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Operations and Maintenance of Water Supply and Sanitation Systems: CASE STUDIES

Operation and Maintenance Working Group

Water Supply and Sanitation Collaborative Council

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Preface

A working group on operation and maintenance was constituted in 1988 under the leadership of the World Health Organization, to advocate the need for intensified action aimed at an improved performance of existing water supply and sanitation systems through better management and operational practices. This working group is constituted by representatives from developing countries' agencies and selected external support agencies.

Since the creation of the Operation and Maintenance Working Group (OMWG) in 1988, several meetings were organized in which relevant ideas, principles and priorities were established and converted into action at the Global, Regional and country level.

Several case studies and concept documents covering different aspects of assets management and sustainability of water supply and sanitation systems have been prepared by members of the OMWG and were presented at the Group's meetings or at workshops which without being planned or organized by the secretariat of the Group were strongly influenced by the O&M conceptual framework developed since the start of this process of cooperation shared by external support agencies and water agencies in developing countries. These case studies provided the basis for the definition of priority issues, structuring of the Operation and Maintenance Working Group, formulation of action plans and carrying out of water supply and sanitation sector development activities.

Considering that the above papers are an impressive collection of case studies dealing with many issues and relevant experiences linked to sector development aspects, it was recognized that the organization of these papers into a coherent document would be of great interest for those dealing with development activities, specially in aspects of water supply and sanitation assets management. This collection of case studies contains important lessons that can orient the adoption of suitable criteria and adequate strategies dealing with projects on different aspects of operation and maintenance.

TOWARDS IMPROVED OPERATIONS AND MAINTENANCE PERFORMANCE

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Introduction

During the International Drinking Water Supply and Sanitation Decade, major efforts have been made in attempts to increase investments in Water Supply and Sanitation. Regrettably, investments in increasing operating and maintenance skills have not kept pace. As a consequence, many water systems are not providing the full services they were designed to deliver and the backlog of rehabilitation needs grows year by year.

Operation and maintenance (O & M) is the activity of a water supply and sanitation agency which has the most immediate impact on the user, the value of the service he receives, and his perception of it. Operation and Maintenance should therefore have the highest priority among an agency's activities. Unfortunately, Operation and Maintenance is rarely so regarded by organizations with a backlog of unmet demand (unserved areas). Both the institutions and the decision makers in External Support Agencies and governments are under considerable pressure to give priority to extensions and new construction. To make things worse, Operation and Maintenance is so intimately connected to sector and institutional issues that it would be difficult, at best to improve it without an understanding of those larger issues and at least their partial resolution. Moreover, the implementation of Operation and Maintenance programmes should be considered as a priority stage in the process of the institutional development of water agencies.

This paper reviews the broader sector and institutional issues to place Operation and Maintenance in proper perspective and suggests minimum actions and activities to improve Operation and Maintenance. The method of analysis followed is to identify and briefly review an issue, to indicate what action by sector and agency decision-makers (or External Support Agencies) is required and to suggest activities to assist decision-makers in the promotion and implementation of Operation and Maintenance improvements. The information generated should convince decision makers of the priority Operation and Maintenance should have for the achievement of long-term sustainability and thus the economic viability of the sector.

Sector Performance

Inadequate maintenance is a symptom of faulty priorities and lack of understanding of the importance of good operating and maintenance practices by decision-makers inside and outside the sector as much as it is a problem of inadequate funds or lack of skills. Decision-makers must be convinced of the benefits of good maintenance before they authorize the allocation of funds and give higher priority to Operation and Maintenance.

To convince decision makers, the cost and benefits of adequate maintenance as well as the costs and disbenefits of inadequate maintenance must be clearly demonstrated. The situation is similar to the often referred to reluctance of economic decision-makers to accept health improvement claims of water supply projects without a quantification of benefits. Decision-makers must be given quantitative evidence in order to provide financial support, for Operation and Maintenance just as for health improvements. One topic which can be used to demonstrate the

costs, benefits and disbenefits of different levels of Operation and Maintenance activities is unaccounted for water. Reduction in unaccounted for water through better operation and Maintenance increases revenues, reduces rehabilitation costs and postpones future investments, issues decision-makers in both External Support Agencies and governments appreciate.

Fortunately, it should be easier to produce the evidence in the case of Operation and Maintenance, although with some difficulties caused by the dispersed character of the sector. Unlike electric energy, which can be transported over great distances and thus is usually supplied by enterprises serving large geographic areas, water supply agencies are relatively small in comparison or consist of a large number of individual units. Exchange of experience and information is consequently more difficult and often neglected, leaving individual units unaware of progress made elsewhere. Training, management, provision of supplies, applied research and development suffer similarly from this dispersion of the sector, particularly in rural areas. Obtaining information on Operation and Maintenance performance, costs and benefits will therefore be an arduous task.

In order to address this situation, government and sector decision-makers should establish policies giving maintenance adequate priority at all levels of project development, implementation and Operation. Specific activities which might be undertaken include undertaking a study of pertinent literature and documentation and preparing a report directed at decision-makers which:

- Defines adequate Operation and Maintenance performance and quantifies its costs and benefits (for different system components or technologies) on the basis of information available from well managed and maintained water supply systems.

- Quantifies disbenefits of inadequate Operation and Maintenance performance for similar systems, such as early replacement of assets inoperative due to lack of maintenance, on the basis of actual experience.

- Provides a cost-benefit analysis to justify increased support for Operation and Maintenance activities.

- Suggests policies establishing financial support and priority of Operation and Maintenance programmes.

Included in this analysis could be such topics as rehabilitation vs. new construction, maintenance vs. planned obsolescence and similar issues.

Funding of Operation and Maintenance

Inadequacy of maintenance funding is usually assumed to be the cause when systems fail because the operating entity was unable to buy materials or engage a sufficient number of adequately trained staff. Unfortunately, that only answers the question of what is inadequate but leaves unanswered what amount of funds would be required for adequate maintenance. To budget adequate financial resources, that question must be answered.

With financial requirements known, policy decisions on how to generate necessary funds can be established. To be sustainable over the long term, the user should be able to pay for maintenance or be capable of undertaking the maintenance tasks himself. This is so because

governments and External Support Agencies have no direct interest or responsibility in Operation and Maintenance (in contrast to the user), have changing priorities, and thus should not be depended upon as sources for Operation and Maintenance funds except during a short term period of transition.

To optimize investment and resource recovery potential for Operation and Maintenance, projects should be designed for "effective demand", i.e. the user's choice of system or technology based on his own judgement of acceptability, willingness and ability to pay (in case or in kind). Design for effective demand requires the project developer to work with the user community. This often results in an iterative process to find the solutions which are acceptable and affordable. The intensity of community participation varies greatly, reflecting the likely technical option. For complex urban systems, users may be asked to approve the broad concept only, while in small communities, periurban and rural areas the user may participate in decisions about layout, technology choice and financing.

Government and sector decision-makers, including those of External Support Agencies, should include in their cost recovery policies the requirement that long-term sustainability of investments must be achieved and that in an effort to do so, projects should be designed on the basis of effective demand, should specifically assess Operation and Maintenance requirements, and provide for agency, community or user capacity to undertake or finance Operation and Maintenance.

To help provide decision-makers with the information necessary to determine the financial requirements of the proposed cost recovery policy, a study should be initiated which analysis the financial requirements for Operation and Maintenance or develops a methodology or a model on how to determine financial requirements for Operation and Maintenance for individual projects. The research should also compile a matrix relating investment and Operation and Maintenance costs for different systems or technologies and describe maintenance needs of technologies listed in the matrix.

ESA Support

External Support Agency (ESA) support has to be based on the recognition that governments are responsible for determining sector policies and priorities and that, ultimately, users must sustain the services they choose to receive. External Support Agencies, in assisting governments and users, can make significant contributions in accelerating progress of the sector, not only by making funds available but by providing advice and information on policy issues, assistance in policy and guideline formulation and support through adopting appropriate policies themselves.

For example, External Support Agencies should give preference to financing projects designed on the basis of effective demand and encourage cost recovery policies which require the user to be ultimately responsible for Operation and Maintenance (in kind or cash), even if this requires a relaxation of procurement rules (tied aid), if their application would result in the use of "inappropriate" technology or equipment.

This imposes on External Support Agencies the responsibility to ensure its staff evaluates projects in accordance with these principles and that the consultants they fund for project preparation are skilled in designing projects for effective demand.

External Support Agencies should also encourage their clients to make better use of management information systems designed (among other things) to provide the data necessary to determine the cost of Operation and Maintenance and its impact in order to be better able to judge the adequacy of Operation and Maintenance. The system should include appropriate indicators for the monitoring and evaluation of Operation and Maintenance and arrangements for feedback to system designers so lessons learned will be incorporated in future designs. External Support Agencies should review their policies to ascertain that they are compatible with the objectives of effective demand design and long-term sustainability through the users own efforts. If necessary, existing guidelines should be adapted. Subsequently, their consistent application should be ensured on projects financed with ESA financial support. There are several specific activities which ESAs could undertake. These include the preparation, for their own use and that of developing country agencies they support of:

- Guidelines and training materials on how to develop and implement projects designed on the basis of effective demand. These guidelines would be for ESA and sector agency staff and their consultants and could be adapted by individual External Support Agencies to meet specific demands.

- Guidelines and indicators for the monitoring and evaluation of Operation and Maintenance performance.

Individual External Support Agencies should define how they will provide feedback to designers about the performance of their designs to ensure that necessary improvements will be made in future designs. The "lessons learned" feedback process should be automatic.

The preparation of the guidelines should be followed by appropriate training of ESA and sector staff and their consultants.

Appropriate Use of Technology

To be appropriate, technology must be least cost, financially affordable and socioculturally acceptable to the user. Where there is any doubt that this definition refers to both investment and operation, additional phrasing such as "and maintainable by the user either through his own labour or by payment to a public or private operating enterprise" may be added. Projects designed in accordance with the principles of effective demand meet these conditions.

The approach not only allows the user to decide what he is able and willing to pay, but it requires the designer to base his designs on cost and/or ease of maintenance of the technology selected. Experience shows that it cannot be simply assumed that needed operators will eventually be trained. It also means that the operators (users or operating agency employees) need to be consulted in the design process.

Sufficient information is available about appropriate technologies for this process of consultation except on the topic of maintenance, particularly its cost. External Support Agencies and developing countries should agree that the appropriate use of technology as described above is a fundamental requirement in the development of joint projects. To ensure implementation, projects are to be designed on the basis of effective demand, i.e. giving the user a voice in defining what is acceptable and affordable to him. Project design is to explicitly consider the ability of the user to maintain the constructed facilities or pay for their Operation and Maintenance. If necessary, policies and guidelines should be amended to reflect this requirement.

To avoid problems of past project development when initial costs only were considered and insufficient attention was paid to the complexity or cost of Operation and Maintenance (particularly when hardware was made available at concessionary terms), the guidelines developed by External Support Agencies for staff and consultants should specific instructions on the evaluation of Operation and Maintenance appropriateness. These should be made available to implementing agencies.

System Performance

Even a system using appropriate technology may perform poorly if design was inadequate, construction shoddy or using faulty construction techniques, materials were of inadequate quality or inappropriate to local conditions. Participation in the construction supervision by those who will operate the system helps overcome the problem.

The use of materials not locally or in country available, such as treatment chemicals, can result in performance defects even with the best Operation and Maintenance staff and procedures if foreign currency is not available to the operating agency. The same is true for spare parts not locally available. Design can minimize this problem, of course.

Poor system performance can also be caused by events not under the control of the operating agency. For example, upstream water pollution may exceed treatment capacity, diversion of scarce water resources (illegal or legal) for other purposes may cause severe supply deficiencies, regardless of operating skills.

In periurban and rural areas, operational responsibilities are at times ill defined and can also result in neglect of Operation and Maintenance activities. Coordination arrangements with other institutions, especially where community participation is an important factor and hygiene education a need, is a must if long-term sustainability is to be achieved.

Implementation of quality control monitoring for manufactured goods and construction, followed by corrective action, is important. The promotion of local production of necessary equipment and material and the use of adequate chemicals or disinfectants locally produced should be encouraged. However, where these locally produced materials, including chemicals, are not suitable their substitution for improved materials should be encouraged (development of better products or purchasing of imported materials).

Strengthening collaboration with other agencies in an effort to overcome water pollution and scarcity problems should be an integral part of water supply management in an effort to overcome related Operation and Maintenance problems. National governments should also issue appropriate guidelines and directives to implement quality control, promote local manufacturing and ensure adequate interagency cooperation.

A review should be undertaken in selected countries to determine the adverse impact on projects dependence of materials not locally available and the effect the lack of adequate spare parts distribution has on system performance. This should lead to conclusions as to what substitutions would be possible, and what design changes in future projects may make such substitution easier to implement. Appropriate design guidelines could then be developed to encourage the engineer to investigate materials availability prior to design and to select process modifications to reduce Operation and Maintenance problems.

Based on the results of the review, a study should be conducted in appropriate countries to determine the feasibility of establishing local manufacturing of equipment, spare parts, materials and chemicals (or substitutes). Subsequent establishment of manufacturing capacity could be part of a water supply investment or a separate project.

Also guidelines on how to determine the feasibility of and promote local manufacturing of spare parts and materials should be developed from these studies in an effort to solve related Operation and Maintenance problems for the long term in other countries.

Institutional Performance

A properly designed and implemented water supply system provided with adequate financial resources depends for its long-term sustainability on the institution in charge of its management. Indeed, inadequate Operation and Maintenance is tied to many institutional problems, most of which are not amendable to corrections without major institutional changes. Clearly, those exceed the capacity of Operation and Maintenance units to modify. The following recommendations address those issues which can be at least partially improved by the operating institution for the benefit of Operation and Maintenance.

Systems will invariably fail as long as the institutional environment concentrates on expansion and neglects Operation and Maintenance. Governments and institutions should recognize that the fundamental purpose of an operating organization is to operate, not to build. That is obvious to a "mature" organization, where capital expansion is a relatively small part of activities. Until developing countries' organizations behave as operators rather than builders, they will forever be building because their neglect of maintenance will require them to rebuild deteriorated assets. Funding allocation between new construction and rehabilitation and maintenance therefore needs to be reconsidered, and organizational arrangements changed to reflect higher priority for Operation and Maintenance.

The traditional public utility arrangement frequently is not effective for periurban and rural areas where community participation is an essential ingredient of successful project development and Operation and Maintenance. The institution must come multidisciplinary, employ behavioral scientists and public health specialists to work with the users, and establish, as part of its own organization or separately, support structures to help the community with tasks of a technical nature it cannot accomplish by itself alone. A multidisciplinary team will also be in a better position to work with other institutions to arrange for corollary activities, for example the hygiene education of the users by the ministry of health.

The participation of the user in the design and implementation process, and his responsibility for Operation and Maintenance, requires the operating agency to pay much closer attention to monitoring and evaluating the performance and impact of the project so lessons learned can be incorporated into future designs. The planning process is no longer one of developing a masterplan with a first stage project for those who can afford a given service standard (technology), but one of preparing a dynamic plan responsive to user preference, i.e. various standards depending on affordability and willingness to pay. Because they change over time, monitoring will indicate needed changes and provide lessons for future project design.

The role of the private sector in the provision of support services to the community,

particularly in Operation and Maintenance, should be considered. Private entrepreneurs are often the supplier of last resort when water is not communally available, usually at high marginal costs. However, entrepreneurs may be able to provide repair and maintenance service more quickly and at lower cost than a centralized institution, especially in periurban and rural areas. Specific tasks, such as computerized billing, leak detection, treatment plant operation, etc. may also be candidates for contracting to the private sector in an effort to make the service more efficient and less expensive in urban areas. The engagement of the private sector in Operation and Maintenance should be carefully considered in the context of an institutional development process, without losing the perspective of the need to ensure the sustainability of this process.

In most developing country institutions, the way to a successful career is through design and construction activities, not by being an excellent Operation and Maintenance manager. Not only do Operation and Maintenance activities suffer from this, but future projects do not reflect operating experience. To change this, institutions should establish career-paths for operating and personnel which are as attractive as those of design and construction staff to encourage talented young staff to consider operations as an option. The chief of operations position should be on a level equal to that of the capital works or chief engineer, with veto power over new project designs. No senior staff appointments should be made of candidates who do not have experience in both operations and design/construction. Training activities should reflect this approach.

The organizational structure of the traditional centralized institution has to be modified to make it more responsive to the needs of the periurban and rural population. Whether this adjustment will be essentially a reorganization of an existing institution or the creation of new agencies will depend on local conditions and government policies for the sector. In either case, an institutional structure has to be implemented which is designed to support local communities and users in their own efforts to develop, implement, operate and maintain systems in periurban and rural areas where the traditional centralized operations have been largely unsuccessful.

Privatizing can be interpreted to imply anything from contracting for minor services to complete private control of the provision of water supply services. In this context it means contracting for specific services, complete privatizing being beyond Operation and Maintenance preview. Appropriate policies should be enacted to give an agency the opportunity to contract for specific services if they prove to be efficient.

Suggested activities which could be undertaken by ESA's and or national governments to improve institutional performance are:

- To study organizational structure and personnel policies of the Operation and Maintenance complex (and its status within the organization) or successful developing and developed country operating organizations and develop models for implementation by other organizations. Included in the analysis and the model should be an assessment of the cost of modifying the organizational structure.

- to investigate alternative arrangements of organizing water and sanitation support structures, capable of working with the community and the user in Operation and Maintenance, suitable for periurban and rural areas and recommend, if deemed necessary, testing an demonstrating appropriate models. Particular emphasis should be paid to the needed relationship between centralized urban utilities and local community organizations serving periurban neighbourhoods. In the rural areas, attention needs to be paid to spare parts distribution. Because Operation and Maintenance cannot

be entirely separated from other institutional considerations, this study should include overall institutional aspects. It should therefore preferably be based on or included in institutional improvement projects.

- To determine the cost of specific unidentifiable tasks, such as meter reading and billing, maintenance of treatment plants or isolated rural facilities, network of spare parts provision, technical assistance to community organizations, and evaluate whether services of private entrepreneurs or nongovernment volunteer organizations would be less expensive, more responsive or more efficient. If private provision of such services is found to be more effective, appropriate policies and contracting procedures should be developed to encouraged privatizing of these services.

User Participation

The traditional engineering approach is to identify a problem, design a solution, construct the resultant project, and leave Operation and Maintenance considerations to local authorities. With the effective demand based design method, this is no longer adequate, except in the case of complex urban projects. Now the user, individually and as part of a community participates in the desision-making process, beginning with project identification through all the intermediary steps ending with the decision as to how the site is to be operated and by whom. As a consequence, the responsible institution must equip itself to work with the community, both by adapting its structure and by engaging appropriately qualified staff.

In the rural and periurban area, community participation will probably be intense as a general rule. In central urban areas, community participation will probably involve traditional public utility marketing practices, supplemented by more intense efforts at convincing consumers to conserve water through modifying personal habits and the use of water saving appliances. This is because the standard of service in densely populated areas is not amendable to individual chose (economies of scale determine technology to be used) and other decision, method of water treatment for example, require expertise users ordinarily do not possess.

User participation in project design is important not only because it allows a determination of willingness to pay, but it permits the user to determine his involvement in Operation and Maintenance activities. Without it, there is no reason to expect user involvement in Operation and Maintenance. User participation also has to include an appropriate degree of hygiene eduction to be successful: the user must understand the health aspects of safe water, technology selection and personal hygiene behaviour. For example, the user needs to understand and practice the protection of water quality within the household (and while carrying water to it) to benefit from improved water quality and to maintain the facility which provides it.

Community participation is recognized to be the key to long-term sustainability of water supply and sanitation facilities in periurban and rural areas. How to organize and maintain user interest, and how to help user in their tasks of operating and maintaining systems is well known among behavioral scientist field staff and community workers. The problem is that traditional public utility staff, in keeping with institutional priorities, have little interest or incentive to promote community participation. Overcoming this problem requires an intensive effort of education, preferably in parallel with such institutional changes as are necessary. Documentation for such an educational effort should be assembled and prepared to suit the needs of the audience. This should not lead to a belief that education along will be sufficient. Institutional attitude and organizational

modifications are necessary, and staff qualified in community participation and user education have to be engaged to complement institutional technical staff who, however willing, will not acquire overnight the necessary skills to implement projects based on community participation.

Institutions have to organize staff units capable of working with the community in improving Operation and Maintenance. The training of present staff is essential and it may be necessary to engage additional staff (community workers).

