combined with agitation by high-velocity jetting can help considerably. Proper choice and design of well screens can have a big impact on the successful rehabilitation of screens. Certain designs are much better adapted for permitting the jetting action to reach the clogged formation around the screen than others.[48]

Corrosion reduces well performance in several ways:

- When it causes enlarged openings in the screen or casing, it can result in sand pumping and subsequent further degradation (or destruction) of the screen, casing, and pump parts.
- It can reduce flow by clogging screens with cathodic deposition material.
- If corrosion pitting actually causes holes in the upper part of the casing, surface water intrusion may contaminate the well water.

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[48] Ibid, p. 630-669. Ideally, 24 or 72 hour test pumping should be done, but if using handpumps on shallow, low-yielding aquifers, this is neither necessary nor cost-effective, since there is probably no other source on which to install the handpump.

Corrosion can be prevented or at least reduced by minimizing the use of dissimilar metals in well and pump components, using annealed rather than work-hardened metals, minimizing the use of stressed parts and high fluid velocities, and avoiding groundwater which is excessively acidic, has high concentrations of dissolved gases or total dissolved solids, or high temperatures. However, there may not be any choice if there is only one water source available.

Proper pump O&M is an important part of maintaining good well production. Pumps can be damaged by cavitation (which pits the impeller), corrosion, lack of or overly large-slotted well screens (which can cause sand pumping), unnecessarily small slots (which cause high water velocities), or improper well development (which may cause the pump to operate well away from its design condition).

To know whether or not the well yield or pump output has deteriorated, you have to know what it was in the first place. It is very important to keep all well and pump records in a safe place. Unfortunately, this is often not done, and well condition (especially of older wells) must be evaluated in the absence of adequate records. When first developed, or later rehabilitated, boreholes should be test-pumped for 24 hours (for a confined aquifer) or 72 hours (for an unconfined aquifer) to determine whether their maximum sustainable yield is adequate to meet anticipated demand.[49] Test-pumping should be done during the dry season if at all possible.

Test-pumping measurements will allow calculation of the well's specific capacity, which is the best indicator of the well's condition (see Figure 12 on the following page). Specific capacity is the ratio of the well yield (in cubic meters per hour, or m^3/h) divided by the drawdown (the drop in water level when the well is being pumped at various rates). Measuring the maximum anticipated drawdown also indicates where to set the pump depth to minimize the possibility of running the pump dry.[50] A well maintenance program should include periodic (at least annual) measurement of specific capacity. The well should be rehabilitated if specific capacity deteriorates by 25 percent (compared to its original measured value). If the well is allowed to deteriorate more than this, it may become very expensive and difficult to restore the well to its original capacity.

In practice, whether to rehabilitate an old well or drill a new one is usually a financial decision. The present worth of the increased water output based on the expected life of the existing well will have to be calculated to determine whether it is worth the cost of rehabilitation, or whether it is more cost-effective to simply drill a new well.[51] Given the physical uncertainties in well development, this is not an easy decision, since the effectiveness of the various well rehabilitation techniques mentioned above (and the subsequent increase in water production)

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[49] Ibid, p. 534-579.

[50] Running pumps dry is especially a problem with electric submersible pumps, since they are water-cooled and lubricated.

[51] *Improving Well and Pump Efficiency*, O. Helweg, V. Scott, and J. Scalmanini, American Water Works Association, 1984, p. 97.

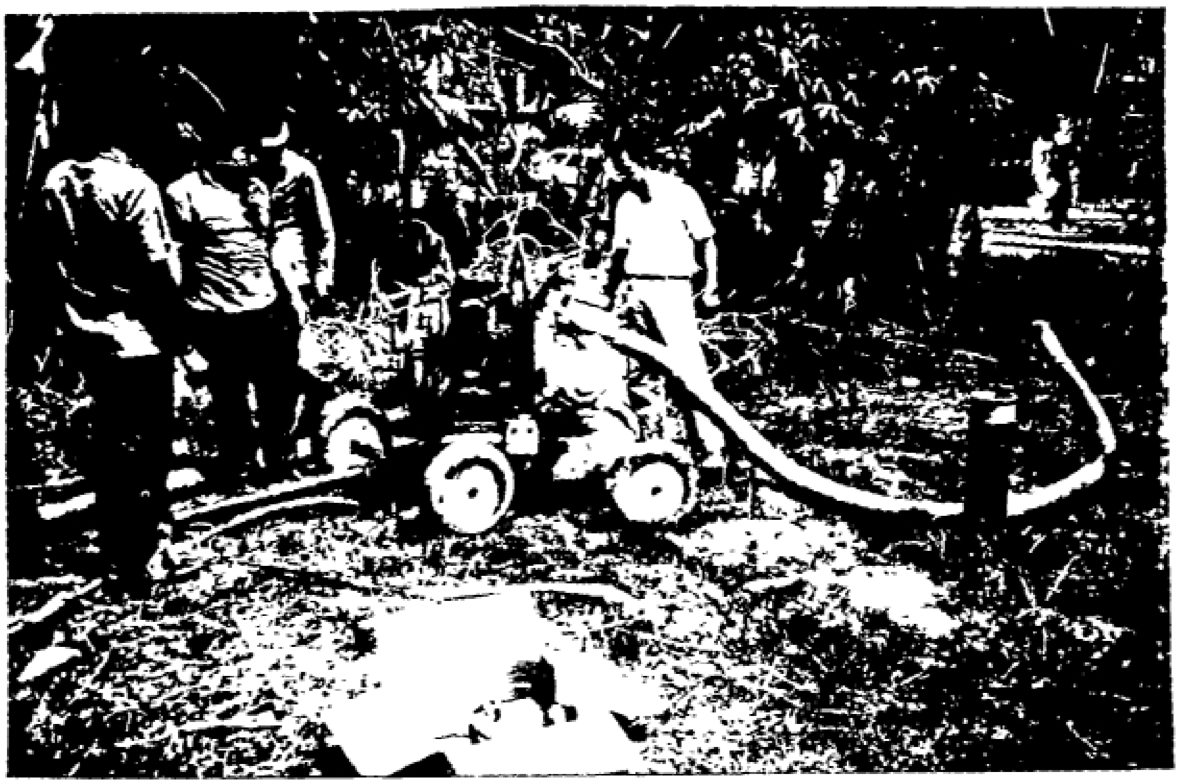

Figure 12

Test-pumping a borehole on Penang Island, Malaysia with a portable pump and diesel engine set to determine its maximum sustainable yield.

varies considerably depending on the specific well conditions. For either new or rehabilitated wells, set up regular maintenance programs are needed to monitor and maintain well output at an acceptable level to minimize the need for future rehabilitation.

7.1.2 Open Wells (Large Diameter)

Rehabilitating boreholes is at the expensive end of the spectrum for source rehabilitation. In terms of water quality and quantity, capping (or recapping) springs and improving open well sources is typically a much less costly undertaking. Open wells are typically hand dug, often by people with limited knowledge of or experience with proper well construction procedures. Besides training communities in proper procedures for cleaning and maintaining an open well, a variety of physical improvements can be made to open wells (the first three also apply to drilled wells) which have differing costs and purposes:[52]

- deepening or widening the well to increase yield;
- constructing drainage channels, soakaway pits, and well aprons (sanitary-sealed to the headwall) to move spilled or dirty water away from the well, reducing contamination;
- disinfecting the well;
- installing or rehabilitating the well lining to minimize contamination from groundwater seepage;
- constructing a headwall to keep foreign objects (as well as people and animals) from falling in; and
- installing a water lifting device (e.g., rope and bucket or handpump) to protect the headwall, draw more water, and minimize contamination.

All of these procedures can be undertaken by communities themselves with some assistance from local technicians or engineers. Open well assessment methods and procedures for cost estimation, planning, and construction are given in detail in the WASH reference cited above.

7.1.3 Water Quality

Poor water quality can be the main reason for having to rehabilitate a system. Besides potential health-related problems, bad taste alone (especially from high iron content) can discourage people from using water. Water quality needs to be assessed at several points in the system. First, the quality of the source must be determined. Source contamination may be a problem that can be dealt with by

- periodically disinfecting the source;
- identifying and eliminating the source of contamination; or

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[52] *A Workshop Design for Well Improvement: Protecting Open Wells*, M. Nagorski, C. Pineo, S. Loomis, and O. Larrea, WASH Technical Report No. 34, May 1988.

- properly treating the water after it is in the system.

Water source quality should always be tested and evaluated prior to any rehabilitation efforts. The source may be so contaminated (or so susceptible to contamination like an open well) that it cannot be properly disinfected (e.g., with a chlorine solution), or adequately treated (at least cost-effectively, for example, with slow sand filters). If so, it may be necessary to develop another source. Any water source to be rehabilitated should be situated well away (at minimum, 15 meters) from any sanitation facility to minimize the potential for fecal contamination.

Secondary contamination sources within the system should also be checked. From the source, water typically flows (or is pumped) to a storage tank(s), and then to public or in-house taps. Water storage tanks require periodic cleaning, and public taps can become contaminated by improper sanitation practices. If necessary, the water may also pass through some treatment device (i.e., a slow sand filter or chemical treatment). Slow sand filters are effective for removing sediment and certain bacteria (but not chemical contamination such as pesticide), and are relatively easy and inexpensive to build, so they are commonly used. There are many other water treatment techniques[53] involving sedimentation, filtration, chemical, and other types of treatment for contaminated groundwater from boreholes or shallow wells, or surface water from rivers, streams, lakes, or irrigation ditches. Two such devices are shown in Figures 13 and 14 on the following page. Due to its expense, chemical treatment is not common in rural areas of developing countries.

The World Health Organization (WHO) sets standards for various contaminants in drinking water supplies.[54] WHO-mandated water quality testing includes measuring

- turbidity;
- total dissolved solids;
- color;
- pathogenic organisms (bacteria such as fecal coliform);
- chemicals which can have adverse health impacts (e.g., nitrates, nitrites, sulfates, fluorides, manganese, and iron); and
- heavy metals (arsenic, chromium, cyanide, mercury, and cadmium).

In addition, other practical considerations for water acceptability include the absence of

- chemicals which have offensive tastes (e.g., iron) or smells (e.g., sulphur dioxide);

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[53] *Surface Water Treatment for Communities in Developing Countries*, D. Okun and C. Schulz, WASH Technical Report No. 29, September 1984.

[54] *International Standards for Drinking Water*, World Health Organization, Geneva, 3rd Revised Edition, 1971.

- chemicals which damage water system equipment (through corrosion or incrustation, such as calcium carbonate); and
- high salinity (measured as electrical conductivity).

Water with low pH values can dissolve iron from pump parts or rising mains.[55] Replacing steel pipe with GI or PVC pipes can address this problem.

A wide variety of water quality testing equipment is available, ranging from the relatively simple (and low-cost) to the sublime (and very high-cost). Unless there is some special contamination problem at the rehabilitation site (e.g., pesticide contamination or industrial pollution), relatively low-cost units[56] may suffice in many areas. Other kits for standard and specialized testing are available from commercial vendors.[57] For more complex testing requirements, where competent local water quality testing laboratories exist, consider using them for water analysis rather than purchasing the more expensive equipment needed otherwise.

7.2 Mechanical Systems—Pumps, Engines, and Motors

While gravity systems are nearly always the best choice where technically feasible, many sites require pumping water to the point of use. Consequently, in addition to the large number of gravity-fed water systems built during the past 30 to 40 years, many community water systems using diesel, hand, electric, and wind pumps were built in developing countries. Diesel pumps were appealing because of their high capacity, relatively inexpensive and reliable fuel supplies, and relatively low capital equipment costs. Handpumps were popular at sites with lower demand requirements, and their low cost was appealing to both poorer communities and donors helping to support those communities. Electric pumps are inexpensive to use where power is available. Wind pumps were installed with the idea that they would seldom, if ever, have to be maintained. The use of solar pumps, while expanding, still represents a very small proportion of mechanical pumping systems (see Figures 15 and 16 on the following page).

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[55] At one project in Mali, nearly 40 percent of the boreholes constructed had this problem. Where other water sources existed nearby (even of lower water quality), people avoided using the project water, which tasted bad and stained their clothes if used for washing.

[56] DelAgua of the Robens Institute at the University of Surrey (UK), in conjunction with OXFAM's Technical Unit, has developed a reasonable cost (£1,000, about US$1,600) water quality testing kit which measures fecal coliform, chlorine, pH, turbidity, conductivity, and temperature. Optionally, it can measure fluorides, nitrates, and do water filterability testing. It does not test for heavy metals, pesticides, volatile organics, phosphates, or sulfates. For comparison, typical commercial equipment just for measuring coliform costs about $600 (including the necessary incubator). A conductivity meter for measuring salinity costs about $500.

[57] Common vendors of water quality testing equipment in the U.S. include Hach, CHEMetrics, Capital Controls, Lovibond.

Figure 13

A slow sand filter for improving river source water quality in East Java, Indonesia.

