United Nations Children's Fund

Programme Division

Technical Guidelines Series

Towards better programming

A Water Handbook

Water, Environment and Sanitation Technical Guidelines Series - No. 2

Water, Environment and Sanitation Technical Guidelines

Towards better programming

A water handbook

United Nations Children's Fund
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A Water Handbook

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This Water Handbook is the second of the Technical Guidelines Series prepared by the Water, Environment and Sanitation Section, Programme Division, UNICEF. Titles of all publications in this series are printed at the end of this Handbook.

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Preface

UNICEF Programme Division is pleased to present the Water Handbook - part of the guidelines series on water, environment and sanitation. The Water Handbook is the result of wide collaboration within UNICEF, and provides a broad overview of state-of-the-art programming for water management, protection and supply.

The original programme guidelines for WES were produced more than ten years ago and stressed what was at that time UNICEF's principal activity in the sector: drilling and handpump technologies. These programming areas remain important and thus continue to be covered in the new Water Handbook. However, in recent years other priorities have emerged from lessons learned over the decade that have changed programming in the sector. These new areas are reflected in this handbook - and in the guidelines series as a whole - and include the importance of community management of water resources and the need for cost-effective solutions and, perhaps most importantly, the need to promote commitment and involvement in sectoral issues from the highest levels of government to the smallest communities .

This handbook continues to be, above all, a practical guide for implementing the operational strategies outlined in the Board-approved WES Strategy Paper (UNICEF Strategies in Water and Environmental Sanitation - E/ICEF/95/17). As such, it is an important tool for field professionals implementation of UNICEF Programme Priorities and the acceleration of progress towards the goals established at the World Summit for Children.

We in Programme Division look forward to receiving your comments on this publication in particular and suggestions and ideas on how to improve our support to WES interventions in general.

Sadig Rasheed
Director, Programme Division
UNICEF New York

Acknowledgments

This publication is the product of broad consultation and collaboration. UNICEF Programme Division would like to particularly acknowledge the contributions of Greg Keast and Ken Gray who collaborated in the creation of this document.

The following people provided contributions, in many forms, that were invaluable in producing this handbook: Colin Davis, Brendan Doyle, Gourisankar Ghosh, Colin Glennie, Christian Hubert, Shamshul Huda, Silvia Luciani, Luzma Montano, Marjorie Newman-Williams, Ashok Nigam, Mary Pigozzi, Dipak Roy, Jane Springer, Rupert Talbot, Vanessa Tobin, Phillip Wan.

A number of existing documents have influenced this work, and have been drawn from for both ideas and examples. Thanks go to the many UNICEF country offices that provided valuable background material for the document.

Finally, to all those too many to name whose contributions have made this a better publication, Programme Division extends its grateful thanks.

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Notes on the use of this Handbook

The Water Handbook is part of a series of modules which were written with the objective of assisting UNICEF programme and project officers in the operationalization of the new WES strategies as presented in: *UNICEF Strategies in Water and Environmental Sanitation.* Although UNICEF POs working with water-related programmes at the country and sub-country level are the primary target of this handbook, it is also useful for Representatives and other UNICEF staff members, in addition to government and NGO partners.

Ideally, *UNICEF Strategies in Water and Environmental Sanitation*[1] should be read prior to using this handbook.

Before proceeding to a specific section of interest in this handbook, Section 1 *Water and Sustainable Development* should be read first. For the reader interested in gaining a general broad understanding of the issues pertinent to UNICEF-assisted water programmes, the entire handbook should be read. For other readers, any individual section can be read as each section is self-contained and can stand on its own.

At the end of each section a set of a summary points has been provided to assist the reader in reviewing the section or of getting an idea of the contents of the section.

Text boxes have been used extensively throughout the handbook. The boxes contain excerpts from case studies or other documents related to the section material and are intended to further illustrate or broaden the material presented in the body of the handbook.

Primary references for additional reading are presented in the bibliography at the end of the handbook. Full details of all references in the text can be found in the bibliography.

[1]Available from UNICEF, PD/WES, E-mail: wesinfo@unicef.org

1. Water and Sustainable Development

A. Water Resources: A New Focus

The focus of activities in the drinking water sector since the 1960s has been the provision of safe and reliable sources of water to unserved segments of the population. The need for water was often urgent, and many UNICEF country water programmes emerged from drought relief programmes. Initially, the primary problem faced by many domestic water supply programmes was overcoming limitations in the availability of water, and the solution was predominantly technical in nature. If there was no acceptable surface water available, new technology was introduced (or existing technology from other sectors - such as the petroleum industry - was adapted) to tap deep groundwater aquifers. When this was achieved, the focus shifted to making the technologies more efficient and cost effective, and more appropriate to national and regional conditions and capabilities. Although work in this area is far from completed (drilling and handpump technologies continue to be improved, and alternative technologies such as rainwater harvesting and filtration of surface waters continue to evolve), UNICEF programme emphasis is tending to move away from technology and towards software aspects of water supply. Much of the work in this area has focussed on maximizing health and other benefits from water through the synergistic integration of water supply with sanitation, health and education programmes, and striving for long term self-sufficiency through the empowerment of communities to manage their own water supply schemes (see subsequent sections in this module).

In recent years some of the gains made in the provision of safe water are being threatened by over-extraction, competition and environmental pollution. In many regions throughout the developing world, sources of water traditionally available in abundance for domestic use is now disappearing. As technological advances were being made in the drinking water sector, parallel advances were being made in the irrigation sector. These advances,

The Dublin Statement on Water and Sustainable Development (excerpts)

Scarcity and misuse of fresh water pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past...

The Conference participants call for fundamental new approaches to the assessment, development and management of freshwater resources, which can only be brought about through political commitment and involvement from the highest levels of government to the smallest communities. Commitment will need to be backed by substantial and immediate investments, public awareness campaigns, legislative and institutional changes, technology development, and capacity building programmes. Underlying all these must be a greater recognition of the interdependence of all peoples, and of their place in the natural world.

From: *International Conference on Water and the Environment: Development issues for the 21st century*, Jan. 1992, Dublin, Ireland (World Meteorological Organization, publisher) together with the increasing demand to produce more food and cash crops from the same land has led to massive programmes of intensive irrigation in many countries. While the technology has allowed drinking water to be pumped from the ground through a borewell and handpump at the rate of thousands of liters per day, the same technology has provided the means to pump hundreds of thousands of litres per day from irrigation borewells (or from surface water sources, whose depletion ultimately affects the groundwater aquifers). Parallel to the over-exploitation of water is an alarming increase in the pollution of water from industry and agriculture, and from other sources. As a result, some handpumps which once provided clean water are now abandoned because of quality problems and people are forced to return to ponds and streams (which are also likely to be more polluted than they were 10 or 20 years ago) for their drinking water needs.

In the coming years, the challenge in the sector will be to promote and facilitate the management of water resources to achieve an equitable balance between competing consumers. Work in this area will not be purely technological in nature (although water management methodologies are assisted by technologies such as artificial recharge of aquifers, groundwater mapping techniques, rainwater catchment, etc.): they will be more in the social, economic and political realms. And, as has been the case for other activities and programmes, the focus will be on the management of water resources by the community itself. As communities acquire the tools and knowledge to manage local water resources, they will increasingly have a stronger voice in influencing factors and events outside of the community which affects the community's water balance.

B. Community-Based Management of the Water Environment [2]

Integrated water management can only be possible if the community is empowered through decentralization and is free to make decisions on their natural resource management. The four main important resources are land, water, livestock and forest which form the village ecosystem. Without a balanced management of all of these four basic resources, the development process cannot be sustainable. The development programmes must be built around a sound land-water-forest-livestock oriented model with decision making at the micro-level.

Rural water supply should not be treated as a mere service delivery process but as a step towards household water security. Water security requires household, community and national actions to protect and preserve water sources, to use water as a scarce resource and to ensure its equitable supply. Investment in the capacity building of the community in planning, development, implementation and maintenance of the water supply project is one of the first steps toward sustainable development. To analyze the complete socioeconomic

[2] Excerpted from the outline of the presentation "Community-Based Management of the Water Environment" to the World Bank, by Gourisankar Ghosh, Chief, Water Sanitation and Environment Cluster, UNICEF. December 1996.

impact of a water supply, sanitation and hygiene project, the full impact should be taken into consideration. They include less disease, better education for children (particularly girls), better nutrition for mothers and children, time energy saving for women and secure livelihoods. To achieve maximum impact through water and sanitation interventions in rural communities there is a need for multilevel and intersectoral actions.

The UNICEF conceptual model for water and environmental sanitation (see *UNICEF Strategies in Water and Environmental Sanitation*) identifies the conditions that have a bearing on achieving the desired outcome at three levels---structural, underlying and immediate. The structural conditions relate to natural, human and economic resources. In order to influence underlying conditions, it is necessary to have social and gender equity in the availability, access and control of these potential resources. The resources need to be organized to cultivate an empowering environment by promoting and supporting self-motivation, building skills, communicating knowledge and aligning social service systems.

The only way the goal of sustainable development can be achieved especially in fragile eco-regions is through deepening democratic values and participation at the grassroots level. Institutional decentralization along with empowerment will ensure the survival base of the rural economy and will promote growth.

Freshwater Management and Attitudinal Change: Emerging Elements of New Thrust with Old Roots

For centuries water resources have been managed by communities themselves and they have sustained those living on it. What is now different is that there is increasing pressure on these resources as a result of advances in technologies for their rapid and widespread exploitation, population growth, pollution, and emphasis on increasing consumption rather than conservation. In many parts of India, it was seen that in the absence of these new factors, there was a natural ecological balance that seemed to prevail. However, with the introduction of unregulated technology and market forces in the productive sectors, this balance has come under strain. In the past, many communities had found ways and means of storing and conserving water through catchment protection, small check dams, and growing the types of crops that they could with the available supply of freshwater resources from surface sources.

There are clearly many lessons to be learned from the old paradigm on sustainable utilization of freshwater resources. While most communities are well aware of the possibilities and constraints that they face, what is far less within their control is those imposed from outside and other levels. In the design of strategies and actions within the new paradigm which has old roots, it will be necessary to learn lessons at the micro level which will be specific to particular eco-regions. It is from these lessons that there can be policy formulation and integration at higher levels and across sectors. Thus for example, some of the lessons that are emerging through a focus on freshwater issues in India in the case studies being sponsored by UNICEF and WWF relate to:

- technology choices and support to technology development - promotion of catchment protection, bunds, small check dams, storage reservoirs, rainwater harvesting - in addition to borewells;
- community awareness of its freshwater resource potential and sustainable rates of extraction;
- community mechanisms, including building institutions and capacities at the local level to manage freshwater resources;
- advocacy and actions at higher levels to influence policy making towards sustainable management of water resources at the community level;
- financing of actions needed at the community level;
- actions and market signals for regulating and ‘pricing’ water resources for sustainability;
- linkages between agricultural prices, price of water and rates of extraction;
- mitigating the impact of fertilizers and pesticides on the soil and use of more environmentally products;
- more efficient utilization of water for irrigation;
- pricing water for irrigation, manufacturing and drinking and designing and using appropriate mechanisms for this purpose;
- defining legal and property rights and issues on ground water and riparian rights for surface water;
- defining and enforcing standards for waste water discharge by manufacturing processes and charging and recovering costs of treatment.

From: *Towards Sustainable Financing of Water Supply and Sanitation Through Community Based Management of the Water Environment*, A. Nigam, UNICEF, 1996

C. Water and Health

Historically, the principal justification for water supply projects has been to improve health, and the link between water and health has long been understood. In the 1960s and 1970s, most water supply projects focussed on the improvement of water quality which, in itself, was expected to eliminate many of the developing world's most prevalent and debilitating diseases, as illustrated in the table below.

Water and Health: the View from 1966

Estimated Potential Reduction of Water-related Diseases in East Africa	
Diagnosis	**Percent Reduction Expected if Water Supply were Excellent**
Guinea Worm	100
Typhoid	80
Schistosomiasis	80
Trypanosomiasis	80
Trachoma	60
Dysentery	50
Diarrhoea of the Newborn	50

From: "Bulletin of the World Health Organization" , Vol. 63, No. 4, September 1985

While there were some successes registered with this approach, experience began to suggest that the implementation of purely technical measures to improve the quality of water did not go nearly far enough, that, for example, a safe source of water will not *automatically* ensure that there will be a 50 percent reduction in diarrhoea (which is among the biggest killers of children worldwide).

Near the beginning of the International Drinking Water Supply and Sanitation Decade (IDWSSD), more emphasis began to be placed on the different disease transmission mechanisms and their interruption (see table below). In addition, studies started to suggest that increasing the quantity of water available for domestic and personal hygiene was at least as important - or more important - than improving the quality of water. And the quantity of water used by consumers is directly related to the distance to the water source, thus reinforcing the need to have water points as close as possible to households.

The importance of sanitation was also now recognized. In practice, however, the majority of resources continued to be channeled towards water supply alone.

Disease Transmission Mechanisms

Transmission Mechanism	Diseases (examples)	Preventative Strategy
Water-borne	Diarrhoea, Cholera, Typhoid	- improve water quality - prevent casual use of other unimproved sources
Water-washed	Roundworm (Ascariasis), Trachoma, Typhus	- improve water quantity - improve water accessibility - improve hygiene
Water-based	Bilharzia (Schistosomiasis), Guinea worm (Dracunculiasis)	- decrease need for water contact - control snail populations - improve quality
Water-related Insect Vector	Malaria, River Blindness (Onchocerciasis), Sleeping Sickness (Trypanosomiasis)	- improve surface water management - destroy breeding sites of insects - decrease need to visit breeding sites - remove need for water storage in the home or improve design of storage vessels

From: *Evaluation for Village Water Supply Planning*, Cairncross et al., 1981

As the IDWSSD progressed, further studies suggested that water supply, even when combined with sanitation, was relatively ineffective as a health improvement measure without a well-integrated hygiene education programme.

Still, however, most projects continued to emphasize water supply alone with sanitation and hygiene education as relatively minor and under-funded components. The main reason for this was that most sector professionals were engineers and hydrogeologists with little experience that could be applied to the design and implementation of meaningful sanitation and hygiene education programmes. In addition, health impact studies yielded few definitive conclusions that could "prove" in quantitative terms the relative importance of water, sanitation and hygiene education. Even to date, comprehensive and conclusive health impact studies of water, sanitation and hygiene education have proven to be notoriously difficult to design and interpret, and expensive to implement.

In the 1990s, experience from many projects, and the cumulative results from an increased number of health impact studies (taken together to compensate, partially, for the inconclusiveness of most individual studies), have led to a consensus among most sector professionals that:

- isolated water supply interventions are not effective in the prevention of disease;
- sanitation alone has a larger impact on health than does water alone;
- hygiene education, together with sanitation, has more of an impact on the reduction

of diarrhoea than does water (because many of the causes of diarrhoea are not water-borne);

- improvements in the quality and quantity of water in communities continues to be important for public health, if implemented together with effective sanitation and hygiene education programmes.

As a consequence of this thinking, sanitation and hygiene education are now becoming at least as important as water supply in UNICEF-assisted programmes, and resources are being allocated (and appropriately qualified professionals posted) accordingly. Water continues to be important in public health programmes as a component of integrated WES programmes, and as a necessary precondition to all hygiene education programmes (which are impossible without water) and most sanitation programmes (especially in societies where water is culturally necessary for excreta disposal).