In order to improve the participation of the consumers in operation and maintenance national governments and project staff should review available user and community training materials, identify gaps and prepare missing documentation. Gaps are likely to be found mostly in the documentation for training/sensitizing of institution staff. Institutions should also be prepared to assist in the preparation and implementation of the necessary training activities. Again, the greater need is probably in the training of institution staff because in the past community work has been primarily undertaken by volunteer organizations.

Summary and Conclusion

There is an urgent need to promote adequate Operation and Maintenance of water supply systems so more people can be served on a sustained basis. It is in the interest of operating agencies to properly maintain their systems so they can successfully provide the services expected and attract additional funds for system expansion. It is of equal interest to External Support Agencies and Governments to ensure that the systems they have helped finance are properly maintained: a) to protect their investment, because without it does not make sense to continue investing in the sector and: b) a malfunctioning system does not contribute to economic development.

A cooperative effort between national governments and External Support Agencies is required as there is a need to agree on the importance and the methods of improving Operation and Maintenance performance. Actions can be implemented individually, but a general agreement on how to proceed is necessary to make efforts more effective.

Finally, exchange of information on cost, methods and benefits of proper Operation and Maintenance can help each individual government and ESA to improve the effectiveness of its own programmes, and networking on specific activities can increase the impact of individual efforts.

A strategy to reach the objective of improved Operation and Maintenance should include:

- Defining the activities needed to generate the information necessary for developing policies and programmes.
- Consulting with other programmes engaged in the procurement of information on similar topics to expand the database.
- Promoting and supporting the elaboration of policies and programmes and propose their implementation to decision-makers in countries and External Support Agencies.
- Assisting in the implementation of policies and programmes.

- Monitoring the implementation and evaluate the results.

and - Suggesting and supporting the reformulation of policies and programmes, as indicated from monitoring, to obtain expected benefits.

ISSUES, CONSTRAINTS AND PRINCIPLES FOR SUSTAINABLE OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS

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Introduction

External support agencies have traditionally been strong supporters of water supply and sanitation programs in the developing world. This support is usually justified on the basis that it will improve the health and well being of the recipients and thus lead to economic improvement.

Since the mid 1960's investments in the water supply and sanitation sector have been increasing. The International Drinking Water Supply and Sanitation Decade (UN Water Decade) from 1981 to 1990 saw an unprecedented focus on water supply and sanitation, with a peaking in investments by external support agencies and national governments.

Increases in coverage were reported globally, and while most countries never achieved the levels confidently predicted at the beginning of the UN Water Decade, major advances appear to have been made.

However, another alarming and disturbing statistic emerged during the UN Water Decade. In rural areas where water supply is usually provided through point sources fitted with handpumps or motorized pumps, a high percentage of facilities were reported out of order. Statistics for inoperative facilities of 40%, 50% and even higher have been reported. In some countries it was discovered that all of the systems constructed under particular aid programs were not working and had been abandoned. In the Western Sudan for example at least 50% of systems were assessed to be inoperative at any one time.

In large cities it was found that on average 30% and even up to 50% of the water produced was unaccounted for. More than half the water in Cairo, Jakarta, Lagos, Mexico City and Lima is unaccounted for. In Jakarta 51 percent or almost 30 billion gallons a year simply disappears. Leakage, illegal connections, broken meters and a whole host of other reasons were identified. In the cities wastage in the areas served is usually high and commonly water rates are subsidized, while the inhabitants in the marginal areas largely go unserved and obtain water on an irregular basis and at very high costs from private vendors.

This high rate of failure of systems in rural areas and unaccounted for water in cities renders the coverage figures reported by national governments and international agencies suspect especially in those countries with high percentages of failed systems.

The failure of systems and the high percentage which are functioning at less than design capacity is directly attributable to poor operation and maintenance and the absence of adequate operation and maintenance programs. In the rush to elevate coverage figures quite often concern for long term sustainability was ignored.

Recently however, there has been a shift in this situation and several external support agencies have been increasingly supporting operation and maintenance projects. As funds have become scarcer, agencies are anxious to maximize resources and have become worried over the sustainability of project benefits. The World Health Organization (WHO) in its eighth program of work, covering the period 1990 to 1995, is emphasizing the importance of operation and maintenance in community water supply and sanitation programs.

Similarly the Collaborative Council on Water Supply and Sanitation has recognized the critical importance of operation and maintenance and one of its key working groups is the O&M Working Group on Water Supply and Sanitation whose mandate is to research and devise strategies to improve operation and maintenance.

This working group which was formed as a WHO working group in 1988, has held a number of meetings involving participants from external support agencies and developing countries to focus on the problems of poor operation and maintenance. The group in 1991 officially became one of the working groups of the Collaborative Council. Discussions have centred on first of all finding out why operation and maintenance levels are sub optimal, isolating the issues and constraints in O&M, and seeking to identify principles and strategies that can be applied to improve operation and maintenance.

This paper describes the issues and constraints to effective O&M and discusses some of the major principles that have been targeted by the Working Group for improving operation and maintenance performance.

Integrated Approach

There is another aspect of the O&M problem which is frequently overlooked.

The relationship between water supply, sanitation and health has been recognized and accepted by water sector professionals, external support agencies and national governments. It has been learned that in order to improve health the provision of water must be accompanied by sanitation and improved hygiene. Without these health benefits are very limited. However in reality when we talk about O&M we are often only talking about water supply; sanitation and hygiene education tend to be largely forgotten. Even at meetings to discuss this issue sanitation and hygiene education are usually given lesser attention except for platitudes about how important they are. The reason for this is easy to understand. Water supply is tangible and the need for water readily apparent, while sanitation and hygiene are more ethereal and have proven extremely difficult program components to implement. In fact many so called integrated programs end up stressing water supply, and sanitation and hygiene education receive limited if any real attention. Sparse data exist on the success and sustainability of hygiene education and sanitation in projects. However it seems clear that the failure rates for these components eclipse the non-operation of water supply facilities.

If we accept the concept that programs in water supply must be integrated and contain sanitation and hygiene education as integral components, then we are also going to have to be concerned about the sustainability of hygiene education and sanitation. If water sector programs are to be successful all three, water supply, sanitation and hygiene education must be sustainable. Therefore, effective O&M strategies are going to have to be devised for hygiene education and sanitation as well as water supply.

Issues and Constraints to Operation and Maintenance

A myriad of reasons have been identified as contributing to or causing the failure of water supply systems. These range from poor organizational structures in the responsible agency, lack of spare parts, inappropriate technology, lack of trained staff, tied aid, absence of career opportunities in the O&M sector, insufficient funding, legal framework problems, lack of motivation by sector personnel, non-involvement of the users, the low profile of operation and maintenance in the sector in general, inadequate tariff and collection systems and political interference. These causes tend to be interrelated and intertwined.

The O&M working group reduced this list and identified seven key issues and constraints for poor operation and maintenance performance. These are:

1. Inadequate Data on Operation and Maintenance
2. Insufficient and Inefficient Use of Funds
3. Poor Management of Water Supply Facilities
4. Inappropriate System Design
5. Low Profile of O and M
6. Inadequate Policies, Legal Frameworks and Overlapping Responsibilities
7. Political Interference

1. Inadequate Data.

There is an overall lack of data regarding operation and maintenance. Precise, accurate data on the number of systems which are not working throughout the world are needed together with information on the main reasons why. Detailed figures are also necessary to determine how much it costs to undertake an adequate operation and maintenance program for various types of facilities in different countries.

Data are also required on the rates of breakdown of different systems such as pumping stations, distribution networks, treatment plants in urban systems, small gravity systems, and diesel motor pumping systems.

Until this information is forthcoming it will be impossible to accurately assess the overall performance of the operation and maintenance subsector and compute the financial losses due to poor operation and maintenance. These exact financial data are urgently needed to demonstrate to decision makers the advisability of implementing sound operation and maintenance programs in order to reduce losses to national economies.

2. Insufficient and Inefficient Use of Funds

Insufficient funding has been identified as a major contributor to poor operation and maintenance performance. This lack of funds hampers the operating and maintaining of water supply facilities, as money is not available to buy spare parts, properly train staff and provide competitive salaries to attract high calibre personnel. External support agencies have traditionally been reluctant to finance operation and maintenance activities, while national governments have often given it a low priority. National governments are frequently stressed for cash, especially hard

currency which is needed to pay for spare parts, and the water supply agencies usually lose out to other, judged more important higher profile sectors.

The users are a potential source of finance for water supply systems. They are often unable or unwilling to pay. Usually it is that they are unwilling to pay rather than unable to. Evidence is mounting that even in the poorest and most underprivileged segments of society people are willing to pay, for a reliable, adequate supply of clean water but unwilling to be charged for an unreliable and unsatisfactory service. It is a vicious cycle. As the service level drops due to a lack of operation and maintenance the users withhold support and become less willing to pay which further constrains operation and maintenance activities.

Sometimes it is the inefficient use of funds rather than a lack of money which contributes to poor operation and maintenance. The poor management of facilities results in the squandering of resources which then reduces the viability of the water supply system. Those responsible for managing water supply facilities need to look carefully at their operations to ensure that they are operating efficiently. Common problems are often too many unskilled staff and poor logistical and organizational structures.

Losses of revenue from unaccounted for water are a problem for most systems. It is difficult to define what is an acceptable level of unaccounted for water. A figure of 25% may be appropriate as a first target for an agency working at unaccounted for water levels of 50%, but significantly lower levels can and should be achieved. What is an acceptable level of unaccounted for water has to be determined on the basis of local conditions, but true wastage should not be significantly above 10% once illegal connections, free supplies, and leakage are reduced to acceptable levels and adequate metering, billing and collections procedures are maintained. High rates of unaccounted for water, whether they are caused by illegal connections, leakage, free water supply, or the results of inadequate commercial operations, result in significant financial losses and consequent poor service performance of the agency.

3. Management of Water Supply Systems

The operation and maintenance of water supply facilities throughout the world is undertaken by a wide range of differently structured agencies. These range from community owned and operated water supply systems at one extreme to government owned and operated utility companies at the other. Some agencies are very small and may only be responsible for the supply to a small rural village using a low cost technology, while other agencies may be controlling a utility employing thousands of staff and operating a high technology system.

However, no matter what the scale of the facility, the system will perform poorly if it is not managed efficiently and well.

Typical management-problems include:

- inefficient organizational structures;
- absence of career structures for staff;
- low salaries; and
- poor relationships between the users and management.

The inefficient organization of many water supply agencies is a serious deficiency. If the

organizational structure does not promote and allow efficient operation then the overall management will function poorly.

Personnel problems are another reason for poor management performance. Low salaries, absence of career structures, lack of trained personnel and the low profile of operation and maintenance as compared to new construction are all constraints. Some of these can be traced to a lack of sufficient funds in the agency, but often they are the result of inadequate management.

The absence of transparent management and accountability to the users is another major issue. Often the customers are not involved in the water supply agency and there is no feedback from the consumers to the management of the utility. This is particularly true in government owned and operated agencies which tend to be bureaucratic. This non involvement of the users in the management of the agency results in stress and in some cases the development of a confrontational relationship between the agency and the consumers. Studies of well run water supply agencies have shown that good customer relations and a sense of management responsibility to the users are common denominators in these organizations; contributing to their overall success.

One of the lessons of the International Drinking Water Supply and Sanitation Decade has been the recognition that the user needs to play an important role in the development, implementation and operation of the facilities if the intended service is to be sustainable over the long term. This role varies according to local conditions. In rural and periurban systems, the user can be intimately involved in the process and may assume planning, construction and, at a minimum, operating functions. In urban systems, the user's role may be that of an informed customer with opportunities to participate, limited principally to commenting on agency proposals, because the technical complexity of sophisticated urban systems are not suitable for "hands-on" participation.

User participation must begin with the design stage; the intended users must determine what they are willing and able to pay for. Subsequently, management and operation of the agency must convince the users that they are receiving full value for payments made. The means of doing so, other than providing good service, vary again with the local conditions; they range from direct participation in the management by the user through boards or committees in rural and periurban organizations, to public meetings, consultations and other participatory activities in the case of organizations serving urban areas.

4. Inappropriate System Design

No matter how good the management of a water supply facility is, if it is not well designed technically, it will not operate efficiently. Many water supply facilities have been badly designed, poorly constructed and use technologies which are inappropriate. When a facility is improperly designed and constructed even with the best will in the world it cannot perform satisfactorily.

There are many reasons for poor system design. In some instances consultants are chosen by external support agencies who are not familiar with suitable technologies for use in the developing world and specify equipment and/or designs which are inappropriate. There has been a compulsion in developing countries to use models and technologies transferred from the developed world. In many instances the economic situation, resources and conditions in the developing world make it difficult to apply these models and technologies. There is a clear need to utilize

technologies and delivery models which are designed for and appropriate to developing countries.

A lack of communication between the system designer and the operators of the system is a further drawback. This applies equally to a rural village receiving a handpump as well as to an urban centre with complex facilities. The operators of the system need to be familiar with, approve of and be comfortable with the technology. In addition there needs to be a continuous feedback of information from the operators to the designers to pinpoint problems with the design and suggest remedial measures.

5. Low profile of Operation and Maintenance

Operation and maintenance in water supply agencies has a low, and usually an inferior profile as compared to new construction and system extension. Thus for career minded engineers the route to top management positions is recognized to be through new construction and not operation and maintenance.

The emphasis on and recognition given to new construction is partly due to its political visibility. The provision of water supply to many developing world communities is a vote winning exercise while good operation and maintenance receives few political accolades.

Within the water sector there is an insufficient appreciation of the magnitude of operation and maintenance problems, or of the skills required to properly operate and maintain the facilities. In part this is due to a lack of financial data. Accurate costs are not available which will demonstrate to decision makers the financial benefits of good operations and maintenance, and conversely the losses to the national economy from poor operations and maintenance. An urgent priority in operations and maintenance is to collect precise figures which clearly show the financial benefits of operations and maintenance to decision makers, ESAs and national governments.

This low priority assigned to operation and maintenance by decision makers is a severe constraint. In order to improve operation and maintenance performance it must be accorded a high priority and importance by national governments in their programs.

6. Inadequate Policies, Legal Frameworks and Overlapping Responsibilities

There is a need for clear sector policies, compatible legal frameworks and a clear division of responsibilities and mandates within the water and sanitation subsectors. Due in part to the low priority assigned to operation and maintenance, no clearly defined policies have been enunciated which adequately address this issue. Commonly the lines of responsibility between the various organizations involved are blurred. This is particularly true of the relations between water supply and sanitation where the agencies usually have limited or no contact.

The policies of ESAs with reference to operation and maintenance are frequently different and may be at variance with the approaches of national governments. National governments and ESAs need to collaborate and coordinate their approaches in order to achieve higher levels of performance for operation and maintenance.

7. Political Interference

Political interference has been identified as a serious contributing reason for poor operations and maintenance. This is most noticeable in countries where the government is directly involved in owning, operating and maintaining the water supply facilities. Political interference manifests itself in several ways. In some countries for political reasons water is free. This decision not to charge for water makes it difficult to run a self financing viable system, even if government provides funding. When governments are short of cash, often it is the water supply facilities which are soft targets and experience the greatest budget cuts.

Political interference is often evident in the choice of technologies. Government officials may for one reason or another support the purchase of a particular technology or system which may not be the best or most appropriate selection. Equipment suppliers and external support agencies frequently hinder the wise choice of a technology by lobbying politicians or through the restrictive policies of tied aid.

The contracts awarded for building even small rural water supply facilities are significant and there is considerable competition between contractors to be selected. In some cases the job may be awarded for political reasons rather than on the basis of performance, with the result that the completed facilities may be shoddily constructed.

The Working Group on O&M concluded that a precondition for the better management of water supply facilities was to devolve the responsibility of managing systems from government to autonomous agencies which will manage the facilities under technical, financial and administrative guidelines from the government. This would greatly limit the extent of political interference by governments and allow the facilities to be managed according to efficient business practices.

Principles

We can identify three distinctly different target populations with different problems, environments and needs for water supply and sanitation. The three are:

- rural;
- urban (large cities); and
- peri urban populations

The rural can be subdivided into dispersed villages and small towns with populations less than 5000, and small urban centres having populations of between 5000 and 50,000. It is worth noting that in the future concern with water supply, sanitation and hygiene education for the peri urban areas is increasingly going to dominate. Rural to urban migration is accelerating in developing countries and at the present time two thirds of the population growth in cities in the developing world is occurring in shanty towns. By the end of the century, to reduce health risks and limit epidemics, greater attention will have to be directed to providing water supply, sanitation and hygiene programs in these peri urban areas.

Just as the conditions, problems and needs of the three population groups differ so do the operation and maintenance issues and appropriate strategies.

In the large cities where piped water supply and possibly some form of sewerage, either

piped (with or without storm drains) or septic tanks provides service to a segment of the population, the O&M problems are different from the rural and periurban situations. In general the rural and peri urban groups have very comparable problems and the programs supplying water, sanitation and hygiene education to these two groups are often quite similar.

The provision of water is a service which requires a service oriented attitude by the agencies involved. To ensure long term sustainability water should be managed as a commodity in exactly the same way as any other resource. Its use and exploitation should be on a financially sound and cost effective basis, subject to the same legal and regulatory controls as other resources to ensure its conservation, protection and wise utilization.

Four general overriding principles can be identified which apply to the provision of water supply to rural urban and peri urban populations. If these principles are not recognized and deferred to then the long term sustainability of the water facilities is at risk, and the establishment of an effective operation and maintenance strategy constrained.

The four principles are:

- Effective Demand;
- Effective, Transparent Management;
- Appropriate Technology Choice; and
- Collaboration and Coordination

Effective Demand

The supply of water should be demand driven. It should be based on the principle of effective demand which can be defined as the standard of service that the users are willing to maintain, operate and finance to ensure adequate public health standards.

The level of service has to be acceptable to the recipients and to accord with their priorities. It should be recognized that the level of service is upgradable and can be changed in response to public pressure. Also in most rural and peri-urban situations a variety of service levels may be most appropriate.

Effective, Transparent Management

Without proper management of the water facilities it is impossible to achieve sustainability. The form management which is appropriate will vary depending on the recipient community.

In large cities with piped water, the water agency will need to be financially viable and properly managed. Here concerns will be with establishing tariffs, billing and collection procedures, choosing and maintaining appropriate technologies, an effective and efficient management structure, and recruiting and keeping trained and motivated staff.

The agency will need to foster good relations with its customers and have transparent management.

In rural and peri urban areas a different form of management may be appropriate. Sector professionals are advocating community management as the most effective way to plan, construct, operate and maintain rural and peri-urban facilities. Many successful examples of community managed water supplies have been described from different parts of Africa (McCommon; Warner and Yohalem, 1990).

The concept of community management is that the community are directly responsible for planning, design, construction, and operation and maintenance. However, community management cannot develop in a vacuum, it must occur and evolve in an enabling environment. External support agencies and national governments can create this enabling environment and facilitate community management by providing institutional and policy frameworks, human resource development and training at the community level, assistance in establishing an appropriate and workable community organization and financial assistance.

Appropriate Technology Choice

Many system failures in the past are directly attributable to the transfer of inappropriate technologies from the developed world to the developing. Water supply system models which are appropriate for affluent developed countries are often not appropriate or realistic for developing countries.

The choice of technology influences the operation and maintenance of the system and thus its sustainability. The level of service must be one which can be operated and maintained by the users.

Low cost appropriate water supply technologies such as handpump wells, gravity water systems and rainwater harvesting have been successfully employed in projects throughout the developing world. However, it is worth remembering a statistics recently given by UNICEF (1992) indicating that presently only 20% of water supply projects implement low cost technologies. As UNICEF points out, much still remains to be done to encourage the use of low cost technologies.

Appropriate technology does not necessarily mean a low level of technology or service. The key consideration is the ability of the users to operate and maintain the facility. In a relatively affluent urban city, the residents may demand and be able to afford, operate and maintain advanced water treatment plants, piped systems and full scale sewerage. Such a system is therefore appropriate.

In a rural area however the users may only be able to afford, operate and maintain a handpump well. In this case handpump wells are appropriate.

The definition of appropriateness may well vary from community to community depending on cultural, economic, social and other conditions.

Proper operation and maintenance is frequently constrained by lack of spare parts and by the absence of local manufacture. When spare parts have to be imported and foreign exchange is in short supply, as is the case in many developing countries, obtaining needed spares become difficult or even impossible.

The best way to overcome this is to have locally manufactured equipment and spare parts. As experience in many developing countries has shown, establishing an economically viable local

manufacturing capability in the private sector is not easy. Often the local companies cannot compete with the imported products which may be brought in tax free, through external support agency or government programs.