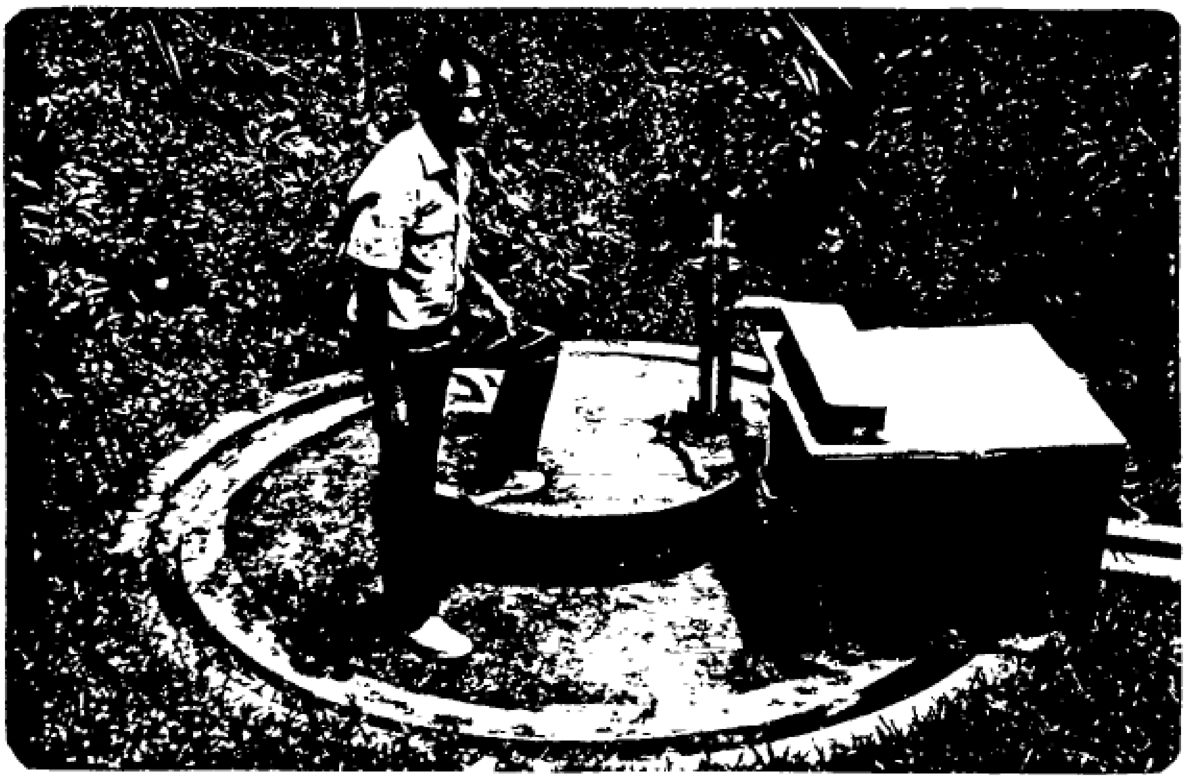

Figure 14

A simple gravel/sand filter box for a handpump on a capped, hand-dug well in Kalutara, Sri Lanka.

During a site assessment, the actual cause of the failure of a pumped system may not be immediately obvious to an outside observer. For example, the cause of failure may appear to be that a diesel engine was run without proper maintenance, and simply stopped working because it was never decarbonized. However, to plan the rehabilitation of this system, it is necessary to find out why it was never properly maintained:

- Did anyone in the community know it needed periodic maintenance?
- If they did, did they think that someone else was responsible for doing it?
- If a government agency was responsible, were they notified? If so, were they unwilling or unable to respond?
- If the community itself was responsible, was there anyone around who knew how to do the maintenance?
- If there was, were the right spare parts locally available?
- If they were, was there enough money available to hire the technician and buy the spare parts?
- If there wasn't, were water users paying their fees regularly, or at all?
- If not, why not? If so, and the fees weren't being diverted for another purpose, were the fees insufficient to cover necessary operation, maintenance, and repair costs?
- If the community was unable (or unwilling) to pay sufficient fees to cover the recurrent costs of the system, was it an appropriate system?

The answers to these questions depend on the type of system installed. Apart from the various technical, management, human resource, and financial issues raised above, it may just be that the community could not afford to support the technology that was first installed at the site.

Different technologies have widely different initial and recurrent costs. It may be that the "right" technology (based on a community's financial and human resource capabilities) which should have been installed was a handpump, not a diesel.[58] When planning rehabilitation, there is no point in rehabilitating an existing system which the community will not be able to support financially or otherwise after project completion.

If the water system is still operating (albeit marginally), it will be easier to determine technical rehabilitation needs. Leaks will be apparent, engine vibrations can be observed, and whether there is any water in the well can be determined. If the system is not operating, the situation is more complex. If the operator has worked on the system for some time, he should understand all the workings of the system. If he does not, it is important to find out why. It may be that he is illiterate and cannot read the equipment manuals (if there are any). If the

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[58] *Pump Selection: A Field Guide for Developing Countries*, R. McGowan and J. Hodgkin, WASH Technical Report No. 61, January 1989, second edition produced in October 1991.

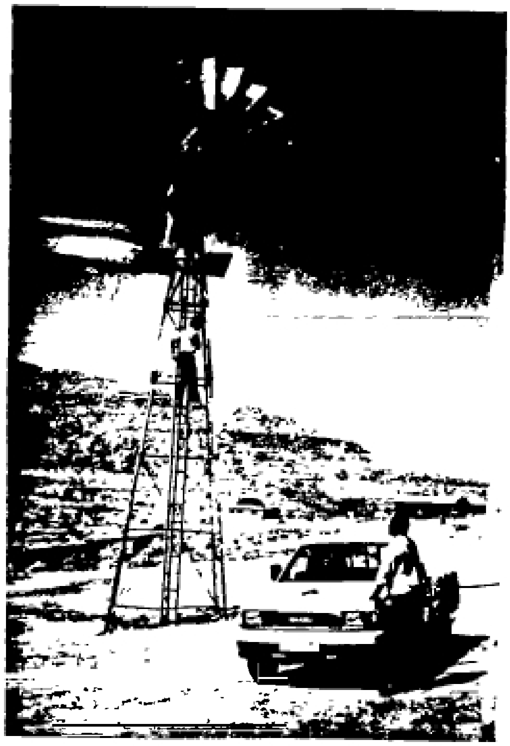

Figure 15

A small water pumping windmill mounted on a shallow borehole for community water supply in the homeland of Ciskei, South Africa.

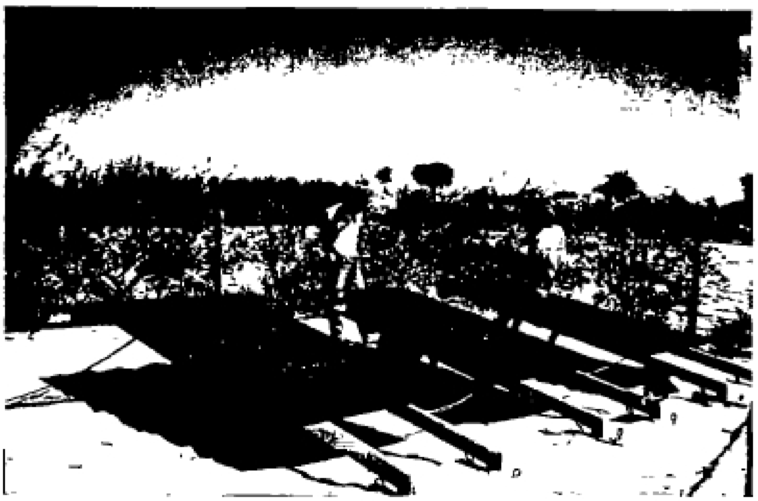

Figure 16

A solar PV pump for community water supply north of Bara, North Kordofan, Sudan community feels that solutions to technical problems are straightforward, this may indicate that they do not understand the complexity of the system, and may have difficulty if given greater responsibility. The condition of the pump house, its cleanliness, and the storage conditions of materials and fuel are also indicators. The engine and pump are big investments. If they are treated as such, it is more likely that a rehabilitation project will be sustainable.

Assume that all in-ground ("downhole") components of a water system (except the well casing) will need replacement. For mechanical systems, pump or engine (or motor,[59] if it is an electric pump) failure is the most common problem. To decide whether or not to stay with the same kind of pump and engine, answer the following questions:

- Is the pump/engine adequate to meet future water demand?
- Is it supportable locally (i.e., are parts and trained technicians available)?
- Is the community willing and able (both financially and managerially) to pay its support costs (including any subsidies by the government, PVOs, or donors, which are assured over the intended lifetime of the system)?

If the answer to any of those questions is no, a different system[60] will have to be used. If the existing system is acceptable (based on the community participation, demand, cost, operation and maintenance, and other issues discussed elsewhere in this report), the first question is whether the existing pump and engine can be fixed (or if necessary, overhauled).[61,62] The answer is dependent largely on the condition of the pump or engine, the availability of spare parts, and the capacity of mechanics and machine shops to properly perform the work. If the right parts are available, diesel engines can be readily overhauled in all developing countries, but it may be a long way from the site to where this could be done. If it is possible to overhaul the engine, then consider whether it is worth it to do so. It may be cheaper over the long run to simply purchase a new engine. Methods to calculate which strategy should be followed are available in WASH reports.[63]

Electric motors can be rewound in many developing countries, but first determine why the motor burned up (overloaded and undersized?), and correct that condition. It may be that the pump over-pumped the borehole, then ran dry and burned out. Even if the previous system

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[59] *Electric Motors*, E. Anderson and R. Miller, 3rd Edition, the Audel Series, Bobs-Merrill Publ., New York, 1981.

[60] *Water Pumping Devices, A Handbook for Users and Choosers*, P. Fraenkel, FAO/ITDG, Intermediate Technology Publications, London, 1986.

[61] *Small Gasoline Engines*, R. Miller and M. Miller, 1st Edition, Audel Series, Bobs-Merrill, New York, 1984.

[62] *Diesel Engine Manual*, Perry O. Black, rev. by W. Scahill, 4th Edition, Audel Series, Bobs-Merrill, New York, 1983.

[63] Op. Cit., R. McGowan and J. Hodgkin, 1991.

did not use them, be sure to use appropriate motor protection devices (low water cut-out switches, current overload and power fluctuation protection) whenever electric pumps are installed.

Engine or motor replacement will depend on its condition, the ability of local technicians to do proper repairs, and the suitability of the engine to perform the work required. This decision may require waiting until the system redesign is complete. Consider replacing the pump house, all meters and valves at the well head, and the concrete engine pad, since in many places these are in poor condition.

The same approach applies to pumps. A pump may not deliver enough water for a variety of reasons, including the following.

- It is improperly matched to the engine (either in terms of required speed or power).
- It is improperly matched to the water source.
    - The total dynamic head of the system may be higher than the pump rating.
    - The suction lift is too high (greater than 5 meters for suction pumps).
    - It may be overpumping the source because the pump capacity is greater than the source yield.
- A variety of physical problems may exist, such as air in the line; clogged inlet; impeller, pipe, strainer, screen or footvalve clogged with foreign matter; overtight stuffing box; loss of prime; incorrect direction of rotation; all manner of leaks; or broken or loose drive belts or other transmission problems.
- There may be a variety of mechanical problems, including failed seals or gaskets; worn rings or cylinder; damaged impeller; vibration from misalignment; bent shaft; or defective packing.

This is not an exhaustive list. When inspecting pumps for repair or replacement, there are several good references[64] which can help to determine what the problem is and what is required to fix it. If it is possible to fix a pump, calculate whether it is financially worth doing so. Otherwise, it may need to be replaced.

Boreholes that are unacceptable for some types of pumps may still be used with other types. For example, if a borehole was poorly constructed so that it is too crooked for shaft-driven pumps, it may still be possible to use it. Mono-type or piston pumps require very straight boreholes because they are driven by rotating or reciprocating drive shafts. Submersible pumps, with motor and pump in one integrated downhole unit, can be used in less straight boreholes where Monos or piston pumps could not. Be sure that the pump has enough clearance from the casing to accommodate any moving parts (such as reciprocating piston pumps).

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[64] *Pumps*, 3rd Edition, H. Stewart, Audel Series, Howard W. Sands & Co. Inc., Indianapolis, IN, 1977.

Obtaining proper spare parts is one of the biggest problems in maintaining a system. In planning rehabilitation, consider current and future local availability of spares. While some projects try to minimize this problem by providing all new or rehabilitated sites with a set of tools and spares (those necessary for, say, a one-to-two-year period), this will not address what the community will do once that time is over. Therefore, whenever possible, it is usually best to procure spare parts and technical support locally. Not only will this help strengthen the local infrastructure which provides support services (equipment and parts procurement, skilled technicians), but it will help ensure that parts will be locally stocked and available the next time they are needed. Be sensitive to local pressure for standardization. Standardizing equipment and system designs whenever possible will significantly reduce the problem of finding spare parts and mechanics who know how to properly use them.

Government water agencies usually have policies on preferred types (sometimes even specific brands) of standardized equipment. These choices may simply have arisen because of availability, or that a particular donor supplied them with a large volume of a certain kind of equipment (whether or not it was appropriate). Sometimes there are good reasons for changing standard specifications if the standard equipment is inefficient, too expensive, not very durable, hard to fix, or has spare parts availability problems. In some cases, changes may be welcomed by the authorities; if they are not, insisting on changing standards should be weighed against other project priorities.[65] Source/origin regulations (when donors are required to provide only equipment manufactured in the donor's country or region) may arise, and should be addressed in agreements with the donor. Sometimes it is possible to waive such requirements and buy standardized equipment from another country or source. If necessary, waivers should be applied for and obtained early on to ensure timely delivery of equipment.

Besides technical questions of suitability and cost, village perceptions or political pressures may require that new equipment (e.g., engines and pumps) be installed during a rehabilitation project, rather than fixing or overhauling the old one, in order for the system to be considered truly rehabilitated.

7.3 Water Storage

Water storage has several purposes which should be taken into account when planning rehabilitation:

- It allows water delivery (at least for a short period of time) at a higher flow rate than the source yield. This is important because the water demand profile (the rate at which

[65] World University Services of Canada (WUSC) insisted on using Canadian-manufactured Mono pumps as part of their diesel wateryard rehabilitation program in Sudan to increase pumping efficiency and reduce fuel costs. The government water agency had standardized on costly and (for these sites) inefficient jack pumps. However, much of the project's time and energy were wasted on trying to convince the government agency to accept WUSC's recommendation.

water is drawn off the system over the day) usually has peaks, during which demand may be greater than could be delivered directly from the source.

- It allows for a relatively continuous, constant pressure water supply.
- It allows a pump to be run for only part of a day, during which time it can pump enough water to meet the entire day's demand.
- It provides assurance that a certain minimum amount of water will still be available in the event of pump, engine, pipe, or other type of system failure.

Tank sizing, while in theory based on daily demand, in practice is often based on what is locally available. In many developing countries, only a limited variety of certain designs, brands, and sizes are available. The "right" size may or may not be available. For example, there might be only 10 or 30 m^3 tanks available. Since daily per capita water demand (according to WHO standards) is 30 liters per day, a 10 m^3 tank would hold enough water for just over 300 people, and the 30 m^3 tank would hold enough for a community of 1,000 people. In practice, communities of 500 people or less would probably get a 10 m^3 tank, and larger communities would get the larger tank. If site-built tanks (e.g., made of ferrocement, or brick and mortar) are used, essentially any size can be built to fit design specifications.