Potential Relation between Water and Sanitation Interventions and Morbidity from Selected Diseases

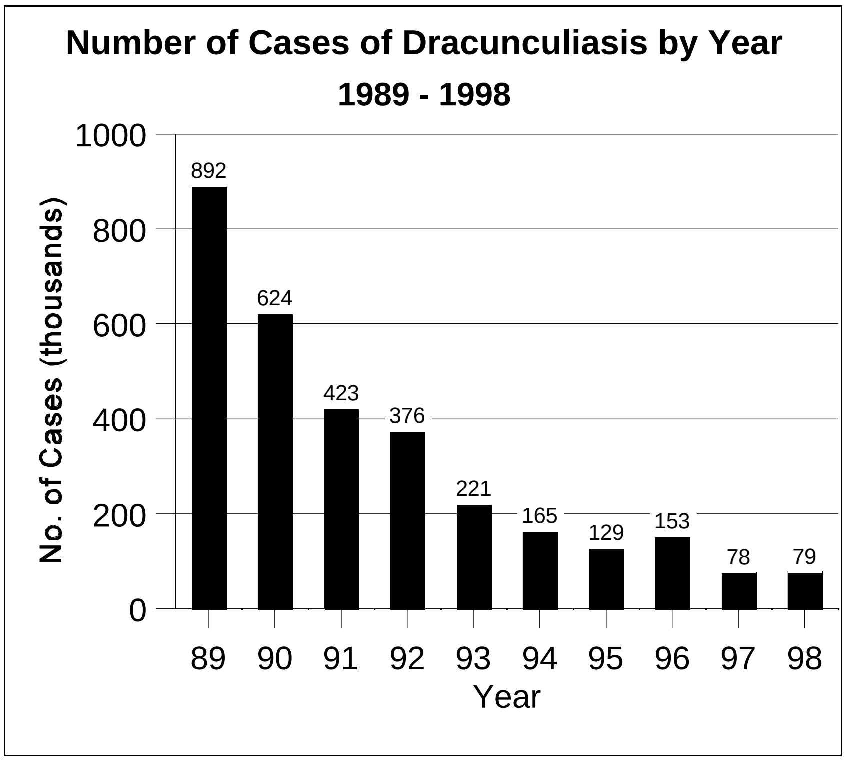
	Intervention			
	Improved Drinking Water	Water for Domestic Hygiene	Water for Personal Hygiene	Human Excreta Disposal
Ascariasis	+	++	-	++
Diarrhoeal Diseases	+	++	++	++
Dracunculiasis	++	-	-	-
Hookworm Infections	-	-	-	++
Schistosomiasis	-	++	++	++
Trachoma	-	+	++	-

From: UNICEF, Planning for Health and Socio-Economic Benefits from Water and Environmental Sanitation Programmes Workshop, 1993, presentation by S. Esrey

Guinea Worm Disease

Guinea Worm disease (Dracunculiasis), unlike all other diseases mentioned in this chapter, can be prevented exclusively through water interventions. The disease is transmitted by drinking water that contains a small crustacean infected by a parasitic worm. Thus, the principal means of prevention is through ensuring access to safe sources and by motivating people to use the safe sources exclusively.

Significant progress has been made in the eradication of the disease since the 1980s. In several countries (e.g. Pakistan, Kenya, Yemen) the number of cases have been reduced to zero through the concentrated efforts of governments, multilateral agencies (including UNICEF) and other agencies and institutions. All remaining endemic countries are in Africa, and the majority of cases in Sudan.



(Source: CDC, Guinea Worm Wrap-Up No. 89, April 19, 1999)

D. Other Benefits from Improved Water Availability

There are a number of potential benefits to improved access to water supply, in addition to the reduction of disease. The reasons that many communities give for placing a high priority on improved water supply usually relate to benefits other than health. These benefits are of particular importance to women. A closer, cleaner source of water can produce immediate and far-reaching improvements on women's lives.

Convenience

Most people, when identifying improved access to water as a priority, are thinking of convenience. Everybody wants water as close as possible to their home, simply because it is more convenient. As such, convenience is as important a consideration as health benefits. In some societies and situations, convenience is also related to the security of women: water closer to home can minimize the chances of abduction or assault.

Time Saved

Women and girls can spend many hours a day collecting water from distant sources and thus the time saved by having a safe water source closer to the household can be very significant. The time saved is used for much needed leisure or, possibly (but not necessarily) activities relating to improved child care, or economic production. Less time spent fetching water is one less possible excuse for not allowing girls to attend school, or in some extreme cases, even to marry.

Energy Saved

Studies have shown that women who walk long distances to collect water can burn as much as 600 calories of energy or more per day, which may be one third of their nutritional intake. Closer sources of water can thus improve the nutritional status of women and children (and hence health and well-being).

40 Billion Hours Lost Each Year in Africa

Estimates indicate that some three hours per household per day are being lost to water hauling by those rural households in Africa which do not have access to a minimum level of service such as a hand-dug well or a handpump-equipped borehole. Some 258 million people lack access to improved water in rural areas of Africa today; these people comprise about 37 million households. At three hours per day, 365 days a year: 40,515 million (40 billion) hours are lost annually to this necessary but unproductive chore, largely undertaken by women and girls. This time could otherwise be used for activities such as child care, education and agricultural production.

(Adapted from UNICEF, *WATERfront*, Issue 2)

Money Saved

In many communities, especially in poor urban areas, households continue to have to buy water from vendors, often at exorbitant rates. Such direct financial costs can absorb up to 30 percent of total household cash income. Measures that improve the availability of water reduce its cost and are therefore of direct benefit to families, and particularly to women, who are often responsible for finding the funds to pay for water.

Prevention of Injury

When girls are forced to carry heavy loads of water over large distances, there is a danger of lasting spinal column and pelvis injury and deformations. Closer water sources minimize this.

Agricultural Use

When water supplies are inadequate for domestic use, they are often also lacking for irrigation, food processing and the rearing of livestock. It has been found that some of the increased quantities of water made available through water supply improvement schemes are in fact used for such "other" purposes, to which the community attach high priority.

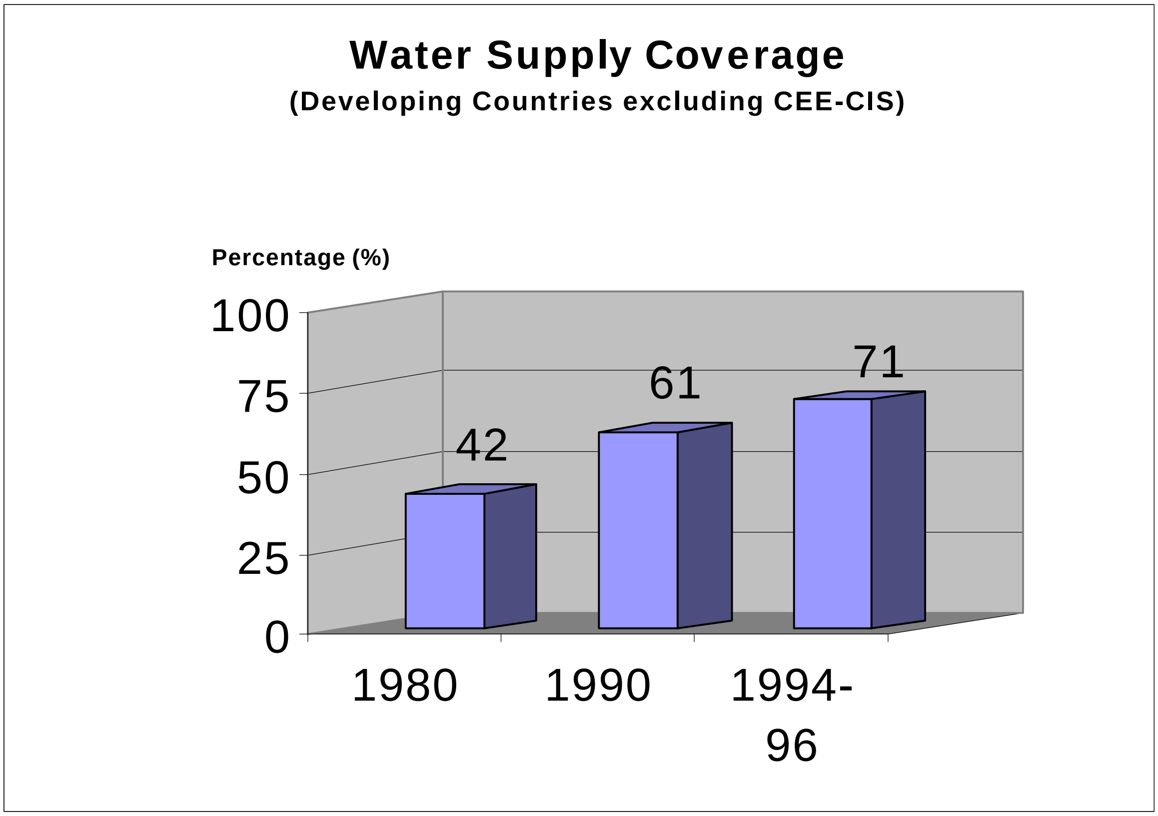
As an "Entry Point"

Water supply is often a high priority for communities. In addition, water supply improvements are very tangible and, when well organized, may represent the first occasion when a community has been truly mobilized to cooperative action. In such cases, the programme sets a valuable precedent and can indeed serve as a "leading edge" for further community-based social and economic development. A well-prepared water programme provides experience in the key elements of community participation: community discussion and decision making, participation in planning, contribution of labour and local resources for construction, arrangements for protecting the installation from pollution, and community responsibility for maintenance. In Zambia, initial UNICEF involvement in a drought relief programme led to the more comprehensive and highly successful WASHE programme that now includes hygiene, sanitation and environment components, and has become the standard with government and other donor partners.

It should be noted that water is not always the highest priority for communities, and thus it can not always be used as an entry point. In such cases, another programme intervention (like a community health post), may be more appropriate and effective as the lead programme.

E. Reaching the Unreached

During the IDWSSD, approximately 1.2 billion people gained access to improved water supply. While this was a tremendous achievement, in 1990 one third of the developing



Source: WHO End of Decade Review; UNICEF/WHO Joint Monitoring Programme; *Implementing the 20/20 Initiative* (UNDP, UNESCO, UNICEF, WHO, WB)

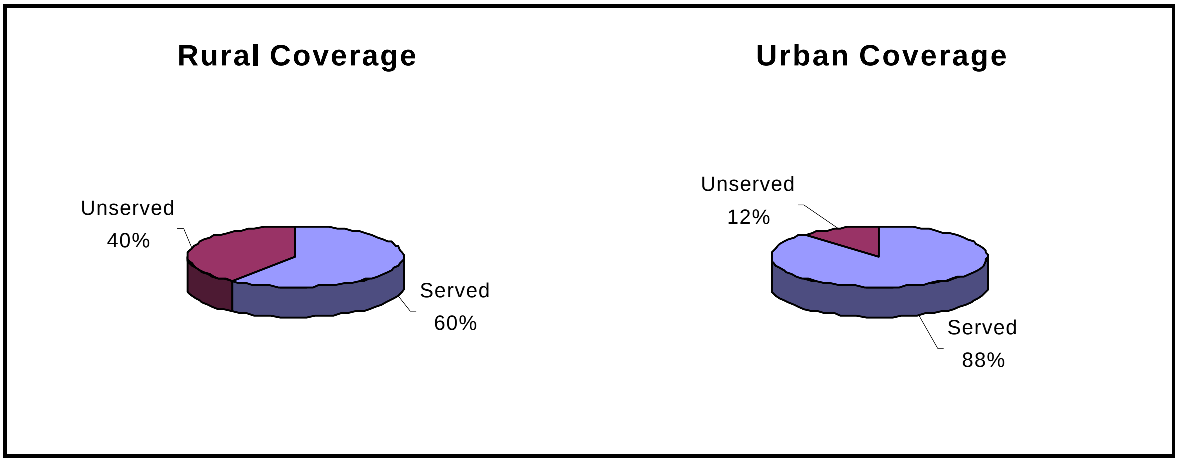
world's population - 1.3 billion people - still did not have access to a safe water source.

According to data from both the WHO/UNICEF Joint Monitoring Programme and UNICEF MICS (multi indicator cluster surveys), by mid-decade the coverage rate had risen above 70%**.** While this represents a significant increase in coverage since 1990, much work remains to be done if the goal of safe water for all is to be reached. While achieving universal coverage is a significant challenge, an even greater challenge is sustaining the gains made to date through community maintenance of water systems and community management of freshwater resources.

Although nominal coverage in urban areas is better than in rural areas (as shown in the figure), due to the difficulties of collecting de-segregated data that distinguishes between poor urban areas and richer urban areas such data does not illustrate the whole picture. In fact, as cities grow, increasingly "the unreached" are living in slums and peri-urban areas.

This accelerating trend will challenge UNICEF country programmes to give increasing attention to ways of meeting the water supply needs in these areas. In some countries (notably in Latin America - see the example below and elsewhere in this handbook), UNICEF already has gained a wealth of experience in urban water projects which can be applied successfully by other country programmes. Country programmes can also draw on their own experiences in rural areas - many methodologies and technologies successfully used in rural areas (like community based handpump maintenance programmes for example) can be modified and applied in urban areas as well.

Water Supply Coverage
Rural and urban: 1994-1996



Sources: UNICEF/WHO Joint Monitoring Programe; and UNICEF MICS

Urban Water Supply: the Guatemala Experience

Due to the war in the countryside and other factors, the slum population of Guatemala City has grown in recent years to one million people, a number which was overwhelming the city's municipal services. A very small proportion of dwellings have house connections and there are few public standpipes - many people are forced to purchase water from private traders at a cost of over 25 times that of the water supplied through the municipal network. With a programme initiated by the Inter-institutional Commission for Marginal Urban Areas (COINAP) and assisted by UNICEF, a community cooperative in the slum of El Mezquital succeeded in providing water to over 2,000 families through the construction of a local water system. Funds collected from the beneficiaries will be used to operate, maintain and expand the system, or for other community projects. There are three keys to this successful model: commitment to the methodology of community participation; coordination among a variety of governmental and non-governmental institutions with experience in the relevant techniques and skills; and the presence of a community organization willing to collaborate in improving their own local conditions.

From: *Improving Water and Sanitation through Urban Basic Services Programme in Guatemala: A Case Study*, UNICEF WATERfront, Issue 7 (May 1995)

F. Summary Points

- *due to over-pumping and increased pollution, the protection and management of freshwater resources is rapidly becoming the overall sectoral priority*
- *freshwater management will be most effective if carried out by communities*
- *water interventions are an important component of public health programmes but only if integrated with hygiene education and sanitation interventions*
- *water interventions are justifiable solely on the basis of convenience, but additional benefits can also result*
- *approximately 25% of the developing world's population still do not have access to a safe source of water*
- *there is an accelerating trend of growing unreached populations in slums and peri-urban areas*

2. Community Participation and Management

A. Community Participation [3]

Community participation arose as a concept in the mid-1960s. It was not adopted by the IDWSSD until the mid-eighties after it became apparent that governments and donors could no longer afford totally centralised operation and maintenance systems for water and sanitation. Planners began to realize that in order to share the responsibilities for maintenance, beneficiaries or users would have to be involved in some way in the on-going maintenance of their own community systems.

It is now realized that if communities are expected to take responsibility for maintenance, they must also be involved in planning and implementation of projects from the initial stages. They must develop a sense of "ownership" and understand that maintenance is essential, and is a community responsibility.

Communities should be perceived as informed consumers, clients and managers, capable of making choices as to the type of services they have the capacity to provide rather than passive receivers. Communities must also acquire management and organisation skills with leadership capable of defining tasks and managing facilities. It should be recognized that many communities may already have considerable management and organizational skills.

Central agencies responsible for water and sanitation must change from "benefactors" who make all the decisions to "facilitators" who enable communities to make their own decisions. Agencies must learn to be responsive to consumer-client demands.

Self-help activities in the construction phase are often ambiguous, calling for analysis on a case-by-case basis. Some projects mention voluntary labour and contributions in cash or kind as a cost saving element. This approach can increase local pride and commitment, offer training possibilities and stimulate proper use and maintenance. However some managers maintain that private contractors are more efficient as they avoid delay, increased costs, over-burdening the community and poor construction leading to frequent breakdowns. There is also a temptation for governments to expect too much from poor communities. Self-help should not be used as an excuse to avoid giving poor communities a fairer share of tax revenues.

[3] This whole section adapted from Sessions 10 to 13 of the WES Training Package, 1992, WES Section, New York

A classification of different types of community participation, developed in 1981[4], is listed below:

1. consultation
2. a financial contribution by the community
3. self-help projects by groups of beneficiaries
4. self-help projects involving the whole community
5. community specialised workers
6. mass action
7. collective commitment to behaviour change
8. endogenous development
9. autonomous community projects
10. approaches to self-sufficiency

A discussion follows describing issues associated with each classification.

Consultation

Consultation is a basic means of giving communities some voice, of involving them in decision-making. Its main rationale is to ensure that projects or programmes introduced by outside agencies are adapted to meet community needs as well as to avoid difficulties in implementation. Consultation may involve:

- consultation with community representatives or leaders only. Such consultation does not amount to real community participation unless the decisions formally made by representatives or leaders are the result of wide consultation and consensus within the community, and unless the community is involved in decision-making on significant aspects of the project.