One concrete way that external support agencies and national governments can assist with improving O&M is to create an economic environment which encourages the local manufacture of equipment and spare parts. This may involve, in the case of national governments changing import tariffs on goods and raw materials, and providing initial start up subsidies and technical and financial assistance to the local private sector.

Collaboration and Coordination

A fourth principle for improving operation and maintenance is effective collaboration between all involved with the development of water supplies. This includes collaboration between all government agencies involved, between the external support agencies assisting the government, between the external support agencies and the government agencies, and between the government, the external support agencies and the users.

Effective mechanisms at both the formal and informal levels are needed to encourage and facilitate a free flow and exchange of ideas and information.

In the Sudan for example a major constraint hindering sustainability and improved operation and maintenance was the absence of cooperation between external support agencies and the national government. A considerable degree of bypassing of government agencies took place and the long term effect of this was to weaken the sustainability of projects and thus of the facilities constructed.

Summary

The vital need to guarantee the long term sustainability of all project benefits has become a priority for national governments and external support agencies. The high failure rates of the past cannot be tolerated in the future, especially as competition for funds heightens.

Strategies to ensure the long term operation of facilities and the realization other benefits need to be included as pivotal parts of programs. The conceptualization and planning of the program should include concern with operation and maintenance as a central component right from the start.

In planning programs and projects the inclusion of the principles of effective demand; sound and transparent management; appropriate technology choice, and coordination and collaboration will assist in assuring better operation and maintenance performance.

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A CRITICAL ANALYSIS OF GENDER STRATEGIES IN THE OPERATION AND MAINTENANCE OF RURAL WATER SUPPLIES

Mary Liao and Lenore Rogers[1]

Women's Centrality in Water Supplies

A recent WHO report, "Women, Water and Sanitation" (Mills 1992) presents a review of a number of studies detailing the many responsibilities that women hold in water and sanitation, and of the impact that these responsibilities have on women's health, daily work burden, and status in a number of Third World countries.

The report confirms that women are the primary collectors of water and that men typically only assist women when water sources are very far away. While men usually have access to some form of cart, donkey, wheelbarrow or bicycle transport, women depend solely on foot transport. Water collection is a major part of the day's work for women, with distance and quantities needed constantly being juggled against time and energy available.

Women are also responsible for caring for the sick (many of the diseases are water and sanitation related) and are exposed to a much greater degree to such diseases than are men. The long hours women spend in water collection and in all of their many daily tasks render them chronically tired, further deteriorating the health of women who may already be undernourished, anaemic, or requiring additional food due to frequent pregnancies. The negative effects of carrying heavy loads of water on the skeletal health of women and children and of the dangers that water collection holds for pregnancies are also discussed in the WHO report.

The report stresses that too often the psychological and emotional stress involved in juggling time, energy, and family needs is overlooked. Women often feel guilty when they cannot complete all of the tasks expected of them and this conflict between expected roles and physical limitations adds considerably to women's stress and feeling of personal (in)adequacy.

However, while the centrality of women as the collectors and users of water supplies is recognized by most, if not all development agencies, the centrality of women to operation and maintenance strategies is not always recognized. In the WHO report it is written:

> Women are the traditional managers of water systems, yet as new water technologies are introduced to communities these roles are taken away by assumptions that men should be trained in the maintenance of the facilities. Women are in the best position to take care of these facilities, as they are aware of when they cease to function and have the most interest in their repairs. Studies have shown that women are capable of performing such roles but are often impeded by community attitudes which restrict their roles in community affairs". (Mills 1992 p.10)

Development agencies have become increasingly more committed to integrating women into formal operation and maintenance strategies for water supply systems. Many initiatives have been undertaken and these deserve due recognition. However, these initiatives also need to be evaluated in terms of how successful they have been, not only for project goals and community needs, but also

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for the improved well being of the women. Have these initiatives, for example, added to women's work burdens or placed women at social or physical risk? Why have women in some instances refused to participate? Are projects justified in using the excuse of "difficult to involve women in this cultural context" to exclude women from operation and maintenance systems? There needs to be a recognition of the possibility that the strategies undertaken may not be meeting the needs of the women even though they may be meeting the goals of the project.

In order to examine these strategies, it is useful to place them within an analytical framework which tries to simplify the many complexities involved with "integrating women into development". For this purpose, general gender development concepts are reviewed.

Gender Development Concepts

Theories and practices to include gender in development have been employed in response to the perceived need to equalize the development process for both women and men. The wide range of approaches, policies and projects utilized since the 1960's have become popularized under the general heading of "Women in Development" or WID. However, although the main purpose of each is to assist women in the Third World, wide differences in their underlying assumptions exist. This holds important implications for the type and impact of the strategies formulated from each. Some recent gender development analyses by Caroline Moser (1989), Eva Rathgeber (1990) and Gita Sen & Caren Grown (1987) provide a wealth of concepts, issues and difficulties surrounding the process of equalizing the development process for women. A review of these will help in the construction of a conceptual framework which can be used to analyze existing initiatives to "integrate women into operation and maintenance of water supply systems".

Caroline Moser

Moser identifies and classifies five different approaches to "Women in Development" which have been formulated in response to changes in macro-level economic and social policy approaches to Third World development; from modernization policies, through the basic needs approach, to social programmes tacked onto structural adjustment policies. These approaches include the welfare, equity, anti-poverty, efficiency and empowerment approach.

Moser evaluates each of the approaches in terms of two criteria. The first is whether it recognizes one, two or three of the roles (reproductive, productive and community management) that women undertake in their everyday lives. Moser argues that if the approach does not recognize that women juggle all three roles on a daily basis, programmes that are intended to help women will add further to the burdens of their already heavy workload, and thus not address women's real needs.

The second criteria is whether it meets practical or strategic gender needs; strategic gender needs being those which are needed to create a more equal organization of society and which challenge the nature of female-male relationships, and practical gender needs being needs which meet the immediate perceived necessities of women within a specific context. While practical gender needs do not in themselves challenge unequal gender relations within society, they may be used in conjunction with an overall strategic gender needs policy to this effect. However, Moser argues that to implement practical gender needs programmes in isolation of the overall goal of creating a more equal society, such programmes do not empower women and can in fact work against the long term

needs of women by overshadowing the need to make fundamental changes in the structure of patriarchal society.

Of the five approaches discussed by Moser, the empowerment and equity approaches are the only two which recognize the need for major structural change to occur before the position of women can be truly improved. Both approaches recognize the triple role burden of women, and the need to work for the realization of long term strategic gender needs utilizing a variety of practical gender needs, and short term strategies. While the equity approach has its genesis within a western feminist perspective, and advocates state, top-down intervention to reduce female-male inequities in social, economic and political spheres, the empowerment approach is grounded in the feminist writings and grassroots organization experience of Third World women and relies on the empowerment of women through bottom-up mobilization around practical gender needs. Both approaches which fall outside of mainstream development theory and practice, are thought to be threatening, and are largely unsupported by governments and agencies alike.

Eva Rathgeber

Rathgeber differentiates between three main gender development perspectives; WID (Women in Development), WAD (Women and Development), and GAD (Gender and Development). WID refers to the process whereby women are integrated into mainstream, development thinking and projects which are based on the modernization paradigm that with increased economic growth, development would trickle down to all segments of society. The WID perspective places primary emphasis on egalitarianism and on the development of strategies and actions which will minimize the disadvantages of women in the productive sector. It does not question the acceptability of the existing unequal social/gender structure and focuses solely on how women can be better integrated into ongoing development initiatives. WID programmes typically focus on income generating projects, with the assumption that greater access to income and skills will allow women to become more equal to men. Women's reproductive roles are not taken into account and women trying to participate in WID programme activities frequently experience stress while trying to manage their already overburdened schedule.

The WAD approach is grounded in a combination of neo-Marxist, feminist and dependency theory and begins from the assumption that women's position in society will not improve until oppressive global political and economic structures becomes more equitable for women and men alike. Unlike the WID approach, WAD argues that women have always been a central part of development processes, but to integrate women into a structure which holds women and men alike in conditions of inequality will not solve the problems of poverty and women's oppression. While WID focuses on strategies which will integrate women into the development process, WAD focuses on the relationship between women and the development process. Both WID and WAD focus solely on women's productive roles and tend to create income generating programmes without taking into account the time burdens that such strategies place on women.

GAD finds its theoretical roots in socialist feminism and links production to reproduction. Socialist feminism questions the validity of the sexual division of labour and why women have been systematically assigned inferior and/or secondary roles. Unlike the WAD and WID approaches, Rathgeber argues that the GAD approach does not focus singularly on women but rather on the social construction of gender and the assignment of specific roles, responsibilities and expectations on women and men. The GAD approach welcomes the potential contribution of men who share

concerns for issues of equality and social justice and that women and men need to work together to fundamentally change power structures.

Rathgeber points out that the majority of mainstream development programmes have strategized for the equality of women from a WID or WAD perspective, and rarely from a GAD perspective. Development programmes have sought to solve identified problems for women by applying a specific intervention strategy such as appropriate technology, family planning, or credit and extension services. However, no programmes have questioned the fundamental inequalities of an international system that perpetuates dependency of the South on the North, or of the social construction of gender that subordinates women to men. Projects formulated from a GAD perspective would be designed to empower women and to give them an equal voice by recognizing the full spectrum of their knowledge, experience and activities, including both productive and reproductive labour. They would question traditional views of gender roles and examine how the sexual division and responsibility of labour places both physical and psychological stress on women. Projects which provide women with labour saving technologies may enable them to carry out their workload with less effort, but do not work to breakdown existing stereotypes and unequal patterns of female-male relationships. Thus there is a need to change men's roles and responsibilities as well.

Gita Sen and Caren Grown

Sen and Grown represent the DAWN perspective (Development Alternatives with Women for a New Era) which Moser refers to as the empowerment approach. DAWN finds its origins in the feminist consciousness of Third World women who, because of their experience of grassroots organization at the community level, have come to affirm that it is through the lives of poor women in the Third World who undertake the daily struggle to ensure the survival of themselves and their families, that the clearest lens for an understanding of development processes is achieved.

DAWN challenges the belief that women's main problem in the Third World is insufficient participation in the development process. DAWN research shows that the socioeconomic status of the great majority of Third World women has worsened considerably throughout the UN Decade for the Advancement of Women. DAWN questions not only the viability of the WID approach used by mainstream development agencies to improve the conditions of women in the Third World, but also the nature of the development process into which women are being integrated.

The DAWN perspective argues that there have been basic flaws in the general approach of "integrating women in development" in that it has been assumed that the development strategies being pursued are generally beneficial to the poor; thus women's only problem is that they have been marginalized from the development mainstream.

In order to improve women's conditions, DAWN recognizes that their strategies must be aimed at challenging prevailing structures and making governments accountable to the people. Short-term ameliorative approaches to improve women's immediate conditions must be combined with long-term strategies which will reestablish people's, especially women's control over the economic decisions which affect their lives.

The structures which create and perpetuate inequalities between gender, class and nations and which act as barriers to development processes responsive to the needs of the people must be broken. The needs of the poor, and the recognition of the centrality of poor women's work to the

development process must become the central focus of planning. Women's voices must enter the definition of development and the making of policy choices.

Common Principles

It is clear to see that gender analyses are varied and complex. Each works from unique underlying assumptions which hold immense implications for policies and programmes fashioned from within their perspective. However, it is also possible to simplify these analyses to find a number of common principles.
These include:

1) A focus on women alone is not sufficient. Instead, it is crucial to take on a holistic approach where the **relationship** between women and men becomes the focus, and where women's and men's roles are seen to be traditionally defined and **not** immutable. The gender perspective thus sees that traditional attitudes must change so that the responsibilities and burdens of family maintenance are shared more equally between women and men. The value of women's work must also be recognized.

2) Society is constructed from unequal economic, politic, social and gender structures. Fundamental changes to these structures are required if equality for women and all peoples is to be achieved.

3) Existing development processes have not been used to effect fundamental change in society. However, development processes developed from within a GAD or empowerment approach can be used to work towards women's equality.

4) Development processes which maintain the status quo will not only perpetuate women's subordination, but will further reduce women's access and control over resources, opportunities and income.

5) The effectiveness of traditional development approaches to "integrate women into development" is challenged. Including women into a process which is inherently unequal does not address why women are in a subordinate position in the first place.

6) The methods used in effecting change can be varied. The DAWN perspective sees the grassroots organization of poor women not only to be a means of effecting change, but also as the means of women's self-empowerment. Caroline Moser and Eva Rathgeber provide an analysis of the First World, development planner's perspective and concur that the need for an empowerment and GAD approach is needed.

7) Strategies to meet short-term/practical gender needs can be used as an entry point to meet long-term/strategic gender needs. Planners must have an understanding of global feminist goals and be aware of whether their programmes and policies are inhibiting or encouraging these goals.

8) Women's knowledge and experience need to be legitimized, documented and translated into a language that development planners and practitioners can no longer

ignore and marginalize. Women's knowledge, views and experience must become an important component of national decision making processes.

9) Gender initiatives which take on a strongly feminist orientation are considered too threatening by state and development agencies. They are often criticized as being "exported Western feminism" and as an unacceptable interference into domestic and cultural sovereignty. These agencies must be made aware that Third World women have long organized around issues within a feminist consciousness. They must also be made aware that the activation of women's organizations is key to the potential betterment of all the poor, for women and men alike. Thus women must be given the opportunity to gain access to and control over the resources and decisions which affect their lives.

These common principles can be applied to an analysis of gender initiatives in operation and maintenance strategies in water supply projects.

Gender Strategies in Operation and Maintenance

Most development agencies operate on the assumption that women and men have the same need for an improved water supply system and will take on equal responsibility for its operation and maintenance. However, it has been shown that when assessing personal and community needs, while women state that water is one of their top priorities, men frequently do not even consider water to be a need, or place it well down on their list of priorities. Men do not appear to have an equal interest in ensuring the continued operation and maintenance of water supply systems.

Hoffman (1992) reports on a FINNIDA water project in Western Kenya:

> Providing water for the household is the woman's responsibility, so the availability of a convenient supply of water is a daily concern for the woman mechanics, just as it is for the other women in the village. A pump breakdown usually results in a long and arduous walk to a traditional water source: a task that can add an additional two to four hours to a day that already begins at dawn. Given the women's already heavy workload, any additional time spent in water collection means less time for sleep at night. This social reality explains the high degree of motivation that these female mechanics have. (p. 19)

The project illustrates the difficulties water projects can experience because of the marginalization of women in the operation and maintenance system. While men were trained and fully employed as handpump mechanics, women were trained only as handpump caretakers and were expected to contribute their labour on a strictly volunteer basis. The male mechanics soon found better jobs with their new skills and ensuring handpump maintenance became increasingly more difficult. The project then trained women as mechanics but did not pay them although the men had been paid. The women soon found that although they enjoyed the status that their new role gave them in the community, they lost two full days to waterpoint maintenance and subsequently had less time to engage in income generating activities necessary to manage their household and family needs. The women informed the male project staff and community members of their concerns, who had previously been unaware that the women's time and resources were being stretched too far by project activities. Yet the loss of the women as mechanics would mean the ineffective operation and maintenance of the new water supply system.

厚生省薬務局医薬品先端技術振興室 江原技官気付　　１９９４年４月26日
局内等への配布をお願いします。

ＯＭＳＢ（２１） ジュネーブの上水

日本でもミネラルウォーターがもてはやされはじめた頃にこちらに来てしまったのですが、最近ダイエットにコントレックス（商品名）が良いという話しがあると聞き小生は、「硬い水だから、大量に飲めば緩下剤になるか？」などと、昔の一般用医薬品基準を思い出しています。
旧環境保健部（ＥＨＥ）は、ＷＨＯの中でも上下水道整備に関る仕事をしており、先般その担当課長と昼食を共にした時の話しですが、「最近、ミネラル・ウォーターを買って飲む風潮が広がっているが、お金の無駄遣いだ。少なくとも、ジュネーブの水道はカルシウム分こそ多いものの、衛生的にはそのまま飲んで何の問題もない。」とのことでした。海外旅行の案内では、食事やホテル内での飲み水に、ビン詰めのミネラル・ウォーターを進めるものが多いようですが、衛生問題からは、水道水をそのまま飲んでもまったく差し支えはありません。もっとも、ホテルなどでの食事では、日本のように、黙っていても冷たい水がサービスされることはないので、つい、ミネラル・ウォーターを注文してしまうということになるようです。
スイス、フランス、イタリアあるいは北欧といった様々な産地、そしてガス入り、あるいはガス無しの「水」が商品として並んでいます。もっとも、スーパーで購入すると、１．５リッターで１ないし２フランといった価格です。逆に、小さな瓶でもキオスク辺りでは１フラン以上となります。不思議なことに、紙パックのアイス・ティーの方が、水よりも安いことが珍しくありません。

「旅券更新」

国際課にお願いして、外務省から電報が当地の領事部（ジュネーブ総領事館）に届き、先日旅券の更新が出来ました。様式は日本を出立したときと同じ小型のものですが、海外での発行のため、機械読み取りが出来ないことと、写真が転写ではなく、張り付けであることが違っています。申請書も同一内容のものを２部記入し、捺印で押印に代えて提出しました。木曜日に書類を記入して、火曜日にその写真を持参して、旅券に貼付して受領しました。１１ヶ月の有効期間で、来年３月１５日迄となっていますので、来年２月頃に同様の手続きをお願いしなければならないものと思われます。
以前、カナダ厚生省に人事院の短期在外研修でお世話になった際、カナダでも一般旅券と公用旅券の区別がありましたが、公用旅券を厚生省のしかるべき部署が一括して保管し、出張命令とともに、本人の一般旅券と引き換えに渡していました。我が国でも、省庁によっては、同様の仕組みを取っているところもあるそうです。米国のように今なおビザの要求をする国では、公用数次旅券を交付して、国際課等で保管するほうが、便利がいいように思えるのですが、如何なものでしょう。
小生のように派遣法の適用に基づくものでは、当該予定期間毎に旅券を交付する必要もそれなりに判るのですが、正直にいえば、何とも不便なというところです。殊に、一般旅券を所持しているわけではありませんから、もしも失効したらという不安は、あまり心地好いものではありません。

「インターネット」

健康文化都市造り（ヘルシー・シティ・プロジェクト）の調査で、保健医療局健康増進栄養課から調査員の方が見えました。同じ局（旧ＥＨＥ）のゴールドシュタイン博士がブラジル出張から帰ってきた翌朝に面会をして下さいました。欧州のみならず、アフリカ圏でも、ヘルシー・シティ・プロジェクトのコーディネーターの人々が、インターネットを通じて、情報の交換を活発に行っていることが、説明の随所に飛び出してきました。米国のゴア副大統領が、上院議員当時から説いていた「情報スーパーハイウェー構想」が今や現実の計画として推進されており、日本でも対応策を検討しようとする民間フォーラムの設立が報じられています。
もともと、インターネットはアメリカ国防省の研究ネットワークにその一端を有しており、きな臭さがあるのですが、いまや世界を結ぶ情報幹線となりつつあり、この発展と維持は、別な国際課題となっています。日本での利用も当初の学術研究機関のみから、大企業の研究所、そしてベンダーを介した一般利用まで広がりつつありますが、米国のような草の根まで根をはった形とはなっていません。まして、アジアの人々との連係を深めるには物理的な環境整備が不可欠となっています。
健康造りにおける情報のディセミネーションが肝要であることは言う迄もありませんが、厚生省がその持てる資源をうまく活用できるよう願っています。

（配布先：薬務局内及び官房国際課、厚生科学課、生活衛生局生活化学安全対策室、保険局医療課などを想定。
取扱いは宜しく御配慮下さい。　文責：ジュネーブ 西沢）

This project provides just one example of some of the many ways in which women are marginalized when it comes to operation and maintenance.

A recent SIDA study (Raditloaneng 1991) examined why women's participation in the water sector in Botswana was so limited. This study provides a unique perspective on women's participation in that instead of focusing on women's participation at the village level, it examines women's participation in the water sector at the institutional level. The study found that women's participation in the government agency responsible for water supply development (District Council Water Department) was mainly concentrated in the lowest clerical positions with sparse representation in the highest policy making positions. The women who did occupy positions which required technical skills and which gave them authority within the Council (and over men), were isolated and did not experience opportunities for promotion as did men in equal positions. The study found a number of reasons why women's participation was limited, including:

1) Traditional attitudes dictate a strong correlation between type of work and gender. Technical work is seen to be a man's job; clerical work is seen to be more appropriate for women.

2) Women's interest in technical occupations is not encouraged or cultivated.