Other than well drilling or unusually long pipelines, bulk water storage can represent the largest single cost item of a water supply system, especially when imported steel or fiberglass tanks are used. Imported elevated steel storage tanks are usually far more expensive than a small diesel engine. Brick or cement ground reservoirs are much less expensive. Due to this expense and the importance of adequate water storage, it is important to evaluate tank options based on the community's need for storage at the site, cost, performance, ease of procurement, and (where appropriate) standard designs. If tanks are to be replaced, planning for this should occur early in the project. Importing tanks and stands can be an expensive and time-consuming process. If a cement or block ground tank could be used, this could be part of the community's in-kind contribution.

When more than one source (well, spring, surface water) exists, the need to provide storage during system downtime is lessened. If the source yield (and pumping rate for pumped systems) is sufficient to meet peak water demand, then the need for storage to balance supply and demand is less. If there are no plans or need for an extensive distribution system, pressurization is probably not necessary. For mechanical systems, water storage is a necessary component of the system since periodic downtime is an expected part of normal operation. If that downtime lasts for more than a few hours (which it inevitably will at times), people will need to use water from storage. At minimum, tanks should be sized to meet one day's demand for the community. For systems which depend on intermittent energy resources (solar or wind pumps, or diesel pumps if fuel delivery is variable), storage capacity should be doubled to supply at least two day's demand. In sizing the tank, anticipated demand growth (based on growth in population, per capita consumption, and expected increases in animal herds) must be included.

If the old tank leaks, it may be repairable depending on its construction and the extent of the damage. Steel tanks can be welded, and fiberglass and masonry tanks can be patched depending on the size of the crack. Unless the tank can be restored essentially to its original condition, consider replacing it. Otherwise, it may fail shortly after the rehabilitation is complete and cost even more to replace later. For some tanks, commercially available liners can be used instead of fixing leaks directly. As long as the tank is structurally sound, this can be cheaper, easier, and faster than patching or replacing the old tank. Periodically tanks need to be cleaned (inside and out). Periodic applications of rust-resistant paint can help extend the useful lifetime of steel tanks. Tanks should be replaced when the annualized cost of repeated maintenance and repair (and associated system downtime) becomes greater than the annualized cost of a new tank.

7.4 Water Distribution

Water distribution systems vary depending on the amount of money available to build them, social organization, community expectations, spatial distribution of the population served by the system, and government, donor, or PVO policy. Distribution can involve:

- single point distribution at the source (e.g., open well with bucket lift, handpump on borehole);
- public tap located well away from the source (gravity system with single tap at the end of the pipeline);
- multiple public taps (with either direct feed from the pipeline, indirect feed through a single central storage tank, or subsystems involving multiple distributed storage tanks and public taps); or
- house or individual yard connections.

Distribution systems are a frequent source of problems. For example, in Botswana, about half of all breakdowns were related to distribution systems. "Ring" systems with subsystem isolation valves should be used, so broken lines can be isolated with minimum loss of service. Pipe trenches must be properly back-filled, especially if PVC pipe is used. This applies to mains, as well as secondary or tertiary distribution lines. PVC lines or other hoses cannot be left exposed, since sunlight will cause them to rapidly degrade.

"Level of service" refers to the type of access (public taps or house connections) people have to their water. Where government agencies are involved in local provision of water, policies usually exist stipulating the level of service to be provided. This may or may not be what communities want or what project planners think it should be. Even if specific guidelines on service levels exist, communities may be able to pay for an expanded level of service (e.g., house connections) if they so desire. Where there is a strong community desire to upgrade service, it is always better to design the upgrade into the rehabilitation plan, rather than have the community put hoses or pipes haphazardly into storage tanks or existing pipelines (see Figure 17). They might also be willing and able to pay for a higher-capacity system involving, for example, upgrading from handpumps or open wells and buckets to a diesel-pumped borehole.

Level of service will have a strong impact on per capita demand. If people have to carry their water 500 meters, they will use much less water than if a public tap is located near their home. Demand will increase even more if house connections are installed (doubling or even quadrupling of per capita consumption is not unusual). Installing connections may over-tax the water source or overall system (especially the main pipeline), or result in some areas that are served by the system running out of water due to overuse in another area.[66] Excessive water wastage (due either to people not closing taps or to broken, missing, or stolen taps) can have the same effect. There are several kinds of spring-loaded, self-closing taps which have been used successfully in some countries. Part of community education during rehabilitation should address water conservation and the potential impact of excessive use or wastage.

The design of public taps or wateryards can be very region- or country-specific, particularly if sanitation facilities are also included. The design of sanitation facilities can reflect strongly held opinions about personal hygiene, modesty, and differences between the sexes. It is important not to impose designs on people that conflict with local expectations or beliefs. Usually, local designs can be suitably and relatively easily modified to incorporate accepted hygiene and sanitation standards. However, incorporating important (but often ignored) health-related components (i.e., adequate drainage channels, soakaway pits) in rehabilitation plans should be insisted upon (see Figures 18 and 19 on following page).

If the distribution system has deteriorated beyond what might be expected to normally occur, find out why this happened. Is there evidence of purposeful damage of system components? Is vandalism a problem? Either of these might have an impact on the choice of equipment or designs used in the rehabilitation. It is not unheard of in communities with multi-ethnic divisions or other subgroup conflicts (such as those now so evident in Sudan and Somalia) for water systems to be vandalized. There might also be unequal system coverage between groups. When discussing the location of pipelines, taps, tanks, and other system components with villagers, be sure all community subgroups are adequately represented, and that the final design insures that coverage is relatively equitable among them.

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[66] This situation occurred at a CARE-assisted rehabilitation project in Indonesia. Water usage from one public tap (due to a proliferation of unofficial house connections) had become so great that a subsystem further down the pipeline never had any water. The resulting community conflict had gone on for several months without resolution.

Figure 17

Unauthorized tapping of a public tank in East Java, with hoses leading to individual houses. This practice can lead to greatly increased demand, and unbalanced water distribution within the community.

Figure 18

Water point with taps and drainage apron at a diesel wateryard rehabilitated with CARE assistance in North Kordofan, Sudan. Villagers pay water fees based on a per container charge.

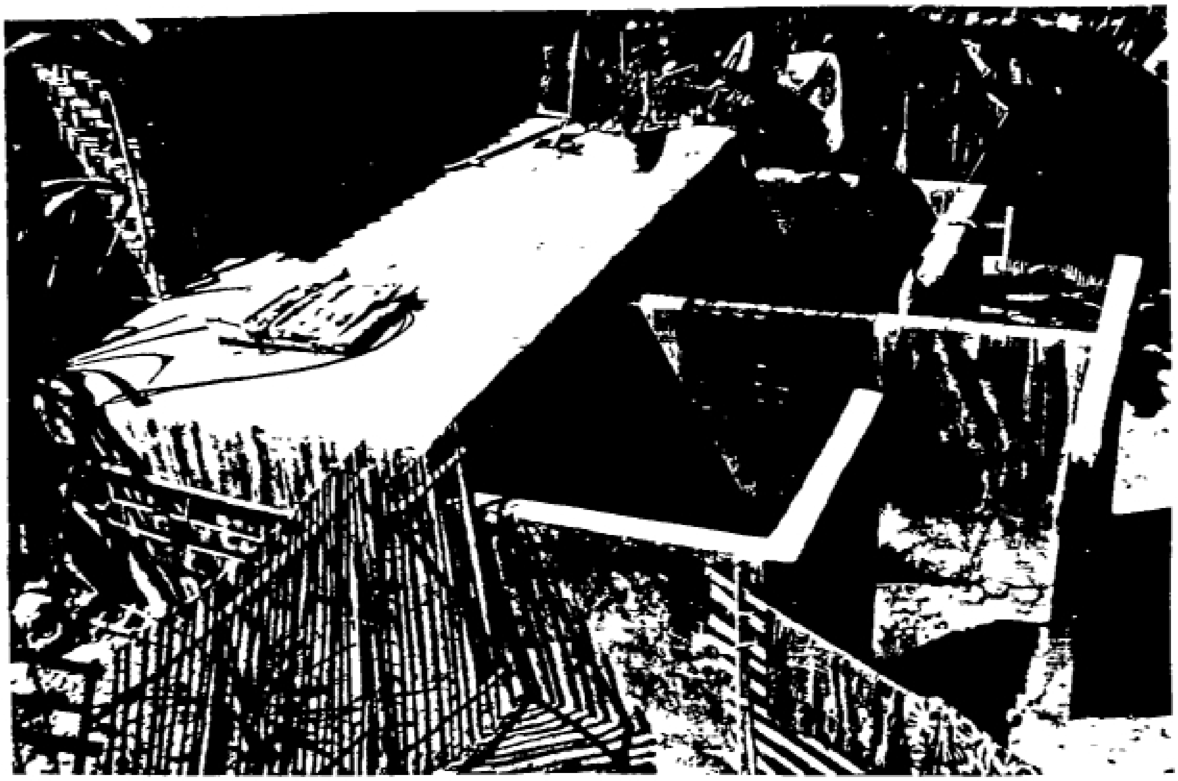

Figure 19

A water distribution point with a built-in storage tank in East Java. Water points can be combined with washing, bathing, and sometimes sanitary facilities designed to meet community needs.

Chapter 8

IMPLEMENTATION AND LOGISTICS

Additional effort put into better planning of implementation and logistical support will help insure the timely completion and ultimate success of the project. Areas covered in this chapter include procurement and delivery of materials and equipment (M&E), skilled and unskilled labor, transportation, subcontracting, and project supervision.

8.1 Materials and Equipment Procurement

The M&E necessary for any water supply or water system rehabilitation project fall into several categories:

- *Equipment to be installed at the site*—including pumps, engines (diesel, electric, solar, wind, or handpumps), borehole (drilled well) casing, water storage tanks, tank towers, pipes, valves, taps, and other fittings used in the main pipeline and distribution system;
- *Construction materials used at the site*—including cement, sand, stone, and gravel for masonry construction;
- *Major equipment needed for construction*—including vehicles, drilling rigs, winches, surveying equipment, major tools (e.g., tripods with block and tackle), and water quality testing equipment. This equipment will be used at each site during design and construction, then moved to the next site; and
- *Small tools and other M&E (used for many sites)*—including all other items not mentioned above such as specialized or replacement tools (e.g., drilling bits), picks and shovels, fuel and lubricants for vehicles, vehicle spares, engine and pump overhaul kits, chain and rope, and logistics support items such as cots, tents, food, and cooking pots needed by construction crews.

A full listing of these items should be developed in consultation with cooperating agency officials, other organizations performing similar work, and community representatives during the early planning phase of the project. This will allow early identification of items which should be procured immediately but are not locally available (e.g., specialized drilling rigs or bits). This will help avoid undue delay of construction activities.

The M&E list should be divided among those items available in-country, those which must clearly be imported, and those which may or may not be procured locally. In some projects, it is also necessary to note what can be purchased with local funds (often covered by the local government) and what must be purchased with foreign exchange[67] (often from donor funds). This is particularly a problem where local currencies are not easily convertible into foreign exchange, or where the official exchange rate differs greatly from the black market rate. Procurement for locally available equipment will depend largely on who is responsible and what procedures must be followed. Government agencies, PVOs, or local private contractors are likely to have different procurement practices which may either slow down or speed up the whole process considerably. Procurement by the donor implementing agency can be faster and more efficient, but, typically, all items procured in this way must be paid for with donor funds.

Local procurement by government agencies is typically quite formalized, and can be a long process of competitive sealed bids for government tenders, usually requiring many signatures, and in some countries, personal incentives. However, this is not always the case. Some governments have vendors bid for standing tenders for certain items, so that M&E stocks may already be available in government warehouses, or in short order through specified vendors.[68] Then, whenever a government agency wants some pipe, it knows that it can relatively quickly and easily buy pipe through that vendor at fixed costs for pipes of a particular specification.

Importing equipment can be a source of difficulty and seemingly interminable delays, depending upon the procurement regulations of the funding source,[69] and the experience and capability of the vendor in providing M&E to developing countries. Difficulties include identifying suitable equipment sources, imposition of import duties, taxes (sometimes development projects are exempted, sometimes not), customs clearance procedures, international warranties, local availability of spare parts, and shipping arrangements. In most cases, customs duties and taxes are formally waived when they are used in development projects. This issue should be resolved as part of any negotiated agreement between the government and the donor or donor representative (see Chapter 6). When possible, it is best for M&E procurement to go through local agents, even if the purchases themselves must be made overseas. This helps insure that similar equipment is already being used in country, and spare parts will be available when required.

Customs clearance in many places can be problematic, confusing, time-consuming, and may require direct incentives to expediters. Clearance may be done by the donor or its representative, the cooperating government agency, the local vendor's agent, or by an

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[67] This may not be the same as what is available locally and what must be imported. In countries such as Burma, many imported items (such as engines from Thailand) available in Rangoon still must be purchased with foreign exchange, most commonly U.S. dollars.

[68] For example, in Botswana the Government bids tenders for certain equipment (i.e., galvanized pipes). The winning bidder guarantees that it will provide pipe of various diameters and lengths at fixed costs over the specified period of the tender.

[69] Donor funding is often "tied," meaning that it can only be used to purchase equipment or materials from particular countries, most often the donor's own. Sometimes waivers can be obtained under certain circumstances.

independently hired clearing agent. Each has its advantages and disadvantages. The local vendor or clearing agent should be familiar with necessary procedures, and will likely be motivated by a direct fee for his services. The government agency may best be able to minimize bureaucratic delays. The donor may already have a mechanism in place for duty-free project equipment procurement.

Procurement responsibilities should be clearly specified in written agreements with all major participants in the proposed project. Contingency plans and funds should be available if other project participants are unable to meet their obligations for reasons beyond their control, such as import freezes, fuel shortages, or inability to obtain foreign currency for payments.

The last stage in procurement is equipment delivery, including both delivery from the supplier or customs to the project warehouse, and delivery from the warehouse to specific sites. Here again, assigning and accepting specific responsibility for delivery is critical. Responsibility may fall to project staff, the government cooperating agency, or a hired freight hauler. Consider the capability of each to deliver M&E on schedule and intact. Security precautions should be taken when hauling and storing expensive and easily divertable items (e.g., diesel fuel or engine parts). Consider using damage and loss insurance if available, just in case. One person should be responsible for inventory at each storage site.