- consultation with all sections of the community. This involves ascertaining the view of those sections of the community which may normally be excluded form decision-making (women, certain ethnic minorities or low caste groups, the poorer sections), whose interest may not be genuinely represented in the existing processes of decision-making in the community. The rationale is to ensure that projects meet their needs also. This is not always easy, and there are differing views on how important broad involvement is.

A Financial Contribution by the Community

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[4] Whyte, A. Guidelines for Planning Community Participation Activities in Water Supply and Sanitation Projects, WHO, Geneva. Offset Publication No. 96. 1986.

Cash collection made by and within the community, generally prior to or at the time of implementation of a project, usually as a contribution to capital construction. Excluded, as not really constituting community participation, are cases which amount to a payment by individual families for service, even when it is an advance payment.

Self-help Projects by Groups of Beneficiaries

In these projects a specific group of local inhabitants contribute their labour (and perhaps other inputs) to its implementation, while there is also the assistance of an external agency. Those who contribute will be recompensed by reduced fees for the services they receive while non-members pay more.

Self-help Projects Involving the Whole Community

Projects in which every family in the community is expected to make a contribution (usually in labour), while there is also an input from an external agency. Food-for-work projects may be included here, though the element of community participation may be considered slight if it consists only of labour which is paid in cash or kind.

Community Specialised Workers

The training and appointment of one or a few community members on a voluntary basis to perform specialised tasks (e.g. as community health worker, or operator of a community water supply system). Training and technical supervision are carried out by an external agency but some form of community authority is usually also exercised over specialised workers.

Mass Action

Collective work in the absence of a major input from an external agency. Often such actions are directed at environmental improvements (e.g. to drain waste water).

Collective Commitment to Behaviour Change

Cases where a community makes a collective decision to change customs or personal habits and collective social pressure is exercised for the realization of such changes. Examples range from penning of domestic animals to construction and use of latrines, or to the reduction of excessive expenditures in connection with weddings, funerals, etc. While changes of behaviour may occur in other ways, community participation is involved when an explicit decision is collectively taken.

Endogenous Development

Cases in which there is an autonomous generation of ideas and movement for the improvement of living conditions within the community as opposed to stimulation by outside agents. The community may, however, have recourse to external agencies to help with implementation, or indeed press for such help. On the other hand, where this is simply pressure for services to be provided, it hardly qualifies for the term "community participation," though in a wider sense this is an example of political participation.

Autonomous Community Projects

Projects where an external resources are paid for by the community with funds raised internally, including the hiring of outside expertise or professional staff. Such projects are therefore under community control.

Approaches to Self-Sufficiency

Projects in which the objective is to satisfy local needs as far as possible by using local materials and manpower directly, not by purchasing good and services from outside. "Self-reliance" is also sometimes understood in these terms.

B. Improving Community Involvement

Information Gathering

In order to plan effectively for community participation, a considerable amount of community information must be gathered by the agency.

Firstly, there is the information about a community which it may be useful to possess before any approach is made to that community in order to ensure it is made in an appropriate way.

Secondly, there is the information which may be required to determine if community conforms to agency selection criteria, or to determine if special subsidies are required.

Thirdly, information is required by supporting agencies in planning and design of the projects. Most of this can be provided by the community during consultation but will need to be supplemented with information gathered by staff in informal contact with community members.

Community Management in Slums:
The Tegucigalpa Model

In Tegucigalpa, the capital of Honduras, a special unit (UEBM) was created by the National Water and Sewerage Service (SANAA) specifically to serve the rapidly expanding poor urban communities. With support from UNICEF, UEBM provided safe water to 45,000 people in 25 low-income neighborhoods in less than four years. All of the operation and maintenance costs of the systems are recovered from the beneficiaries as well as some of the capital and future replacement costs through monthly water billing and a special

Administrative Arrangements

Community participation techniques require dialogue with community members in which their ideas are treated as valuable contributions. These dialogues are conducted by lower-level staff whose own social position may lead them to emphasize superiority of their technical training. The solution may lie in developing a special cadre of promoters/community development staff within a technical agency.

Representative Bodies in the Community

It is essential to consider which community groups are to be the focus of consultations and will have responsibility for community actions.

> ***Local authorities**:* While some consultation take place with local authorities as a matter of course in the introduction of a new water supply or other facility, in many countries local authorities work at levels considerably removed from that of the ordinary villagers or low-income urban residents. Consultation with local authorities cannot realistically be regarded as community consultation.
>
> ***Development committees***: Where they exist and cover an area which coincides with that of the projected water or sanitary improvement, a development committee is the obvious community focus for the project. A committee started for the water/sanitation project may subsequently take on other functions. Development committees are often founded with broad aims including that of health, raising agricultural or other economic production. But it is precisely in the area of communal services such as water and sanitation that they are often found to have their greatest potential.
>
> ***"Traditional" bodies***: In some countries, traditional institutions - chiefs, councils of elders - retain considerable authority. It may be expected that initial community approaches will be made through them. In fact, it may be difficult for outsiders to penetrate beyond the appearance of full harmony and unanimity presented by the community's formal spokesmen. Yet, again, there may be undercurrents of dissent within the community.

C. From Community Involvement to Community Management

In light of the Decade's experiences, terminology is needed which addresses communities as not mere users or beneficiaries. Some now favour employing the word "clients". However, even that term, rooted in the Latin word *clinare* ... to lean upon, can be misleading. Dictionary definitions of "client" include: (1) person under protection of authority; (2) person who engages a professional; (3) person served by or utilizing service of social organizations. Perhaps terms such as "partners," "co-owners" or even "community owners" deserve consideration in developing participatory models and community management strategies for the 1990's.

According the 1992 IRC workshop on community management, "there is no fixed formula for community management. It is an approach seeking to make the best use of resources available within the community with support from government agencies, NGOs, the private sector, and other communities. Relationships among the partners may change and evolve as communities become better able to manage their own affairs. Some key characteristics are common to all forms of community management, but no single model can adequately encompass all the possible variations".

If real community participation and management are accepted as essential to the global thrust toward universal access to water supply and sanitation, it must be recognized that concepts of empowerment and equity cannot end at the water source. Traditional power structures can be threatened by new pumps and latrines which benefit the poor. Communities who learn to manage safe water will go on from there to make other demands on the system, and to demand management of other aspects of their individual or community lives. People can be motivated to participate and manage only up to a given point in a given direction.

UNICEF-assisted programmes should be clear regarding the definition of community management. Obviously, it is implied that communities should be more actively involved in all aspects of programme development, including situation analyses, development of programme strategies, monitoring, evaluation, and influencing management and administration, including being able to expect timely responses to expressed concerns.

According to McCommon et al.[5], "the distinctive feature of community management is the nature of decision making and the locale of responsibility for executing those decisions. Community management refers to the capability of a community to control, or at least strongly influence, the development of its water and sanitation system. Community management consist of three basic components:

- ***Responsibility:*** the community takes on the ownership of and attendant obligations to the system.
- ***Authority:*** the community has the legitimate right to make decisions regarding the system on behalf o the users.
- ***Control:*** the community is able to carry out and determine the outcome of its decisions."

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[5]McCommon, C., Warner, D. and Yohalem, D. *Community Management of Rural Water Supply and Sanitation Services* UNDP/World Bank. WASH Technical Report No. 67. 1990

An emphasis should be placed upon establishing good communications between professionals and communities facilitating closer dialogue and partnership, helping governments to move from being providers to becoming promoters and facilitators.

According to McCommon et al., important preconditions for community management are likely to include the following:

- "there must be community demand for an improved system;
- the information required to make informed decisions must be available to the community;
- technologies and levels of service must be commensurate with the community's needs and capacity to finance, manage, and maintain them;
- the community must understand its options and be willing to take responsibility for the system;
- the community must be willing to invest in capital and recurrent costs;
- the community must be empowered to make decisions to control the system;
- they should have the institutional capacity to manage the development and operation of the system;
- the community should have the human resources to run these institutions;
- there should be a policy framework to permit and support community management;
- effective external support services must be available from governments, donors, and the private sector (training, technical advice, credit, construction, contractors, etc.)."

The benefits of community management should include the following (McCommon et al., 1990):

- short term improvements in system performance such as greater use of water and sanitation facilities, adoption of improved hygiene practices, and greater community support for system maintenance;
- changes in support conditions: long term improvements in available resources and complementary investments;
- long term impacts: anticipated health, social well-being, economic and environmental quality changes.

The workshop held in The Hague, The Netherlands (1992) studied in depth seven case studies from developing countries including Honduras, Guatemala, Cameroon, Yemen, Indonesia, Pakistan and Uganda. The principal findings were the following:

Community Management goes beyond community participation and equips communities to take charge of their own water supply improvements.

Some critical features distinguish community management from community participation and are at the heart of successful community managed water systems.

- The community has legitimate authority and effective control over management of the water supply system and over the use of the water.

- The community commits people and raises money toward the implementation and upkeep of the water system. The link between the scale of community contribution and the resulting sense of ownership is not yet well understood, but the need for a significant contribution is well established.

- Supporting agencies provide advice and technical support, but all key decisions are taken with the community. This means that real choices must be offered, backed by a full appraisal of all the resources needed for each.

- Development of people is a parallel goal with development of water. Community management is "people-centered". Its success depends on the user community and support agency staff acquiring new skills and confidence in applying them. Special capacity-building techniques are required.

- Local organisations for water management are in tune with existing community decision making structures and ensure that the views of all section of the community are reflected in management decisions. Strong community leadership, or the continuous involvement of a charismatic individual, has been shown to be a major factor in the success of many community-managed water supplies. Women are known to be highly influential in community-managed water supplies, though the influence is not always apparent in organizational structures.

Community Management involves a long-term and changing partnership between communities and supporting agencies. It strengthens the capacity of each partner and enables their combined resources to be used more effectively.

A community's partners in the management of its water supply system may include government agencies, NGOs, the private sector and crucially, other communities. Relationships change as the community develops greater capacity to manage its own affairs and to choose for itself where to acquire the support services it needs to keep its water system functioning reliably. Inter-community collaboration can add a new dimension in terms of both resource sharing and replicability.

The case studies include a wide variety of community management applications matched to particular cultural and socio-economic settings. In Guatemala, Pakistan and Indonesia, support from national and international NGOs enable communities to implement and sustain cost-effective water projects and in some cases to replicate those projects through evolving community networks. In Yemen, Honduras, Uganda and Cameroon, government agencies successfully transfer control of water projects to communities while enhancing their own performance and status.

Making Community Management Happen: Lessons from Experience

Successful community management does not happen by accident. Projects and programmes must actively and systematically pursue it as a goal, and create the right conditions in which a self-reliant, community-based approach can work. A study of 122 completed rural water supply projects from around the developing world revealed that the following factors positively contribute to raising the level of popular participation:

- The establishment of clear project goals and strategies, based on a consensus of agency and community views
- A strong commitment by project managers to a participatory process and willingness to respond positively to community views
- Willingness by managers and supervisors to listen to and respect the views of field based staff
- The development of flexible project strategies, with a high degree of decentralized control
- A balance between community and agency decision making powers which favours the community
- The extensive use of local knowledge and existing forms of local organization
- Project approaches which fit comfortably into existing social and cultural contexts
- The existence of a broader social and political context which is conducive to popular participation and control

From Appleton, B. (ed). *The Role of Communities in the Management of Improved Water Supply Systems*, Community Management Workshop Report, IRC, The Hague.

Ten Key Steps to Enhance the Involvement of Women in Water Supply Programmes

The following steps can be taken by water agencies as a means of advancing women's involvement:

- Orient male management and staff in how women's involvement helps to realize project objectives
- Work with women field workers, both from the agency itself and from other services and/or with local intermediaries
- Discuss with local leaders and authorities why women should be involved in the planning and management of water services, and how this can best be achieved
- Inform women about project and programme meeting, using a variety of different channels, and encourage their participation
- Organize meeting at times and places suitable for women to attend
- Make it easy for women to hear and to be heard at meetings, by sitting them together in the main gathering, not at the back, and by conduction meetings in the vernacular or arranging translation
- Stimulate dialogue by presentation techniques, inviting comments/questions/criticism, inserting discussion breaks, and involving respected and representative spokeswomen
- If the participation of women in general, or poor women in particular, is difficult, organize separate meetings at more convenient times and places
- Explain the tasks and the authority involved in system maintenance, management, hygiene education, and system finance before choosing local candidates; discuss which roles are best performed by women and who are the most suitable candidates
- Give training adapted to women's conditions and roles, and include follow-up visits for monitoring and support

Source: C van Wijk, 1989, *Community Management and Sustainable Water Supply in Developing Countries*, Mimeo, IRC, The Hague

Community Management can mean more widespread implementation of sustainable water supply systems.

In the past, community management has often been seen as an approach which requires repeated time-consuming activities in one community at a time. The case studies provide important new evidence that successful community management can stimulate inter-community activities which in turn foster more rapid replication. Community organizations can combine to form associations to share knowledge and experience and build local capacities to manage.

Community Management means a new role for support agencies as facilitators rather than providers, demanding new skills and offering greater opportunities.

There is a powerful logic to community management of water supplies. The resource is local, its use is local and its effects are local. Nevertheless, it has to be recognized that there are genuine fears among agency staff (and at higher levels of government) that empowerment of communities to manage their own systems may diminish the role of and respect for water agency staff or conflict with national government priorities. In Cameroon, Yemen, Uganda and Honduras, such fears have proved unjustified. Support for community managed water supplies has brought more effectiveness and greater job satisfaction in the implementing agencies while the community water management organization have remained non-political.

Community management does not mean less work for agencies. It means a greater emphasis on the development of supporting and enabling skills and less on routine management and maintenance. This frees institutional, human and financial resources to enable agencies to reach more communities. Government has a vital continuing role in establishing the policy and legislative framework to enable community management to work. It also retains the duty to protect water resources ant the environment and to maintain public health standards.

Benefits of community management can extend beyond water into other development activities.

The skills and knowledge acquired in building a community's capacity to manage its water system can become a stimulus for further community-led development. In Indonesia and Honduras, access to a convenient water supply plus awareness gained in project self-surveys led to the self-help construction of sanitary latrines and changes in hygiene behaviour. In Guatemala, successful water development was followed by income generation from coffee production which provided further support for the upkeep and extension of the water system. In Pakistan, there are examples of water development following from other community activities based on income generation, when the village organizing committee acquired the skills and the resources to implement programmes based on its own priorities.

The scope for community management extends beyond rural water supplies.

Most current models for community management are based on rural experience. However, successful community management is also being achieved in peri-urban areas with Honduras being a good example. Further study is needed to establish the criteria which make community management effective in peri-urban situations.

Conventional progress indicators need to be adjusted to monitor and evaluate community management.

Mobilizing and equipping communities for water system management takes time. Indications are that this initial investment is paid back in greater cost effectiveness. Further work is needed to provide conclusive demonstration of the economic benefits in the long term. Conventional indicators are not an appropriate way to monitor progress in community management in which capacity building is a major component. Alternative progress indicators are being developed and need to be tested along with innovative participatory evaluation techniques.

D. Training for Improved Community Management

In any sector where the focus is on achieving large scale physical targets within a set time frame, there may be a tendency to treat attitudinal constraints lightly. Project personnel may be aware of community resistance and behaviours which run counter to project objectives. But many believe that these attitudes and behaviours will change when the facilities or devices are in place.

According to Srinivasan[6], "the overriding goal of community participation in the water and sanitation sector is not simply to ensure sustainability of a system by teaching people how to function in a committee or how to fix a pump. Rather it is to help people to develop the outlook, the competence, the self-confidence and the commitment which will ensure a sustained and responsible community effort in the sector."

If a project comes up against fears, doubts, suspicion, lack of self-assurance or traditional beliefs and values that run counter to the proposed change, a participatory approach can be vital. In communities where such attitudes commonly prevail, behaviourial change is unlikely to take place unless a sufficiently sensitive and facilitative approach is used to uncover, examine and address social constraints as cited below:

- diffidence in the presence of authority
- fear of speaking up in group meetings
- low self-esteem
- distrust of the motives of those in power
- reluctance to take risks
- fear of economic consequences or social loss of face
- fear of criticism for overstepping customary roles
- factional differences
- a sense of powerlessness or fatalism
- lack of experience in working with groups
- lack of skills in planning and problem solving

[6]Srinivasan, L. *Tools for Community Participation: A Manual for Training Trainers in Participatory Techniques* PROWWESS/UNDP. 1990

- conflicting beliefs, customs, "superstitions"

Trainers assume a large measure of responsibility for the quality of community participation. A participatory training programme cannot take place in isolation. Training programmes exist within a project context which involves many other people who affect project outcome.