3) Very few women go for training in technical institutes.

4) Very few women as compared to men are recruited for technical government positions.

5) Although recruitment and selection procedures are "non-discriminatory", traditional attitudes cannot be excluded. There are many individuals in the government who feel that women cannot perform technical jobs at all, or as well as men. There are no affirmative recruitment policies in effect.

6) Women, because of their lesser technical training and skills, are most often relegated to the lowest technical positions which are less financially rewarding and which have less progression routes than do professional and engineer positions which are mainly occupied by men. Women become discouraged and easily lose their motivation to stay in government work.

7) Women have low levels of self-esteem and self-confidence and do not recognize their potential and worth. They often perceive that they cannot make meaningful contributions to what they think are "men-oriented jobs".

Projects, however, are becoming increasingly committed to integrating women into operation and maintenance systems. One approach used by development agencies to "integrate women into operation and maintenance" has been to establish female/male quotas for participation in water and sanitation committees. In cultures where it is inappropriate for women and men to participate in decision making processes together, or where women's public participation is restricted almost entirely, projects have attempted to establish women/men only committees, or to involve women only in hygiene education programmes while the operation and maintenance systems are left entirely to men.

In addition, women have been trained by some projects as handpump caretakers to perform simple preventative maintenance measures while in others, women have been trained as handpump mechanics to perform major repairs. Women have also taken on the responsibility for water tariff collection or have become treasurers in charge of the management of rotating and reserve funds. These are the standard responsibilities which have been assigned to women and represent the typical strategies that project planners have employed in their concern to integrate women in operation and maintenance and "enhance their participation" in water supply projects.

However, while these initiatives have, in many cases promoted the success of project goals, they have also had some negative effects on the women. A number of problems have emerged in projects attempting to integrate women into operation and maintenance strategies (Hoffman 1992; Yacoob & Walker 1991; Hannan-Anderson 1990; Karp, Martin & Guild 1990; Versteylen-Leyzer 1991; Carr & Sandhu 1988; Kamminga 1991; Jonsson & Rudengren 1991; Chachage, Nawe, & Wilfred 1990; Grady 1991; van Wijk 1992) . These include:

1) The work burden of women increases when women are expected to maintain their traditional responsibilities as well as take on new responsibilities as educators, mechanics, collectors, etc. Women have complained that they often need to hire extra help to assist them in their household chores.

2) While male mechanics are usually paid for their work, women are often expected to work on a volunteer basis. Women often agree to work without pay because of the stake they have in maintaining access to a safe and convenient water supply. Not paying women undermines the status of women in the community for it gives the message that women's work is not of equal value to that of men.

3) While women are often expected to take on these new responsibilities, they are usually not accorded recognized status or accompanying authority. They are still placed in a dependent position whereby they must report to a higher (usually male) authority, and frequently have to turn over collected funds to (all-male) community decision making bodies with no direct control over these funds.

4) In most societies, women tend to be less confident than men and typically have a low self-esteem, a product of societal stereotyping about the value of girls and women. Projects sometimes expect women to take on non-traditional roles, such as technical handpump maintenance or repairs but do not assist these women in coping with negative feelings coming from members of the community who feel that these roles are not appropriate for women. Awareness raising programmes for boys and men, as well as confidence building support for women are not typical project activities.

5) Women are less mobile than men. Women may be culturally forbidden to travel outside of their home area, or be constrained due to fears for their physical and sexual safety. Projects however, often expect women to be able to travel from village to village, just like men. They may also be expected to work alone rather than in pairs for mutual support.

6) Some projects assume that women will put a lot of time into project activities because of the expected increased health benefits. However, often women's

perceptions of the project are more influenced by the economic benefits they can derive from the project. Projects do not often study how women's time schedules are related to their economic potential and how projects can assist women in turning increased time and health benefits into economic benefits.

7) Women may be expected to pay water tariffs equal to men, without recognizing that female headed households exist, or that women may not have control over the household cash income. Even when women are appointed a smaller nominal contribution, they are likely to spend a relatively greater proportion of their income than men. Women almost always have a lower cash income generation potential than men. Income generating projects for women are not often included in water supply projects[2].

8) Projects often ask women to participate in water or sanitation committees. However, in some cultures, women are not encouraged to participate actively in community meetings and depend on representation by a male member of the household. Other times, women cannot attend meetings because they clash with their other responsibilities during the day or husbands may be reluctant to allow their wives to attend gatherings that they feel are a waste of time or an interference with their wives' other duties. Thus, water committees may not be the most appropriate strategy for projects wishing to key in on women's central roles.

The question must be raised. Have women merely been used as an inexpensive means to achieve better functioning, use, hygiene and finances of water supplies and then left to cope with whatever negative effects such participation incurs?

These problems represent a summary of the psychological, social, cultural, political and economic constraints which are faced by women when participating in the water sector throughout the developing world. Agencies have implemented many different measures to mitigate these problems, to remove all possible constraints to women's participation, and to minimize the negative impacts that project activities have had on women. However, very few agencies have questioned whether the nature of their project design is suitable for women to be integrated in to. When difficulties with women's participation are encountered, the problem is perceived to be with the women rather than with the project design.

A number of evaluative questions about the nature and impact of "WID" initiatives in projects can be raised:

1) Do the initiatives utilize and mobilize women's indigenous knowledge and experience?

2) Will the project increase the status of women within the community?

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[2] However, income generating projects in themselves are often problematic for women. They frequently aim to increase women's productivity in activities traditionally undertaken by women instead of introducing them to new skills and areas of work. More often than not, they are small-scale with limited funding, tacked onto integrated rural development projects, or poor designed in terms of production capacity and viable and profitable marketing strategies.

3) Are the project and the specific WID initiatives committed to long-term/strategic needs (feminist) goals or do they maintain the status quo?

4) Are women really empowered within the project and what criteria are used to define and measure empowerment?

5) Are women given extra responsibilities without accompanying status and authority?

6) Do the initiatives increase women's workload?

7) Will women's self-esteem and self-confidence be increased as a result of the project?

8) Does the project expect women to take on non-traditional responsibilities without giving appropriate support?

9) Will community (both women and men's) attitudes towards women and the value of women changed by project activities?

These questions provide a framework which combines both a conceptual, and a practical understanding of the strategies needed to work towards women's equality. Initiatives intended to "enhance women's roles and participation", "empower women" and "integrate women into project activities" need to be examined critically in order to understand the full effects that they will have on women's lives in relation to themselves, men, and society.

Alternative Strategies

Alternative strategies for improved WID initiatives in operation and maintenance can take two directions. The first approach would be to strengthen the initiatives already being implemented to integrate women into operation and maintenance systems. This would require that the many problems women experience in water supply projects be mitigated to ensure that all negative impacts on women are eradicated.

To this end, much more attention should be paid to conducting detailed and comprehensive gender analyses, and **to have these analyses more equitably integrated into project design and implementation.** In too many cases, "women's issues and concerns" are not considered to be central to project goals and the recommendations coming out of gender analyses have been marginalized in project planning processes. Gender analyses should not only be directed to examining what impact women's participation has on project goals and community well being, but just as importantly, what impacts women's participation have on women's well being; their social status, self-confidence, self-esteem, time, work burden, economic position, political power, and on the attitudes that the community holds towards women and the value of women's work.

An second and alternative approach to improving WID initiatives in operation and maintenance systems would be to reconceptualize and redesign such systems from scratch. This paper has summarized the many problems experienced by development agencies and women alike in trying to integrate women into operation and maintenance. The possibility of integrating women while simultaneously ensuring that women suffer no ill effects in the face of all these problems

needs to be seriously questioned.

For example, would it be possible to organize meetings, conferences, or workshops by women and strictly for women; women from villages and communities, government agencies, universities, non-governmental organizations, and external support agencies, where the one question on the agenda would be: "How would you maintain the sustainable operation and maintenance of water supply systems?" Could a large number of meetings, conferences and workshops, held at local, regional, national and international levels be held so that all women's voices can be heard. Very importantly, the question would **not** be: "How would you integrate women into operation and maintenance systems?" Thus, the meetings could start with a clean conceptual and practical slate, with the participants able to create and design appropriate O & M strategies based upon their skills, experience, and knowledge. The ideas coming out of these meetings could then be combined with other ideas and strategies to form the backbone of local and national operation and maintenance strategies.

The concept of a meeting or conference where only women would take an active role addresses two important issues related to the possibilities of women's equality within the development process. The first is that the majority of conferences and meetings which are held to define and enact policies which will affect women's lives, tend to be dominated by men in senior management, professional and political positions. Very few women achieve positions which grant them entry into such meetings and it cannot be expected that these few women can adequately represent the wide diversity of women's needs, interests and skills. The women's perspectives which are most needed, those grounded in the daily struggle for survival, are almost always excluded.

The second issue is that women have a very different way of interacting amongst themselves than with men. Women have different ways of organizing, holding dialogues, processing information, making decisions and resolving conflicts. Women's interactions tend to be more open, democratic, and non-hierarchical and are very often based on a need to share personal pain and experiences. Women do not often feel safe in environments which are created and controlled by men. Spaces which **are** safe for women need to be established in order for women's perspectives to be forthcoming. Mechanisms which would allow these perspectives to then become policy **equal to male defined perspectives** also need to be established. It can no longer be assumed that the WID approach whereby men's needs, interests and solutions are given full access to resources while those of women are marginalized and given "special attention" will allow true development for all people to occur.

Within the conceptual framework discussed in this paper, it can be seen that the first approach is more of an ameliorative one, whereby women are still being integrated into top-down, externally planned and designed interventions. Women are not truly empowered by such an approach in the sense that they are still **given limited roles to perform**. Such an approach still takes on the perspective that women are somehow peripheral to the management of water supply systems and the whole development process.

The second approach, by contrast, is committed to women's empowerment. It recognizes the skills, experience and abilities of women to define their own problems, and to create and enact the solutions needed to solve these problems. It creates a mechanism whereby specific project goals, community needs and women's empowerment are taken care of simultaneously.

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WATER SUPPLY AND SANITATION SECTOR DEVELOPMENT IN GHANA

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INTRODUCTION

Ghana is a relatively small country in West Africa bordered on the west by Cote D'Ivoire, on the east by the Republic of Togo, on the north by Burkina Faso, and on the south by the Atlantic Ocean.

The total population of Ghana was estimated in 1990 to be 14.3 million, 9.7 million (i.e. 65%) of whom lived in rural communities of less than 5000 people. 90% of this rural population live in about 16,000 communities with populations between 100 and 5000 and the rest live in some 40,000 smaller settlements. With the rural population growth rate of 2.2% per annum the rural population is expected to increase to about 12 million by the year 2000.

The capital city is Accra, and other major cities are Kumasi, Sekondi/Takoradi and Cape Coast.

The main export commodities which form the backbone of the domestic economy are cocoa, gold and timber, the annual export being in the order of US $1.5 billion.

Economic activities in the rural areas are based on agriculture and livestock, with cocoa production as the most important source of income. The average income of a farming household of six persons ranges from an estimated US $120 to US $300 which is sufficient to meet the minimum requirements of food, clothing, housing and some discretionary spending for such infrastructure improvements as schools, clinics and water and sanitation facilities.

Two-thirds of the poorest Ghanaians live in communities of less than 1,500 people with a marked concentration in the savannah areas in the north of the country.

Between 1957, when Ghana gained its Independence and 1982, its economy deteriorated under the combined effects of inappropriate macro economic policies adverse external circumstances, and fruitless attempts to manage the pricing of the primary export commodities - cocoa, gold, timber and bauxite. An Economic Recovery Programme (ERP) launched by the Government of Ghana (GOG) since 1983 has succeeded in reviving the economy, with GDP growing at an annual rate of 6% over the period 1984 - 1989. Among the measures taken during the period to offset the negative impact of the ERP on the poorer rural population was the Programme of Action to Mitigate the Social Cost
of Adjustment (PAMSCAD) under which a wide range of rural infrastructure work has been undertaken, including the construction of several thousand dug wells and VIP latrines.

The Sector

The climate of Ghana is tropical, with a wide variation of rainfall that is heavily influenced by the southwest monsoon. The mean rainfall varies from 2,000 mm in the south-west coastal area, to about 850 mm on the east coastal area, and 1,000 mm in the north. The surface waters dominated by the River Volta which has a total catchment area of 166,000 km^2 within the country, the Volta lake stretching some 300 km through the centre of the country. The remaining rivers, all in the south and south-west, drain about one-third of the country, but because of the high rainfall they account for more than 50% of Ghana's internal run off.

Most of the water for urban areas is supplied from rivers at dams and diversion structures. In the rural areas, groundwater is the best option as it is usually available in sufficient quantities for household uses within the community and is more reliable throughout the year and does not require treatment. The quality of groundwater is generally good except for the presence of iron and manganese in some isolated locations.

Most of Ghana is underlain by crystalline and strongly cemented sedimentary rocks which have low primary porosity and permeability. Good yields are generally obtained from boreholes completed in the more permeable partially weathered rock zone, in fractures in the bedrock, and in younger sedimentary rock formations. The success rates of boreholes varies from region to region, the national success rate of drilling being approximately 70%. The cost of a typical drilled well with handpump is about US$12,000 and that of a dug-well with handpump is US$2,000 and that of a dug-well with a bucket is US$1,200. For a given investment about five times more people could be served with a dug well than with a borehole.

Sanitation services are rather poorly developed. Although at least 60% of the rural population have access to some form of public/communal facilities, the majority of these are in poor condition. The range of technologies used are trench latrines, traditional pit latrines, bucket latrines and flush toilets.

Development of Ghana's water resources began in 1928 with a piped system in Cape Coast, the national capital at the time, followed by Accra the current national capital and other regional capitals. At that time the Public Works Department (PWD) was responsible for both urban and rural water supply. In 1958, the Water Supply Division of PWD became a separate entity as a parastatal organization under the name Ghana Water and Sewerage Corporation (GWSC) incorporated under an act of parliament and placed under the Ministry of Works and Housing (MOWH) which has responsibility for urban development.

The GWSC is the lead agency in the water supply and sewerage sector, being responsible for both urban and rural water supply. It is responsible for broad sector policy formulation, External Support Agency (ESA) coordination, planning and construction, operation and maintenance. The GWSC has its head of office in Accra, ten regional offices headed by Technical Directors responsible for activities in the region, and district maintenance centres headed by technical supervisors in charge of all O & M of WSS systems in the district.

Urban water coverage is about 93% (of the 40% of the urbanized population) and rural coverage is 30%.

The present water supply coverage stands at:

208 piped systems
10,500 mechanised boreholes, and
40,000 hand dug wells.

The GWSC defines urban population as centres with population over 5000, and those below 5000 are considered rural. In the determination of level of service, however, the following criteria are used:

pop. 2000 above have pipe-borne system
pop. 500-2000 have mechanised boreholes (handpump)
pop. 200-500 have dug-wells.

These definitions were responsible for the rapid increase in pipe-borne systems from 68 at the time of Independence in 1957 to 208 by 1970. An analysis of current O & M costs has revealed however that 77 out of the 208 systems would be classified as rural systems to qualify them for government subsidy to meet O & M costs.

The GWSC has a Director for Rural Water Supply and Sanitation Development (RWSS) who supervises a drilling unit of the organization, and coordinates and monitors all RWSS activities including ESA and NGO activities.

In addition to the piped systems which mainly serve urban and semi-urban areas, GWSC is responsible for the maintenance of some 7000 drilled wells with handpumps serving rural communities.

Rural sanitation in the rural areas of Ghana has in the past been handled by District Councils with the support of the Environmental Health Services Division of the Ministry of Health.

A review of sanitation coverage pattern in the country reveals that communal latrine usage is over 50%. The K-VIP (Kumasi VIP) latrine was chosen in 1982 as an appropriate rural sanitation technology and since then some 800 have been constructed with an additional 200 under construction. A number of Mozambique slab type latrines has also been constructed in some areas.

The functions of District Councils have however been taken over by District Assemblies created by law and mandated to "plan, initiate, coordinate, manage, and execute policies in respect of all matters affecting the people within their areas with a view to ultimately achieving localisation of those activities" including Rural WSS.

The performance of GWSC in the development of WSS facilities in Ghana have over the years been hampered by several factors, such as:

i) political sensitivity of government to full cost recovery by means of tariff,

ii) inability of government to provide adequate subsidies to meet O & M costs,

iii) unaffordability

resulting in the inability of GWSC to:

i) maintain plant and equipment,

ii) offer adequate levels of service, and

iii) finance new WSS facilities.

GWSC therefore depends on the Government of Ghana (GOG) and ESA's for all development of WSS in the country.

External Support Agencies (ESA's) have been engaged in supporting urban and rural water supply (primarily through the drilling of boreholes and installation of handpumps) for over 20 years. Over the period some 8000 boreholes, 250 piped systems and 2,500 hand dug-wells have been developed.

There are also 33 NGO's actively engaged in the sector in all the regions of the country.

Through the combined efforts of such support organizations, there are currently about 10,500 drilled wells with handpumps and over 40,000 hand dug-wells in the country.

It is envisaged to raise the present potable water supplies coverage of 50% (urban & rural) in the country to 70% by year 2002 by extending supplies to over 7 million people. To achieve this, some 25,000 dug-wells, 7,500 boreholes and 450 piped systems will be required. In addition, it will be necessary to rehabilitate or replace many of the existing small piped systems and handpumps.

The World Bank has financed four water supply and sewerage projects in Ghana. The fourth project which is on-going was designed to strengthen the management of GWSC and includes institutional development, rehabilitation and expansion of urban water supply systems.

Several other donors have been active in the rural WSS sector. The first World Bank Rural WSS project is based on a sector strategy which calls for the establishment of community based management of WSS services, more effective donor coordination, hygiene education, sanitation promotion, greater private sector involvement, and a restructuring of institutional roles.

O & M PRACTICES IN GHANA (GWSC)

Effective O & M of WSS facilities in Ghana has over the years suffered to a large extent due to the following constraints:

i) lack of funds to purchase spare parts, to properly train staff and provide competitive salaries to attract high calibre personnel,

ii) reluctance of ESA's to finance O & M activities

iii) government inability to provide adequate subsidies

iv) poor management of facilities by low calibre and/or unskilled staff

v) low profile of O & M as compared to construction of new projects

vi) non-involvement of the users in the management of the facility

vii) unwillingness of consumers to pay for tariffs levied.

A conference on "Sustainable O & M of Rural and Urban WSS in Ghana" organized in April 1993 by the Ministry of Works and Housing (MOWH) (on behalf of the GOG) and the Donor Collaborative Group in Ghana has succeeded in placing the problem of WSS of the rural communities on the priority agenda of the GOG which has indicated its determination to address the problem with the objective of ensuring sustainability in development in Ghana. The MOWH has commissioned a study group to evolve a national strategic plan to provide guidelines for implementation of a policy of community management of rural WSS. The plan is expected to define the responsibilities of the following:

i) the community

ii) the District Assemblies

iii) GWSC

iv) ESA's and NGO's

v) the private sector.

The Rural WSS division of GWSC is to be restructured to provide support and perform the monitoring role required to ensure success of the new strategy.

A UNDP/GWSC Rural WSS Project (supported by the Government of Netherlands) which is currently on-going in the Eastern Region of Ghana was perceived and designed in line with the thoughts that are going into the preparation of the national strategy on WSS. The communities in the project area were adequately prepared through animation and education to respond to the demand-driven approach to development.

The implementation strategy adopted for the project dovetails into the concept of Village Level Operation and Management (VLOM) which entails the community being responsible for the O & M of the WSS systems.

Under the system, pump caretakers (2 selected by each community) and area mechanics are being trained to promote efficiency in O & M practices in order to prevent system breakdowns. The pump caretakers are to be entrusted with VIP and pump site development, pump inspection, repair of minor faults, and, in some cases, tariff collection. Area mechanics are to be designated to superintendent at least 20 pumps to repair, fix, maintain and charge the community accordingly. A spare parts distribution system is to be established in the project area to ensure availability of spare parts to both the pump caretakers and area mechanics. Repairs beyond the capability of the area mechanics are to be reported to GWSC for repair for which the community would be required to effect payment.

CONCLUSION

The absence of sound O & M of WSS systems in developing countries and the devastating effects on the services for which they were constructed are well known. Since the neglect of sound O & M practices often results in the deterioration of valuable physical assets which result in major losses to national economies, an awareness should be created which recognizes that maintenance is an essential component of successful development and resource utilization.