Rapid rural appraisal techniques and common sense observation will help flag potential procurement problems. Procurement or delivery difficulties can be identified during discussions with others undertaking similar projects, or by asking private businesses in the project area about delivery lead times for imported items (e.g., engines) and domestically produced items (e.g., cement or PVC pipe). The availability of imported items in the project area is a positive sign. Discussions with equipment dealers and agents can help identify potential bottlenecks (e.g., lengthy customs clearances or warehousing difficulties) needing further investigation.

Project staff must be willing and able to take on responsibility for expediting procurement, working with local agents, and tracking procurement carefully. Long procurement lead times conflict with the need to design individual systems, so it is wise to standardize designs and components whenever possible and to make sure the right equipment is procured the first time to avoid difficult problems later on. Whenever possible, obtain donor and government assistance in customs clearance and waivers of customs duties or other taxes to avoid having imported M&E become a very time-consuming and frustrating process.

8.2 Transportation for Construction and O&M

Transportation is almost always an important issue for development projects, especially for water projects that typically require moving personnel and materials to remote areas. Issues include the following:

- What types of vehicles are required (e.g., small four-wheel drive trucks for transportation of personnel, or flatbeds for hauling large equipment or materials such as well casing) and what brands are available?[70]

- Who is responsible for providing the necessary vehicles, and on what schedule?

- Who provides fuel, spare parts, maintenance mechanics, and drivers?

- How are vehicles allocated to regions or agencies, and who controls their movement and use (both during and after working hours)?

Donors commonly provide light vehicles (often four-wheel drives) for project use and subsequent turnover to the cooperating government agency at project completion. Heavier vehicles (5-10 ton lorries used for moving supplies such as pipes and steel water tanks) are often purchased directly by the cooperating government agency. Fuel is often part of the government's contribution to the project. Vehicles can be maintained and repaired by government shops, project personnel, or private mechanics. Because they usually need to be imported, spare parts are often supplied by the donor. Arrangements vary from project to project, but what is important is to have the arrangements clear and agreed upon by all parties prior to project start-up.

Once it is clear who will provide which vehicles, the vehicles must be registered and decisions reached about who will control their movement. Depending on the government regulations in a particular country, registration of project vehicles as government vehicles can severely hamper activities. Several problems may arise if the vehicles must be assigned to the cooperating government agency (a situation usually to be avoided).

- Government drivers may be required.

- Additional signatures for even minor trips may be required.

- Vehicles may be temporarily assigned to non-project activities.

- Repair and maintenance may be restricted to government shops (with subsequent lengthy queues).

- Vehicle movement may be restricted to the formal working hours of government or specific geographical areas.

On the other hand, private registration (at least until the project is completed) may obligate the project to be responsible for monitoring any vehicle abuse, carry insurance for liability and personal injury, and accept responsibility for all maintenance and repair. If the government agrees to provide fuel, retaining private registration may complicate obtaining fuel at

[70] Always buy the best available vehicles, and make sure parts for them are available on the local market. Most often, saving money by buying cheap vehicles unsuited to the local driving conditions or not locally maintainable leads to disaster.

government depots. To minimize complications later, make sure project agreements directly address these issues so as to minimize potential logistics problems.

Consider maintaining the project's own vehicle fleet by locating a good mechanic part-time or hiring one full-time. Proper and regular maintenance is *absolutely essential* to successful completion of the project. Even if the government motor pool is supposed to be at the project's disposal, assume that conflicting priorities, time delays in obtaining vehicle use authorization, and the potentially poor condition of government vehicles are not likely to make using government vehicles worthwhile. However, it may be necessary to depend on a government pool for transport requiring large vehicles.

8.3 Labor (Skilled and Unskilled)

Labor issues cover expatriate and local professional staff, skilled labor (i.e., mechanics or welders), and unskilled workers. Agreements between cooperating agencies (and communities) should specify:

- what types of personnel are required for the project, what their qualifications must be, how many of each type are required, and their respective levels of compensation and benefits;
- what agency or group will provide these personnel;
- an approximate schedule of when they will be needed on the project;
- how all project personnel will be supported both while working at project headquarters and while working in the field; and
- if any personnel will work part-time on the project or have other non-project duties (such as existing government staff temporarily assigned to the project), what portion of their time will be spent directly supporting project activities.

Shortages of qualified professional and technical support staff within government agencies typically limit their capacity to provide qualified personnel on a full-time basis. The project team should have the right to review the qualifications of proposed personnel, and reject them if they appear unqualified. Issues of compensation (especially topping off salaries of government personnel seconded to the project) and secondment of personnel from agencies other than the primary cooperating agency may also arise. It should be clear who will pay salaries, and whether additional compensation may be available for performance bonuses, overtime, per diem, and meal allowances.

Besides full-time project staff, other professional staff (local or expatriate) may also participate on an as-needed basis, including hydrogeologists, design engineers, construction supervisors, and sanitation and hygiene educators. These personnel may perform services as part of their ongoing work obligations,[71] or may be contracted or temporarily seconded to complete a specific task. It may be necessary to hire professional staff from either the public or private sector (or both) as project personnel. In any case, it should be clear what obligations the project has for their compensation.

Rehabilitation projects require the services of several kinds of skilled laborers, such as mechanics to rebuild pumps and engines or to install new equipment, pipe-fitters, welders, carpenters, surveyors, or masons. These skilled workers may be provided by the cooperating agency, or contracted either by the project or the beneficiary community. Unskilled and semi-skilled labor is typically part of a community's contribution to the project. Coordination of these workers, as well as any payment for their services, should be managed directly by the community. They may be members of the community contributing their services, or people hired by the community for the job. When there are already people who have been and will continue to be responsible for various O&M activities (the system operator, a local mechanic, or technically inclined members of the village water committee), always include them in the rehabilitation activities. This will ensure that they know the location and proper operation of all taps, valve-boxes, pipes, and other physical components of the rehabilitated system. This is particularly important if there has been extensive system redesign or expansion, or if different equipment will be installed.

Perhaps more important than construction issues is labor for O&M. If skilled people are not already available, they must be trained as part of the rehabilitation effort. It is vitally important that system operators and their assistants know the proper use and care of all system components. Operators, regardless of whether they are paid by the villagers or the government, should be literate village residents. If it is not possible or practical to replace an illiterate operator, a literate assistant should be identified to keep a running log of water system O&M requirements. This will help outside technicians to identify and solve problems which may arise over the lifetime of the system.

Be willing to invest the time and money necessary to properly train project staff and representatives of beneficiary groups as necessary. Hire good staff, and try to provide a visible track for advancement. Promotions should be based on performance.

8.4 Subcontracting

Subcontracting out certain tasks can be a convenient way to obtain needed skills and reduce the management burden on project implementing agencies. Subcontracts can have the following advantages and disadvantages:

[71] For example, field workers from rural health clinics under the Ministry of Health may work on a part-time basis with communities being assisted by the project, or simply assist those communities anyway as part of their responsibility for all communities in the area.

- They can take advantage of locally available skilled resources in either the private or public sector, rather than the project having to recruit and train additional local personnel.
- Some tasks can be expedited by using quality of performance or early completion bonuses as incentives.
- Outside contractors may require more direct supervision than project personnel to maintain quality control.
- Depending on the particular contractor, their services may be more expensive, less responsive to particular site requirements, or less flexibly scheduled than using project personnel.

Whenever subcontractors are used, detailed contracts *must* specify required M&E, scheduling, construction methods (where appropriate), and costs. Contracts should include:

- *exact engineering specifications* for each system component (e.g., storage volume, construction materials, foundation design, wall thicknesses, and required fittings for a water tank);
- *estimated costs* of all M&E provided by the subcontractor;
- *construction supervision procedures* and responsibilities, including scheduling of periodic quality control inspections;
- *mention of any construction components for which the subcontractor is not responsible* (e.g., drainage around well aprons);
- *method and timing of payment for services*, including any performance bonuses; and
- *procedures for dealing with contract default* (e.g., unacceptable delays, poor quality of construction, or use of unacceptable materials).

Subcontracting out such components as system design and surveying, well drilling, pipeline installation, storage tank construction, and pumping equipment installation are not uncommon. If subcontracts are used, it is important to follow any existing government guidelines and procedures for subcontractors. There may be government restrictions, competitive tender processes, or specific completion and sign-off policies for subcontractors. Among project personnel, one person should be in charge of evaluating the quality of the work and ensuring that completion includes all "as-built" specifications and drawings for project records.

The success of subcontracts depends upon proper construction supervision. Project technical staff will normally perform periodic inspections to insure that quality control is maintained. However, certain tasks may be the responsibility of the community, which may not have the skills to properly evaluate construction work. Since the community is paying the cost, it may choose to use substandard construction practices to save money. This practice must be discouraged. If communities choose to subcontract out certain tasks, they may require outside assistance to ensure that the tasks are properly completed.[72]

When using subcontractors, avoid advance payments if possible. Making regular (and prompt) payments upon completion and inspection of specified construction tasks provides a good incentive for their timely completion. Consider using early completion bonuses, with the understanding that only after final inspections are successfully completed will final payments be made. Withhold at least 25 percent of total payment pending satisfactory completion of the entire job. This will help insure that the subcontractor doesn't decide to leave in the middle of a job for a more lucrative opportunity. Where possible, consider subcontracting out long-term operation or maintenance services, particularly for mechanical systems using pumps and engines. If this is possible and appears financially justifiable, discuss it with the community. Details should be worked out between the community and any individual or company providing service. The project team should be available to offer suggestions and review arrangements.

An active local private sector and a government tolerant of installation and O&M services being provided by the private sector are good indicators for the use of private subcontracts. If government agencies have subcontracted work in the past, there should already be approved mechanisms for soliciting bids, evaluating responses, letting contracts, and monitoring contractors' performance. If so and if the work was done well, use these procedures.

8.5 Project Supervision

Proper supervision of construction and other rehabilitation activities is critical to the success of rehabilitation projects. Both the pace and quality of the work performed depend on proper supervision. Major constraints to proper supervision commonly involve transportation, appropriate technical skills, and time constraints on the staff responsible. The importance of using responsible and honest construction supervisors and inspectors cannot be over-emphasized.[73]

Project technical staff should be on site during all major construction. Once something is built improperly, it can be very difficult and costly to fix. Schedule periodic inspections before

[72] For example, in the past, CARE/Indonesia's rural water supply and sanitation projects required communities to supply only unskilled labor and local materials (e.g., stone, sand, bricks, bamboo). This has evolved to where communities in some cases now pay for all system costs except technical assistance (which is provided gratis by CARE). In one instance, rather than build them themselves, one community hired a local contractor to build several storage tanks. The tanks were of very poor quality, in part due to the contractor using less than the required amount of cement in order to reduce costs.

[73] It is not uncommon to see concrete structures (e.g., water tanks or pipeline thrust block supports) in which insufficient cement was used to mix the concrete. This may not be initially apparent when inspecting systems, but can cause systems to fail early and catastrophically if not properly done. Builders unfortunately see this practice ("short-sacking") as an easy way to increase profits for a fixed price job. Responsible construction supervisors must be in attendance and pay close attention when concrete is mixed.

making any major next steps. For example, inspect the entire pipeline before back-filling the pipe trench. Leaks are much easier to find and fix if they are not covered with two feet of dirt and rock. Similarly, check the position and size of all rebar and forms before pouring the concrete for a tank foundation.

Construction monitoring and supervision should include community members to make sure that system designs and layouts reflect their needs. Prior to any construction work, a review of site requirements must be made by qualified project technicians (not necessarily engineers) and the designs discussed with the community. Communities should receive some technical training prior to construction so that they are better qualified to assess:

- *System design*—choice of different systems may have implications for O&M requirements and costs. Standardized designs should be used as much as possible to minimize the need for redesign by technicians during construction.
- *Layout*—location, number and size of storage tanks and public taps and/or house connections, which will affect convenience of water collection.
- *Component quality*—higher-quality components often have a higher initial cost, but lower recurrent costs for operating and maintaining. This is especially true for pipe (GI or PVC). Depending on who is paying for rehabilitation or O&M costs, donors or villagers may want to choose higher- or lower-cost components. Standardized components (e.g., locally available engines and pumps, for which spare parts are readily available) should be used whenever possible.
- *Construction procedures*—villagers should be trained in proper construction procedures and informed of the implications of short-cutting those procedures in misguided efforts to cut system costs.

With such training, communities will not only be better able to contribute in initial construction, but they will be much more able to take care of later problems themselves without having to seek external assistance.

The final system inspection should occur before formal transfer of ownership and responsibility from the project to either the beneficiary community or the relevant government agency. At project completion, a formal handing-over procedure should be organized. Such a ceremony should include specifying community and government responsibilities for long-term operation, maintenance, and repair.

Chapter 9

OPERATION, MAINTENANCE, AND REPAIR

Lack of proper operation, maintenance, and repair practices (usually combined and referred to as O&M) can be the direct cause of water system breakdowns. It can increase system running costs and decrease reliability by causing failure and premature replacement of expensive or difficult to replace components. Proper O&M requires careful management of the material, financial, and human resources available to communities and government water agencies. During the RRA process described in Chapter 4, it will become quickly apparent whether or not the community or government agency has managed to successfully plan and manage O&M. If not, determining why will be the key to developing a sustainable O&M management system for that community. One advantage of rehabilitation over new construction is the opportunity to identify causes of previous O&M problems, to determine which groups and individuals were willing and able to carry out O&M responsibilities (and which were not), and to use this information to develop more sustainable O&M strategies.

This chapter summarizes the more important planning and management issues related to O&M, including:

- *Organization*—among all groups responsible for various O&M tasks;
- *Procedures*—well-defined system operating standards, a preventive maintenance schedule, corrective maintenance procedures, and an appropriate monitoring system to make sure these procedures are being followed;
- *Human resources*—people trained, willing, and able to undertake all of the procedures mentioned above;
- *M&E*—local inventories of M&E needed on a regular basis, and regional stocks of all M&E needed to support the system over the long term; and
- *Money*—to pay for all of the above, whether collected from beneficiary groups through user fees, or provided by external funding agencies such as governments, donors, or PVOs.

The WASH report *Assessment of the Operations and Maintenance Component of Water Supply Projects*[74] is a useful reference, and should be reviewed during rehabilitation project planning.

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[74] By J. Jordan, P. Buijs, and A. Wyatt, WASH Technical Report No. 35, June 1986. This report includes lists of questions useful to include in the RRA to identify O&M problems. There are numerous WASH field reports dealing with O&M components of particular projects. Since project field offices typically have few useful references to help the field staff deal with day-to-day system design, construction, and O&M problems, it is strongly recommended that field offices maintain a small reference library including publications listed in the Bibliography.