One cannot rely upon training alone to change the way extension staff relate to local communities. They need support, guidance and a continuing flow of inspiration from those who make policies and set standards.

Participatory Training

A participatory training strategy can be incorporated into ongoing programmes. It is pointless to train communities unless there is adequate follow-up and some structure whereby the training can be assessed and further training given at later stages of the project. Training programmes involve many people who affect project outcomes. All these people must become familiar with the goals of participatory training if the project is to succeed.

The participatory approach uses a learner-centered approach in which the focus is on the learner developing ability and skills to diagnose and solve their own problems. The trainer merely facilitates a process of competency-building and self-discovery for the learners whose needs, experiences and goals are the focus of the training.

In order to train communities effectively, one has to train field staff to become aware of how to work more effectively at the community level. Trainers should include not only those who are on the faculty of training institutions but also all those who provide in-service guidance and support through field supervision, programme monitoring and evaluation. This includes engineers, technicians, community development officers, agronomists, environmental sanitarians and health assistants.

Without this kind of back-up from policy makers and trainers, they are not likely to innovate or make special efforts to involve people, particularly if a good performance is judged mainly in quantitative terms e.g. number of meetings held, demonstrations given or pump caretakers trained.

Many agencies, especially UNDP/Promotion of the Role of Women in Water and Environmental Sanitation (PROWWESS), have developed methods to train trainers to work more effectively with communities. They have developed a manual titled "Tools for Community Participation" by L. Srinivasan which outlines different methods that can be used including innovative exercises which allow project staff and communities to analyze their problems more effectively.

E. Summary Points

- ♦ *there are many types of community participation including:*

    - *consultation*
    - *a financial contribution by the community*
    - *self-help projects by groups of beneficiaries*
    - *self-help projects involving the whole community*
    - *community specialized workers*
    - *mass action*
    - *collective commitment to behaviour change*
    - *endogenous development*
    - *autonomous community projects*
    - *approaches to self-sufficiency*

- ♦ *improving community involvement involves information gathering, consultation, the making of administrative arrangements and a full consideration of representative bodies in the community*

- ♦ *UNICEF programmes must actively promote a shift from community involvement to community management*

- ♦ *while programmes cannot "create" real community management, they can assist in the formation of important preconditions such as ensuring access to information, institutional capacity and effective external support services*

- ♦ *training should no longer focus on the technology (how to fix a pump) but rather as a tool to assist in the development of the communities' competence, self-confidence and commitment*

- ♦ *participatory, learner-centered approaches to training should be developed and implemented for greater effectiveness*

3. Cost and Cost Effectiveness

A. The Cost of Water

Establishment and Operation and Maintenance Costs

The establishment costs (or capital costs) of a water system include the more obvious costs such as the cost of the labour, materials and equipment needed for the construction of the system but also include less transparent (and more easily forgotten) costs such as those associated with project planning and administration, donor agency overheads, import duties, equipment amortization, etc.

Operation and maintenance costs are frequently higher than originally anticipated and not fully taken into account at the project planning stage. Although the situation has improved in recent years with the application of lessons learned over the last two decades, there are still many water supply projects that ultimately fail because of inadequate provisions for these costs. The classic (and still too common) example of this is a rise in the cost of fuel or electricity for pumps in a piped water system. However there are also many examples of "low maintenance" options such as handpumps or photovoltaic solar systems in which the operation and maintenance costs become far higher than originally planned.

Variables Affecting Cost

The cost of water can vary from a couple of dollars to several hundred dollars per person served and depends on a number of variables:

Technology Choice

There is always a choice of technologies for new water supply systems that affects the final cost of the system. This choice is often related to the level of service desired (e.g. in-house connections vs. handpumps) but can also be influenced by other factors such as the type of source (see below), government and donor agency preference, and the lack of awareness of or unavailability of alternatives.

Level of Service

The two basic indicators for level of service are the quantity of water per person per day (often expressed as the number of people served by each water point) and the minimum distance from a water point. A country that has defined the minimum level of service to be 500 people per water point within 2 kilometres will pay less than a neighbouring country that has defined the minimum as 150 people within half a kilometre. Or, within the same country, the cost of an urban system based on in-house connections (one family per water point within 0 kilometres) will be significantly higher than the cost of rural systems.

Labour and Material Costs

These cost are highly variable within and between countries and regions and have a major influence on the final cost of the system. The degree to which a project depends on highly skilled national or expatriate technicians influences the overall cost. Another important factor is the amount of material and equipment which must be imported from abroad. While importing equipment such as handpumps may be economically justifiable (and may be the only option available) during the construction phase of the project, it can create problems later with the maintenance of the system, especially if no provision has been made for the continuing import of spare parts once the project has finished.

Accessibility and Quality of the Water Source

The least expensive water supply systems are, with few exceptions, based on shallow-to-medium depth groundwater sources. This is because there are a variety of inexpensive technologies to tap and pump the water (hand-dug wells or borewells with handpumps) and, of equal or greater importance, the water does not often have to be treated before use. The use of other water sources such as deep groundwater that is beyond the range of handpumps, bacteriologically polluted ponds or streams, or groundwater with high concentrations of iron or fluoride, can significantly increase system costs. Even water sources which, at first glance, appear to be plentiful and of good quality can be much more expensive to tap than shallow groundwater. Examples include rainwater-based systems, which can become very expensive because of the need to construct large storage reservoirs, and springs, which are often too far from beneficiaries and thus require expensive piped systems. In all cases the specific situation determines the final choice of water source - in hilly areas, for example, a spring-fed piped water system may be more cost effective than hand-dug wells or borewells.

Efficiency and Cost Effectiveness of Project Management

The cost of management can be a significant proportion of the overall project cost. Overhead costs of government, NGOs and donor agencies contribute to, and thus must be included, in the overall cost of a water system. Management expenses and overheads in some projects can easily add 25 percent or more to the total project cost, and can thus significantly affect its cost effectiveness. Inefficient project management is often a factor that results in costly projects. Poor logistics resulting in equipment down-time, non-standardization of equipment, problems relating to transportation or port clearance, and the under-utilization of labour or equipment are all common examples of inefficient project management.

Community Management

Numerous examples have shown that a project that is managed by the community itself is much more cost effective in the long run than a "top down" project. When the community is involved at every stage from planning to operation and maintenance, and thus has a real sense of ownership of the system from the outset, many costs are minimized or eliminated. Cost savings can be direct such as when the community provides volunteer or low-cost labour during construction or contributes locally available materials. Indirect cost savings are often more important: for example, when the community is involved in the planning stage of the project, it may provide the local knowledge necessary to avoid using a water source that would be inappropriate for cultural reasons or identifying a water source such as a spring which may have been overlooked by outsiders. Cost savings through community management are often significant in the area of operation and maintenance: a routine maintenance programme designed and implemented by the community itself will function much better than a system imposed from outside and will result in a reduction in repair and replacement costs.

Involvement of Women

Women are the primary stakeholders in the area of domestic water supply. They are responsible for water at the household level, and are traditionally influential in any decisions regarding communal water supplies. If women are fully involved at all stages of project implementation, the risk of costly errors in system design will be minimized. In addition, the active participation of women in community management bodies will ensure that these bodies are effective, and therefore cost efficient.

B. Improving Cost Effectiveness [7]

Large per capita cost variations between water supply projects in the same region and experience of successful cost reductions within individual projects illustrates that cost effectiveness can be dramatically improved if appropriate measures are taken.

[7] The seven points below are adapted from *Improving Cost-effectiveness of Rural Water Supply and Sanitation Programmes* by Nigam/Heyward, UNICEF, 1993

Systems Management

Control of system management costs can reduce the unit cost of a water point significantly. However, there are limits depending upon the technical and management capacity available in the country and the quality of programme management. Countries which generally have the capacity, such as Pakistan, can deliver the output using more local staff instead of costly expatriate staff. In other countries, where there is insufficient local system management expertise, the use of expatriate staff is imperative for success. While system management costs can be controlled to a certain extent, much of the effort in the short run could usefully be directed at ways and means of increasing output using available manpower resources which could contribute to both an increase in the number of facilities and unit cost reduction. In this context, greater coordination between donor agencies active within the country and their long-term commitment of resources in the provision of rural water supply can contribute to a significant reduction in system management costs.

Capacity Building

Long-term cost reduction and sustainability in the sector can only be achieved if national capacity for delivery of these services is enhanced through training, planning and organization. Capacity building should ideally be carried out at the community, technical and managerial levels.

Ensuring Community Management and the Participation of Women

Ensuring that communities are the managers of their own water supply systems should be given high priority, as a means of reducing long-term costs. The formalization of the differing roles of government, the donor agency, private contractors and the community through contractual agreements is a good first step towards achieving true community management. Project design must also address the key role of women as water providers. The full and meaningful participation of women in community management structures is essential for long-term efficiency and success.

Technical and Logistical Considerations

Even when considering only one technical option, that of the borewell handpump, a variety of cost-saving measures can be applied. The largest single cost item in the handpump option, and one which acts as a constraint to expansion, is the drilling operation and drilling success rate. Correct choice of drilling equipment, drilling area, and drilling rig movement can reduce overall costs. Selection of the right equipment depends on the geological conditions and anticipated drilling depths. Proper surveys prior to drilling can contribute significantly to cost reduction. For example, in Nigeria the failure rate in the government programme, due to inadequate surveys, has been particularly high with a number of boreholes running dry after a short period of time. Since drilling costs are the single major component of cost, actions to optimize the use of surveys, rig movement and monitoring can have a major impact.

Experience suggests that improvements can be made in the purely technical and engineering aspects for lowering costs of a borewell with handpump. Some key factors are:

- Yield of the well - The target yield in borewell design should be only that required by the handpump to be installed, which is usually in the range 750 to 1,000 litres an hour. Taking additional measures to increase the yield to, say, 2,000 litres an hour "just in case," is unnecessary and often costly. This practice can become a major drain on resources, especially in projects drilling large numbers of borewells.

- Diameter and depth of the well - Doubling the diameter of a well, or increasing its depth will substantially increase the costs. In most situations, the diameter of the well is the sole function of the handpump to be installed (100mm to 125mm diameter borewell is sufficient for most handpumps). The depth range of the wells should be defined by scientific investigations and proper surveys in accordance with the design yield.

- Equipment selection - Commonly there is an over-specification of equipment required for drilling "just in case" it is needed. Large equipment not only requires greater capital investment but also means higher running costs, as seen from the example of Ethiopia in the table below.

Big Rigs vs. Small Rigs

Rig Type	Capital Cost (US$)	Daily Depreciation (over 7 years, US$)	Consumables per metre (US$)	Fuel Cost per Hour (US$)
Big Rigs	700,000	274	81	57
Small Rigs	520,000	204	43	23

Equipment selection should be based on the diameter of the wells to be drilled, the average depth to be drilled, the geological formation to be drilled and the accessibility of the drilling sites. For wider coverage smaller rigs should be used with larger rigs for drilling in certain areas only.

- Standardization - Non-standardization of drilling equipment, materials and handpump models increases the spare parts requirements, increasing operation cost. The successful expansion of the rural water supply programme in India, for example, was due to a great extent to the use of one type of handpump, the India Mark II. The production of hardware, the design of maintenance systems, and the spare parts procurement and distribution systems were all built around this one pump, simplifying and improving the cost effectiveness of the programme.

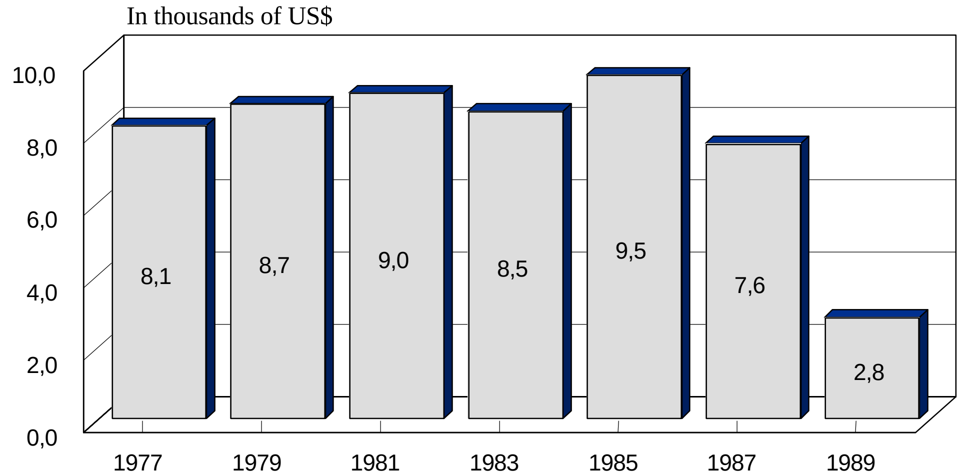
- Logistics - The timely availability of materials, particularly imported items, can also help reduce costs. If economies of scale are to be realized and drilling costs reduced, there should be sufficient advance planning and lead time for obtaining the supplies. In one large long-running UNICEF-supported drilling programme, spare parts are ordered eight to ten months in advance. Developing countries also need to be provided some form of "certainty" of financial support from donors to enable proper logistical planning. If financial support for programmes is cut or reduced mid-stream, the costs of rural water supply increases considerably. Idle rigs, due to poor logistics, add significantly to costs. There are numerous examples of rigs which

Reducing Drilling Costs in Sudan and Zambia

Over a two-year period, from 1987 to 1989, UNICEF Sudan succeeded in decreasing the unit cost of handpump-equipped borewells by 63 percent through a series of measures, including:

- Convergence of resources (consolidation of several small displaced drilling projects into one larger project), leading to reduction of overheads and the cost of logistical support.
- Production incentives (a bonus wage system linked to productivity), leading to increased output.
- Community participation and cost recovery, allowing government to optimize capital resources and minimize recurrent cost disbursements, it also fosters community ownership and control and hence sustainability.

Unit Costs of Handpump-equipped Borewells - Sudan



In Zambia, drilling costs were reduced from an average of US$5,000 per borewell to US$2,600 from 1996 to 1998 through the application of a series of reforms in UNICEF-supported programmes including:

- reducing specifications of borewells to a level more appropriate for handpumps;
- the issuance of a single contract for both hydrological survey and drilling;
- drilling payments based on unit tasks instead of lump sums;
- and no payments made for dry wells.

Not only are more boreholes being drilled because of reduced costs, but the number of contracts being awarded by other donors has also risen, because of increased confidence in getting value for money.

Contracting

The use of private sector contractors may increase the cost effectiveness of a programme in certain situations. It may be necessary to support the private sector through incentives for a limited period and to ensure the conditions and environment exist for their operation. It could include the provision of an adequate market size to make it attractive for private contractors to invest in expensive drilling rigs and other equipment. At the same time, it is essential that capacity building of government is provided to ensure the effective monitoring and supervision of the contractors.

Regional Differences in the Cost of Water

In the 1995 paper "A Model of Costs and Resources for Rural and Peri-urban Water Supply and Sanitation in the 1990s" (Nigam/Ghosh), an attempt was made to estimate cost differences between the regions of Africa, Latin America and Asia. The results, summarized below, illustrate the major differences between the regions and between rural and peri-urban areas.

Cost per Capita in US$	Africa	Asia	Latin America
Rural Water	15	6	30
Peri-Urban Water	95	6	100

C. Summary Points

♦ *operation and maintenance costs frequently are greater, over the long term, than capital costs and thus should be fully considered during planning*

♦ *there are many variables that affect the cost of a water project, including:*
- *technology choice*
- *level of service*
- *labour and material costs*
- *accessibility and quality of the water source*
- *efficiency and cost effectiveness of project management*
- *community management*
- *involvement of women*

♦ *project costs can be significantly reduced if appropriate measures are taken within the following areas:*
- *systems management*
- *capacity building*
- *ensuring community management and the participation of women*
- *technical and logistical considerations*
- *local production of materials and spare parts*
- *tariff reduction*
- *contracting*

4. Water Technologies

A. Design Options, Constraints and Choices

Design Options

Water can be "produced" from different sources by various technical means. The supplies can then be "delivered" to consumers in different ways. Whatever the technical solution adopted, the aim is to make adequate quantities of water, which is safe for human consumption, reasonably accessible to all, including especially, the underprivileged groups of society.