OVERVIEW OF EXISTING OPERATION AND MAINTENANCE BY THE GHANA WATER AND SEWERAGE CORPORATION

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Introduction

Over the past years, governments in many parts of the world have invested large amounts of money in creating structures for the provision of water supply services to their citizens as well as industries. Of late however, population increases especially in Africa with the resultant increased demand for water services, is placing strains on the limited budgets of many governments. To further aggravate matters the operation and maintenance costs of most of the water supply facilities are rising in such a way as to cast doubts on the future sustainability of the services, unless tariffs are revised to such a level as to make the services no longer affordable for the poorer stratum of the society. This is a question which is assuming increasing importance in the water supply industry. Although various countries have adopted different measures to ensure the viability of their water supply facilities, none of these have been found to be completely satisfactory.

The GWSC Experience

Prior to the formation of the GWSC in 1965, water supplies were provided by two organisations; the Water Supplies Division of the Public Works Department, which had responsibility for supplies to municipal and urban centres, and the Rural Water Supplies Unit which had responsibility for the rural communities providing mainly dug wells, with or without handpumps. Construction of piped water supply systems in this country started as far back as the early 1900s and were mostly limited to urban centres where the colonial administration had its offices and officials.

At the achievement of independence in 1957, Ghana had 35 pipe borne water supply systems. However under the country's accelerated development programme, the number of pipe borne water systems had risen to 144 by 1980. In consonance, with the increasing scope of operations in the water sector, the GWSC was established by Parliamentary Act in 1965 and charged as the sole water supply authority in Ghana, and therefore took over the running of all pipe borne water systems in the country. The GWSC now operates 209 piped water systems throughout the country serving 93% of the country's urban population. Furthermore, four major district water supply schemes, construction of which began some years ago, are expected to come into operation during the next two years.

Present Operation Status

Until 1986, the GWSC was a government subverted organisation. Under this arrangement the central government set water tariffs and agreed to reimburse the GWSC with the difference between operating costs and tariffs. However, under the economic decline of the mid 1970s and early 80s

these governmental commitments were never fully met. These shortfalls in operating budget seriously affected operations and maintenance activities especially in the small non-viable rural systems. One glaring result is the deterioration and sometimes complete breakdown of some of these systems. Even well established city/municipal large scale capacity systems were not spared the effects of these economic upheavals.
The Rural Water Department of GWSC has been mainly concerned with the operation and maintenance of handpumps. After the major drilling programmes were completed maintenance units were instituted. These units were equipped with transport and lifting devices for the underground components of pumps as well as workshops and tools. Handpump selection programmes were run by the units to find the most robust and lasting pumps. The Monarch, Moyno and the India Mark II pumps were chosen.

Government policy to levy tariffs on handpumps was announced in 1985. Tariff rates have increased from their original level of 500 Cedis per pump per month per household.

The maintenance units have been structured to perform preventive maintenance service on all handpumps. In the beginning, repair techniques were complicated due to use of sophisticated maintenance equipment.
The central maintenance system has worked satisfactorily except for doubts about its sustainability. The main problem with the system is the collection of tariffs, a function of insufficient education, lack of funds, transparency and mistrust of GWSC by the consumer communities.

Because of the scattered distribution of handpumps, community participation in any maintenance system should go beyond paying tariffs, reporting of breakdowns and lending a hand to the GWSC mechanics, to the concept of village level operation maintenance (VLOM). Successful VLOM depends on type of pump and standardisation.

NGOs have taken the lead toward participatory approaches to maintenance and proved the point that free maintenance service on pumps results in disaster.

Major Cost of Operations and Maintenance

The major costs which determine the level of operation and maintenance are:

- personnel;
- fuel and lubricants;
- electrical energy;
- chemicals; and
- spare parts and replacement equipment.

As indicated earlier, shortfalls in the operating budget as well as increases in personnel, energy and commodity costs have seriously affected the efficient performance of the Corporation and therefore the level of service to the consuming public.

Lessons Learnt

After the Corporation went off government subvention in 1986, it had to resort to the "cross-subsidy" arrangement, under which revenue was siphoned from economically viable systems to

subsidise the operations of non viable systems. This arrangement, although undesirable, was the only reasonable alternative left to the Corporation. A careful evaluation of some of these non viable systems have revealed the following characteristics:

- use of obsolete plant and equipment;
- use of inappropriate technology; and
- installation of plants with capacities far in excess of immediate community requirements.

In fact, had it not been for the provision of certain essential inputs such as spare parts, replacement equipment and other logistic support (i.e. vehicles, tools, etc.) by overseas donors, a greater number of these systems would have been out of operation by now. Here, agencies like CIDA, KFW, ODA, GTZ, etc. should come in for special mention for their assistance over the years.

Remedial Measures

The GWSC realising the deterioration of the quality of its services and fiscal constraints under which it was operating did organise a donors' conference in 1987 at which proposals were put forward for the rehabilitation of the various water supply systems in the country. As a result of the above conference, loans and grants have been obtained from the World Bank, CIDA, and other external support agencies for the rehabilitation of 76 water supply systems, with counterpart funding being provided by the Government of Ghana and GWSC.

The following measures are envisaged under the above Project:

a. A number of systems will be rehabilitated and their capabilities expanded, after thorough studies and designs by consultants.

b. Careful attention will also be paid to the choice of technology to be used, and the type of water system to be provided. The beneficiary communities are expected to participate fully in reaching these decisions.

c. The operation and maintenance section is to be strengthened with appropriate and adequately trained manpower, tools, vehicles, workshop facilities as well as coordinated maintenance programmes to ensure longer life span of plant and equipment as well as ensuring a high level of service to consumer.

d. Wherever possible water supply installations shall be connected to the national power grid as a way of reducing operation and maintenance costs.

The evolving policy on maintenance of rural water supply and sanitation systems is community management. Important issues related to the success of the system include:

a. A uniform procedure for development.

b. Uniform levels of contributions from the community, government and donors.

c. Uniform procedures for maintenance.

d. Institutional arrangements for promoting services, monitoring and coordination.

Future Prospects

With the renewed interest being shown by the Ghana Government in the development of the water sector as well as favourable offers being received from various donor/external support and lending agencies, it is expected that over the next few years the water supply sector will be given a new lease of life. This together with cost saving measures being put in place by the Corporation, with sound operation and maintenance practices and with the full co-operation of the consuming public are expected to go a long way in enhancing the sustainability of the present and future water supply systems in Ghana.

Beneficiary communities shall be given the opportunity to decide on the mode of operation and management of the rehabilitated systems. The public sector will be encouraged to provide services to the communities to ensure sustainability of the systems.

COMMUNITY MANAGEMENT OF SMALL URBAN WATER SUPPLIES IN SUDAN AND GHANA

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Introduction

Community management of water supplies is an approach that is gaining popularity among sector development professionals and practitioners, and promises to be the most sustainable effort in the sector tried to date. Two fundamental characteristics distinguish community management from other participatory and community development-oriented approaches in the sector.

First, community management occurs when the people of a community, through representative community organisations, have the legal right to assume ownership and responsibility for their water supply. They are entitled and able to make decisions and implement actions controlling use of the water supply.

Second, community management occurs within an enabling environment. Government sector agencies and donors play a major role in providing this enabling environment, which includes: a policy framework to foster community management; adequate information and assistance in organisation at the community level; the promotion of affordable and appropriate technologies and service levels; training and human resource development focused at the community organisations; and appropriate financial arrangements for capital and recurrent costs, with significant cash contributions from the community, and access to external loans and grants.

Successful examples of community managed water supplies can be found in various African countries. In Sierra Leone, Kenya and Togo for example, village organisations have been encouraged to define their water supply problems, and to formulate their own solutions. These solutions, often shallow wells, handpumps, spring catchments or rainwater harvesting, are then implemented by the villages, with assistance from various government and non-government organisations (McCommon, Warner and Yohalem, 1990). In Malawi, communities take the lead in planning, mobilising, constructing and maintaining their own gravity-fed piped water supplies (Nyumbu, 1990). In Ghana, community management of handpump schemes has been established on a pilot basis (Yanore, 1990).

While these successes are encouraging, and add to our knowledge and understanding of the dynamic and evolving approach of community management, they are limited to relatively small communities, utilising relatively simple levels of technology. Several researchers have described examples of community management of mechanised water supplies, but in the context of developed countries in Europe and North America (Tamm, 1991. Katko, 1992. Livingstone and McPherson, 1993). While these examples are useful in understanding some of the processes involved and constraints faced, they are not directly applicable to African situations.

Since 1987, the author has been involved in an experimental approach to community management of small urban water supplies in both Sudan and Ghana. The purpose of this paper

is to describe some of the special considerations involved in small urban water supply situations, the strategies developed to enable community management, and the experiences gained.

DEVELOPMENT CONTEXT

The community management of small urban water supplies discussed in this paper takes place in two development contexts.

In **Sudan**, the activity was focused upon the Northern Darfur Water, Sanitation and Hygiene Education Project (1987 to 1990). In this project, 25 towns in two districts of Northern Darfur Region were involved. Towns ranged in size from 3,000 to 10,000 people: 15 towns had existing mechanised water supplies that were to be rehabilitated; the remaining 10 towns developed new water supplies. In all cases, the technology utilised was the same. Very deep boreholes, the only available reliable water sources, were equipped with diesel-powered pumps, and supplied water to elevated storage tanks. A limited distribution system of standpipes, troughs for watering livestock, and a tank filling outlet were provided in each town. Some 3,000 wateryards are in existence in Sudan, most constructed by the National Corporation for the Development of Rural Water Resources (NCDRWR) in the 1960s and early 1970s. More than 50 percent are inoperative, and most require major rehabilitation (McPherson and Livingstone, 1990).

In **Ghana**, the activity is focused upon the Ghana Water and Sewerage Corporation (GWSC) Assistance Project (1990 to 1997). In this project, towns and cities in the three regions of northern Ghana are involved. In the initial phase of the project, 12 towns and cities are involved. Towns and cities range in size from 6,000 to 50,000 people. All have existing mechanised water supplies that are to be rehabilitated. Also, each town and city has a variety of non-mechanised water supplies that are in use; predominantly boreholes with handpumps and shallow hand-dug wells. The technology utilised is blended, to incorporate rehabilitation of both the mechanised and non-mechanised water supplies within each town and city. Mechanised supplies use diesel-powered, solar powered or electrical grid-powered pumps to withdraw water from boreholes, or from surface water reservoirs and streams with accompanying water treatment. Water is supplied to elevated storage tanks, and distributed through pipelines to public standpipes and private house connections. Non-mechanised supplies include boreholes and shallow wells with VLOM handpumps. Some 50 mechanised water supplies, 3,000 boreholes with handpumps, and innumerable shallow hand-dug wells exist in northern Ghana. They have been constructed primarily by GWSC, but also by non-government organisations and religious agencies. Most mechanised water supplies are inoperative or operating far below original capacity, and all require major rehabilitation. While more than 80 percent of boreholes with handpumps are claimed to be operational, most shallow hand-dug wells run out of water in the dry season each year (GWSC, 1992a).

Both projects were supported financially and technically by the Canadian International Development Agency (CIDA). The Northern Darfur Water, Sanitation and Hygiene Project was implemented through the NCDRWR by a Canadian non-governmental organisation. The Ghana Water and Sewerage Corporation Assistance Project is implemented through the GWSC by a Canadian consulting engineering company, Wardrop Engineering Inc.

COMMUNITY ORGANISATION

Towns with wateryards in Northern Darfur Region, **Sudan**, usually had existing formal committees or informal groups with some interest in town water supply, but in most cases town

health committees (formed by the Ministry of Health) or town development committees (formed by local/district government) played the main role in relation to water supply. Towns without existing wateryards normally had health and/or town development committees already established.

Project community development workers gauged the relative strengths of the existing community organisations, and attempted to reorganise or restructure them into wateryard committees. This was possible in many cases. Where existing community organisations were relatively weak or ineffective, attempts were made to amalgamate organisations into wateryard committees, and to organise and structure them. In a few specific instances, town youth organisations proved to be active and effective, and were incorporated into the wateryard committee structure. Wateryard committees averaged eight members, and given the traditional Islamic environment in the towns, it was necessary to have separate sub-committees for men and women. The male sub-committees normally had five or six members, and chose to concentrate upon technical and financial aspects of wateryard operation and maintenance. The female sub-committees normally consisted of two or three members, and chose to address hygiene, sanitation and water utilisation issues, but frequently played a major role in financial management.

Initially, 18 months was spent identifying community organisations and mobilising wateryard committees. This activity was done in conjunction with town baseline and demographic surveying. Since NCDRWR has no existing capacity for such work, community development workers were seconded to the project from the Ministries of Health and Social Welfare, and additional community development workers were hired on contract from an extension organisation attached to the University of Khartoum.

Towns and cities in northern **Ghana** dealt with in the GWSC Assistance Project all had existing mechanised water supplies, but no effective community water supply committees or groups existed. In some towns where boreholes equipped with handpumps has been installed by a previous CIDA - supported project, handpump committees had been formed, but concentrated upon raising funds for the handpump tariff and keeping the pumpsite clean. Two towns had experience in running their mechanised water supply through their town development committees, but both attempts had failed and the committees had become inactive.

More than one year was spent investigating various options for community organisation that could potentially manage the mechanised water supplies to be rehabilitated. The consensus among the project, community leaders and the Government of Ghana was that a formally constituted Water and Sanitation Development Board (WSDB) would be the optimal organisation. Linked directly to the district government structure, and thus supported by established decentralisation legislation, the WSDB would have a high degree of autonomy in decision-making, and government support of its activities, within a defined water service area encompassing the entire community. The WSDB could control the total community water supply, both mechanised and non-mechanised.

Project community development workers spent a total of 30 months, first preparing and mobilising communities, and then assisting in the organisation and official formation of WSDBs. This activity was done in conjunction with community baseline, socioeconomic and demographic surveying. GWSC has no existing capacity for community development work, so the project retained a team of experienced community development workers through a Ghanaian consulting company. Each community development worker had a part-time GWSC counterpart assigned.

WSDBs averaged 12 members, elected or appointed by the various traditional, political,

social, residential and economic groups that comprised the community. Women's interests were well-represented, with usually four to six members being female. Three WSDBs out of a total of 12 formed were headed by women, and women were present on the executive committees of all WSDBs. The executive committees consisted of the chairperson, secretary and treasurer, and they delegated management responsibilities to designated administrative, financial, technical and utilisation management officers. In this way, all WSDB members were active in water supply management.

PLANNING FOR REHABILITATION

Although both projects were guided by similar overall objectives, to improve the sustainability of the water supplies being rehabilitated, they exhibited differing emphases upon community participation in planning for rehabilitation.

Communities in **Sudan** had little input into the technology employed in water supply rehabilitation. Although choices were limited, due to restricted water resource availability in the project area, wateryard equipment and layout was predetermined by the project. As the project was implemented, improved communications between wateryard committees and project management resulted in some modifications to wateryard layout and configuration, but these were relatively minor. No attempts were made to introduce the concept of solar-powered pumping equipment for example, to lessen the communities' dependency on unreliable supplies of diesel fuel. To great extent, the NCDRWR was responsible for insisting upon wateryard conformity to national standards, seeing themselves as being operators and owners of the rehabilitated supplies once the project's experiment in community management had failed and was over.

By contrast, in **Ghana** communities had considerable input into planning the rehabilitation of their water supplies. A wide variety of water supply options were available in most communities, and WSDBs were encouraged to examine and evaluate the suitability and acceptability of these options. Rather than focusing exclusively on the mechanised supply in the community, most WSDBs included various non-mechanised supplies as part of the community water rehabilitation plan they were helped to prepare by GWSC. In particular, water service levels were chosen in reference to the consumers' willingness and ability to pay for the chosen service. Resulting WSDB rehabilitation plans were a blend of water supplies, technologies and levels of water service. For the mechanised components of these plans, alternative energy options were chosen whenever feasible by the communities to reduce operation and maintenance cost.

Hygiene education and sanitation planning also exhibited differing emphases upon community participation. The project in **Sudan** was more fully integrated, with substantial budgets for both hygiene education and sanitation promotion. With the NCDRWR lacking expertise and interest in these areas, communities were encouraged to plan and implement these components of project activity to a much fuller degree. In particular, wateryard committees, especially the female sub-committees, took an active role in formulating and delivering community hygiene education campaigns and messages. Both men and women took an active role in sanitation promotion: selecting sites for demonstration; constructing VIP latrines under supervision; designing appropriate latrine superstructures and promoting the concept of improved sanitation facilities throughout the community. In several cases, wateryard committees chose to subsidise latrine construction by interested home owners through wateryard water revenues.

By contrast, in **Ghana** the project had a strong water supply emphasis. The budget available for hygiene education was small, and no budget was available for sanitation promotion. Despite this, community WSDBs became actively involved in planning and delivering community hygiene education campaigns and messages. Sanitation improvements have also been identified by the WSDBs as being urgently required, but without financial support from the project they were unable to progress beyond public education on sanitation improvements. Plans for community demonstrations of sanitation improvements to be funded possibly from water revenues, or from other sources were encouraged.

FINANCIAL ARRANGEMENTS

In both projects, communities made some contribution towards the capital cost of water supply rehabilitation and construction. However, in the both cases, these contributions were relatively minor.

In **Sudan**, capital costs ranged from $30 US to $100 US (1990) per capita, depending upon the population of the towns. The equipment installed in each town was essentially the same, regardless of the population to be served. This deliberate oversizing of water supply facilities in smaller towns was a decision made by the NCDRWR, in order to standardise wateryard equipment and configuration. In several of the largest towns, two identical wateryards were installed if water demand exceeded the supply obtainable from a single wateryard. Community residents were not expected to contribute cash towards the capital cost of rehabilitation and construction. In some communities, wateryards committees organised community labour to undertake perimeter fencing of the wateryard.

In **Ghana**, capital costs ranged from $60 US to $160 US (1992) per capita, depending upon the technology utilised and the equipment installed. In some towns, groundwater was the main source and electrical grid power for pumping was readily available; resulting per capita rehabilitation and construction costs were in the lower end of the range. In other towns, treatment of surface water and/or the use of diesel or solar-powered pumps was necessary, resulting in per capita costs in the higher end of the range. Community residents who had opted for private house connections were expected to contribute cash towards the installation of this increased level of service. The number of houses choosing private connections ranged from 15 percent to 50 percent approximately, and individual contributions per house were in the order of $100 US to $160 US (1992). These contributions represented from approximately two up to seven percent of the total capital costs of rehabilitation and construction. In some communities, WSDBs organised community labour to undertake trenching for pipeline installation, on a sub-contract basis to the project.

In both projects, communities were responsible for paying the full cost of operating and maintaining the water supply. The approaches taken towards cost-recovery of operation and maintenance were somewhat different however.

In **Sudan**, a revolving fund was established into which all 25 towns paid their water revenues. Water tariffs in each town were the same, initially set at $0.46 US/m^3 (1990). Tariffs were collected by wateryard attendants on a volumetric basis in the case of domestic consumption, and on a per head basis in the case of livestock consumption. Each wateryard committee purchased their own diesel fuel, oil and spare parts, and paid their own wateryard staff. In addition, each committee made a unit contribution to receive maintenance, repair and advisory assistance services

from the district maintenance teams established by the project. Surpluses of water revenues over operation and maintenance expenditures accruing in the revolving fund were the property of each wateryard committee. These funds were intended to cover depreciation and replacement of wateryard equipment, and possibly future wateryard and sanitation facility expansion or upgrading. A summary of the monthly financial performance of a sample of wateryards is given in the Table 1. On average, revenue was collected for 80 percent of the water pumped each month, leaving a wateryard committee with an average surplus of \$0.19 US /m^3.

In **Ghana**, each WSDB established their own local bank account into which their water revenues were to be paid. They were encouraged to collect a deposit of approximately half a year's anticipated operation and maintenance cost prior to rehabilitation of the water supply. Each WSDB sets water tariffs to cover the cost of operating and maintaining their water supply, and tariffs ranged from \$0.10 US/m^3 to \$0.27 US/m^3 (1992). Tariffs are collected by WSDB members and employees on a volumetric basis from institutional and commercial customers, and a flat rate basis from domestic customers. Each WSDB will purchase their own diesel fuel or electricity, spare parts, oil and water treatment chemicals if required, and pay their own water supply operating staff. WSDBs have the option of undertaking maintenance and repairs using their own staff, contracting this service from the GWSC or from the private sector.

Surpluses of water revenues over operation and maintenance expenditures accruing in each WSDB bank account are used to cover WSDB administrative overhead, depreciation and replacement of water supply equipment, and allow for future water supply expansion or upgrading. A summary of the projected monthly financial performance of a sample of small urban water supplies is given in Table 2.