9.1 Incorporating O&M into Rehabilitation Design

O&M requirements should be considered during system design and construction. Well designed and constructed systems will help minimize O&M requirements. Poorly designed or built systems can result in difficult to resolve problems such as the following:

- Poorly matched pumps can result in under-loaded engines which run inefficiently, and have unnecessarily high fuel consumption and greater maintenance requirements. O&M procedures cannot fix this. The pump or the engine must be replaced to fix the problem.
- Under-sized main pipelines or distribution pipes will increase system head and reduce flowrate. For pumped systems, this means higher energy (hence fuel) requirements, and possibly pumps mismatched with their loads. For gravity systems, it may mean that the flowrate will not meet daily water requirements, thus requiring installing another pipeline.[75]
- Poorly constructed systems can produce other costly O&M problems such as
  - pipelines poorly laid through streambeds which may wash out during storms and require costly replacement;
  - misaligned boreholes which can produce pump drive shaft problems, excessive vibration, and power losses;
  - improperly buried pipelines which can be punctured by backfill rocks or crushed by vehicle traffic; and
  - insufficient cement ("short-sacking") in concrete structures which can cause premature failure, so that a little money saved in construction will cost a lot more later for repairs.

There can be direct trade-offs between higher construction costs and lower long-term O&M costs for water systems. For example, buying or building higher-quality, longer-lasting system components (pipes, tanks, pumps, engines) usually increases up-front cost. But better quality systems usually have fewer breakdowns and longer periods between major repairs. Comparing life cycle costs[76] (including O&M costs,[77] see Chapter 10) for different quality systems is

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[75] Heavily corroded pipelines will also reduce flow. Rather than replacing a pipeline, if pipes are structurally sound, they can be lined with cement mortar or epoxy coatings with relatively low cost and short downtime (only for pipes of 100 mm or greater diameter). They can also be slip-lined with medium density polyethylene (MDPE) pipe to structurally rehabilitate a mainline, or replacement-moled (where the old pipeline is shattered by a horizontal reciprocating hammer and compressed into the surrounding soil).

[76] *Pump Selection: A Field Guide for Energy Efficient and Cost Effective Water Pumping Systems for Developing Countries*, R. McGowan and J. Hodgkin, WASH Technical Report No. 61, gives procedures and examples for such calculations which apply to both pumped and gravity-fed systems.

important, but it is also important to know who will pay the price. In some rehabilitation projects, donors pay all equipment and installation costs, but require that beneficiary communities pay for some or all O&M. If so, reducing the community's recurrent cost burden by installing higher-quality but more expensive equipment may be one way for a donor to increase system sustainability. Reducing construction costs will have the reverse effect (see Figure 20).

Systems should be designed with O&M needs that can be covered by local human, financial, and material resources. Consider including an M&E supply (enough to last for one or two years, including a basic set of tools) as part of project assistance. If responsible for O&M, communities must have the tools they need to undertake basic maintenance and repairs, whether they buy them themselves or are given them by the project.

Complex systems often require more O&M and additional training so that local personnel can provide that support. Where possible, use equipment and parts that are already used and locally available. That way, when maintenance and repair become necessary, needed parts and supplies (and the people who know how to use them) will be available. Equipment standardization is an important O&M consideration. The more standardized the equipment (by manufacturer, model, or type of system) in a particular district, region, or country, the more likely there will be a market for M&E and a supplier who will support that market. Finding parts for uncommon equipment can be quite difficult, if not impossible.

9.2 Organizational Responsibilities and Procedures

Planning O&M requires identifying all groups (government agencies, communities, PVOs, private contractors) that will play roles in O&M, listing all necessary procedures, then reaching agreement on who will be responsible for each of those procedures. These arrangements are then formalized in the project agreements discussed in Section 6.3. Not all people taking responsibility for O&M need be paid workers. It is common for community members to take on certain tasks (e.g., cleaning water tanks or sanitation facilities, or making periodic inspections of the system) on a volunteer basis (see Figure 21). Private mechanics or government water engineers will require payment. The private mechanic would probably be paid directly for services rendered. The water agency engineer will be paid through system support agreements funded either by water tariffs or government/donor grants.

When developing an O&M plan, a good place to start is to determine who had what responsibilities for the existing system. Assess where problems arose with those arrangements in supporting the system. If the assessment indicates that existing institutions, perhaps with additional financial or technical support, could fulfill the necessary O&M roles, work with those existing institutions. If not, other arrangements must be made to work with or develop new organizations to provide that support.

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[77] *Estimating Operations and Maintenance Costs for Water Supply Systems in Developing Countries*, J. Jordan and A. Wyatt, WASH Technical Report No. 48, January 1989.

An O&M plan must be established for each system, listing each necessary task, the overall task schedule, and who will undertake the task. Review the previous O&M plan (whether or not it was actually written down) and determine what procedures were used, what appeared to work, what did not, and what was overlooked. Much of this information is probably readily available in the community or the local water agency.

There are four major steps in developing an O&M plan:

- *Identifying system operating standards*—how the system was designed to operate, including design parameters for water quantity, quality, and system layout;
- *Developing a preventive maintenance schedule*—a schedule and description of all procedures necessary to keep the system up and running as designed;
- *Developing corrective maintenance* **procedures**—a set of actions to take when various problems (system malfunction or breakdown) occur; and
- *Developing monitoring procedures*—periodic inspections to monitor preventive maintenance, note any needs for corrective maintenance, inventory M&E stores, and audit accounts.

Training in each of these activities should be provided to communities and other support agencies (if required) as part of the rehabilitation project. System operating standards are basically the physical system description and overall design specifications for how the system should work. It includes such things as how much water the system should supply, anticipated demand and expected per capita consumption, location and size of storage tank(s), and minimum acceptable water quality standards (usually WHO standards).

Well thought out preventive maintenance (PM) programs help minimize system breakdowns, ensure that components work efficiently together, and prolong the useful lives of all components and the overall system. PM does not include the repair procedures (corrective maintenance) necessary after a breakdown has already occurred. PM is most often done by the system operator or community volunteers from the VWC, and includes tasks such as the following:[78]

- regularly cleaning spring catchments, water storage tanks, and sanitation facilities;
- cleaning or replacing filters or filtration materials;
- fixing minor tank or pipe leaks;
- cleaning drainage ditches and soakaways around water points; and

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[78] Procedures for planning and managing O&M programs, along with checklists of specific required tasks, are given in *Preventative Maintenance of Rural Water Supplies*, World Health Organization, WHO/CWS/ETS, Geneva, 1984.

Figure 20

A diesel pump installation for community water supply north of Hodeida in the Tihama Region of North Yemen. Reducing construction costs by using a cheap foundation and no pumphouse will increase maintenance and repair costs in later years.

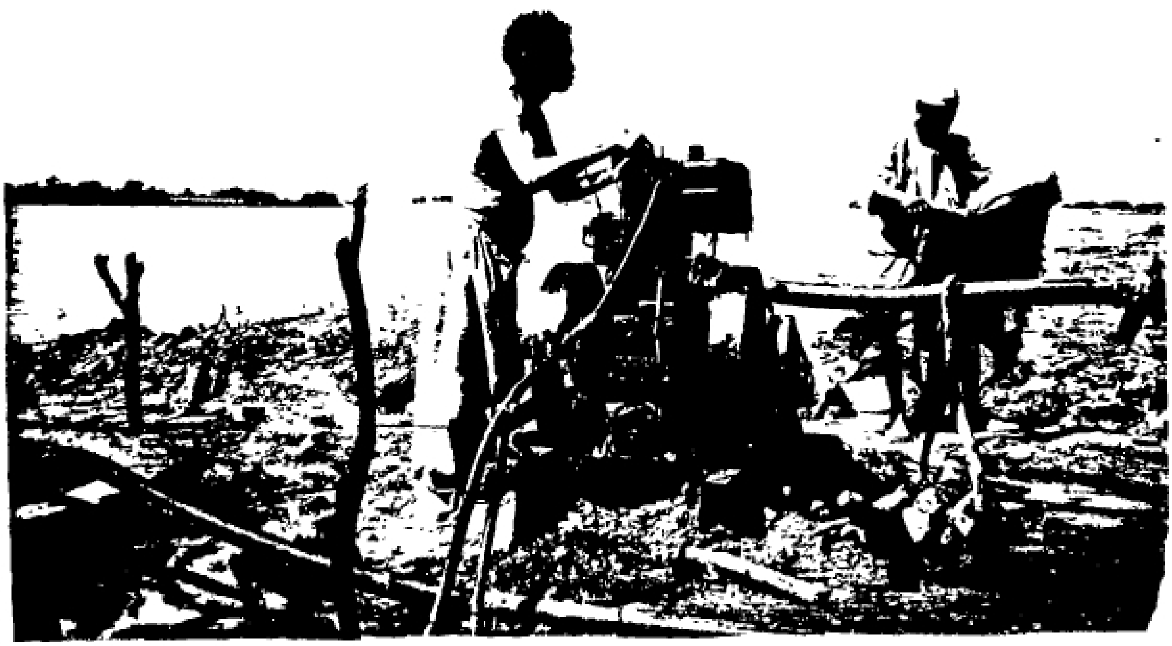

Figure 21

A private mechanic fixing a diesel engine for a farmer on the bank of the White Nile south of Khartoum, Sudan.

- for mechanical systems, tightening all nuts and bolts, changing oil and filters, and making minor adjustments to engines and pumps.

As the name implies, corrective maintenance is needed when the system malfunctions or breaks down. Corrective maintenance is needed for tasks such as:

- fixing broken pipes or major tank leaks;
- repairing broken pumps or engines; and
- repairing or replacing broken taps, valves, or other controls.

Preventive and corrective maintenance plans should include estimates of required M&E for routine procedures, so that adequate inventory can be kept on-site or at regional maintenance shops. For major unexpected problems, facilities and trained personnel must be identified nearby to deal with all possible contingencies.

The purpose of system monitoring is to determine whether the system is operating properly, and if not, to take the appropriate action. Monitoring system performance involves comparing the system's actual performance with its operating standards. It requires regular periodic inspections of all system components and support activities to ensure that:

- proper operating procedures are being followed;
- preventive maintenance is being undertaken according to schedule;
- any needed corrective maintenance is quickly and properly done;
- stocks of spare parts and all necessary supplies are available when they are required; and
- the system is operating as it should.

To determine whether the system is operating according to design, physical quantities such as water volume and quality can be measured using flowmeters, tank gauges, and water quality testing kits.[79] Unless VWC members are personally responsible for system monitoring, they should meet on a periodic basis to review monitoring results, assess any problems, and audit the financial books.

Government water agencies may be responsible for O&M and may willingly undertake these monitoring tasks. If not, the VWC should take responsibility for them.[80] When technical or logistical problems are identified, the VWC should deal with them as soon as possible. If the

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[79] Water quality tests can be done either by water agency staff visiting sites once a year, or more simply by the VWC or system operator taking periodic water samples and sending them to a local government or private water quality lab for analysis.

[80] *Partners for Progress - An Approach to Sustainable Piped Water Supplies*, B. Appleton, M. Seager, P. Reina, Technical Paper Series No. 28, IRC International Water and Sanitation Center, the Hague, 1991.

VWC is unable or unwilling to do so directly, trained technicians should be brought in to assist. Regular inspections help ensure that small problems are dealt with before they become big (and expensive) problems.

9.3 Training and System Management

Rehabilitation projects should include training for beneficiary communities and other support personnel in:

- ***O&M management***—for preventive and corrective maintenance, and system monitoring;
- ***community organization***—for organizing the community (discussed in Chapter 5) or VWC to manage their system; and
- ***financial management***—for collecting, managing, and disbursing user contributions (for initial construction) or water fees (to cover O&M costs, discussed in detail in Chapter 10).

O&M procedures can require a variety of support personnel such as system operators, technicians, mechanics, welders, masons, carpenters, pipe fitters, sanitation and hygiene educators, community organizers, and bookkeepers. If these people are not readily available either in the community itself (which is unlikely) or through nearby private or public organizations, additional training may be required to assure that they are available when needed. During system planning at each site, do a basic training needs assessment of the community (and/or local private or public sector support agencies) to determine what skills are locally available to support the system. Active community participation in all phases of design and construction will help give them many skills which can be directly applied to O&M. It may also be necessary to train staff of government water agencies in certain technical and management skills. If training courses are given,[81] include local private contractors whenever possible. Periodic training must be conducted to update skills and replace skills as people leave the community.

Record keeping is an important part of O&M and financial management. It is important to keep good records (preferably in the office of the VWC or the local water agency) of standard operating procedures, maintenance and repair activities, and costs as they occur. These records should include updates of M&E inventory and storage procedures. This will allow the VWCs to better understand what their O&M requirements and associated costs really are. It will also help any technicians brought in from the outside to understand how the system

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[81] Training materials for many skills needed for technical, organizational, and financial management of rural water systems have already been developed by organizations such as WASH, CARE, and IDRC, so they need not be developed from scratch for each project. Contact these organizations for further information (see Bibliography).

works, and what problems were encountered in the past, and to diagnose the source of new problems as they occur.

Records should include day-to-day operation notes (e.g., hours per day of operation, amount of water delivered), dates and results of periodic inspections, descriptions of PM activities, descriptions of all repairs (including any needed parts, materials, and technical assistance), and any expenses associated with any of those items. VWCs should review these records periodically to see if any needs are being left unmet, and if so, to find out why. Financial records should be meticulously maintained and periodically audited. Where collected, user fees should be kept in local bank accounts which require more than one signature for withdrawal, to minimize the possibility of any diversion of O&M funds.

Communities in different countries deal with common expenses in different ways. Communities may be wholly or partly responsible for paying for their own system. External assistance may be available from the government, donors, or PVOs. However devised, the tariff structure for water user fees (if there are any) must reflect not only user willingness and ability to pay, but also be able to cover all O&M costs, including unanticipated major repairs. Some communities choose to collect O&M funds on a daily basis from each user as they draw their water (per container, per person, or per animal). Other communities use meters so that users are billed monthly based on consumption. Other communities collect fees only when funds are needed immediately for a repair. This last method is generally not recommended, since community members may not have enough money available to cover needed repair costs on short notice when a major problem occurs. It is usually preferable to establish a fund to cover unanticipated repair costs, financed by excess water fees not used for routine O&M. Although funds may be available from other sources to cover major repair costs (e.g., from donors, PVOs, government grants, or commercial or private loans), communities should not rely on such assistance. Financial issues are dealt with in more detail in the following chapter.