Decisions on the level of service to be provided - how, where and in what quantities water will be delivered to users - are crucial in the planning of any water supply project. System design options are:

- **Single Point** systems, which usually consist of dug wells or small-diameter drilled wells from which water is drawn using a handpump.

- **Standpipes**: piped distribution systems which feed a limited number of public taps, each of which serves all households - and other users - in the vicinity.

- **Household Connections**: piped systems which deliver water to taps in individual household compounds or homes.

Piped systems are fed by gravity-flow directly from the source (e.g. a mountain spring) or from an elevated tank into which water is pumped from, for example, a deep borewell. Treatment of the supplies, where necessary, is possible in intermediate storage tanks.

Public water points, whether open wells, handpumps or standpipes, must always be provided with solid, watertight platforms (aprons) from which waste water is drained away. These can also be supplemented with laundry, bathing and other facilities, including troughs for watering animals and collection systems for watering small vegetable gardens.

Piped systems, especially with household connections, provide greater convenience and are thus preferred by people in most communities. Increased convenience always results in increased consumption/usage, which in itself can be expected to have an impact on health status and yield other benefits. Consumption increases of up to 500 percent have been recorded following the introduction of yard taps.

Whether the extra cost of pumping, elevated tanks and yard taps can be justified depends on the natural or external resources available for large-scale coverage and the capacity and willingness of users and communities to pay the much higher operating costs of motor pumping.

Constraints and Choices

The idea of making large quantities of safe water readily accessible to all households is often not easily realizable. In many situations:

- The resources of safe water available in the area are limited, situated at some distance and/or difficult to access;

- Financial resources are limited, and insufficient to meet the high costs of extensive pipe-work and pumping;

- The technical expertise - the trained workforce and institutional capacity - required to design, establish and operate extensive pumping and piped systems may also be lacking.

The existence of adequate water resources in the locality is, of course, an essential prerequisite. Some programmes have, however, spent much time and money drilling without locating any worthwhile quantities of groundwater. This unproductive effort is not only costly but discouraging for the communities; it can be reduced by proper surveys. Elsewhere, in the Sahel and Bangladesh for example, the level of the groundwater table has fallen considerably since the rates of drilling and pumping, especially of larger wells with power pumps for irrigation or industry, have increased. In consequence, many existing village wells run the risk of drying up. The required water resources legislation and management may be difficult to institute. Deeper set handpumps are often the only solution.

The need for good survey data and careful exploration before major drilling activities are undertaken is obvious. Careful and continuous monitoring of the condition of groundwater reserves and control of pumping, where necessary, are no less important.

The limitation on funds available is an obvious major constraint. Where programmes have been planned to provide high levels of service, the number of communities covered has often been small and high proportions of the total population have remained without any reasonable access to safe supplies.

As a general rule, piped systems are more costly to establish and maintain than single point systems. However, there are situations where standpipe systems are the most economical alternative. Most commonly this occurs in areas with high population densities, such as poor urban areas. There are also cases where communities are willing and able to pay the increased cost for the added convenience of standpipes or yard taps. Finally, in some areas in which point sources are not feasible for technical reasons (usually the absence, or the chemical contamination of groundwater) piped systems are a necessity.

Notwithstanding such instances, sturdy and reliable handpumps installed in small-diameter wells are probably the main way in which water can be provided, at a reasonable cost, close to the homes of the majority of rural people who are presently lacking adequate, safe water supplies.

B. Sources of Water

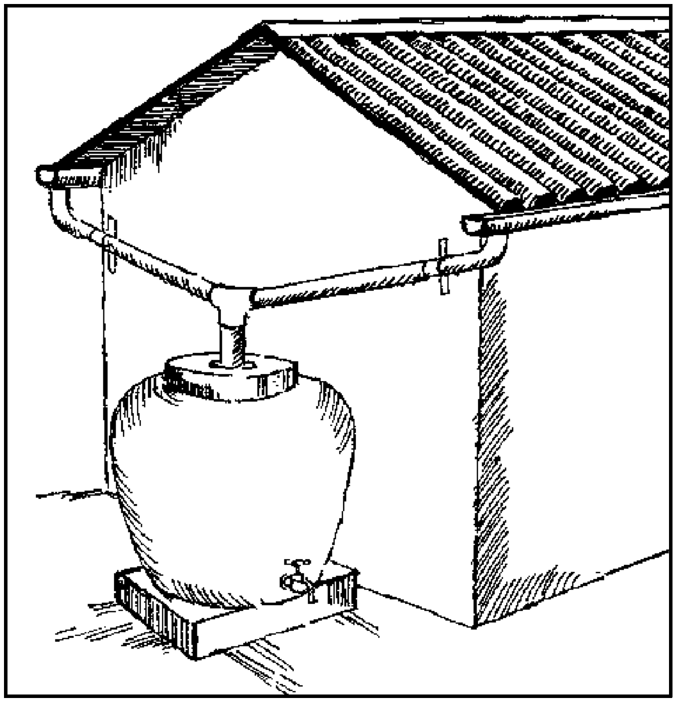
There are basically three categories of naturally occurring water resources: groundwater, rainwater and surface water.

> *Groundwater* occurs under most of the world's land surface, but there are great variations in the depths at which it is found, its mineral quality, the quantities present and the rates of infiltration (thus yield potential) and the nature of the ground above it (thus accessibility). In hilly areas it emerges from the ground in places as natural springs, otherwise wells have to be constructed and pumps or other lift mechanisms installed.
>
> *Rainwater* collection, from roofs or larger catchment areas, can be utilized as a source of drinking water, particularly where there are no other safe water sources available (for example in areas where groundwater is polluted or too deep to economically tap). In extreme situations, small quantities of water can be condensed from the atmosphere (as dew) on screens or similar devices.
>
> *Surface Water,* in streams, lakes and ponds is readily available in many populated areas, but it is almost always polluted, often grossly so. It should only be used if there are no other safe sources of water available.

The amount and reliability of background data on water resources varies between countries. In many, a certain amount of additional surveying and exploration is necessary before projects can be planned in detail, especially where groundwater is concerned.

Groundwater

Groundwater is the primary source of water in UNICEF-assisted projects. Such sources are usually bacteriologically pure, so disinfection is not necessary. However, groundwater aquifers can become bacteriologically polluted from sources of contamination such as latrines, garbage dumps, corrals and cemeteries, and through poorly constructed wells. For example, a deep borewell that has been improperly sealed can serve as a conduit that transmits polluted surface water into the aquifer. It must be remembered that bacteriologically pure groundwater that is drawn from a well is often polluted during its transport and storage and thus the identification and tapping of a pure water source does not automatically guarantee safe drinking water.



Roof Catchment (Source: Water Supply Options for Guinea Worm Eradication, UNICEF et al)

Groundwater may also be chemically contaminated, making it unfit for consumption without treatment. As described later in the chapter, common contaminants include iron, excessive dissolved salts and fluoride.

In many areas groundwater is, in principle, accessible at relatively low cost, but the technology to reach it and get it out of the ground in most cases requires considerable skill. There are also limits to all groundwater resources, even when they appear to be plentiful. Over-pumping can result in a lowering of groundwater levels to a point where it is no longer feasible or possible to continue pumping. This has become an increasingly common occurrence throughout the world, where over-pumping for irrigation, industry or large-scale urban water supply systems results in rural handpump-equipped wells going dry.

Women and Rainwater Harvesting

At Nagercoil, in India, during 1994, a group of women previously engaged by masons as head load carriers were trained in the construction of ferro-cement structures with the objective of ensuring the sustainability of rainwater harvesting systems. Over a 15-day period they learnt to construct doors, roofing sheets and water- retaining ferro-cement tanks.

This small group of women gained skills in the construction, maintenance and repair of their own rainwater harvesting systems and were subsequently able to find jobs themselves as masons. UNICEF supported training enabled several communities to provide themselves with safe drinking water in addition to enhancing the confidence and status of the women who were trained.

Groundwater resources must therefore be properly managed, and conservation measures be enforced where necessary, including control of exploitation and the use and re-infiltration of contaminated surface water. The management of groundwater resources should be assured by appropriate institutions and legislation.

Since groundwater is the most common source of water in UNICEF sponsored projects, methods for exploiting it are covered in detail later in the section.

Rainwater

Rainwater may be collected ("harvested") from surfaces by:

- Roof Catchment: After passing through a screen and/or filter, the water is conducted through gutters to cisterns. These cisterns can be large enough to serve a community or institution (such as a school) or relatively small, for single-family use. Innovative designs, and the use of ferro-cement in cistern construction in some countries (Indonesia, Thailand, India) have reduced costs and popularized this solution, especially for family use.

- Ground Catchment: The run-off from hard ground during heavy rains may be caught in lined pits, or may be diverted into a special borewell as a means of artificially recharging a groundwater aquifer. In addition, dams can be constructed to retain water flowing in gulleys and valleys. The environmental impact of larger dams and any artificial recharge system must be carefully examined at the design stage.

Once designs appropriate to local conditions are available, collection systems can be constructed at relatively low cost by communities themselves with the help of local craftsmen.

Surface Water

Where no other sources are readily available, surface water can be contained, collected and used after some form of filtration.

Large-scale treatment is generally feasible only in major urban contexts: the installations are costly and require very close and continuous technical supervision to ensure correct, reliable functioning. In areas where there is no other option but the village pond or stream, lower

Surface Water Tastes Better

"*It is five PM in the village of Jhadol, Rajasthan, India. Kavita, 25 years old and the mother of three young children, carries a large brass water jug on her head. She leaves her hut to fetch water for cooking and drinking. She passes by a handpump which, although it is in working condition, in not her destination. Ten minutes later she arrives at the village* nari - *a large pond which has collected rainwater - where she sees several women taking water from it. She catches a glimpse of some cows and goats drinking, their legs submerged in the water. She fills her jug with water but does not notice that the water is murky and dirty. After her jug is filled, she stops awhile to chat with her neighbour, and then heads on home.*"

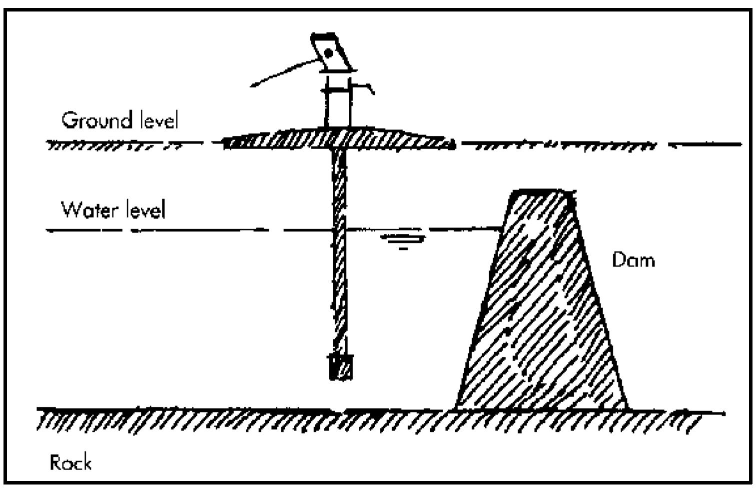
Although groundwater is usually a better option than surface water from a public health engineering standpoint, there is often some resistance by villagers who have traditionally had a surface water source to using a new, groundwater source. This is most often the case in areas (as in the example above) where the groundwater has a high level of salt, iron or other mineral. But in some cases, people simply prefer the taste of the surface water.

(Source: UNICEF *WATERfront*, Issue 6, pg. 22)

C. Groundwater Systems

Sub-Surface Dams

Sub-surface dams trap groundwater where it flows close to the surface in valleys or dried-up river beds. The water is stored as a shallow aquifer beneath the surface and therefore very little water is lost through evaporation, and there is a natural purification of the water as it filters through the ground. The dam must be constructed across the width of the valley and down to an impermeable layer to be effective. The water is accessed by wells - preferably combined with infiltration galleries - constructed upstream of the dam.

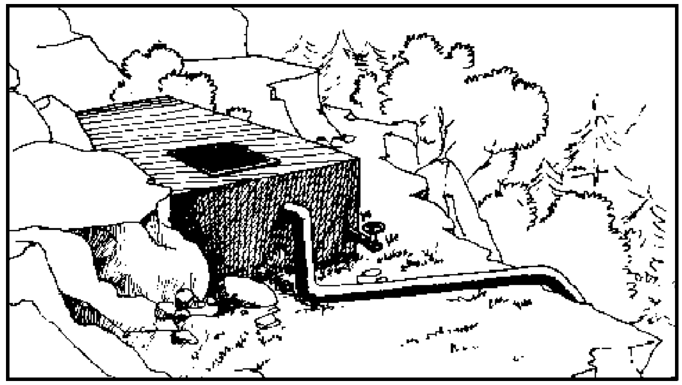


Sub-Surface Dam (Source: Water Supply Options for Guinea Worm Eradication, UNICEF et al)

Spring Protection

A spring occurs where the groundwater table intersects the surface. Springs are often the traditional source of water, especially for communities living in hilly areas and thus are already a culturally acceptable water supply solution.

Only springs which match the following criteria should be considered for improvement:



Spring Protection (Source: A Design Manual, UNICEF-Pakistan)

- the spring should provide a minimum yield of water throughout the year (except in specific cases where the spring is being developed to increase the community's water security for a portion of the year - 9 to 10 months for example);
- there should be no major sources of contamination (such as a town, factory, cattle yard, etc.) upstream of the spring, and the water quality should be checked and found acceptable;
- the distance between the spring and the beneficiary community should be within the national norms (unless a gravity feed system is being contemplated - see below).

The protection of the spring usually involves the construction of a sealed "spring box" which traps the water, provides for some basic filtration and sedimentation through the use of a gravel filter and sump, and, in some cases, provides water storage space to satisfy peak demand. It can be constructed using locally available resources and expertise.

The yield of some springs can be improved through the construction of a "filtration gallery," the insertion of filter pipe around the spring, leading to the spring box.

In all cases, the area immediately upstream of the spring should be protected from the defecation of animals through the use of a fence or hedge. Erosion can also be a problem in spring areas: the area upstream from the spring should be protected with vegetation and bunds if necessary, while the excess flow from the stream should be channeled into an existing stream or drain, or directed back into the ground using a soakage pit.

A protected spring can also be used as a source for a gravity-flow piped water system leading to a village below. Since no pumping is required, spring-fed piped systems are generally less costly and simpler than pumped piped systems.

Hand-Dug Wells

Hand-dug wells are widely used in developing countries, and in many areas for hundreds of years. There are also a large number of donor-funded rural water supply projects based on the construction of hand-dug wells.

There are many advantages to this technology:

- it does not require highly skilled labour;
- the level of community involvement and ownership can be enhanced through the appropriate participation of beneficiaries in the actual construction of the water point;
- an efficiently managed hand-dug well construction programme can be the most inexpensive water supply option;
- the improvement in an existing hand-dug well is often the first step towards a safe water source for the community;
- unlike most borewells, water can continue to be drawn from a hand-dug well even if the pump is broken or where a pump has never been installed;
- much of the well can be constructed using locally available material;
- since hand-dug wells are of a larger diameter than borewells, a certain amount of water storage space is available which can help to provide sufficient water for peak use times.

However, the disadvantages of hand-dug wells must also be taken into account:

- in the absence of appropriate safety measures and equipment, the construction of wells can be dangerous;
- although there are many cases of very deep hand-dug wells, most are relatively shallow (less than 15 to 20m) and tend to tap water from the uppermost (unconfined) aquifer, and are thus more susceptible to bacteriological contamination and the effects of falling water tables;
- unsealed hand-dug wells are especially susceptible to contamination from people and animals;
- the fact that this technology is only efficient in soft geological formations with relatively high groundwater levels restricts its application to specific areas and regions.

Although there are a wide range of construction methods and materials that can be used to construct hand-dug wells, most larger well programmes make use of circular concrete well "rings" that are pre-cast (on site or in a local production centre) and sunk into the ground. In very soft formations, the rings are sunk starting from the surface: digging from the inside of the ring, removing the material with a bucket (usually with the help of a tripod and pulley), and adding new rings as required. In harder, semi-consolidated formations, an unlined hole can be excavated down to the water table and only then are the ring liners inserted. In any case, the concrete rings are usually 1 to 1.3 metres in diameter and 0.5 to 1 metres high (large enough to allow a person to work inside it, but small enough to be economical and easily transported).