Table 1: Monthly Financial Performance of Wateryards in Sudan (1990)

	Tabit	Shengel Tobia	Musko
Water Pumped (m^3)	2177	2719	2894
O&M Costs· *			
Fuel	91.60	121.30	111.10
Oil/Spares	12.40	21.60	15 90
Staff	138.30	163.30	146.70
District O&M/Team	201.00	201.00	201.00
Service	443.30	507.20	507.20
Total			
Unit O&M Cost/m^3	0.20	0.19	0.16
Tariff Charged/m^3	0.46	0.46	0.46

* In 1990 U.S Dollars Source: Livingstone, 1990

Table 2: Projected Monthly Financial Performance of Town Water Supplies in Ghana (1992)

	Zebilla	Nandom	Saboba
Water Pumped (m^3)	9,000	12,990	5,520
O&M Costs: *			
Fuel/Electricity	313.30	1136.10	801.70
O&M Supplies/Services	77.80	95 90	159.80
Staff	240.00	240.00	240.00
Total	631.10	1472.00	1201.50
Unit O&M Cost/m^3	0.07	0.11	0.22
Tariff Charged/m^3	0.10	0.14	0.27

* in 1992 U.S Dollars Source: GWSC, 1992b

TRAINING ACTIVITIES TO SUPPORT THE COMMUNITIES

Wateryard committees in **Sudan** selected two members to be trained as a wateryard clerk and a wateryard operator. These individuals received training from project staff during the wateryard rehabilitation and construction activities, to ensure their familiarity with the equipment installed. The wateryard clerk also received training in the control of water sales, revenue collection, daily recording, monthly report preparation, and the deposit of revenues into the revolving fund. The wateryard operator received training in operation, routine and preventive maintenance of the pump, engine and other wateryard equipment. Training was also provided to the wateryard operator in daily operational record keeping, including water meter and hour meter reading and fuel consumption measurement.

In addition to the wateryard committee personnel, the NCDRWR maintained staff at the project wateryards. Normally, a clerk, an operator and two guards were provided. For an interim period, the committee personnel and the NCDRWR personnel worked together with the wateryard committee managing the process. It was planned to eventually phase out the NCDRWR personnel at each wateryard and replace them with committee personnel. This is fact did not happen.

Training was also provided at the community level in Sudan in the areas of hygiene education and sanitation improvements. Normally, the female sub-committees at each wateryard were trained by the project in these areas. This training consisted of non-formal sessions conducted over a 6 to 12 month period. These women were then encouraged to develop community hygiene education and sanitation promotion campaigns and messages, which were subsequently delivered by the women and project staff in each community. Public education techniques included the use of audio-visuals, drama and role play, and puppetry on a limited basis. In some cases males in the community became sufficiently motivated by this training to assist the women in subsequent demonstration sanitation improvement activities. A total of about 60 demonstration VIP latrines were constructed in about 16 communities as a result.

WSDBs in **Ghana** delegated water supply management functions among all members. These individuals received management training through a series of workshops in the areas of financial management, technical management, administration, and water utilisation, hygiene and sanitation. WSDBs were encouraged to develop public education campaigns in their communities: to promote proper water utilisation; payment of water tariff; improved hygiene practices; and

sanitation improvements in individual compounds and in the community-at-large. After initial training, WSDB members and project staff jointly conducted public education session in the individual communities. Techniques included the use of audio-visuals, drama, role play, music, songs, dance and puppetry.

During rehabilitation and construction activities, WSDB employees such as supply operators will receive training from project staff and from GWSC personnel, to ensure their familiarity with equipment installed. WSDB members also will receive on-going training through regular meetings with project staff. Once the water supply rehabilitation and construction is completed in each community, it is proposed to provide approximately three to six months of practical management and operating training to the WSDB and their employees. After the completion of this "break-in" period, full management and operating responsibility for the water supply would be formally handed over from GWSC to the WSDB.

INSTITUTIONALISING THE APPROACH

Institutionalisation of a community management approach to the operation and maintenance of small urban water supplies includes comprehensive human resources development within government sector institutions, and the creation of enabling legislative, administrative and financial arrangements to support community management.

The project in **Sudan** was specifically formulated as a pilot, to test the feasibility of a community management approach in two districts. Training was provided to NCDRWR staff at the operational and management level, to sensitise them to issues such as least-cost appropriate technology, community management of operation and maintenance, and hygiene education and sanitation promotion and integration with water supply activities. Training consisted of a series of in-country workshops, seminars and a conference. Participants included NCDRWR district/regional (Northern Darfur) and national headquarters personnel. Linkages were established between these personnel and sector personnel from other agencies within Sudan and from external support agencies. In addition, a limited number of external training courses in Canada and the United Kingdom were provided for project and NCDRWR personnel.

At the project level, arrangements were made to proceed with the community management approach, with the support of NCDRWR headquarters and the Ministry of Finance and Economic Planning. However, these arrangements were not consistent with national sector policy, which did not encourage community participation in water supply planning, development or management. Attempts were made by project, in collaboration with the UNDP/World Bank Regional Water and Sanitation Group and other donors, to encourage reformulation of national sector policy. These efforts were largely unsuccessful.

The project in **Ghana** was formulated primarily as an institutional strengthening exercise for the GWSC. A community management approach to water supply rehabilitation, operation and maintenance was the major component of this exercise. Training was provided to GWSC operational and management staff at the regional and national levels. Training topics included: community participation and community management of rehabilitation, operation and maintenance; least-cost appropriate technology; improved engineering planning, design and construction supervision; technical/industrial training for mechanical, electrical and workshop staff; commercial optimisation and improved financial management; hygiene education and sanitation promotion and

integration with water supply activities. Training consisted of a series of in-country workshops, seminars and a conference, as well as a considerable amount of structured on-the-job training. Participants included GWSC district and regional personnel (primarily from the three northern regions), and national headquarters personnel. Linkages were established between these personnel and sector personnel from other agencies within Ghana and from external support agencies. In addition, it is proposed to provide a limited number of external training courses in other African countries and in the United Kingdom for project and GWSC personnel.

National sector policy in Ghana embodies the principle of community management of water supply rehabilitation, operation and maintenance. However, the main sector agency, GWSC, has not been able to progress very far in establishing community management of rural and urban water supplies. The project is perceived as being a means by which GWSC can proceed in this area, and gain experience in following a community management approach. Similarly, GWSC is being encouraged by the project to improve collaboration and cooperation with other sector agencies pursuing this approach. Legislative, administrative and financial arrangements to support community management are currently evolving at a national level, and are encouraging GWSC to pursue this approach.

GOVERNMENT COMMITMENT

The Government of **Sudan** appeared to regard the Northern Darfur Water, Sanitation and Hygiene Education Project primarily as a means to rehabilitate existing and construct additional wateryards in a problematic area of the country. Although some individuals within government sector agencies showed personal commitment to the project's activities in community management, tangible commitment from the NCDRWR was absent. While the project's significant external financial support was attractive to the NCDRWR, government financial support under their control was frequently delayed and eventually cut substantially. Generally, funds for rehabilitation and construction were forthcoming, but government funds for community development, hygiene education and sanitation promotion were always difficult to obtain.

Eventually, after the Northern Darfur Water, Sanitation and Hygiene Education Project was completed in 1990, and after the feasibility of community managed wateryards was demonstrated, the government of Sudan withdrew its physical support from the wateryard committees and confiscated the wateryard operation and maintenance revolving fund. As a result, the wateryards reverted to the former centralised, NCDRWR-controlled operation and maintenance system, which had been repeatedly proven to be ineffective, inappropriate and non-sustainable.

The Government of **Ghana** appears to regard the GWSC Assistance Project as a means to strengthen and streamline GWSC, and to establish community management of urban and rural water supplies. A considerable number of individuals within government sector agencies are supportive of the project's activities in community management, and tangible commitment from the GWSC is present and increasing. While a significant number of operational and management personnel within the GWSC remain sceptical of community management, deliberate obstruction is not evident. Government financial support to match external financial support is forthcoming. Although fiscal difficulties have resulted in reductions in government funding of all development projects in Ghana, the majority of funds received by the project are allocated towards community management enabling activities.

The GWSC Assistance Project will not be completed until 1997. Therefore, it is too early to properly determine the true degree of commitment to community management. However, concurrent government-supported initiatives in the rural water sector, and planned initiatives in the urban water sector, indicate that the Government of Ghana is seriously addressing the issue and actively exploring means to enable community management of water supplies.

CONCLUSIONS

Development, social, economic and political conditions in Sudan and Ghana are quite different. Also, the two projects to enable community management of small urban water supplies were formulated and implemented with significant differences. The communities involved are unique to both countries, and the water needs and supply options for the communities in Sudan and in Ghana are not really comparable. However, certain conclusions can be drawn from the comparisons presented in this paper, that indicate potentially successful strategies for community management of small urban water supplies, and that indicate common difficulties and constraints likely to be faced in implementing such strategies.

An Effective and Representative Community Organisation

For many years, water committees have been formed by projects and by governments, to take part in development projects. Many of these committees have proven to be ineffective, and often slip into dormancy. To enable community management of small urban water supplies, strong and confident community organisations are an essential precondition. The main conclusions regarding community organisation from this analysis are:

- sufficient time and appropriate mobilisation assistance must be provided to allow community residents to select members to represent them in a community organisation;
- a community organisation must represent all significant residential, economic, political, ethnic and special interest groups in the community;
- highly-motivated or skilled individuals should be encouraged to lead the community organisation, regardless of their relationship to existing political or traditional leadership within the community;
- it is usually difficult to ensure that women are effectively represented in a community organisation, but patience, flexibility and innovative ideas can often result in ensuring that women are fully involved;
- membership in a community organisation should be for a specific time, such as two or three years, to allow members to be replaced as they or the community residents see fit;
- the community organisation must have strong institutional support and legal backing within existing sector policy and national/regional/state legislation; and
- comprehensive training in a wide variety of areas, and on-going training and support is required to build confidence and capabilities within the community organisation.

Participatory Planning and Design of Water Supplies

Community management of small urban water supplies is only possible when community residents and their organisations initiate and control the water supply planning and design process. The main conclusions regarding participatory planning and design from this analysis are:

- communities need sufficient time and appropriate assistance to identify and define their various water supply and sanitation needs;
- existing community water supplies and sanitation facilities need to fully assessed and evaluated with regards to their present suitability and opportunities for their future improvement;
- communities need assistance to identify and evaluate an array of options for water supply and sanitation facilities, especially regarding the cost and the operation and maintenance requirements of each option;
- a community-wide process of discussion, negotiation and decision-making is required before a water supply and sanitation plan can be prepared;
- input from external support agencies and government agencies during the design process must be sensitive to, and adhere to the parameters established in the community plan;
- the final plan and design prepared for the community water supply and sanitation facilities must be endorsed by the community-at-large; and
- the participatory planning and design process is frequently non-linear, and support personnel must maintain a flexible and responsive approach in assisting the community organisations.

Financial Arrangements To Enable Community Management

Appropriate financial arrangements are required to enable communities to construct, operate and maintain the water supply and sanitation facilities that they have planned and designed. The main conclusions regarding financial arrangements from this analysis are:

- the level of external and government support for capital costs must be well-defined, and should be flexible enough to accommodate the community's need, willingness and ability to pay for water and sanitation services, and the infrastructure development goals of government and external support agencies;
- communities are usually prepared to make a significant contribution towards capital costs, either in cash, in kind or in combination, and community labour inputs must be assigned a realistic cash-equivalent value;
- communities are nearly always prepared to pay the full cost of operating and maintaining the chosen water supply and sanitation facilities;
- appropriate training and assistance will be required, for a significant period of time, to

enable community organisations to financially manage and administer their water supply and sanitation facilities; and

- significant opportunities exist for government agencies and the private sector to provide supplies and services to community organisation on a cost-recovery basis.

Broad-based Human Resources Development

Training and institutional strengthening is required at the community, government agency and sector levels to promote community management of small urban water supplies. The main conclusions regarding human resources development from this analysis are:

- at the community level, human resource development is frequently needed in the areas of (1) planning and decision-making; (2) management and administration, and (3) water utilisation, hygiene and sanitation;

- at the government agency level, human resource development is frequently needed in the areas of (1) community development, participation and management, (2) water supply, sanitation and hygiene education integration, and (3) training programme development, delivery and evaluation;

- at the sector level, human resource development is frequently need in the areas of (1) the community management approach in development planning, implementation, monitoring and evaluation, (2) integrated water supply, sanitation and hygiene education, (3) sustainable operation and maintenance of rural and urban water supplies, and (4) collaborative planning and implementation of sector activities; and

- broad-based human resources development is best accomplished by a multi-disciplinary group of trainers, including resource persons from communities, government agencies, external support agencies and non-government organisations.

Institutionalisation and Government Commitment to Community Management

Without proper institutionalisation and a clear and coherent government commitment to community management of small urban water supplies, sustainability is unlikely. The main conclusions regarding institutionalisation and government commitment from this analysis are:

- the first and most important step towards attaining institutionalised community management is comprehensive human resources development at all levels;

- sector policy must clearly support community management, and sector planning and implementation management procedures and practices must embody the concepts of participatory and community-based development;

- appropriate legal, financial and administrative arrangements are required to foster and support community management initiatives;

- institutionalisation is most likely to occur when both communities and especially government agencies perceive that community management offers tangible benefits and

desirable outcomes;

- government commitment must be substantial and long term, since enabling community management requires considerable resources for substantial periods of time; and
- external support agencies must collaborate and harmonise their technical and financial support to the sector, since long term programme support is required instead of short term project support, in order to build capacity for community management at the community and at the government agency levels.

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WOMEN IN THE OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS IN GHANA

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INTRODUCTION

The need for community management of water supply systems is increasingly recognized as a necessary ingredient for the long-term sustainability of such systems. It is also well recognized that women play a central role in the collection, utilization, and management of domestic water supplies in developing countries. Women have the most interest in keeping close, convenient and safe water sources available as they are the ones who must revert back to traditional sources, often distant and unsafe, when these fall into disrepair. Women, by virtue of their daily contact with water sources have immediate knowledge of their operational status and are the most appropriate community members to take charge of the long-term operation and maintenance of water supply systems.

Increasingly, national government, external support agencies, and non-governmental organizations have attempted to implement community based management approaches. However, in many cases, women have not been effectively integrated into such approaches. Projects which have attempted to include women into operation and maintenance systems have often caused women to experience negative effects such as increased work burdens, financial stress, social disapproval, risk of physical and sexual safety, and increased stress on their time. It cannot be assumed that women will continue to bear the burden of keeping these community based operation and maintenance systems afloat. When women's time, energy and resources become too stretched, women have no choice but to allow modern water systems to fall into disrepair and revert back to traditional water sources (Hoffman 1992).

The Accra (1993) Conference on the Sustainable Operation and Maintenance of Rural and Urban Water Supplies in Ghana recognized the need for the better integration of women into the community based approach to water supply system management. The authors have worked on several water supply and sanitation projects being implemented in northern Ghana. The approaches taken to integrate women into these water supply projects, and kinds of problems experienced by women as a result of their participation in these projects will be highlighted in this paper. The collective experiences of these projects brings to light a number of main areas of concern which will need to be addressed if women's participation in operation and maintenance systems is to be sustained over the long term.

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WOMEN IN OPERATION AND MAINTENANCE IN GHANA

The authors have worked as gender specialists and community mobilization specialists on a number of water supply projects, both rural and urban, in northern Ghana. These projects include the three CIDA funded GWSC Assistance Project (GAP), the Integrated Village Water Project (IVWP) of the Northern Region Rural Integrated Program (NORRIP II), and the Water Utilization Project (WUP), as well as the UNDP Pilot Project. All of these projects have attempted to integrate women into operation and maintenance. The positive and negative experiences of these projects shall be highlighted.

GWSC Assistance Project (GAP)

The GWSC Assistance Project has as its main objective to ensure the sustained operation and maintenance of the existing water supply infrastructure in towns and cities on the three regions of northern Ghana. Mechanised (diesel and electric powered pumps from boreholes or surface water reservoirs and streams) and non-mechanized (boreholes and shallow wells with VLOM pumps) systems are rehabilitated and upgraded, with some 1,845,000 people expected to directly benefit from this project. Community management of all water systems has been instituted through Water and Sanitation Development Boards (WSDB) which are linked directly to the district government structure and which control the total community water supply, both mechanized and non-mechanized.

In GAP, the integration of women has become an increasingly important aspect of the community management process. GAP has experimented with, and instituted a number of WID/GAD initiatives. For example:

1. The implementing agency has instituted an internal monitoring system for gender. The project has collected disaggregated baseline data to enable the project to monitor gender involvement and to use monitoring results as a planning tool for further improvements in women's involvement.

2. A policy was set forth that 50% of the Community Liaison Workers should be women.

3. All GWSC, Implementing Agency and Community Liaison Workers receive gender analysis training.

4. Gender sensitive male Community Liaison Workers have had a positive influence on the messages being disseminated at the village level. They play a key role in changing traditional attitudes amongst the male village population and creating a more favourable environment for greater women's participation in leadership roles.

5. The structure of the Water and Sanitation Development Boards (WSDBs) was made gender sensitive in that the categories of board membership were made favourable to women. For example, the Boards included such organizations as the PITO Brewers Association and the Food Sellers Associations which are basically all women's groups, as well as a health care professional and teacher who are also predominantly women. Approximately 1/3 to 1/2 of the Board members became women.

6. Three WSDBs out of a total of 12 formed are chaired by women and women are present on the executive committees of all WSDBs.
7. The project has a part-time Gender Equity Advisor who conducts the monitoring of gender and women's involvement and advises the project on future needs.

In addition, GAP has recently made the distinction between a WID (women in development) focus and a GAD (gender and development) focus. The project has recognized that in order for women to be fully empowered to participate in community and national development, efforts must be made to focus on both women and men, and the relationship between them, so that traditional attitudes, the division of labour and other gender based constraints which affect women's participation can be changed.

In GAP, women's participation is not defined simply by the number of women involved in project activities. Within the community management approach, the project has focused on enabling women to participate at an effective, decision making level.

However, it should also be noted that there are still a number of constraints to women's full participation. These include:

1. Women still experience resistance from men who are uncomfortable with women in leadership roles. Outspoken women are seen to be a threat and some men try to suppress this attitude.
2. Many women in the communities are illiterate and these women find that their participation is constrained not only by their illiteracy, but also because of the little value attached to their opinions by other villagers, particularly men.
3. Women, especially in rural areas, do not possess high levels of self confidence and do not believe that they are capable of taking on leadership positions. Literate women tend to have much more self confidence and will take on such positions.
4. The project has succeeded in achieving greater women's participation, but has not sought to reduce women's other reproductive, productive and community responsibilities. Thus women's time and energy have been taxed by their participation in project activities. Men have not assisted women by taking on non-traditional work such as childcare or housework.
5. Women are still very much controlled by men. In many cases, women have to obtain permission from their husbands to participate in project activities. As well, unless women have established their own financial and material status, women are still defined by their husband's position in the community. In some cases, a husband's position influences the selection of a woman for a particular position.

Integrated Village Water Project/NORRIP

The Integrated Village Water Project (IVWP) encompasses the second phase of the Northern Region Rural Integrated Program whose first phase was established to assist the Government of Ghana with the assessment of the resource potential of the region and the formulation of sectoral plans for future development. IVWP is to provide 350 boreholes and hand dug wells fitted with VLOM handpumps with the support of a community development programme to ensure continued operation and maintenance of these systems.

Village Water and Health Committees (VWHC) have been established in the villages and are responsible for the management of the community water supply systems and sanitation facilities. Village Extension Teams (VETs) cover six villages each to mobilise communities, establish VWHCs and train these committees to take over management of the water supply and sanitation systems. The VETs liaise with District Management Teams (DMT) which in turn liaise with the NORRIP executing agencies.

Specific actions have been undertaken in IVWP to integrate women into its activities. These include:

1. A WID/GAD coordinator was appointed to the project.
2. A WID/GAD sector oriented strategy and policy paper was developed for all project activities.
3. Gender analysis workshops have been held at the village, district and regional levels.
4. As of March 1992, there were 7 women in the 27 member DMTs.
5. The VETs are made up of one woman and one man. The female extension worker can reach out to village women to get them involved in community discussions and enable them to receive information first hand.
6. A goal of 50% female membership was set for the VHWCs.
7. Two members of the VHWC, one female and one male, are to be trained as handpump mechanics by the VLOM Support Unit.
8. Female handpump mechanics have been a good role model for other women, and for villagers who may be sceptical about women's ability to participate in project activities.