In even the best laid plans, situations may arise in which those responsible for a support task are either technically, financially, or organizationally unable to respond appropriately. For this eventuality, try to provide communities with whatever information and contacts are available about possible sources of external assistance such as local or international PVOs, or possible donor assistance not provided for in the original project plans.

Chapter 10

RESOURCE MOBILIZATION AND FINANCIAL MANAGEMENT

Financing for rural water supplies varies so widely from country to country (and even among regions within the same country) that it is useful to consider several common arrangements to see what impact they might have on rehabilitation. The following examples illustrate the range of financing arrangements in different countries.

- In Botswana, the government's Department of Water Affairs (or other government agencies in certain circumstances) takes total responsibility for providing water to villagers in all but the smallest villages. All system costs are financed by the government, including design, installation, operation, maintenance, and repair. Users are not charged water fees. Systems are well-managed, and coverage is high.[82]

- In Sudan, the National Corporation for Rural Water Resources Development (NCRWRD) pays for installation of village water supplies. However, villagers in most provinces are required to pay water user fees to support O&M costs. In fact, these fees are not only inadequate to cover actual costs, but are often diverted to support other non-water-related activities. Villagers often end up paying fees twice: once to the government water system operator, and again to a local village fee collector.[83] The latter fees are used to purchase fuel, parts, and skilled labor to keep existing systems running. New systems are rarely installed, and usually only through direct donor support. The system is on the verge of collapse.

- In Indonesia, the government is in principle responsible for providing water to villagers at no cost. However, limited resources and personnel often prevent small communities from receiving O&M support, or sometimes from having any system at all. Some communities take responsibility for financing their own systems, with technical assistance provided by PVOs such as CARE. Villagers organize themselves, mobilize resources, take out loans from banks or M&E suppliers if necessary, and build their own systems supervised by CARE technical staff.[84] Sustainability appears much better than average in developing countries.

Financing of rehabilitation projects will vary considerably in each of these situations. In Botswana, rehabilitation would involve little community participation or training, and would

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[82] *Small-Scale Water Pumping in Botswana, Volume I: Comparisons*, J. Hodgkin, R. McGowan, and R. White, WASH Field Report No. 235, December 1987.

[83] *Evaluation of the CARE/Sudan Interim Water Supply and Management Project*, R. McGowan and K. Burns, WASH Field Report No. 227, May 1988.

[84] *Rural Water Supply and Sanitation in Indonesia*, R. McGowan, D. Rahardjo, and N. Ritchie, CARE/Indonesia, Jakarta, June 1991.

likely involve only government technicians (or private contractors hired by the government) repairing or replacing existing system components. In Sudan, rehabilitation occurs in several ways. Politically well-connected communities have the clout necessary to have NCRWRD staff replace engines and pumps, and sometimes to drill new boreholes when existing ones have failed or have low output. Less fortunate communities may try to enroll in donor wateryard rehabilitation programs (similar to those of CARE/Sudan), where they are required to provide unskilled labor as their contribution to rehabilitation. CARE provides all necessary M&E (pumps, engines, pipe) without charge. Thereafter, ownership of the systems is held by NCRWRD, and villagers pay user fees just as in other communities. Less fortunate villagers simply have to walk further or move.

In Indonesia, the government water agency rehabilitates some village systems, but rehabilitation needs far exceed existing human and financial resources. However, since rural villagers in many parts of Indonesia (especially Java and Bali) are more affluent than their counterparts in Sudan, Indonesian villagers are often able to mobilize resources from within their own communities to pay for rehabilitation or system expansion themselves. Having a tradition of community self-financing for building mosques and roads, it is not surprising that this concept can be extended to water supplies. In cultures where there are weak traditions of self-reliance or expectations of government responsibility for providing water,[85] community self-financing can be much more difficult to promote.

Developing realistic financial support plans is fundamental to the success of rehabilitation projects. Lack of adequate O&M financing is a major cause of system failure and the subsequent need for rehabilitation. Financing plans need to be jointly developed and agreed upon by all interested parties if systems are to be sustainable. These plans need to address the following:

- capital and recurrent O&M costs;
- funding sources for local and foreign currency;
- contributions from communities themselves, government agencies, and donors, or more commonly, from all three sources; and
- procedures for assessing, collecting, managing, and disbursing funds for system support.

When water systems are installed with external funding, that funding typically draws to a close at the end of the project. Responsibility for continuing system costs then falls to the cooperating government agency or the community itself. It is at this transfer point that

[85] Although there may be cultural or religious barriers against doing so, people should be encouraged to view water like any other commodity, such as electricity. Politicians find it easy to develop constituencies by promising and sometimes delivering government-funded water systems, but few developing country governments can afford to expand coverage in rural areas to a great extent without grant or loan funds.

traditional water development projects all too often begin to fail due to inadequate financing. Numerous field assessments have recommended that beneficiary communities should participate in system financing from the very beginning.[86] When governments or donors cooperate to install a community water system with little or no involvement of the community members themselves, there is little sense of community ownership of the system. Without this sense of ownership, communities often are unwilling to take management or financial responsibility for keeping the system running. They may expect the government, donor, or PVO to continue to finance the system over the long term, regardless of the terms of the initial assistance agreement. If the external funding agency or the government is fully committed and able to provide all required funding over the lifetime of the system, this presents no problem. If not, and if communities are not willing to shoulder the responsibility, the system runs (often without proper maintenance) only until it needs repair, then falls into disuse.

10.1 Resource Mobilization

Most (if not all) water system rehabilitation (and new construction) projects now stipulate that communities should directly contribute to system costs. Contributions of 10 to 20 percent of the construction cost in cash or in-kind (labor, local materials) are typical. Communities are also often expected to contribute to O&M costs, often through payment of water user fees. In some cases, communities contribute 100 percent of all system costs, except for technical assistance and logistical support. A policy of requiring direct community contributions has two direct benefits:

- *Increased sustainability*—which helps develop the sense of ownership and responsibility so closely tied to a willingness to properly operate and maintain a water system; and
- *Expanded coverage*—which allows the limited financial resources of the donor, government, or NGO assisting the project to be spread over a greater number of communities.

While there are many physical reasons why water systems require rehabilitation (e.g., depleted water source, unexpectedly high-demand growth, natural disaster), the most common reason is lack of adequate financial resources to properly support the system. There are circumstances in which users simply cannot afford to contribute (at least in terms of cash) to system rehabilitation, and it may seem reasonable for the donor or government to simply pay all associated costs. However, unless they plan to continue paying all system costs for the foreseeable future, this is not a sustainable approach. There are many ways communities can contribute to their water systems:

- *Labor*—probably the most common form of community contribution. Communities are almost always required to provide all unskilled labor (e.g., for digging, carrying materials, and cooking meals for other laborers). Whenever possible, they should also

[86] For example, see *Final Evaluation of the Benin Rural Water Supply and Sanitation Project*, J. Chauvin, S. Plopper, and A. Malina. WASH Field Report No. 349, March 1992.

provide skilled laborers (masons, carpenters) or provide suitable people for technical training;

- *Cash*—local and/or foreign currency, either collected before construction takes place (recommended), or as user fees on a regular basis after the rehabilitation is completed. Cash can come from direct community contributions, by obtaining loans, or by selling commodities (crops), services, or simply labor; and
- *In-kind*—communities can provide local materials and equipment such as sand, stone, bamboo, bricks, lumber, and palm fiber for construction, or tools and animals for ditch or well digging and earth moving.

Communities may not always be aware of contributions they can make. It can be helpful to assist communities with resource mobilization through income-generation schemes (e.g., facilitating the sale of agricultural produce or stock animals, or developing small cottage industries) to help finance a water system. Sometimes, initial cash outlays can be covered by loans from banks, other formal or informal lending institutions, or M&E suppliers. For example, in Indonesia both commercial and government development banks make loans for community water supplies. Occasionally, pipe vendors are also willing to make loans for the purchase of large quantities of pipe for water systems. Community savings and loan associations exist in some areas which support community construction projects such as mosques, roads, or water systems.

Approaching donor agencies for assistance with water supply rehabilitation is often an implicit admission that the government and/or communities themselves do not believe that they have the financial and/or technical resources to undertake the rehabilitation themselves. In bilateral development projects, donors typically cover most (if not all) foreign exchange costs for M&E. Government water agencies may have separate budgets for capital development and O&M costs, but they are often inadequate for either function. Officials are under constant pressure to expand coverage to unserved communities, as well as to repair or expand existing systems. Well-planned rehabilitation and proper system O&M can ultimately reduce demands on both capital and recurrent cost budgets. Even if the cooperating agency is unable to financially support the development project, it may still be able to contribute engineering support, skilled labor, equipment, transportation, and fuel. Locally available M&E which can be purchased with local currency (e.g., pipe, locally fabricated water storage tanks, and cement) are also appropriate contributions.[87]

There are no straightforward rules to determine appropriate levels of community and government contributions to rehabilitation projects. Negotiated contribution levels must reflect a community's willingness and ability to pay, which are often much greater than has been traditionally assumed. Government contributions vary greatly from one country to the next,

[87] In Sudan, the government water agency provides only technical support for rehabilitation. In Indonesia, it provides M&E funding to support CARE's construction and rehabilitation work.

depending upon national priorities and availability of financing. If communities are reluctant to contribute, explore with them the following questions:

- What would the community do otherwise (without rehabilitation)?
- Would they continue using a distant or low-quality water source?
- What is it worth for them to avoid having to carry water several hours a day?
- Do they assign a cash value to women's labor for carrying that water?
- Are there any cultural or religious constraints about paying for water? How about for provision of water?

In many areas, people may be willing to pay for water quantity and accessibility, but not for better water quality. The level of awareness of the relationship between health, sanitation practices, and water quality are a good indicator of a community's willingness to pay for improved water quality. Social customs and traditions about payment for services such as water supply vary greatly among countries and cultures. Contribution levels may be based on any of the following:

- a per capita basis, which may count people, animals, or, more typically, both;
- equal contributions from each family, regardless of family and/or herd size;
- variable amounts depending on a person or family's ability to pay;
- a per-unit volume basis, depending on water quantity consumed;
- a basis of proximity to the public tap (i.e., families may be willing to pay more to have a tap located near their home);
- flat monthly rates or metered house connections; or
- some traditional method of allocating common expenses according to social ranking, and various indicators of ability to pay such as herd size, etc.

None of these are necessarily better arrangements than any other. Explore various possibilities with the community. Timing of fee collection can also be an issue. People may not be willing or able to pay on a regular monthly basis. For example, farmers may only be able to pay an annual assessment after the harvest. If possible, encourage regular collection of fees, so that the O&M fund is not caught short during a time when the community may not be able to raise cash quickly in the event of an emergency repair.[88]

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[88] Although communities in some places (e.g., Benin, Indonesia) have demonstrated an ability to collect large funds needed for repairs on short notice.

10.2 Financing Requirements

Financing requirements can be broadly divided into two categories: capital costs which must be paid up front to get the system working, and recurrent costs which cover O&M and needed repairs. Either may require local or foreign currency, typically both. If both, issues regarding foreign exchange rates and access to hard currency must be addressed.

10.2.1 Capital Costs

Here, capital costs are those paid to get the system back in working order. Capital cost requirements for rehabilitation projects fall into three broad categories:

- construction materials and equipment (M&E);
- labor (both skilled and unskilled); and
- logistical support (a broad item including all remaining costs such as transportation, communications, per diem, and other support costs).

Equipment may include well casing, pumps, engines, water storage tanks, pipes and pipe fittings, valves, and water meters. Materials may include cement, stone, sand, bamboo, wire, steel reinforcing bar, lumber, storage tank sealer, GI pipe joint compound, or PVC pipe cleaner and glue. Labor might include skilled laborers such as mechanics, pipe-fitters, masons, carpenters, foremen, and construction supervisors. Semiskilled and unskilled labor includes helpers for the skilled laborers, and unskilled labor for digging, moving materials, and other such work.

Logistical support costs include vehicles needed to transport M&E to the construction site, fuel, lubricants, any needed maintenance, and consumables such as drilling mud and bits. This may be a major cost if many trips with large trucks are required and distances are long. Additional support costs might include food, lodging, and water, although it is common for the community contribution to include meals and overnight lodging for skilled workers who live elsewhere. Village visits will also be required by project supervisory personnel to meet with villagers, supervise construction, and bring additional materials as required.

10.2.2 Recurrent Costs

Once construction and training are completed and the system is again operating, recurrent costs begin to occur. Recurrent costs include all operation, maintenance, repair, and replacement costs. These overlap somewhat, and may be defined differently for different communities. The distinctions can be important because of their financial implications. O&M costs include the cost of a water system operator (and all systems need one, including windmills, solar pumps, and gravity systems) and any other support staff needed. They also include the cost of fuel and lubricants, replacement drive belts, fixing minor pipe and tank leaks, and any other items normally required for smooth system operation. O&M costs typically also include preventive maintenance such as periodic decarbonization and overhauls for diesel engines, replacing any filter elements, cleaning the water storage tank and spring catchment, and replacing defective taps and valves.

Repair costs occur periodically when the system unexpectedly breaks down. Even with a well-trained operator and a good preventive maintenance program, breakdowns will occur (water distribution line breaks, tank failures, or engine and pump breakdown). Component replacement costs for pipelines, engine, pump, water storage tank, or major elements of the distribution system can be quite expensive. The goal is to minimize their occurrence.

10.2.3 Foreign Exchange and Local Currency

Pay particular attention to foreign exchange needs, particularly if the existing system failed due to the community or government's inability to obtain adequate foreign exchange. While local currency costs should be paid wherever possible from local sources, foreign exchange requirements can be more problematic due to unrealistic foreign exchange rates or legal restrictions. There may also be major recurrent cost components which require foreign exchange, such as for replacement parts, fuel, and vehicles. Although it may be possible to buy these items with local currency, their continuing availability and price may depend heavily on changing macroeconomic conditions within the country which may have a highly inflationary effect on prices in local currency.