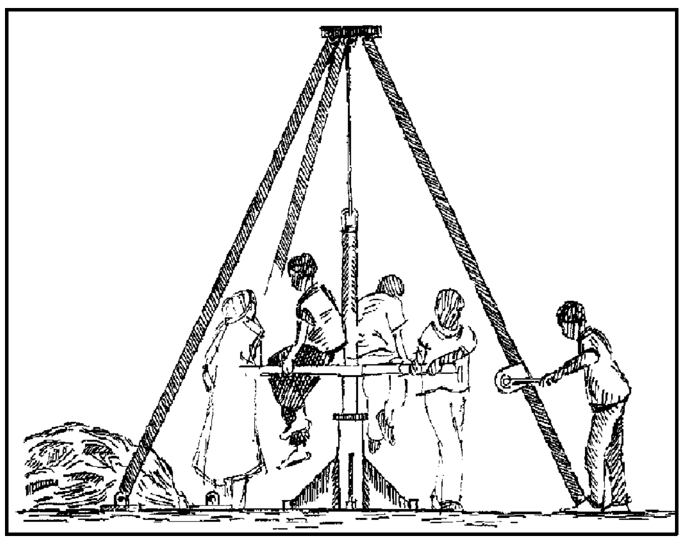
In most cases a motorized pump is required to de-water the well to allow excavation below the water table; however, in some cases high-flow handpumps (such as diaphragm pumps) can also be successfully used. A filter at the bottom of the finished well is often necessary, especially in formations with fine sand or silt particles. The filter can be a layer of gravel and coarse sand or a porous concrete plug (some of the lower well rings can also have porous areas to allow greater flow in poorer aquifers).

The well is finished with a headwall, a sealing slab and a surrounding apron with a drain. Care must be taken that the drain ultimately directs water to a natural or artificial drainage system and that the apron drain does not create a pool of water three metres away from the well. Although some new wells are still constructed without the installation of a handpump (instead relying on a windlass or bucket and pulley system), a handpump is preferable to avoid contamination but only in areas where handpumps are already prevalent.

It is sometimes appropriate, and economical, to concentrate on the improvement or rehabilitation of existing wells rather than the construction of new wells. This usually involves the deepening and disinfection of the existing well, the repair or replacement of the well lining, and the installation of a sealing slab, an apron and a handpump.

Hand-Drilled Borewells

The drilling of borewells using simple, inexpensive hand-operated equipment is a very appropriate technique under certain conditions: the aquifer must be relatively shallow (usually less than 25 to 30 metres), and the formation must be soft. Under these conditions, hand-drilled borewells can be completed much faster than hand-dug wells, and can reach slightly greater depths.



Hand-drilling (Source: Water Supply Options for Guinea Worm Eradication, UNICEF et al)

The most common type of hand-drilling equipment consists of a tripod and winch with drill rods and bits. The rods are manually turned (usually by four people) and extra downward force is applied by people sitting on the cross bars.

Well Construction Technologies					
	Hand-digging	**Hand-drilling**	**Cable-tool rig**	**Small air-flush rotary rig**	**Multi-purpose rotary rig**
Approx. capital cost range in US$	$1,000	$1,000-5,000	$20,000-100,000	$100,000-250,000	$200,000-500,000
Running cost	very low	low	low	medium	very high
Training needs for operation	very low	low	low-medium	medium	very high
Repair skills	very low	low	low-medium	medium	very high
Back-up support	very low	low	low-medium	medium	very high
Approx. range of penetration rates in metres per 8-hr day	0.1-2.0m	1-15m	1-15m	20-100m	20-100m
200 mm* holes to 15m in unconsolidated formation	-	fast	fast	impossible	very fast**
200 mm* holes to 50m in unconsolidated formation	-	slow and difficult	fairly fast	impossible	very fast**
200 mm* holes to 15/50m in semi-consolidated formation	-	impossible	fairly fast	impossible	very fast**
100 mm holes to 15/50m in consolidated (hard) formation (not gravel packed)	-	impossible	very slow	very fast**	very fast**
* 200 mm holes to give 100 mm diameter finished well after screening and gravel packing. ** constrained by logistical support					
From: Arlosoroff, S. et al. *Community Water Supply, The Handpump Option*, UNDP/World Bank.					

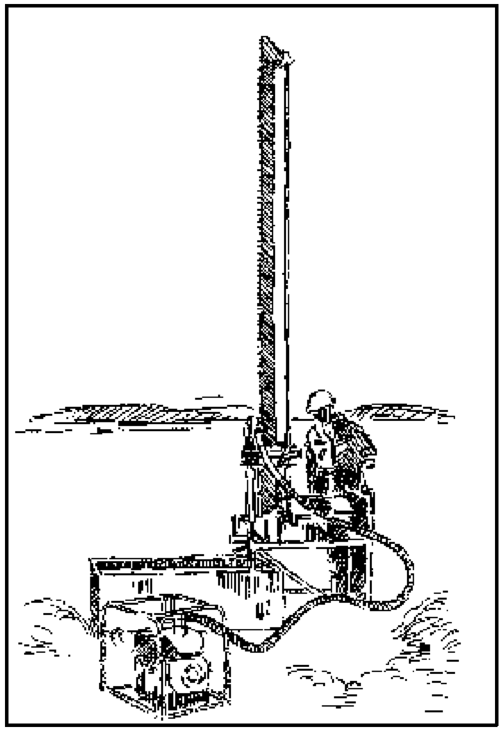
As in all borewells, the design and completion of the hand-drilled well is vitally important. The appropriate type and length of well screen (slotted well-casing pipes) must be placed at the correct depth, and, in most cases, a gravel pack must also be applied. An improperly designed or finished well is sometimes a cause for failure when drilling is carried out by less-skilled labour. As such, the hand-drilled well is less "forgiving" and more dependent on skilled labour than is the hand-dug well. However, the hand-drilled well does share with the hand-dug well, to a large extent, the advantage of being very suitable for a high degree of community participation as people can assist in the actual construction of the well.

A related technique, hand-jetting or sludging, is widely used in some alluvial areas. Hand-jetting is only suitable in very soft formations. However hand-jetted borewells have been constructed as deep as 200 metres and have served large numbers of people living on river flood-plains and deltas (in India and Bangladesh, for example).

Jetting involves pumping water into drill pipes, which allows them to be forced downward with a turning motion. Additional pipes are added as jetting proceeds. Upon reaching the desired depth, the drill pipes are removed and well casing is inserted into the hole. The pump most commonly used is a high flow handpump (usually operated by two people simultaneously), but small diesel or petrol centrifugal pumps can also be used.

Machine-Drilled Borewells

The majority of water points constructed in UNICEF-assisted programmes are machine-drilled borewells. Mechanized drilling is chosen over hand-digging or hand-drilling for three principal reasons: borewells can be drilled much faster than with the other two methods, much greater depths can be achieved, and drilling rigs are available which can efficiently produce borewells in semi-consolidated and consolidated (hard) formations. In fact, in many regions, mechanized drilling rigs are the only choice for groundwater-based water supply programmes.



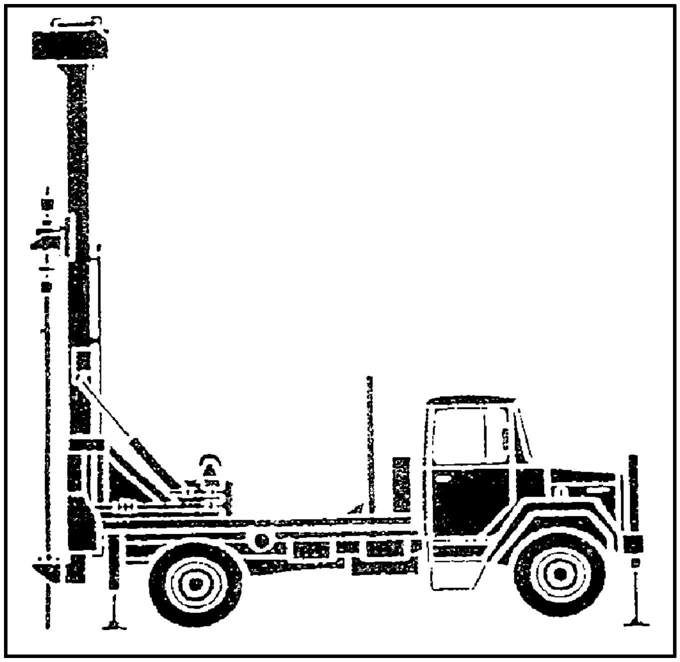
Portable Drilling Rig (Source: Water Supply Options for Guinea Worm Eradication, UNICEF et al)

The main disadvantage is that the capital, operating and maintenance costs are much higher with mechanized drilling rigs than with hand-drilling or digging. An efficient drilling programme offsets these costs by the speed of drilling, and can produce water points for less than $1,000 each in some cases. On the other hand, the speed of a drilling rig is always limited by the efficiency of the logistical infrastructure it operates within. There are cases where drilling rigs theoretically capable of drilling 150 borewells a year only drill 10 or less because of the lack of fuel, spare parts, skilled operators or poor planning and management. The operation of drilling rigs, and the management of mechanized drilling programmes, are complex occupations requiring skilled and experienced personnel.

Two types of mechanized drilling rigs are most commonly used in UNICEF-assisted programmes: cable-tool rigs and small rotary rigs:

Cable-tool rigs, or percussion rigs, are of very simple design and have been used for many years. The machine drills a hole by repeatedly driving a heavy drill string and bit into the ground, removing the cuttings with a bailer, and repeating the process until the desired depth is reached. The drill string is not rotated (some natural rotation takes place which assists in the cutting operation) - the rigs engine is used for repeatedly raising the heavy drill string through a winch and cable system. Since the rigs, although mechanized, are of very simple design, capital and operating costs are reasonable low. High drilling speeds can be achieved in unconsolidated and semi-consolidated formations, but this drilling method is not suitable for hard formations.

Unlike cable-tool rigs, *rotary rigs* drill by boring - the engine turns the drilling stem and bit at high torques to produce a hole. There are many types and designs of rotary rigs. A common subdivision of type is into rigs which use mud (water mixed with clay) for the removal of cuttings ("flushing") and those which use air (usually mixed with a foaming agent to increase efficiency). In all cases the air or mud is forced down the drilling stem and then returns back up the stem carrying the cuttings to the surface. In addition to flushing, the drilling fluid (mud or air) also serves to cool and lubricate the drilling bit and stabilize the hole and prevent it from collapsing (in unconsolidated and semi-consolidated formations) until the drilling operation is finished and the casing installed.



Truck-mounted Drilling Rig (Source: UNICEF India)

> Air-flush rotary rigs are used mainly in hard-rock formations, and are capable of efficiently drilling to great depths at high speeds (especially with the now commonly used "down-the-hole hammer" which provides percussion at the foot of the drill stem, and is powered by the same compressed air used for flushing). Although not overly complex in themselves, air-flush rigs require a separate air compressor unit which are typically expensive, bulky and complex.
>
> Mud-flush rigs are most efficient in unconsolidated to semi-consolidated formations, but can also be used in hard rock. A "mud pump," which is expensive and often maintenance intensive, is required for circulating the drilling fluid. A logistical bottleneck often encountered with mud-flush rigs, particularly in dry areas, is the need for fairly large amounts of water for operation.

All categories of drilling rigs come in a variety of models and sizes. Rigs can be so large as to require a 20-ton carrier truck, or small enough to fit in the back of a pick-up truck. UNICEF has been purchasing (and even designing) drilling rigs for thirty years, and there is consequently a wealth of resources available (in Copenhagen and elsewhere), for assistance in purchasing rigs and initiating a drilling programme.

Due to the continuing importance of drilling in UNICEF WES programmes, the cost and management of drilling programmes is covered extensively in the next section.

D. Pumping

With a few exceptions (springs and artesian wells), all groundwater systems must make use of pumps to draw the water to the surface (non-pumping solutions such as lowering buckets into dug wells, or large open step-wells where people walk down inside the well to collect water are highly prone to contamination and thus should not be considered as viable options).

Handpumps

Handpumps are the most common and, in most cases, the only economically feasible water lifting device for community needs. Yield depends on the depth and design, normally in the range of 600 to 1,500 litres per hour during constant use. Thus the maximum number of users for any one pump should, ideally, be not more than 150 persons. However in many countries, and especially in Africa, the actual number of users per handpump is 500 or higher.

The first force-mode handpumps used in UNICEF-assisted water projects in the 1960s were based on single-family cast-iron pumps used in the developed nations for more than a century. These pumps were quickly demonstrated to be inappropriate for community water supply projects because they were unable to withstand being used by hundreds of people a day, and because they were difficult to maintain. As the result of this, an effort initiated in the 1970s was launched to develop a handpump that was sturdy, easy to maintain, and that could be manufactured in developing countries. The first and most successful outcome of this effort was the India Mark II handpump which became the standard pump in India and many other countries in the late 1970s and the 1980s.

While suction pumps can only lift water from a maximum depth of about seven metres, they are still widely used and continue to serve hundreds of millions of people (many of which live on the Gangetic plain and delta in Bangladesh and India). Where groundwater levels are falling (or where shallow groundwater is becoming polluted), these pumps are gradually being replaced with force-mode pumps like the Tara. However, suction pumps continue to be appropriate in many situations and they remain the easiest pump to maintain due to the fact that all moving parts are above ground.

The handpump development effort also led to new thinking in the area of maintenance programmes and the realization that a decentralized management of maintenance structure is the most successful model, and that the most important design criteria for a handpump is its maintainability (see the following chapter on maintenance).

During the 1980s a UNDP global project for handpump testing and development (executed by the World Bank and with active UNICEF input) further studied and developed the design and manufacture of handpumps. It established standards and testing procedures that are used by UNICEF and other organizations for the selection and procurement of handpumps (see the box in this section on UNICEF-specific selection and standardization guidelines). The findings of the project are contained in the book *Community Water Supply - The Handpump Option (Arlosoroff et al, UNDP/World Bank),* which remains one of the most important texts in the sector to this day.

Handpump Classification

Type	**Description**	**Depth Range**	**Common Examples**
Suction	Raise water to the surface through a vacuum (sucking) action. All moving parts are above ground. Typically in the form of cast iron pumps, but also come in different forms such as the plastic Rower pump and diaphragm pumps.	Shallow (0 to 7 m)	- Nepal No. 6
Force-mode (lift)	Create a force lift of the water, most commonly using a piston with leather, rubber or plastic washers (cup seals) located in a pump cylinder below groundwater level. The piston travels up and down in the cylinder through a up and down motion at the pump head (direct action), a lever type handle, or a circular motion handle. Other mechanisms include spiral or helical stainless steel rotors encased in a rubber stator in the cylinder, and rubber diaphragms actuated hydraulically.	Low-lift (0 to 25 m) (Direct Action)	- Tara, Maya - Nira
		Intermediate-lift (25 to 50 m)	- India Mark II and III - Afridev - Vergnet
		Deep-set (50 to 90 m)	- India Mark II Extra Deep Well - Volanta

Although much handpump development work is still being carried out, it is mainly in the area of improving or modifying existing handpumps rather than "inventing" a new handpump. Good handpumps for most applications already exist, and efforts to design a "new" handpump for a specific project or country are misguided and wasteful. UNICEF issued guidelines for handpump selection and standardization issued as a memo from Programme Division to all UNICEF Representatives and Assistant Representatives. (10 June 1996, Ref: 96/402/TEC.CO., excerpted in the box below) to assist country offices involved in handpump policy and technology. These guidelines should be used to avoid costly repetition and unnecessary experimentation.

Most effort in the area of handpumps in the coming years will be in the implementation of a workable management of maintenance structure and the promotion of a nation or region-wide standardization. The in-country production of handpumps, while desirable in principle, is only potentially feasible in medium and larger countries with an established manufacturing base and a market large enough to support it. Experience has shown that it is more efficient for smaller countries to procure handpumps from abroad, especially from other developing nations with long experience in the production of public domain handpumps (India is the notable example here, producing - and exporting - thousands of Mark II/III, Afridev and Tara handpumps at prices significantly lower than anywhere else in the world).

Other Pumping

Systems

The handpump is, and will remain, the pump of choice for most UNICEF sponsored water supply projects. All other pumping systems, including those based on alternative energy sources, have greater capital and operating costs associated with them and in most cases, greater maintenance costs as well. However there are specific situations where power pumps can be more appropriate than handpumps, such as:

- areas where a storage and distribution system is necessary (e.g. rural hospitals), economically feasible (e.g. high density poor urban neighborhoods), or desired by a community willing and able to pay the higher capital, operation and maintenance costs associated with such a system;
- areas with a relatively inexpensive and reliable source of energy (usually electricity);
- situations where greater yields than that available from a handpump is required (e.g. communities with only one borewell which require water for additional needs such as cattle and irrigation);
- areas where the only available water is groundwater which is deeper than 90 m;
- some emergency situations (e.g. rapidly expanding refugee camps);
- in some areas where the only source is surface water.