A number of constraints to women's full and effective participation in IVWP activities still, however, exist. These include:

1. Although it was envisaged that women would make up 50% of the VHWC membership, only 33% has so far been achieved, and within these committees, women have not taken on leadership positions such as chair or secretary.
2. Even though women are present in committee meetings, their participation is low. The leader of the women's group (magazia) is usually the spokeswoman. A few other women who are economically better off or who have travelled out to urban centres may participate actively in the discussion, but the rest remain silent.
3. Men are still very much resistant to sharing power with women. Women have been relegated to labour and routine tasks such as pump site cleaning while men take on the leadership roles.
4. Women's multiple roles and heavy work schedule constrain women in participating in training programmes. If such programmes run over 2 to 3 days, women cannot afford the time to attend. Thus, even though the project has actively sought to involve women in training programmes, it has not taken women's multiple roles into account in terms of the mechanism and timing of delivery.
5. Women have taken on the full responsibility for making contributions to the Hand Pump Fund. Men often view water tariffs as the responsibility of women because of their prominent role in domestic water supply. The current water tariff collection mechanism in fact assists men in shirking their responsibility. Theoretically, the household is supposed to actively go out to make their contribution. However, in most cases, this is not done and so on-the-spot contributions are taken at the pump site, where usually only women are found.

6. Some women have found it difficult to make these contributions. The project has not incorporated an income generating component which may assist women in making money available for the Fund.
7. Women being trained as handpump mechanics are enjoying their new role in the communities and the new status that it accords them. However, many feel that they should receive remuneration for their services. They have not brought up their concerns in community/committee meetings.
8. Health education messages were targeted only at women. If real change is to occur, with men taking on responsibility for household hygiene men also must be targeted.

The Water Utilization Project (WUP)

By the scheduled end of WUP, the project will have gone through three phases. The first phase concentrated on increasing the coverage levels of water supply and sanitation systems with very little community involvement, except as handpump caretakers within a centrally organized operation and maintenance system (only men were recruited as caretakers), and as recipients of a hygiene education programme. Village Education Workers (VEWs) were responsible for the delivery of the programme. The second phase changed its primary emphasis onto the effective delivery of health
messages. Community Water Organizers (CWOs) took over the VEW's and handpump caretaker's responsibilities. Half of the CWO's were women. The third phase will replace existing handpumps with VLOM handpumps and will extend coverage in the Upper regions.

A number of positive WID initiatives have been undertaken in WUP. These include:

1. By 1991, half of the CWO's were women.
2. To encourage women's participation within the district and regional management teams, WUP III will offer specialized training to women in order to develop their leadership and managerial skills (Thibault and Tsikata 1992).
3. Each village water committee will have a minimum of 2 female members.
4. As far as possible, all individuals trained as hand pump mechanics will be women.
5. Female CWOs are being trained in the technical aspects of VLOM.
6. WUP developed effective educational strategies for delivering health messages. The use of radio programmes was particularly effective, especially for women who are constrained from participating in traditionally structured workshops.

The UNDP Pilot Project

In the UNDP Pilot Project, there has been marked success in achieving the integration of women in project activities.

1. Out of the seven member Water and Sanitation Committee, at least three are women. In some cases, all seven are women.
2. Women hold leadership positions in these committees, ranging from chairwoman to secretary to treasurer.
3. Women are regarded as being more careful and honest than men, and thus are entrusted with the treasurer position.

4. There is a female handpump mechanic in every community alongside a male counterpart.

In fact, women are responsible for organizing and leading almost all of the communal activities surrounding the water system; including tariff collection and saving, pump site development, and the decisions affecting the operation and maintenance of the systems.

TOWARDS NEW OPERATION AND MAINTENANCE SYSTEMS

From the collective experiences of these four projects a number of similarities, not only in the approaches taken in integrating women into O&M, but also in the kinds of problems that women have experienced as a result of their participation in operation and maintenance emerge. These experiences are also very similar to the experiences of women in operation and maintenance in other developing countries. An analysis of these commonalities provides a useful planning tool for the formulation of operation and maintenance systems which do not place further burdens on women's time, energy and financial resources. Unless women can derive major benefits from their participation in water projects; not just in health, but also in economic, social, and political spheres, operation and maintenance systems which depend on women's labour will ultimately fail.

There is a need for continued exposure to the needs and opinions of women within the community, for further research and experimentation with different approaches and the initiation of a collaborative process between the various agencies working in community management of water supply systems in Ghana in order for more appropriate O&M systems to be developed. The authors believe there are four main areas of concern which need to be addressed within this process of experimentation and collaboration.

First, projects have shown very little understanding of the need to focus not only on women in WID initiatives but rather on women and men, and the relationship between them. Projects have too often identified the problem as being women, rather than as unequal power relations between women and men which allow women to become overburdened with work without the political, economic and legal power to change their position. Projects have perceived these gender roles to be immutable, and therefore unchangeable. However, true success of community based operation and maintenance systems will only be realized if men take on more household and childcare responsibilities so that women will have more time to pursue work in the community development and productive spheres.

A second major issue identified is that within the community management approach, projects have often allowed women to take on the brunt of the burden for carrying out the routine work involved in keeping O&M systems working. Women have taken on many responsibilities including preventative maintenance measures, health and hygiene education training, committee or board meetings, tariff payment and collection and pump site and latrine cleanliness. These responsibilities have placed additional stress on women's time and energy as well as their financial resources. Although women's contributions to the project is regarded as very important, overall women's status in the community has not been substantially raised. Projects have sought to satisfy the practical needs of both women and men, but have not addressed the need to integrate strategic needs of women such as consciousness raising, increasing self-confidence, and training and strengthening of women's organizations. Women need to be empowered so that they can improve their position in society and transform power relations so that all constraints to their participation in the development process can be eradicated.

Thirdly, there is a need for an enabling environment within which community management can be fostered. An enabling environment has been defined as one that includes the formulation of a policy framework, adequate information and assistance in organization at the community level, training and human resource development focused at community organizations and appropriate financial arrangements for capital and recurrent costs, and access to external loans and grants (Livingstone 1993).

An enabling environment specifically for gender should encompass:

1. The formulation of a national gender policy for women in water supply and sanitation projects, created in collaboration with government agencies, external support agencies and community organizations. Importantly, because gender undercuts all development sectors, persons involved in this collaboration should not be limited to the water sector, but include specialists from any agency or organization working on gender issues in Ghana.

2. The provision of human resource development for women and women's groups at the community level. This would encompass training in leadership, managerial, organizational, technical and financial skills. Such programmes should not be limited to enhancing women's participation just in project activities, but should extend to any activity women are involved with and need further development of skills in order to achieve greater well-being. Within this issue is the need to develop better delivery mechanisms for training programmes. It has been shown that women cannot afford the time to attend traditional day and week long workshops. Radio programmes show great promise in terms of allowing women to stay home as well as in reaching as many women as possible.

3. Traditional attitudes within the communities was identified as perhaps the primary constraint to women's more effective participation in the community management of water supply and sanitation systems. Both women and men believe that women's work and abilities are inferior to those of men. This attitude can be changed so that girls and women gain more self confidence, and boys and men recognize the value of women and women's work. Although much progress has been made by simply carrying out project activities, deliberate consciousness raising programmes need to be integrated into community mobilization activities. It not only takes a great deal of time to change deeply engrained attitudes, but also change needs to occur within a non-threatening environment.

4. There needs to be greater representation of women in all agencies involved with community development work, both in government sector agencies and external support agencies. There are very few women in decision making positions in most external support agencies. Many difficulties arise from this underrepresentation. Programmes and projects are often initially designed without adequate gender sensitivity. Subsequent gender initiatives tend to be added on and marginal to the main thrust of the programme. In many cases, disaggregated baseline data were not used in the design of the project. This makes subsequent monitoring of gender initiatives difficult. In some cases, a WID/gender specialist is not appointed to the project or is only appointed on a periodic basis. Gender work, however, takes a great deal of time and location specific sensitivity. Much more attention needs to be paid to the integration of gender at the external support level. Within government water sector agencies, women are also underrepresented. Additionally, such agencies usually do not have a gender analysis capability. For agencies to acquire such capability, two actions must be taken. First male agents need to be trained in gender analysis. Second, more women need to be recruited. This would entail the encouragement of women to attend technical educational institutions, as

well as the application of affirmative policies for hiring women.

5. The institutional linkages between government agencies working with women at the village level also needs to be strengthened. Unless the Ghana Water and Sewerage acquires a strong gender analysis capability, working with women at the village level will require continued input from government agencies which do have this capability, such as the Department of Community Development and Ministry of Health.

4. Appropriate financial schemes need to be integrated into project designs so that women are not burdened with water tariff payment. Income generating schemes may provide women petty cash but have been known to create more work for women without providing proportionate financial benefits. Much more attention needs to be paid to this issue if projects are to avoid placing additional burden on women in the community.

Fourthly, there is an urgent requirement to focus on the **effective** participation of women in water supply and sanitation projects. The participation of women should not be defined simply by the number of women sitting on committees, or by the fact that women are actively involved with water tariff collection or pump site cleaning. If women are not vocalizing their concerns at committee meetings, or are simply performing the routine labour needed to keep operation and maintenance systems afloat, this neither enhances women's well-being nor improves their status relative to men. It simply adds work.

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TECHNICAL AND COMMERCIAL ISSUES IN THE OPERATION OF PIPED WATER SYSTEMS IN NORTHERN GHANA

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INTRODUCTION

Northern Ghana is composed of Northern Region, Upper East Region, and Upper West Region, with a combined population of approximately 3 million broken down as follows; Northern Region 1.5 million; Upper East Region 0.9 million; and Upper West Region 0.6 million.

There are presently 32 piped water systems all operated by GWSC, and distributed as follows:

Northern Region 14;
Upper East Region 10; and
Upper West Region 8.

Upper East and Upper West Regions, with more favourable geological formations for the extraction of groundwater, have piped systems based on mechanised boreholes requiring very little treatment; the only exception being Bolgatanga water supply, which is a conventional treatment plant deriving its raw water source from an impoundment.

In the Northern Region, the story is however different. Prevailing hydrogeological conditions produce less groundwater than in the Upper Regions, and 12 of the piped systems are based on surface sources and only two have borehole sources. Four of the systems are conventional treatment plants whilst eight systems are packaged treatment plants. Four systems (Tamale, Yendi, Saboba and Salaga) derive their raw water sources from perennial rivers, while eight systems derive their raw water sources from impoundments created on streams, which dry out during the dry season (between November and May).

Before the arrival of Northern Electricity Department/Volta River Authority (NED/VRA) grid power in the Northern Ghana, all the systems used diesel engines or diesel generators to drive the pumps. Presently two systems in Upper East (Bolgatanga and Bawku), as well as two systems in the Northern Region (Tamale and Yendi) have been connected to VRA/NED grid power. Two boreholes in Bole in Northern Region are operated using solar power.

Prior to the incorporation of the Ghana Water and Sewerage Corporation (GWSC) in 1968, the commercial activities relating to these water systems were executed by the Municipal and District Council offices, while the water supply division of Public Works Department concentrated on the technical activities. After the incorporation, GWSC took over both the commercial and technical activities.

Earlier operations of Public Works Department water supply division was not commercially

oriented, with little emphasis on revenue collection. Most of the personnel in the revenue units of the Municipal and District Councils had inadequate academic qualifications and backgrounds. They were either labourers who were otherwise redundant in their former functions, dispirited clerks, or semi-literate watchmen from the Municipal and Local Councils. Some of them were transferred to form the nucleus of the GWSC commercial section.

The calibre of these GWSC commercial staff was rather low, and was a testimony of the marginality to which commercial duties were relegated. They were seen as an appendage to the corporation of no real consequence. Since government was then financing a large proportion of the operation and maintenance costs, internal generation of revenue was not seen as a priority. The commercial department's role was to receive monies from those who willingly came to pay the tariffs, which were so low as to be gratis in disguise.

In 1986 under the government's rationalisation scheme, GWSC was reorganised to be self sustaining. This meant that GWSC was to cover its operation and maintenance costs from its own resources; subsequently revenue generation needed attention. It therefore became necessary to reorganise and strengthen the commercial department. March 1986 marked the transition from non-commercialism to pseudo-commercialism. The post of commercial director was created, and commercial functions were divorced from the finance section. Qualified middle management staff for the commercial department were recruited. During this time, tariffs were increased by about 295%, to reflect commodity cost.

Technical and commercial problems in operation and maintenance from March 1986 to date will be discussed in this paper, and will be classified into those issues internal to GWSC, and those issues that are external to GWSC.

INTERNAL ISSUES

Internal issues such as adequacy of the plant, system maintenance, logistic and human support, unaccounted for water and debt management, are matters that are within the control of GWSC.

Adequacy of the Plant

In an attempt to increase the potable water supply coverage in the water budget year of 1968, small standardised packaged water treatment plants producing 2,000 gallon/hour were installed in Northern Ghana, some in very remote locations. All these systems are now inadequate to meet the communities' water demand. Their outputs can no longer sustain the communities. Because of the simplicity of some of the designs and because of rapid population growth, the distribution system does not serve the whole community. Although valves exist in the distribution network, designs are such that it is not always possible to allow water to be directed to different zones at different times for the day, or on different days. Consequently, water is very scarce when it is most needed and, in their desperate search for potable water, people often break the pipes to create collection points and sometimes empty the water into underground reservoirs for their use. Sometimes, valves, air valves and washouts are deliberately tampered with to create leakages to water livestock.

As a result of too little water being produced, service connections closest to the source

and/or the storage tank take all of the supply before it reaches further into the distribution system. In some instances, service connections have been made on the pumping mains, and consequently the water never reaches the overhead tanks, let alone the distribution systems. In such situations, those people receiving the water sell it to the less fortunate ones; they pay very little to GWSC, but make a good profit for themselves. This shows that there is a serious competition for potable water, emphasising the inadequacy of the systems as a result of increased water demand.

To prove the case of increased water demand, an experiment was conducted in Malshegu, a village near Tamale, to determine the actual per capita consumption. The net average result for the three month experiment showed that the per capita daily consumption was about 40 gallons, while what is being assumed for them is seven gallons/capita/day. This figure might include water used by cattle and other livestock. Allowing 20 gallons/capita/day for waste and livestock water use, the remaining 20 gallons/capita/day is quite alarming for a rural area. This increase in consumption at the village is not translated into revenue, and attempts to have the consumers metered have been met with violent resistance. This increased consumption constitutes a revenue loss to GWSC.

The reason for the increase in water use can be attributed to increasing population, improved hygiene and sanitation practices, and higher standards of living. This has both commercial and technical implications. Technically, extensions have to be made, plant and equipment have to be expanded and distribution system improvements made.

System Maintenance

An important issue related to the operation of the piped systems is the question of system maintenance. The operators who operate the system in the remote areas are often not skilled enough to carry out certain types of maintenance and repair works on the equipment. All major repairs and maintenance works at the stations are therefore referred to the GWSC centralised maintenance team. Repairs of breakdowns and maintenance of the system can therefore be delayed if this team is not readily available.

With very little revenue being derived from these systems, GWSC has very limited funds for stocking spare parts and lubricants for maintenance. It is therefore difficult to keep to a planned maintenance schedule. Consequently, there are often long delays in attending to breakdowns. With repair and maintenance costs alone being 23% of the operating cost, there is no way the systems can be maintained regularly if the communities neglect to promptly pay their bills.

Logistic And Human Support

Other important issues worth considering as far as operation and maintenance of piped water systems in Northern Ghana are concerned are logistic and human support. Most of the water supply systems are located in remote parts of the regions with a very poor road network. The operators often have no means of transport or reliable means of communication which can assist them to report a breakdown. They normally depend on local transport, which is often not regular. A breakdown can take several days, even weeks to be reported. In situations there is a long break in the operation of the system, the consumers lose confidence in the system and in GWSC, and payment of water bills becomes more of a problem.

Some of the station managers are from other parts of the country and are unhappy and disillusioned at being posted in these small remote centres. This is worsened by the low levels of remuneration existing in GWSC. This affects morale and job performance and results in poor plant operation, more down time and lower rates of tariff collection.

The commercial department is not sufficiently equipped to deal with marketing issues, public education, customer relations, consumer surveys, etc. This has created suspicion, antagonism and a communication gap between GWSC and customers in Northern Ghana.

Unaccounted for Water

Leakages are a universal problem in the water industry worldwide, and this paper will concentrate on factors creating high levels of unaccounted for water which are specific to GWSC in Northern Ghana. The paper will look at the issue of standpipes, and unmetered connections and vandalism.

Standpipes

Consumption through public standpipes is a major source of unaccounted for water in the Northern Region. For example, using a minimum per capita consumption of seven gallons for this category (which is the approved GWSC minimum consumption per person), and a surveyed average population per household or compound of 15, the consumption per household is about 3,000 gallons per month. By GWSC regulation, 2,000 gal per month consumption is assumed and charged for (until 1992, 1,000 gals was assumed) thus creating 1000 gal per compound of unaccounted for water every month. This constitutes a perpetual loss of revenue for the corporation. If GWSC is to be fully commercialised, then a much more better way has to be found to reduce this revenue loss.

Unmetered Connections

Most private connections are unmetered, and relatives come to such unmetered places to draw water. In effect, one service connection may serve about six or more compounds, but only a flat rate of 3000 gal a month is charged. In cases where an assessment is made, it is made with reference to the inhabitants of the compound and not the outsiders who flock there. For example, in a survey in Zabzugu in the Northern Region, it was revealed that from October 1990 to March 1991, the monthly average metered water consumption was 534,000 gallons with 49 private connections; an average of 363 gals per day per household. Assuming seven gallons per capita per day, it shows that 52 people were drawing water from each connection on the average. This is what a metering experiment revealed. If there had been no meters, assessment would have been based on only 15 people fetching from each connection whereas in actual fact about 52 were using that facility. The water drawn by the extra 37 people constitutes a revenue loss to the corporation.

It could also be that, in actual fact, the per capita consumption of seven gallons being assumed by GWSC is rather low. The irony is that metering may be the solution, but the lack of money to purchase meters and the fact that they generate their own operation and maintenance cost which increases the already high collection cost, keeps the vicious cycle going.

Vandalism

In Northern Ghana a greater proportion of leakages are the result of vandalism. Members

of the communities see such leakages, but allow them to go unreported, because they provides a source of drinking water for their livestock.

Debt Management

Dealing with recalcitrant debtors requires adequate customer information, legal resources and staff solely dedicated to the process of debt recovery. This means that a department should be set up to deal with the issue of debt recovery. However, comparing costs against benefits may produce unacceptable results. For example, the cost of collection in Zabzugu in 1991 was 442,800 Cedis while revenue collection for the year stood at 1,116,616 Cedis. Almost 50% of revenue collected went to pay for the cost of collection. It must be pointed out that this is cost incurred in collecting tariffs from those willing to pay. One can imagine if recalcitrant customers were the target. Again, if cost of collection is held constant, it becomes very expensive to deal with small customers whose debts are small and many. Unfortunately, this is the situation in Northern Ghana as opposed to Accra, Takoradi and Kumasi. The corporation is in a dilemma as to whether to let debt pile up or institutionalise an expensive debt recovery programme

EXTERNAL ISSUES

Issues that are external to and beyond the control of GWSC are examined under the following subheadings; raw water sources, power sources, spare parts acquisition, free water notion, government control, cultural practices and factionalism.

Raw Water Sources

Apart from the White Volta and River Oti which are perennial, all the other water sources have no inflow between December and May. The systems therefore rely on the water that can be stored during the past rainy season. However, the storage areas are shallow and large due to the flat nature of the landscape, and therefore, considerable amount of water is lost through evaporation.

There are also very intensive farming activities in the watersheds, despite concerns expressed by GWSC to the District Assemblies. Consequently, tremendous amounts of sediment are carried over from these farmlands into the impoundments, causing serious siltation problems and reducing the volume of the raw water stored. These impoundments should be dredged frequently to restore their capacities.

The unpreventable seasonal bush fires and deliberate farmland burning destroys the vegetation in the watersheds every dry season, inducing higher evaporation losses. The raw water sources therefore keep depleting. The legislation on bush fires and farming activities around river catchments should be enforced through the District Assemblies and through to the chiefs.

Power Sources

Only four of the water systems in Northern Ghana are connected to the National Electricity Grid, and one system is on solar power. The power to run the pumps in the remaining systems is

provided by small diesel engines and diesel generating sets. It has been established that the single largest component of the water plant operation cost is the fuel and lubricants for the diesel engines. Fuel and lubricant cost is up to 40% of the total operating cost.