If previous parts or fuel shortages were due to government trade or economic policies, the sustainability of the rehabilitation effort might be brought into question. If shortages were only a temporary aberration, providing a stock of spare parts for short-term O&M requirements may be necessary, but this is not a long-term solution. The system may again fail as soon as an unavailable spare part is needed. If this problem is not easily resolved, it may be necessary to consider much simpler systems with reduced levels of service for the community. If a lower level of service from a less expensive system is unacceptable to the community, the project may need to be abandoned. This may present an opportunity to leverage certain policy reforms, if the government remains supportive of the project's goals.

10.3 Willingness to Pay and Cost Recovery

Cost recovery is a key requirement for sustainability. Recent studies in many countries have shown that there is frequently a willingness on the part of water users to pay for services. The most obvious evidence of this is the proliferation of water vending in many urban and peri-urban areas.[89] Water vending is also common in small rural towns in many developing countries (see Figures 22 and 23). When planning rehabilitation projects, user willingness to pay should be determined in advance. In many rural communities with diesel-driven water

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[89] *Water Vending and Development: Lessons from Two Countries*, D. Whittington et al., WASH Technical Report No. 45, May 1988.

supplies, community members either pay a government agency for O&M services, organize themselves to cover these costs, or use some combination of the two. For example, in Sudan, the government policy is to pay all installation costs, and collect only modest user fees from communities for O&M. Water agency staff argue that it is in the government's interest to subsidize rural systems to help stem rural-urban migration.[90] Similarly, in Indonesia, water fees assessed by district governments are collected by the local water system maintenance agency and used to finance O&M.

Cost recovery typically includes only the recovery of O&M costs, but can cover other costs as well, such as the installed capital cost, the cost of major repairs, system upgrading or expansion, training costs, and any associated overhead costs.[91] These fees may be managed at the community level, or may revert to the district government water agency for its direct use, or revert to the provincial or national water agency budget. If community-managed user fees are designed to cover some or all of these additional costs, a large surplus will likely develop in the community's account during the first few (hopefully) trouble-free years of system operation.

It may be difficult or unwise to accrue a large cash surplus in the O&M account, since pressure may develop to use the savings for community development activities other than the water system itself (e.g., roads or mosques). It may be wise to make advance purchases of M&E needed in the future for system repairs (pipes, valves, spare parts) to prevent this. If villagers are aware that large reserves exist, they may also be unwilling to continue to pay user fees, even though the reserves may not be adequate to cover a major unexpected cost, such as replacing an engine. Community funds are sometimes diverted for private use; it is best to require multiple signatures for withdrawal of funds. If the user fee fund is substantial, consider using it as the basis of a savings and loan organization. Assuming loans are given at commercial rates, this will help reduce the impact of inflation on the fund.

During rehabilitation planning:

- Evaluate water tariff levels (if there are any) for the existing system, or those in the nearby region for similar systems;
- Estimate the cost of all current and future expenses related to the rehabilitated system;

[90] In fact, user fees collected at a village site often do not support the system for which they were collected. Instead, they are routed to the regional then national water agency, then directly added to the national budget for reallocation. How much actually makes it back down to the village level to support O&M is questionable. Villagers are often forced to collect a separate user fee to buy parts and fuel directly, where government support is not forthcoming.

[91] This is already being done in scores of communities in Indonesia which have been assisted in developing water and sanitation systems by CARE/International.

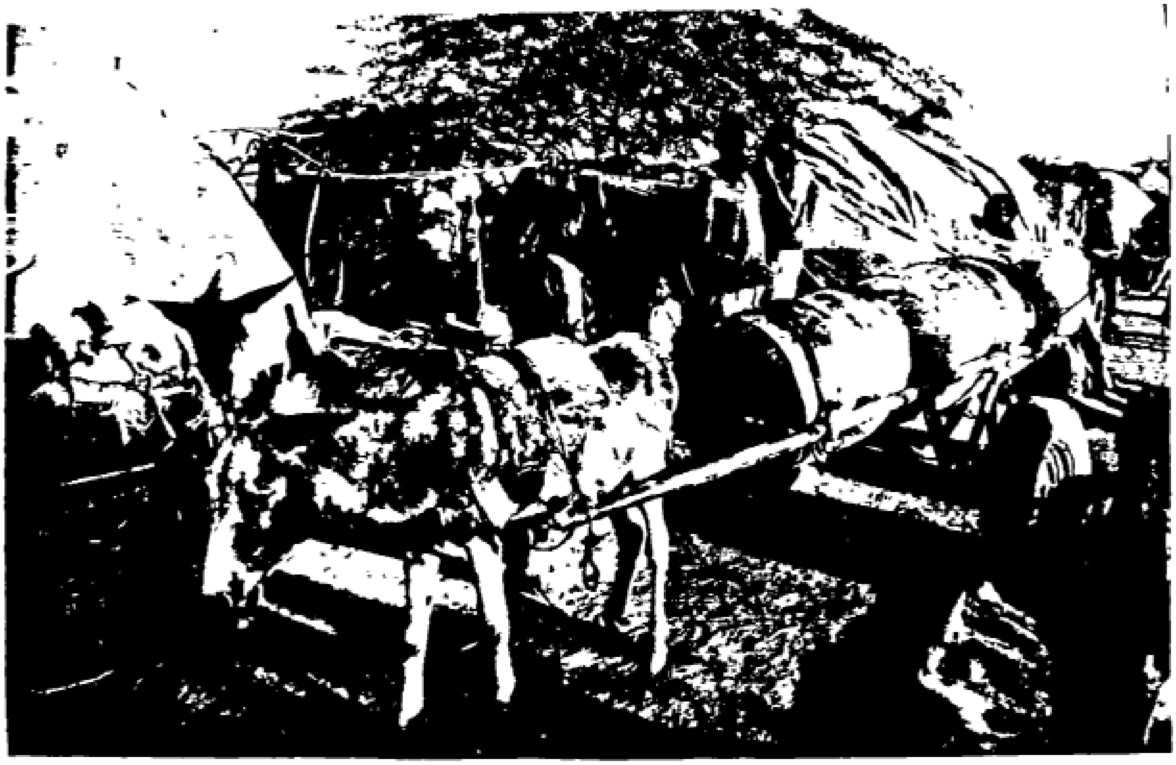

Figure 22

Water vending in a refugee camp south of Khartoum. Refugees from the war-torn South were paying triple what urban residents on the city main system were paying for their water.

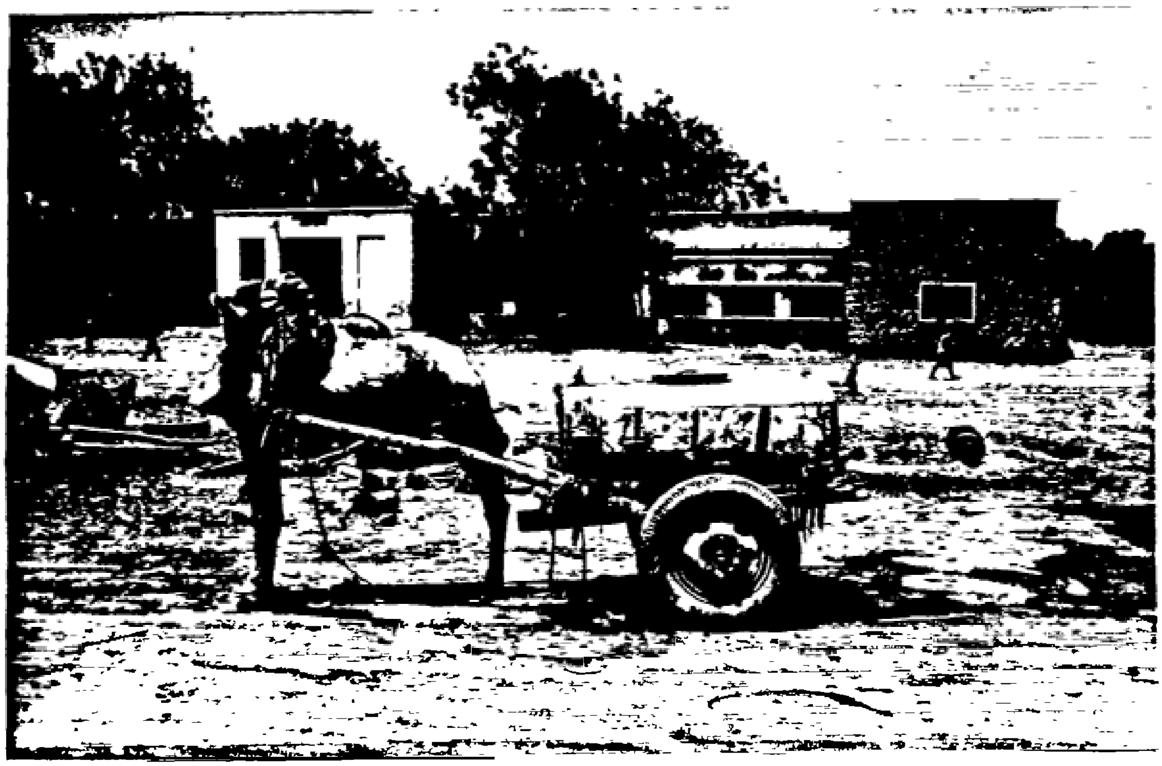

Figure 23

Water vending in a peri-urban area near Aden, South Yemen.

- Determine the appropriate level of community contribution to these costs, including any anticipated external subsidies; and

- Propose a minimum water tariff to the community for negotiation.

If villagers are expected to cover some but not all costs, other funding sources (e.g., government or donor subsidies, commercial or development bank loans, grants from other sources) must be identified and formally agree to cover any remaining costs.

10.4 Financial Management

The key financial management issues are who collects fees, who keeps what records, where the money is kept, and how funds are disbursed to cover incurred costs. The RRA should address financial management issues, and indicate if and how villagers are adequately organized to meet financial obligations, whether they can open an account at a financial institution, and whether the village water committee can qualify for credit to cover major expenditures. If villagers take no active role in financial management, then it is unlikely that rehabilitation will be sustainable. In most developing countries, rural villagers are likely to require training in the financial management of their water systems. This need not be a tedious or overly involved process. A series of simple yet effective skills and practices need to be taught to water committee members:

- How to develop a realistic plan for financing a sustainable water system;

- How to estimate system costs and subsequent water tariffs sufficient to cover expected costs;

- How to mobilize existing resources to pay for water systems;

- How to develop new community-based funding sources (e.g., sale of locally available commodities and labor) to finance water systems;

- How to equitably apply and collect water user fees,[92] proper bookkeeping procedures, the importance of keeping receipts for all goods and services, and the need for periodic audits;

- How and where to open a bank account, how to withdraw funds, and the importance of requiring multiple signatures for all withdrawals;

- How to approach commercial banks and other lenders (national development banks, M&E suppliers, village or district savings and loan associations) for loans—negotiating interest rates and payments, estimating the size of payments a village can live with,

[92] For larger systems, this may mean improved billing and collection systems, and the use of meters to assign direct responsibility for payment wherever feasible, particularly on all house connections. Some communities (in West Java, Indonesia) even use progressive water rates (with severe penalties—including cutting off the user—if maximum limits are exceeded) to encourage water conservation. Penalties must be enforceable somehow to be taken seriously.

determining what can be used for collateral, keeping track of loan payments and balances, and knowing what to do in case of default; and

- Where and how to seek assistance grants for helping communities to build water systems.

This training need not be developed from scratch for every project and for every country. Perfectly workable training programs already exist (e.g., those developed by CARE/International for its WS&S and primary health care projects). In some countries, legal issues (e.g., whether VWCs are legal entities for purposes of taking out commercial loans) may require clarification or even new legislation before certain funding arrangements can be used. Helping communities become good financial managers may not be an easy task, but without this skill, they will probably have difficulty independently managing and supporting their water system.

Chapter 11

THE REHABILITATION DECISION

This chapter summarizes the overall approach to deciding what to do at each prospective rehabilitation site. Based on the project objectives in Section 2.2, and the site selection criteria in Section 3.3, lists of candidate sites have been developed and prioritized. Based on social, institutional, technical, economic, and political information gathered during the RRA, an initial decision has been made to try and assist a particular community. Depending on the condition of its existing system, community needs, and resources available to the project and the community, one of the following options (given in generally increasing order of cost and complexity) must be chosen:

- *Repair*—identify and fix whatever physical component(s) directly caused the existing system to break down, and provide no further assistance;
- *Replace*—replace either major system physical components or the entire system, make any needed minor repairs, and provide no further assistance;
- *Rehabilitate*—repair and replace components as necessary, and provide necessary assistance to strengthen the system support infrastructure (for management, financing, community organization, and technical and logistic support for O&M) so that the system will be sustainable;
- *Expand*—repair, replace, or rehabilitate the existing system as required, and expand its capacity to account for increasing demand. This may require additional technical or financial assistance to increase the capacity of the support infrastructure as well; or
- *Provide no further assistance.*

The driving principle behind successful rehabilitation projects is sustainability. If rehabilitation projects are well implemented, someone else will not have to come back in several years and do the work all over again, just because critical inputs were ignored or overlooked. The choice of the appropriate option should clearly reflect the project's goal and objectives. While the project *goal* might be:

> **to provide safe, reliable drinking water supply to as many people as possible in a given area,**

one of the *objectives* might be:

> **to do this in the most cost-effective way possible, so that any community system receiving assistance will meet anticipated water demand for at least a five-year period afterward.**

The following sections recommend when and when not to choose each of these options.

11.1 Repair and Replacement

Besides the option of not providing any assistance at all, repair will generally be the least costly and simplest option. Here, repair means only dealing with the physical problem(s) which directly caused the system to fail. It may be as simple as replacing a piece of pipe, or as complex as completely rebuilding an engine or storage tank. No further assistance need be provided if the following conditions exist:

- A repair is sufficient to get the system operating again;
- It is determined that no additional assistance is needed to strengthen the support infrastructure; and
- The repaired system meets community needs in terms of water quantity, accessibility, reliability, and quality (both now and until the chosen project planning horizon).