Electric pumps are reliable, easy to operate and require little maintenance. Where villages and urban neighborhoods are connected to an electric grid network, the installation of piped systems with an electric pump can be appropriate. However, the electricity supply must be reliable, and the additional operation and maintenance costs must be taken into account during the project design phase. There are a wide variety of electric pumps available, including shaft drive, centrifugal and submersible (which is the most common). A type of electric pump known as the jet pump, which pumps water down a well through a venturi forcing more water up the well, is becoming more common and, in some areas, very inexpensive.

UNICEF Guidelines for Handpump Selection and Standardization (issued 09/96)

A. UNICEF's Role

UNICEF, in most cases, is a major partner with host Governments, and a powerful advocate for low cost technologies and community based strategies in the Rural Water Supply and Sanitation sector.

Advocating for a better handpump that is cost effective, reliable and affordable by user groups is part of UNICEF's role. However, UNICEF should facilitate appropriate decisions such as technology choice through negotiations between the host Government, potential manufacturers, sector partners, donors and communities. UNICEF should offer unbiased support, maintaining at all times, objectivity. *UNICEF staff members should in no case advocate for a new handpump based solely on individual preference but be guided by the UNICEF strategies in Water and Environmental Sanitation and this guideline.*

B. Handpump Technology Choice

A number of handpump designs both branded (proprietary) and public domain are available to meet various field conditions. The Handpump Project of World Bank/UNDP extensively documented laboratory and field test results from 70 different handpump models from developing and developed countries. It is not easy to choose a handpump unless a proven selection process is followed. The salient features of UNICEF's handpump selection process, proven over 25 years, are summarized below.

Define Field Conditions: Collect field data on water quality, static water level during the dry season, type of borehole (lined or unlined), number of users per pump, local resources (technical and financial) available for maintenance and local capacity and capability for manufacture. If the water is corrosive, for example, the use of handpumps with non-corrodible components will be preferable.

Establish Selection Criteria: Define the selection requirements, which will include minimum acceptable discharge against the maximum head, reliability (number of maintenance interventions per year), maintainability (level of skill and number of tools required to carry out normal maintenance) and robustness (to withstand expected usage), resistance to corrosion and abrasion and suitability for local manufacture.

Carry out Literature Search: Prepare a list of handpumps broadly meeting the selection requirements. Compare the handpumps based on reliable field data available within UNICEF and outside in order to select pumps that have performed well under similar field conditions. Select maximum two handpump designs for pilot scale trials.

Prefer a Public Domain Handpump Design: Public domain handpumps (Afridev, India Mark II, India Mark III and Tara and their local brand names like U2, etc.) developed as a result of concerted efforts of many years by donors, governments and manufacturers have been adopted on a large scale in several countries and a vast amount of reliable data is available on their performance. These designs are updated regularly and detailed product specifications are available. Moreover, a number of manufacturers make each of these public domain handpumps in many countries. Competition results in lower prices and faster deliveries. Additionally, there is no need for the payment of royalties in case a manufacturer in a country wishes to start local production. Unless there are overriding reasons, a public domain handpump design, backed by R&D for the continuous fine tuning of the design, is preferred. However, depending on the country situation, well established pumps like Vergnet and Nira are not discouraged. But the decision has to be based on many factors including affordability.

Pilot Scale Testing: A small number (maximum 50) of each handpump selected as per the process described above should be field tested (under maximum static water level [SWL] and high usage conditions) and monitored meticulously for at least two years to assess the pump's performance in terms of reliability, maintainability, cost effectiveness and sustainability. This field testing is considered sufficient to make a decision for introducing a handpump on a larger scale in a rural water supply project.

Large-scale Testing: However, if it is intended to adopt a handpump design on a national scale, it is necessary to carry out large-scale field trials. In such a case, the most successful handpump in the pilot testing should then be installed and monitored for at least two years for its Village Level Operation and Management of Maintenance (VLOM) performance in greater numbers (say 500 to 1,000), preferably spread over three or four locations representing various hydrogeological and cultural conditions. The performance should be assessed in terms of maintainability, reliability, maintenance costs and user acceptability. If the large-scale trials are successful, the handpump design may be considered for adoption at the national level.

C. Standardization

Handpump standardization on a national scale requires a firm and long term commitment from the government and donors on the use of a particular handpump. However, to eliminate ambiguity during procurement, production and quality control, it is necessary to define the handpump adequately and document it in the form of a standard covering material specifications, design, quality control, packaging, performance and warranty aspects. Establishing a handpump standard in a country is a major accomplishment and is the final step in the handpump selection process.

Standardization on the use of a handpump at the national level offers valuable benefits. These include, limiting the variety of spare parts and training that is required, easier inventory control, reduced training costs, preventing fragmentation of market demand thereby increasing economic viability of local production and reduction in handpump and spare parts costs.

Experience over the last two decades indicates that several countries have benefitted immensely by standardizing on one handpump. Standardization of a handpump - the India Mark II/III in India and Nigeria, the Tara handpump in Bangladesh and the Afridev in Pakistan and the Mark II in Sudan and Uganda - has proven the single most important factor leading to programme sustainability.

The visible benefit of standardization on public domain handpumps is reduction in handpump prices - the India Mark II was priced at U.S. $180 in the early 1980s; in 1996 it is available for U.S. $98 without rising main pipes. The Afridev handpump price reduced from over U.S. $600 in the early 1980s to U.S. $250 in 1996.

D. Lessons Learned

Country level handpump choice and standardization may take 4 to 5 years. There are no short cuts to attain standardization. No matter how strong the desire is to introduce a new handpump or make a change in the design, the time tested process of choosing an appropriate handpump must precede standardization. Any compromise will result in loss of faith in handpump technology and the technical capability of UNICEF.

Note: Although the standardization on one pump in a country is the most desirable outcome, there are cases where it is necessary to standardize on two pumps. Such cases are most common in countries where there are two or more significantly different hydrogeological zones -- for example, a hilly or high plain area characterized by deep static water levels and a coastal or alluvial zone with shallow water levels. If these zones are large enough (and with large enough populations) it can be more economically efficient to standardize on two different pumps. An example where this has happened is India where the India Mark II/Mark III is the standard in most of the country, but the lower lift Tara handpump is now becoming the standard in the Gangetic alluvial plain. If it is found to be necessary to choose two pumps, it is best to choose two pumps from the same family. For example, if some very deep SWL zones exist in a country which is using the India Mark III in all other areas, it makes more sense to choose the India Mark II Extra Deep Well handpump to cover these zones rather than choosing a completely unrelated pump like the Volanta.

From *UNICEF Guidelines for Handpump Selection and Standardization*, UNICEF NYHQ, 1996

Diesel and petrol powered pumps are usually more expensive to operate and maintain than those using electricity. Maintenance frequently poses problems, and fuel supplies are often difficult to assure as well as being expensive. Only in exceptional circumstances should they be considered, and then only the simplest possible technology - a reciprocating pump powered by a single-cylinder diesel engine.

Windmills have been experimented with in many water supply projects throughout the world and are most commonly attached to a handpump-like force lift pump in a borewell. The fact that there are no energy costs associated with this technology makes it very attractive. However, windmills have gained a reputation of being very difficult to maintain and there are many cases where they have broken down permanently after a relatively short life span. Nevertheless, much work is being carried out with the technology, and improved models are beginning to address the high capital cost and maintenance problems. A result of this work is that there are now many companies manufacturing windmills, some of which donate windmills to UNICEF for testing. While interesting and potentially useful in UNICEF-assisted projects, it should be noted that such testing programmes can be very time-consuming and thus, in some cases, counterproductive.

Solar power pumps have been used in many parts of the world, but are very expensive and continue to share, to a large extent, the windmill's reputation of unreliability. The most common solar pump is based on photovoltaic cell technology and power electric submersible pumps. Much of the expense (and breakdowns) associated with the technology is related to the fact that the DC power produced by the photovoltaic cells must usually be stored in batteries and/or converted to AC power. The large photovoltaic cells required are fragile and very susceptible to vandalism. A new, less expensive type of solar pump which uses the sun's heat to displace a liquid which powers a submersed piston pump, rather than using photovoltaic cells, is now being field tested and may prove to be a successful technology. Solar pumping systems are often most successful in institutional settings (schools, health posts, etc.) where resources are available for their proper operation, maintenance and protection.

Hydraulic rams consist of a special pipe assembly with a single moving valve which enables a part of the water in a fast-flowing stream at a low level to be pushed up and delivered at a higher level, using only the force of the original flow for energy. Although these pumps provide a relatively inexpensive and reliable pumping solution, they can be used only in very specific and limited situations. In some cases, the stream can be modified through the use of aqueducts, ditches and piping to produce the necessary head to power the hydraulic ram.

Indicative Cost Comparison of Pumps		
Handpumps	Suction Pump (Nepal No. 6)	0.3
	Tara	0.9

	Nira	1.4
	India Mark II	1.0
	India Mark III	1.3
	Afridev	1.4
	Mark II Extra Deep Well	1.7
	Volanta	10.0
Power Pumps	Electric Jet Pump	2 to 10
	Hydraulic Ram	3 to 15
	Electric Submersible	8 to 20
	Diesel Reciprocating	10 to 25
	Windmill Pump	15 to 100
	Solar (Photovoltaic)	50 to 175
Baseline of 1.0 is the India Mark II Handpump with 30 m rising main (FOB Bombay) at a cost of $US 175 in 1996. Costs change constantly but the indicative ratios remain roughly the same.		

E. Storage and Distribution Systems

Storage systems are required in the following situations:

- for most standpipe and household connection piped systems and for some systems designed to serve an institution like a school or health post (in some cases storage is not required: for some gravity flow spring catchment systems where water is flowing continuously, and where automatic electric pressure pumps are used to replace storage systems);

- in rainwater collection systems, whether for individual households or for communities;

- on some single point source systems, usually when a power pump is used to draw water from a deep borewell at set times throughout the day (often corresponding to electricity availability).

Storage tanks are usually elevated, and water is drawn from them by gravity.

Most commonly, storage tanks and elevation towers are constructed from reinforced concrete or steel. However, lower cost options - such as ferrocement (thin-walled concrete structures with chicken wire or bamboo reinforcing) and, in some countries like India, medium density polyethylene (MDPE) or other plastic pre-fabricated tanks - are becoming increasingly available.

Distribution systems should always be designed by experienced professionals or artisans to ensure economy and reliability.

Pipes come in a variety of materials, appropriate for different uses.

- Galvanized iron (GI) pipes are used for high-pressure pipeline stretches and for areas where pipes cannot be buried. GI pipes are much more expensive than most other pipes.

- Poly vinyl chloride (PVC) pipes are used for lower water pressures, and must be buried as the material deteriorates with prolonged exposure to sunlight and is easily broken by impact.

- High density polyethylene (HDPE) pipes are often used as an alternative to GI pipes as they can withstand similar pressures and are less expensive. They are often more appropriate than PVC pipes because they come in rolls which are easier to transport and handle than lengths of PVC pipe, and they do not deteriorate in sunlight.

- Bamboo trunks formed into pipes are appropriate only in the following specific situation: in a very isolated area with no road access (making other pipes unavailable or prohibitively expensive), with plenty of bamboo, and for use in a low pressure system (usually gravity spring fed systems). Problems with bamboo include its rapid deterioration unless chemically treated, and difficulties in connecting the bamboo pipes to fittings such as valves.

Standpipes must be of sturdy design and include an apron and drain for waste water. As in the case of hand-dug wells and borewells, care should be taken to ensure that the water is drained completely away, that it reach some ultimate drainage system. In most systems, standard taps are not used as they are easily damaged and tend to be left open, wasting water. "Waste-not" taps are usually employed instead. These taps are of two designs: a spring loaded or a weighted system which ensures that taps cannot be left on. Standpipe and tap design is ultimately less important than the degree of community management and ownership for the success of the system. There are many cases, for example, where standard taps are used successfully on standpipes as the system stakeholders are careful to turn them off, and are able and willing to repair them when necessary.

F. Water Quality

All UNICEF offices with past or ongoing water programmes of cooperation should take adequate steps to ensure that the water quality of systems supported by UNICEF is within acceptable limits as defined by government standards. Such standards are commonly based on WHO guidelines[8] and local considerations. In cases where government standards have

[8]WHO. Guidelines for drinking-water quality, 2nd ed. Geneva. 1993/96/97 (Volume 1: Recommendations, Volume 2: Health criteria and other supporting information, Volume 3: Small Community Supplies)

not been established, or are in need of revision, UNICEF offices (in consultation with WHO) may consider providing technical support to government for the development of standards and/or monitoring systems. UNICEF has significant experience in the promotion of community-based water quality surveillance systems in India and elsewhere that may be highly applicable in other countries.

The discussion in the bacteriological and chemical quality sections below is a practical introduction to water quality issues and common pollutants and contaminants typically encountered in UNICEF-supported programmes. The WHO guidelines should be used for the more detailed information necessary for programme design and implementation.

Bacteriological Quality

Bacteria and other pathogens are the greatest threat to the quality of water for domestic consumption. Bacteria originating from human faeces is a leading cause of child mortality, and water is a common transmission route. This faecal-oral cycle can best be broken by preventing bacteria from entering water for domestic consumption or, if necessary, by purifying water which is already contaminated.

The first step towards achieving this is by ensuring that the water source is protected. Groundwater systems are relatively easy to protect, if a few simple guidelines are taken into account:

- aprons with drains should always be constructed around the well;
- the well should be properly sealed: cement or clay grouting should be used to seal borewells and impervious well lining (usually concrete) should be used for hand-dug wells;
- the new well should be disinfected after completion, and cleaned annually during the dry season;
- there should be no sources of contamination (latrines, garbage dumps, corrals, etc.) close to or up hill of the well;
- people, and especially children, should be prevented from contaminating the well through community education and mobilization;
- the well should be fenced off in areas with a high concentration of domesticated animals such as cattle or swine;
- the provision of separate facilities for washing (washing platforms) and livestock watering (drinking troughs) also help to protect the water source.

Surface water sources are harder to protect, and most efforts centre around preventing people and animals from entering the pond or stream through the construction of fences and even, in some extreme cases, the posting of guards. Sources of contamination close to the surface water source should also be removed.

It should be emphasized that a protected source will help to reduce health problems only if it is used continuously and exclusively by the community. If the water source dries up seasonally, is too far away or is unacceptable in some other way, people will be forced to use another, unprotected water source.

Protecting the source does not ensure that the water people drink will be bacteria free. There are many cases of water which is bacteria-free at the source becoming contaminated during transportation, storage and consumption. Any water supply project that neglects this aspect will be ineffective.

Most efforts to reduce or eliminate the contamination of water during storage, transportation and consumption are centred around the provision of effective hygiene education in the community. The message is simple: dirty hands or implements should never touch drinking water. However, the fact that the message is simple does not mean that the hygiene education programme is easily carried out or, as is often the case, that it is merely a small component of a large project and it is ill defined and poorly financed and staffed. The hygiene education programme must be designed and implemented by field professionals in close consultation with, and with the willing participation of, the community stakeholders. See the Hygiene Promotion Manual in this series for a complete description of the design and implementation of hygiene programmes.

The provision and promotion of covered receptacles for water storage in the home, and long-handled ladles for use with the storage pots, can assist families in keeping their water clean.

Although the prevention of bacteria from entering water supplies is the most effective solution, there are cases where it is necessary to purify water that is already contaminated. Some methods for this include:

- Chlorination: while technically very effective, a functional chlorination system is often difficult to implement, especially in rural areas. However, some successes have been achieved with simple pot chlorinators on wells and storage tanks (often using bleaching powder as the source of chlorine). The treatment of water with chlorine can also be effective in institutional settings such as health posts and schools where resources are available and supervision is assured. The use of chlorine tablets to purify small amounts of drinking water in households is not effective as a long-term measure and should only be used in emergencies.

- Boiling: in most cases boiling is not a sustainable option because of the difficulty in obtaining firewood (and the resulting damage it causes to the environment), and the expense of other fuels.