This situation might occur if some unusual circumstance prevented the community (or another group normally responsible for repairs) from doing so, such as:

- An unexpected breakdown caused by natural disaster, damaging the system beyond the community's capability of repairing it;
- The community was unable to obtain the M&E needed to make the repair due to temporary political instability in the area disrupting supply;
- The normally very reliable technician who is responsible for fixing the system was unavailable for extraordinary reasons when needed; or
- The O&M fund, maintained on a regular basis with good community support, was at its seasonal low point (e.g., just before the annual harvest in a farming community) and there was insufficient money to buy the part and hire a technician to fix it, or someone absconded with the community's O&M fund.

Repair is generally the least expensive option to get the system running again. However, fixing one problem may simply make another problem more obvious, requiring further assistance. The initial problem may have been due to a weakness in system design or infrastructure support. Repairing a system without addressing the underlying problem of why the community or the responsible government agency did not do it themselves is only appropriate when there has been some unusual circumstance. If a community has a history of needing repairs and not being able to finance them, find out why money either wasn't being collected, or was collected but used for other purposes.

If basic repairs will not solve the problem, it may be necessary to replace major system components, or the entire system. Replacement may be appropriate if:

- Major component or system replacement is sufficient to get the system functioning again;

- The support infrastructure appears otherwise adequate, so that the system will be sustainable after component replacement; and

- After replacement, the system meets community needs in terms of water quantity, accessibility, reliability, and quality.

As in the case of repair, there are several reasonable explanations why component replacement may be an adequate response. The replaced component(s) may have failed due to:

- a catastrophic failure (e.g., a landslide or flood);

- poor system design with poorly matched components;

- old or obsolete equipment which can no longer be supported;

- shoddy construction practices; or

- a system so complex or expensive that the community (or other responsible group) could not support it due to either technical, financial, or management constraints.

Much of the system may be perfectly functional, and so may continue to be used (if it makes sense to do so) without incurring additional and unnecessary component replacement costs. Depending upon the actual expense involved, replacing one or more system components may not be the most cost-effective way to meet community water demand over the five-year planning horizon.[93] For example, the system may be poorly designed, use obsolete equipment for which spare parts are no longer available, or be unable to meet anticipated demand. If so, it may be necessary to replace the entire system. In some pumped water supplies, it may be difficult or even impossible to obtain proper spare parts for the original equipment since the manufacturer went out of business or could not be accessed for reasons outside the control of the community.[94] If so, communities may have little recourse but to replace major system components which might otherwise only need one part to work again. This is one of the strongest arguments for equipment standardization. If the system is too difficult or expensive for the responsible group to support, it may be necessary to replace it with a simpler (and less costly) system, possibly even reducing the level of service provided to the community.

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[93] If that is the planning horizon being used for the project.

[94] In Somalia, pumped water supplies have been supplied by a wide variety of donors over the years. Since Somalia has switched from being a client state of the West, then of Communist Bloc countries, then of the West again, an astounding variety of engines and pumps from Poland, Italy, Britain, China, Japan, West Germany, East Germany, Denmark, and the United States are found in different Somali communities. In the past, it was difficult to obtain parts for all the different makes and models. With the recent civil war, it became simply impossible. Whenever a critical part needed replacement, it was often necessary to replace the entire pump or engine, a costly procedure which could have a devastating effect on a small community's financial well-being.

When component replacement is an acceptable choice, it is sometimes better to replace the failed component with one of larger capacity to deal with increased demand.[95] Whatever option is chosen, be sure not to underestimate future water demand (especially if increased level of service such as house connections is planned). Take into account anticipated population growth rates in the community, possible changes in per capita consumption, and secondary consumption such as animal herds, gardens, or small-scale manufacturing operations which may arise.

11.2 Rehabilitation

If repairs or replacement are not sufficient to create a sustainable system with adequate capacity, rehabilitation may be necessary. That means looking beyond the physical source of the system failure, and modifying the support infrastructure as required. Determine whether suitable preventive and corrective maintenance programs were developed, and if they were being followed. Be certain the community and other responsible support agencies understand, agree with, and have adequate resources to implement those programs. Determine if proper monitoring procedures were carried out, and if not, why not. In addition to repair and replacement, rehabilitation may also require:

- Additional training of those responsible for various aspects of system support;
- Reallocation of system support responsibilities to those more willing and able to accept them; and
- Identification of other funding sources, including grants from the government or external donors, loans from banks or M&E suppliers, or increased financial support from the beneficiary community in terms of water user fees or other contributions.

If they do not already exist, VWCs should be organized so that communities have an institutional structure for managing, operating, maintaining, repairing, and financing their systems. Training communities in basic O&M (the basis for the village-level O&M or VLOM concept) is important to help ensure sustainability. The need to bring in outside technicians will be greatly reduced by training user groups in simple maintenance and repairs. Access to reasonably priced M&E may also be a problem, particularly in outlying areas or in those experiencing political or economic instability. If suitable M&E distribution systems are not accessible, it may be necessary to use another type of system[96] which can be locally supported.

[95] For example, if there is a deteriorating section of pipeline which must be replaced anyway, consider replacing that section (or even the entire pipeline) with larger diameter pipe which can greatly increase system capacity to meet growing community demand at a modest incremental increase in overall cost.

[96] For example, if it is difficult to guarantee a reliable and reasonably priced diesel fuel supply, the community may have to consider using another type of system such as handpumps.

Where public sector support is weak, assess the capability of the local private sector to provide all necessary supplies and technical and management skills regularly and reliably. If the supplies and skills are inadequate, it will probably be difficult, expensive, and time-consuming to try and develop that infrastructure from scratch. Therefore, consider using another type of system requiring a lower level of external support. If there is a promising (but not yet fully developed) capability within the local private sector, work with M&E suppliers and local technicians to assure them that adequate markets do exist to make it worthwhile to extend their services to more remote areas. Make sure that the rehabilitated system meets the community's needs, and not just those of the project. Of course, any project intervention should include plans to mitigate the adverse environmental impacts of construction.

11.3 Expansion

It is common for a community to have a well-functioning water system which no longer meets the demand, either in terms of per capita consumption or level of service. This may be due to the following:

- *Source limits*—the yield of the existing water source may be insufficient. If so, expand or supplement the yield of the existing source.
    - For a borehole, clean, deepen, widen, or redevelop it, or drill a second borehole to feed the system.
    - For a spring catchment, build an infiltration gallery, build a larger catchment tank, or tap an adjacent spring.
- *System limits*—the system may not fully utilize its existing source. Pipeline diameter may reduce available flow, small tanks may not provide enough storage, filtration systems (e.g., slow sand filters) may have insufficient capacity and bottleneck the system. Expand or replace the constraining component(s).[97]
- *Water wastage*—implement water conservation measures to meet surplus demand. Not only will this strategy minimize construction costs, but it will reduce adverse environmental impacts by minimizing wastewater production and the need to construct facilities to deal with it.
- *Cost constraints*—increasing level of service (e.g., from public taps to household connections) can be expensive and can overtax system capacity. It is recommended that level of service be increased *only* if beneficiaries are willing to absorb the full cost thereof.

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[97] For handpumps, this may mean installing a second handpump on an existing covered hand-dug well.

Make sure that the expanded system can be adequately maintained by the existing support infrastructure. Larger systems may require training more local operators and technicians to maintain the system. Include discussion of system expansion design in on-the-job technical training during construction. Villagers may not realize that certain engineering problems will occur if they decide to modify the system on their own without suitable technical assistance. Unless the community has been trained in system design and construction,[98] they should be encouraged to obtain external technical support from trained government agency staff, or to hire private contractors who have a demonstrated capability to construct systems at a reasonable cost.

11.4 No Further Assistance

Sometimes the situation in a particular community may not lend itself to assistance. It may not be possible to rehabilitate or replace a water system so that it adequately addresses community needs. It may not be possible to identify a suitable secondary water source near enough to the community to develop. Unresolvable internal community conflicts may sabotage any water development efforts. The national, regional, or local economy may be in such poor condition that local financial resources are simply not available to support water systems over the long term. In these fortunately rare cases, consideration should be given to excluding such communities from project assistance. This is a difficult but sometimes necessary decision to make. It may well save government agencies, PVOs, donors, and everyone else involved from a lot of problems over the long run. Sites which should be eliminated from consideration during the site selection process are those in which:

- there is no suitable water source, or none which can be developed without excessive expense;
- crucial components of the support infrastructure (mechanics, spare parts and fuel, money) are not locally available and are unlikely to be in the near future; or
- no one is willing or able to accept responsibility for maintaining the system.

11.5 In Closing

Whatever option above is chosen (except the last), make certain that all responsibilities (especially financial ones) are clearly specified and accepted by all parties prior to initiating any procurement or construction for a particular site. Project preparation decisions should include agreement upon how and to whom the improved system is to be legally turned over after completion of the project. Long-term financing should come from the beneficiary community as far as possible (with or without assistance from external support agencies). Some minimum level of self-financing should be a precondition for project activity in any community. Where

[98] At the level they have been, for example, in CARE/Indonesia's series of community self-help water supply and sanitation projects.

financial responsibilities are divided among several groups, provision should be made about unanticipated cost overruns, who will cover them, and whether there are maximum ceilings on the contributions of each participant. External support agencies should make clear the maximum extent of their participation, as limited by total project funding and the desire to maximize coverage across numerous communities.

Developing cost-effective rehabilitation plans responsive to community's needs will maximize the potential for long-term sustainability, so that some other agency will not have to come back in a few short years to start all over again.

Appendix A

THE RRA APPROACH

The Rapid Rural Appraisal is an information-gathering approach which is useful in reaching decisions about rural water systems. Carried out by multidisciplinary teams, this method has the following salient characteristics:

- ***semi-structured***—questions can be tailored to the particular situation as the RRA proceeds;
- ***field-based***—the emphasis of the approach is on informal field interviews and discussions; and
- ***triangulated***—emphasis is placed on investigating each aspect of the situation in a variety of ways.

RRAs attempt to identify the relationship of the community to the water supply system, as well as ongoing patterns of O&M. RRAs would typically require several person-days per site (a small team of two to three persons could complete each site in one day) to adequately answer the questions given in Chapter 4. This information is used to identify critical constraints and to suggest mechanisms for overcoming these constraints. Although RRA techniques should be flexible, certain conditions should be followed:

- A multidisciplinary team should include at least a social scientist and an engineer/technician. A designated team leader should assign tasks and coordinate findings.[1]
- All relevant existing data should be assessed by the team before field visits, to help focus the RRA questioning by identifying missing information.
- Key questions are first developed, and community responses then indicate further lines of questioning. Interaction between interviewers and respondents should be encouraged so villagers see that interviewers understand their answers.
- Each interview should have both an assigned leader and a person selected to take notes, recording answers to the questions asked.
- An appropriate time and location needs to be selected for each interview. If a respondent is being asked to speak frankly and openly, it may be best to take a walk with him/her to inspect some component of the water system. Timing should be at the convenience of the respondents, with no interview lasting more than an hour.

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[1] Depending on project resources, it may be advisable to include other persons in the team, such as a specialist in women's issues.

In conducting semi-structured interviews, follow these guidelines:

- Start the interview with traditional greetings in the local manner and observe local customs.
- State who you are and what you have come to learn. Here, you want to learn about the water system and the village, in order to make a decision regarding whether or not to rehabilitate the system.
- Have the general line of questioning in mind so that you don't need to refer to a list.
- Begin questioning by referring to someone or something concrete and specific rather than abstract. Do not ask leading questions (where the answer is likely to be determined by the way the question is asked).
- Probe each subtopic using six prompts—Who? Why? What? Where? When? and How?
- Lead up to sensitive questions, holding these until the end of the interview. The description and history of the water system is usually a good starting point, holding questions about community conflicts or finances until near the end of the interview.
- Finish the interview politely, thanking all respondents.

Following are some of the approaches used in the RRA method:

- Group interviews, which are an effective way to obtain information and a cross-section of opinion. Information regarding the history of the pumping system, recent operational difficulties, and village water needs can be explored in this way.
- Participant observation, which is a valuable means of collecting information. Team members should be aware of the procedures, leadership, participation, and politics of any village meetings they attend.
- Interviews with key informants or knowledgeable villagers can provide the answers to particular questions. For example, pump operators will have specific information not available from other individuals. Where possible, cross-check information to confirm it, or perhaps reveal important issues and conflicts.
- Direct observation of objects, events, processes, and relationships: recording observations and drawing diagrams, visiting physical structures, walking along the distribution system with a key informant, and interacting with others along the way.
- Interviews with ordinary, individual villagers, whose perceptions can provide valuable insight concerning their needs and information collected from key informants.

Appendix B

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Camp Dresser & McKee International Inc.
Associates in Rural Development, Inc.
International Science and Technology Institute
Research Triangle Institute
University Research Corporation
Training Resources Group
University of North Carolina at Chapel Hill

WASH Operations Center
1611 N. Kent St., Room 1001
Arlington, VA 22209-2111
Phone: (703) 243-8200
Fax: (703) 243-9004
Telex: WUI 64552
Cable Address: WASHAID

THE WASH PROJECT

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (A.I.D.) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH). The funding mechanism was a multi-year, multi-million dollar contract, secured through competitive bidding. The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc. (CDM), an international consulting firm specializing in environmental engineering services. Through two other bid proceedings since then, CDM has continued as the prime contractor.

Working under the close direction of A.I.D.'s Bureau for Science and Technology, Office of Health, the WASH Project provides technical assistance to A.I.D. missions or bureaus, other U.S. agencies (such as the Peace Corps), host governments, and non-governmental organizations to provide a wide range of technical assistance that includes the design, implementation, and evaluation of water and sanitation projects, to troubleshoot on-going projects, and to assist in disaster relief operations. WASH technical assistance is multi-disciplinary, drawing on experts in public health, training, financing, epidemiology, anthropology, management, engineering, community organization, environmental protection, and other subspecialties.

The WASH Information Center serves as a clearinghouse in water and sanitation, providing networking on guinea worm disease, rainwater harvesting, and peri-urban issues as well as technical information backstopping for most WASH assignments.

The WASH Project issues about thirty or forty reports a year. WASH *Field Reports* relate to specific assignments in specific countries; they articulate the findings of the consultancy. The more widely applicable *Technical Reports* consist of guidelines or "how-to" manuals on topics such as pump selection, detailed training workshop designs, and state-of-the-art information on finance, community organization, and many other topics of vital interest to the water and sanitation sector. In addition, WASH occasionally publishes special reports to synthesize the lessons it has learned from its wide field experience.

For more information about the WASH Project or to request a WASH report, contact the WASH Operations Center at the above address.