- Slow sand filters: in areas where the only source of water is contaminated, such as a village pond, community-scale filters have been constructed and used successfully. These filters require considerable care and thus their success hinges upon a community managed maintenance system. Another option is household sand filters, usually based on traditional water containers. These filters are only effective if used continuously and maintained properly by the family.

- Solar disinfection: a simple technology using natural solar radiation to inactivate and destroy pathogenic microorganisms in water through a combination of ultra-violet (UV) rays and heat. The treatment essentially consists of filling transparent containers with water and exposing them to full sunlight for several hours; usually at the household level. This is a promising, very low-cost system that is gaining acceptance in several countries throughout the world. To be effective, this system must be part of an intensive community mobilisation and education programme to ensure correct and consistent application. It is also highly sensitive to seasonal, climatic and geographahic factors.

Chemical Quality

Although chemically contaminated water supplies are less widespread and more localized than bacteriologically contaminated water, specific contaminants can greatly affect the quality of water in different areas. The most common contaminants found in water sources throughout the world are iron and dissolved salts. Others include fluoride, arsenic and chromium.

Iron, while not harmful to the human body except in very high concentrations (and in fact is necessary for good health), clogs up well installations, pumps, pipes and storage tanks, discolours laundry and gives a distinct taste to the water. The result is that people may abandon the new source that contains iron and return to a traditional source which may be bacteriologically contaminated. Removing iron from water is a problem. In small rural systems simple aeration devices can be built but need frequent cleaning and maintenance. Small iron removal plants have been set up at reasonable cost in Bangladesh, Sri Lanka and India.

High concentrations of dissolved salts in water (above 2,000 ppm) is a widespread problem for which there is no low-cost solution. In many areas the problem can be minimized through hydrogeological investigation and well siting to find sweet water zones (which often overlie saline aquifers). It should be noted that in areas with chronic brackish water problems, people have become accustomed to consuming water with a salt content of 5,000 ppm or higher with no reported ill effects.

Corrosion and other chemical damage, notable incrustations of calcium, iron or other deposits, can render any water installation - pumps, pipes, pump rods and fittings - inoperable within a short time. The use of plastic and stainless steel instead of metal parts greatly reduces these problems. Some handpumps, like the Afridev, are built entirely of corrosion-resistant components. However, plastic riser mains are usually not as durable as steel pipes and are prone to abrasion, especially in unlined hard-rock borewells. Where borewells are lined, the use of PVC casing and screen is now widespread. Stainless steel pump rods and riser mains, while very effective and durable, are prohibitively expensive in most situations.

In areas with high concentrations of fluoride in water sources - which can cause very serious public health problems - solutions have been principally based on finding alternatives to the contaminated sources. However advances have been made in the area of water treatment using activated alumina filtration media. Low-cost community-maintained filters (at the source itself or in households) have been field tested on a large scale in India with positive results.

Some geological formations contain naturally-occurring inorganic arsenic compounds that can contaminate groundwater aquifers in concentrations high enough to pose a serious public health risk. Such contamination has been recorded in small scattered locations throughout the world, including in Taiwan and Chile where the element has been identified as the cause of a number of health problems including cancer. More recently, groundwater aquifers in geological zones not previously associated with inorganic arsenic have also been found to be contaminated in Bangladesh, India, China and Vietnam. Arsenic has now been recognised as being a major public health threat, with tens of millions of people potentially at risk. Arsenic is relatively difficult to detect in water because of the very low concentrations involved (the WHO recommended limit for arsenic is 0.01 mg/l or 10 parts per billion - although most country standards remain at 50 ppb). Detection is further complicated by the fact that symptoms in people may not appear for 5 to 15 years of drinking contaminated water. The fact that some of the arsenic contaminated wells were drilled through UNICEF-supported programmes highlights the need for country programmes to place greater emphasis on water quality issues.

Water Quality Monitoring

As water quality problems become more widespread, water quality monitoring will necessarily become a more important component of national water resources management programmes and UNICEF will likely be called upon to play an increasingly active role in this area. Given UNICEF's traditional strengths, a natural focus area could be on promoting grassroots-level water quality monitoring initiatives in the form of community-based water quality surveillance systems. Such systems have the potential to strengthen the existing national water quality monitoring systems by providing the means for better and more timely sampling and analysis by stakeholders themselves. An additional benefit of such community-based systems is that people will gain direct knowledge of the quality of water in their own sources. This knowledge can then be put to good use by the community as a tool for negotiating with governments for service improvements, or for monitoring the work of contractors from the private sector

A necessary pre-condition for the success of community-based monitoring systems is the availability of user-friendly, simple and cheap water quality test kits. Recently such kits are becoming better and more common, and in several countries UNICEF is actively involved in test kit development. In the past, testing for bacteriological contamination of water supplies was relatively difficult and time consuming as it was necessary to send water samples to a properly equipped laboratory. In recent years, however, less cumbersome testing procedures have become available. In India, for example, a system that uses hydrogen sulphide (H_2S) impregnated strips of paper as an indicator of coliform bacteria has been developed. This simple system is being used successfully not only by technicians, but by the community itself to evaluate its own water sources and to advocate with political leaders for improved sources (by proving that an existing source is contaminated). Similar advances have been made for chemical quality parameters as well. In Bangladesh, for example, UNICEF and partners have developed a simple and inexpensive arsenic field test kit.

G. Summary Points

- *all projects start with a decision on the level of service to be provided: single point systems, standpipes or household connections*
- *in many situations there are three principal constraints affecting the implementation of a water system: water resource availability and quality, financial resources and technical and managerial skills of the community and the service providers*
- *there are three basic categories of water sources: groundwater, rainwater and surface water*
- *groundwater is the most commonly used source for water supply projects due to its general good quality and wide availability*
- *there are five principal methods for extracting groundwater:*
    - *sub-surface dams*
    - *spring protection*
    - *hand-dug wells*
    - *hand-drilled borewells*
    - *machine drilled borewells*

- *handpumps are the most common and, in most cases, the only economically feasible water lifting device for community needs*

- *the UNICEF guidelines for handpump selection and standardization should be used by all country programmes involved in handpump policy and technology*

- *while other pumping systems such as diesel, petrol, electric, wind and solar powered pumps are available and appropriate in specific situations, handpumps are generally an order of magnitude cheaper*

- *water storage systems are required for most piped systems, all rainwater collection systems and on some single point systems*

- *bacteria from human faeces are the most serious threat to water quality and are best eliminated by breaking the faecal-oral cycle through source protection, periodic disinfection, removal of contamination sources and, most importantly, through community education and mobilization*

- *chemical contaminants such as iron, fluoride and dissolved salts are more widely affecting community water systems and must be minimized or eliminated through appropriate technologies and methodologies*

- *Water quality monitoring should become a more important part of UNICEF water programmes, in the light of increasing pollution and contamination. Community-based quality surveillance systems can help to empower communities with knowledge about the quality of their own systems.*

5. Maintenance of Water Supply Systems

A. Institutional Arrangements

The majority of failures in water supply projects, over the long term, are attributable to problems with maintenance; and most of these problems are institutional rather than technical in nature. A successful, cost-effective maintenance programme is often much more difficult to achieve than the installation of the water system itself.

Systems of maintenance and repair which depend upon mechanics going out from a limited number of centres (e.g. district level workshops) have often been found to entail:

- high costs - mainly from transportation;
- long system down-times because of long waits for mechanics to arrive;
- reluctance of communities to take any initiatives to protect and prevent misuse of installations which are considered to be the responsibility of a distant government.

In recognition of these problems, most governments and country programmes are now establishing systems of village level operation and maintenance where community members are primarily responsible for the operation and maintenance of installations.

One of the most common institutional arrangements is the three-tier system, originating in India and used there and elsewhere, where:

- handpump caretakers, selected from among the villagers, are responsible for the general care and routine maintenance of the handpumps in their own villages;

The VLOM Concept

Village Level Operation and Maintenance (VLOM) is a strategy to help in solving the widespread problems experienced with centralized maintenance.

Experience in one country after another has shown that a central maintenance system, requiring a motor vehicle and crew to move out from a base camp, is unable to keep pumps in satisfactory operational condition. The large expense of such maintenance and the logistical and staffing needs to supply enough experienced and motivated teams of mechanics to carry out repairs promptly have proved very difficult to sustain. But the desirable alternative of village-level maintenance is only feasible if the pump design allows for it.

A common feature of successful handpump projects is the emphasis on village management of maintenance, reducing the dependence on central government support of essential functions. In the extended VLOM concept, where "M" means management of maintenance, these elements have been added:

- Community choice of when to service pumps
- Community choice of who will service pumps and
- Direct payment to repairers by the community.

Extracted from *Community Water Supply - The Handpump Option,* UNDP/WB (Arlosoroff et al)

- pump mechanics at the sub-district level regularly inspect all installations and make minor repairs as and when necessary;

- teams of more highly trained mechanics based at state/provincial level are called in for major repair and replacement work; they are equipped with all the necessary tools and machinery.

In some countries and regions, it has been found that even a fairly general institutional framework like that of three-tier maintenance cannot be applied everywhere. The institutional arrangements should be made (or modified) on a case-by-case basis, as far as possible. The ultimate decision of the form of the maintenance system should be made by the community itself. In India, for example, even though the three-tier system is long established and widely implemented throughout the country, in some areas communities or districts are using different systems that are more locally appropriate, such as combining the first two tiers and training "caretaker cum mechanics" instead of separate groups of caretakers and mechanics, or eliminating caretakers altogether and expanding the duties of the mechanic.

Training of personnel at all levels should include operation and maintenance. Technicians should be specifically trained in these techniques and selected community members trained to undertake specific tasks within their capabilities.

In some cases the government pays local-level pump mechanics and repair teams and subsidizes prices of spare parts which are made available at different levels; in other cases, communities have to pay. Caretakers are remunerated by their communities which also pay for spare parts, either out of communal funds (from regular payments by households) or by collecting money when necessary for repairs. While project planners and government staff can provide training and suggestions to the community in the area of managing the financial arrangements for maintenance, the final decision on the structure and details of the financial system used is best left to the community itself.

Over-reliance on central government bodies should be avoided for managing individual on-site projects and ongoing operation and maintenance of systems. The development of local government and community capacity to operate and maintain the system and design the institutional arrangements, will help to ensure long system lifetimes.

B. Technical Issues

All water supply systems require some maintenance and occasional repairs. Some need frequent attention even when there are no problems of misuse. Typical maintenance programmes include:

- Handpumps: periodic lubrication of above-ground components, replacement of washers and seals, replacement of plastic bearings, occasional replacement of individual riser mains;

- Borewells: occasional re-development (or rejuvenation) of borewells with compressed air and, if necessary, hydrofracturing to increase yield;

- Aprons and drains (around hand-dug wells, borewells and standpipes): regular cleaning, repair of cracked and broken concrete, unclogging of drains;

- Hand-dug Wells: repair of concrete lining, cap and head wall, deepening if necessary, replacement of gravel filter;

- Spring Boxes: regular cleaning, repair of masonry, unclogging of drain;

- Motorized Pumps: extensive mechanical maintenance;

- Rainwater Systems: regular cleaning and repair of guttering, replacement or cleaning of filters;

- Distribution Systems: inspection and repair of leaks in pipelines, replacement and repair of taps and fittings;

- Storage and Filtration Tanks: regular cleaning, replacement of filter media.

Maintenance difficulties and problems with frequent breakdowns are multiplied by selecting inappropriate pumps and other materials. Handpumps, in particular, are not always appropriate for the heavy intense use to which they are subjected as communal facilities. Pumps which require specialised tools and equipment are sometimes selected, so that even the smallest maintenance task is beyond the capability of willing community members.

In the selection and procurement of pumps there should be the maximum possible standardization on one or a small number of models which are robust, appropriate to the local situation, simple and on which maintenance can be undertaken by community members with a minimum of tools and training. To ensure a consistent level of quality in the handpumps used in water supply programmes, a national quality assurance and inspection system should be established in all countries which have large-scale handpump programmes, using international standards and quality control procedures which are available for most popular handpumps.

What is a VLOM Handpump?

No single set of features or technical characteristics makes one pump a "VLOM pump" and another a "non VLOM pump". A VLOM handpump is simply a pump that can be, and is being, maintained by the community itself, using predominately local resources. Thus it depends more on the community - its collective skills, resources and degree of mobilization - than on the pump. There are many examples of one model of handpump being successfully maintained at the community level in one country, but not in another.

There are however, a couple of common and general technical features that have clearly been proven to reduce the degree of difficulty of pump maintenance, and thus contribute to the success of a decentralized maintenance programme. Another aspect of the technical simplification of maintenance is that in societies where women have less technical or mechanical experience than men, there is a tendency not to train them as handpumps mechanics because "it is too complicated". Simplified maintenance procedures is one good response to this argument. Again it should be noted that these technical characteristics do not, in themselves, assure a successful maintenance programme, nor are they absolutely necessary in all situations.

- Open-top Cylinders: The diameter of the riser main is less than the diameter of the cylinder in most earlier handpumps like the India Mark II. This design necessitates the removal of the rods and riser pipes to gain access to the cylinder components for maintenance or replacement. Since the riser pipes are heavy (especially with the added weight of the water contained in them), in many cases it is not possible to lift them by hand and thus lifting tackle and a tripod is necessary. Given that most routine maintenance involves these cylinder components, this situation is a serious deterrent to community maintenance in some areas. In open-top cylinder design, the diameter of the cylinder and the riser main are the same which allows the cylinder to be removed, without removing the riser pipes; only the rods must be removed. Since this operation can be done by hand, maintenance is simplified. Many newer handpumps (India Mark III, Afridev, Nira, Tara, Volanta, etc.) are of open-top cylinder design.

- Fewer Tools: The fewer tools needed, the less likely a pump will go without maintenance or repair for want of a missing tool. Fewer tools also cuts down on capital costs of a project and, in some cases, the cost of transportation (some handpumps require so many tools that traveling by bicycle, or even motorcycle, is not viable for pump mechanics). Some handpumps (Afridev, Tara, etc.) require only one or two tools for all maintenance and most repairs.

- "Hook and Eye" Rod Connectors: In some countries the use of threaded rod connectors has never been an obstacle for decentralized maintenance: communities possessed or acquired the necessary skills and tools to successfully install or dismantle threaded rods. However, in other countries the use of these connectors has been problematic and has resulted in failed maintenance programmes (and the costly replacement or repair of damaged rods). The use of threadless rod connectors (like the Afridev's hook and eye system, or in pumps using Mondesh connectors) minimizes or eliminates this problem.

Even when responsibility for maintenance and repairs is clearly defined and accepted, and funds, and technical skills are available, neither routine maintenance nor repairs will be done promptly unless the necessary tools and spare parts are also on hand at the local level, and at reasonable and affordable prices.

The types and quantities of spare parts which must be kept need to be specified on the basis of the manufactures' recommendations as well as in-country experience. These stocks may be held by the communities themselves (which implies adequate planning, financing and storage facilities), by the caretakers or mechanics, or by private merchants who sell them to the community or mechanic when required. The use of the private merchandise distribution system is probably the most desirable alternative, given that government-managed systems are expensive and often inefficient. However, such private channels only exist in some countries and regions; and the volume of the spares to be sold must be high enough to be commercially viable.

Tools must, similarly, be immediately available. Provision may be made to supply each community with the tools necessary for routine maintenance and simple repairs.

C. Summary Points

- *a successful, cost-effective maintenance programme is often much more difficult to achieve than the installation of the water system itself*

- *institutional arrangements should be made on a case-by-case basis, as far as possible, and the ultimate decision of the form of the maintenance system should be made by the community itself*

- *maintenance difficulties and problems with frequent breakdowns are multiplied by selecting inappropriate pumps and other materials and by the failure to establish an appropriate spare parts distribution network*

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Glossary

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PROWWESS	Promotion of the Role of Women in Water and Environmental Sanitation Services (UNDP)
public domain handpump	a handpump design for which there is no privately held patent and is thus freely reproducible by anybody
PVC	poly vinyl chloride (a type of plastic)
standpipe	a water tap in either a communal area or a yard
SWL	Static Water Level
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
VLOM	Village Level Operation and (Management of) Maintenance
WASH	Water and Sanitation for Health Project
WATSAN	Water and Sanitation
WES	Water, Environment and Sanitation (a cluster in UNICEF New York - formerly known as Water and Environmental Sanitation)
WHO	World Health Organization
WWF	World Wildlife Fund
yield, well yield	volume of water per unit of time produced by a water well

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