Studies conducted at Zabzugu showed that the cost of operating and maintaining these diesel engines which drive the pumps directly (no electric generators or electric motors) is more than eight times the cost of NED/VRA electricity needed to power electric motors to drive the same pumps. Consequently, the cost of production is much higher than the tariff collected by GWSC. Therefore, operational self sufficiency is not possible in the systems where power to run the pumps is provided by diesel engines and generator sets: the systems are uneconomic. To give examples of uneconomic systems in the Northern Region, we shall look at operations in Saboba and Zabzugu. (Table I)

Table 1. Revenue and Operation Cost (in Cedis) in Saboba and Zabzugu. October, 1990 - September, 1991

Town	O&M Cost	Population	Billing	Collection	O&M/Billing Ratio	O&M/Collection Ratio
Zabzugu	6,548,500	4,160	1,594,699	1,095,206	4.0 1	6.0.1
Saboba	6,604,800	5,370	1,415,982	1,116,616	4 7:1	5 9.1

Source: SSDP Report 1992

These systems are uneconomic because no commercial miracle can raise revenue to equal operation and maintenance cost. The maximum revenue for Saboba was 1.1 million Cedis while operation and maintenance cost stood at 6.5 million Cedis. All efforts should therefore be made to connect these systems where possible to the NED/VRA grid power. It is hoped that the Government policy of extending electricity to the District Capitals will address this problem.

Spare Parts Acquisition

Makes and models of mechanical equipment in the water systems are many and varied, originating from diverse geographic areas such as the United Kingdom, Canada, Germany, Japan, Denmark and the USA, depending on which country provided aid, etc. Most often local agents of the suppliers of the equipment are small, disorganised and under-financed and do not have a ready supply of spare parts. Initiating orders of spare parts and expediting orders can take about nine months. If parts cannot be purchased locally, then there is a long down time when a machine breaks down. There should be an active program to standardise the equipment. Local manufacture of water works equipment should also be encouraged.

"Free Water" Notion

Programs to increase the perception and recognition of water as a manufactured commodity entailing costs have achieved little success in Northern Ghana. Water is still widely seen as a free gift of nature. In rural areas, the distinction between treated water and untreated water is not the essence. To these people, water is water, if it can serve their purpose. The long term and widespread use of dirty water and the ignorance of water borne diseases reinforces the above. There are others who still believe that potable water is being offered free by government, with GWSC acting as an agent of government benevolence, and not being a self-sustaining enterprise.

This situation has been compounded in the past by some unguarded political aspirants who use water as a tool for winning political office, promising rural dwellers free water when they know very well that it is impracticable.

Uncoordinated water supply development in the small towns also lends support to the "Free Water" notion. In most of these places where GWSC has water supply systems, NGOs have also developed water systems. These are basically boreholes fitted with handpumps which are being used freely by the inhabitants. It must be stated that in some instances minimal deposits are required before installations begin. It is obvious then that payment for a similar water supply from GWSC will be difficult. The net result is antagonism and suspicion of GWSC by the customers. A situation that is basically anti-commercial.

Government Control

Government control also constitutes another source of concern for commercial optimisation. The tariffs of GWSC are regulated by government, without whose approval tariffs cannot be increased. The market forces are not allowed to determine the price of treated water, nor can the corporation manipulate the pricing structure to achieve maximum gain.

Related to this is the fact that non-viable systems, with their miserable revenue base, cannot be closed down, due to legislature that gives to GWSC the responsibility of producing and supplying potable water in all communities.

Cultural Practices

Family

Strong family ties, as well as the culture of not denying anyone water, has also created a problem for the commercial department. If customers fail to honour their bills and are subsequently disconnected, the effect is very minimal, as they resort to drawing water from neighbours free of charge. This is against the background of a corporation that is unable to meter every consumer. In any case metering small systems tends to be expensive in the long run. The disconnected customers get water free of charge while their debts remain outstanding.

There are others who take advantage of disconnected and unserved customers in the urban towns like Yendi and Damongo to initiate water vending, which deprives GWSC of revenue.

Meters

Water meters are seen by customers to be instruments of extortion. A lot of people equate water meters with high bills and not high consumption with high bills. Remarks like " the meter reads fast", "the meter is recording air" or "the meters turn when there is no flow", have created their own headaches. There is little confidence in the meter in the Northern Ghana, yet it is the instrument needed to ensure accurate billing, so as to reduce underbilling and unaccounted for water.

Family Head

In Northern Ghana the landlord, or leader of the family or compound, pays for all water bills regardless of the number of occupants in the house and their economic status vis-a-vis the landlord

or leader. Women, who are sensitive to the issue of water, are not supposed to pay water tariffs, and the same applies to working children. In most situations the landlord may be well advanced in age and incapable of work. It becomes obvious that he may not be able to honour his bills. Against this background, a survey was conducted at Yendi which indicated that on the average, each compound has four working people who could share the burden of payment, instead of letting it fall on one person. If this were to happen, arrears would stop escalating.

Factionalism

Traditional factionalism also plays a leading role in disrupting commercial improvement activities. For example, an experiment to determine the relationship between reliability of water supply and payment of water tariffs failed in Nalerigu/Gambaga on account of traditional factionalism. The reliability of water supply was improved greatly, but unfortunately instead of revenue collection increasing, it remained at the pre-improvement level, and even decreased. The system, located at Nalerigu, serves the twin towns of Gambaga and Nalerigu. Antagonism between the two towns threw all planned activities into disarray.

Though this experiment was a failure, it showed that social issues play a great role in water supply sustainability.

SOLUTIONS

In this portion an attempt is made to highlight some of the issues raised and see if solutions can be found.

Water Vending

One commercial issue worth looking at is the institutionalisation of water vending in Northern Ghana. To some, water vending is a way of life, to others a source of livelihood, and to yet others, a matter of necessity.

There are various forms of water vending ranging from trucks carrying water drums, the use of buckets to draw from standpipes for resale, direct sales at private standpipes, and the use of water tankers. Stopping it will be a herculean task.

One idea is to create public standpipes where sales would be made by members of the community. This was tried in several villages and towns in Northern in Region. The result was not satisfactory. The approved standpipes suffered from underpricing by people without meters. In other instances those who acted as collecting agents made use of monies, thus becoming indebted to GWSC. Untreated water vending also competed with treated water vending. Pay-as-you draw is seen as alien to the cultures of the North.

Another option is to institutionalise what is being practised, identify people with private connections involved in water vending, and give them special reduced rates to continue selling from their private connections that are metered.

Water hydrants can be installed for water tanker use and appropriate rates charged. This

can be done in consultation with the District Assemblies, especially when by laws are made to this effect.

Another option is for GWSC to produce the water and sell in bulk to private entrepreneurs or a community organisation, so that distribution and sale will be done by private entrepreneurs or the community. This is being envisaged in Navrongo under GWSC Assistance Project.

Government Involvement

Another issue is whether government should continue to play the leading role in water supply, or should adopt one of monitoring water supply management which would be in the hands of private entrepreneurs, with profit as the moving force?

Probably it is time water supply became a matter of commerce. What can be done in the interim is to distinguish between water supply management as a social service for the rural areas, and as a commercial venture for the urban areas. In most rural areas, potable water is a means of eradicating water borne diseases like guinea worm, etc, which have an effect on the nation's productivity levels. It therefore means that water for rural areas and small towns has a social value and therefore the cost must be borne by all Ghanaians through indirect taxes and not only the villagers.

In the coordinating role of the government, emphasis should be placed on the activities of NGOs involved in water supply development to bring maximum benefit to the nation.

Cost of Collection

The present cost of revenue collection is very high; for example, about 36 staff are directly responsible for revenue collection in Northern Region. Their salaries, medical bills, overtime, night allowances, etc, constitute an ever increasing cost of revenue collection. Logistic requirements for effective revenue collection such as vehicles, meters, etc, have very high cost. The solution might be to privatise or employ cost saving methods.

In view of the above, it is becoming clear that privatising certain aspects of the commercial section like meter reading, etc, in the small communities would be very economical and yield efficient results. There are some who are even advocating wholesale privatisation of the commercial section. An alternative to privatisation is the computerisation of the commercial section where a lot of the workload like billing, recording, controls, and information on customers would be computerised. This will reduce the revenue staff strength by about 2/3. With good training on the computers, this would be a substantial gain.

Debt Management

Another issue is to deal with the huge debt accumulation. For example, at the end of December 1992, the debt for GWSC Northern Region stood at 103 million Cedis, with the small urban systems debt contributing 9.9 million Cedis[1]. General write offs may not be effective, as they encourage others to renege on tariff payments. The flip side of it is that these debts may

[1] In August 1993 700 CEDIS = 1 US$

remain unpaid for a very long time, thus causing external monitors to think that GWSC is not efficient, and therefore government may not agree to tariff increases.

In an attempt to address this issue, some authorities have advocated a *laissez faire* approach, which is interpreted as no-disconnection of the customers. Their contention is that when the person is disconnected, the moral duty to pay is lost; if not disconnected, at one point in time, his conscience will prick him to pay. Legal action must be strengthened by making laws that empower imprisonment for non-payment, on confiscation of assets, etc. Empowering laws are needed to enhance optimal commercial operation for Northern Ghana.

CONCLUSION

Logistic and Human Resource Development

In Northern Ghana under the GWSC Assistance Project (GAP), funded by CIDA vehicles have been provided to enhance the efficiency of the technical and commercial departments. Also under GAP, a commercial optimisation program has been put in place with the view to raising the status of the commercial department. This includes extensive training and computerisation, provision of vehicles for the Regional Commercial Managers, radios for communication, motorbikes for the meter readers, etc.

In an attempt to decentralise the central maintenance unit, workshops have been constructed in some of the district capitals, vehicles have been provided under GAP for the District Managers of GWSC for technical operation, and to improve communication with the regional office of GWSC radios have been installed at all the district capitals.

Currently there is an extensive metering programme. This will enable GWSC to have a greater percentage of customers metered and billed accurately.

During the redeployment exercise, certain weak elements in the commercial and technical department were affected, and this has provided room for energetic workers to be recruited. There is however the need to review salaries to help motivate workers in GWSC.

Commercial/Community Management

If GWSC in Northern Ghana is to be fully commercialised, then it must address some of the issues raised. One way of doing this is to encourage community management. This will relieve GWSC of the obligation to provide water service to the rural communities and small towns that see water supply management as a social service, and allow GWSC to concentrate on the urban centres on a purely commercial basis devoid of government intervention. This means that GWSC would have to go public, with a national monitoring and control unit established by government to monitor and control the activities of water supply managers. This will be the period of commercialisation. From the technical point of view, the situation is not different. From the preceding technical discussion, it can be seen that there is no way GWSC can operate these small remote systems on sustainable basis.

The community based management of the small piped systems should be encouraged because if the responsibility for managing the system lies with the community, they will always find ways of making the operation viable. If most of the management and operating tasks are performed

by the local people living in the community, operation costs will be reduced significantly.

The time and cost of travel from GWSC Regional Offices for plant repairs, revenue collection, etc, add significantly to the systems' operating cost. These outside services should only be employed when the tasks (major repairs) cannot be handled by the community, possibly on a cost-recovery basis.

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Introduction

The Federal Republic of Germany has over the past twenty years made available to Ghana assistance in various forms to cover almost every sector of the economy. Amongst the many projects either directly sponsored or indirectly supported by the German Government, through its Technical Cooperation Agency (GTZ), is the water delivery intervention under the Eastern Region Rehabilitation Project.

The Project commenced in 1980 and has RODECO as consultants for its implementation and involves the rehabilitation or refurbishing of water works and facilities in the Eastern Region for which the Federal Republic of Germany has provided over DM 17 million. Since the principal objectives of the Easter Region Rehabilitation Project are to provide potable water to communities and to eradicate water borne diseases in the Region, the project has components for the construction of KVIP public places of convenience to improve public health in the Region.

The Project started in 1980 as an advisory project to GWSC Head Office, Department of Planning and Research and Chief Engineer. In 1982 the project was altered into a regional rehabilitation project. Thirty-three stations out of the 39 stations in the Eastern Region were chosen to be rehabilitated in three phases from 1982 to mid 1989. Six major systems (Koforidua, Nsawam, Somanya, Tafo, Akwapem Ridge and Kwahu Ridge) were not included in the project due to limited financial resources.

Out of the 33 systems, 11 systems drew groundwater through boreholes and 22 systems had a surface water source with either conventional sand filters, PCI filters or Hydropur filter treatment.

The Project acted as a "firebrigade" to reinstall basic supply at a number of completely broken down systems in the region to stop the accelerating trend of decreased production. In 1989 a sanitation component was added to the project and a manpower development component was started.

Rehabilitation means putting something back into the as-it-was status, but does not necessarily contribute to sustained water supply services if the water supply corporation is not efficient.

The only way to achieve long term sustainability in water supply is to ensure that the corporation is economically viable and can still provide for the customer affordably priced potable water.

Hence in 1989 the project was extended and the following measures were incorporated:

- institutional strengthening;

- electrification programme;
- metering programme;
- revenue programme;
- public standpipes programme; and
- standard maintenance and rehabilitation programme.

Institutional Strengthening

Subsequent to the staff retrenchment scheme of GWSC in 1990, the project embarked on a massive manpower training programme at all levels, from pump attendants though revenue staff up to management level, to regain the necessary skills since a lot of well trained elder staff took advantage of the retrenchment.

At the same time a management information system (OVI, objectively verifiable indicators) was introduced, based on the performance indicators, allowing management to monitor data of all stations easily on a monthly basis.

Monthly joint meetings between GWSC Regional Management, the Project Management and the District Mangers as well as fortnightly sectional heads meetings were introduced to create a better upside-down flow of information between decision makers.

Electrification Programme

It is the policy of GWSC to electrify as many stations as possible to reduce operation costs and it is intended t electrify all except nine stations in the region. Despite this achievement, operation at electrified station stations has its constraints. The power supplied by the Electricity Corporation of Ghana (ECG) has such fluctuations that 3-phase pumps could not be operated as scheduled and were frequently burnt out.

The Akwapim Ridge water supply for example is seriously hampered by constant low voltage problems from the 11kV supply. It is hoped that the ongoing ECG power V project will improve the situation in some parts of the region.

Metering Programme

The actual high unaccounted for water (non revenue water) rate of GWSC (57% in 1991) is mainly created by insufficient production and consumer metering. The practice was in the Eastern Region, and still is in many regions, that production was estimated by multiplying pumping hours with outdated pump capacities, hence the production was always over estimated. Only a few consumers were metered and many of the fixed flat rates were to a low. As a result the high unaccounted for water figure never reflected the real situations. At the same time about 3,500 consumer meters were installed in the region. (Today approximately 8,000). These two measures resulted into a drop of the unaccounted for water figure of the 33 towns under the project from 40% in 1989 to a record setting 18% in 1992.

Revenue Programme

As mentioned before, intensive training for revenue staff was implemented. The main problems were:

- conversion from metric meters into gallons (non availability of calculators with 10 digits);
- inaccurate billing; and
- inconsistency in records.

As a result of the training programme, the collection ratio at the 33 stations covered by the project could be increased from 78% in 1989 to 91% in 1992. The collection rate of the first quarter 1993 is 103% due to a task force programme to recover outstanding debts.

Public Standpipes Programme

In 1989 the Regional Management introduced privatisation of the public standpipes. A Town Water and Sanitation Committee had to nominate private persons to operate the public standpipes, preferably women living close to the standpipes. As a policy all existing and new standpipes could only be operated if a consumer meter was operating. And agreements made with the operators stipulating that:

- the meter was read and revenue was collected by GWSC staff on a regular basis (daily, weekly);
- the operator could sell the water at 2.5 Cedis a bucket;
- that she could retain 20% of the revenue as profit; and
- has to maintain the standpipe hygienically.

In 1992 the price was increased to five Cedis per bucket at the request of the operators and population because the 2.5 Cedis caused a lot of change and record keeping problems. The region collected in 1991 about 18% of its total revenue from private consumers through the 496 standpipes available.

Standard Maintenance and Rehabilitation Programme

This programme is divided into three categories: inspection; maintenance; and rehabilitation.

The Regional Maintenance Engineer has two equipped maintenance and rehabilitation teams at his disposition which are visit the various stations according to an annual itinerary. The core problem is that frequent breakdowns of systems are overthrowing this itinerary constantly. A high performance in coordination between the two maintenance teams and the rehabilitation team is required.

To allow better coordination, all vehicles and the regional workshop have been equipped with radio systems. If the works requirements found during a visit of a maintenance team are urgent and exceed their capabilities the rehabilitation team be summoned immediately. In cases of less urgency the maintenance team prepares a report, to be signed by the District Maintenance Engineer

for further action. It is very difficult to assess costs per unit and comprehensive figures are not yet available.

Future Development

GWSC Regional Management together with the Project Management has chosen two villages in the region for a pilot project to test the capability of the communities to operate smaller piped borne water supply systems.

The following arrangements are in the implementation stage:

1. GWSC is acting as an advisory unit.

2. GWSC inspects the village and assesses the possibility of transforming rehabilitating handpump systems and prepares a provisional cost estimate separated into material and labour costs.

3. The village has to create a water and sanitation committee.

4. The village decides whether they could raise the necessary funds, in which case:

   - An agreement with GWSC comes into effect, if the village has raised 100% of the material costs and deposited them in a separate account.

   - GWSC orders the materials, supplies from overseas like pumps could be channelled through local importing agencies, and the village pays the invoices. This system is nowadays possible in Ghana due to unrestricted foreign exchange procedure.

   - Once commissioned, the system is operated by employees of the committee, which have been trained by GWSC. Water is sold from public standpipes at five Cedis a bucket (1993 level) or at GWSC rates to private consumers. All consumers must be metered.

   - The committee retains 80% of the revenue and pays monthly 20% to GWSC as a maintenance fee. The operators are paid by the committee, i.e 20% of the specific revenue at the standpipe. The committee has to retain 30% of the revenue on a separated fixed bank account to secure purchase of spares, depreciation and provide for future extensions. The remaining 30% are the profit of the community.

   - Against their fee GWSC provides regular inspection and maintenance visits. In the case of breakdowns GWSC orders the spares, the village pays and GWSC implements the repair.

   - All remaining handpumps in the village must be either abandoned to avoid competition or operated by a caretaker and water sold at the same price to consumers.

KVIP Component

For the implementation of the sanitation component, GWSC/RODECO has set up a KVIP team, comprising of trained artisans and a block/slab moulding unit and has also developed a

standard design for a KVIP facility which could be adapted to suit the requirements of communities. The first facility was constructed and commissioned in November 1989 at Begoro in the Fanteakwa District. To date, the KVIP team has committed funds for the construction of thirty projects in twenty communities at the cost of 42 million Cedis of which 28.3 million Cedis is outstanding as loans to communities. Average cost of a 12 seater KVIP is currently estimated as 3.2 million Cedis.

In order to expedite the implementation of the KVIP programme, and to encourage and reduce the financial burden on communities, the German Government has created a Sanitation Revolving Fund with a grant to extend credit to communities to finance the construction of public places of convenience. The provision of credit not withstanding, access to the facility must as a policy be demand driven and communities are expected to provide not only an initial down payment of 25% of the total cost of the facility, but are also expected to participate in the construction by the provision of non-technical services, such as pit-digging, block moulding, etc.

It is gratifying to note that almost all the communities that have benefited under the programme have cooperated with our team, especially chiefs, District Chief Executives and Assemblymen.

This is not to say that the KVIP programme is without its problems. The team over the years has had to battle with escalations in construction cost, low levels of loan recovery, and indifference amongst some communities about maintenance which nearly undermined the acceptability of KVIP as a low cost and efficient sanitation option. Fortunately, with the combined efforts of the GWSC and GTZ/RODECO staff, community education and counselling, the project has recorded a marked improvement in the loan recovery, to over 73% to date and expects further improvement to 80% by 1994.

Since the KVIP component of the main project is of a limited duration, the problem facing the project management is its sustainability. The main constraint to continuity will be financing beyond the limits of the Revolving Fund although the project is technically sustainable. To this end, the project has explored the possibility of institutionalising the financing of the extended phase by involving local banking institutions.

Happily agreement has been reached with a Rural Bank and the Fanteakwa District Assembly to co-finance the construction of KVIPs in the District, using the Revolving Funding as collateral to be indemnified by the District Assembly. By this arrangement, communities will continue to have access to loans to finance KVIP construction after paying 25% of total cost, the lending Bank's exposure will be limited to 50% of total cost and fully guaranteed by the Sanitation Revolving Fund and District Assemblies. Negotiations are on-going with other Rural Banks in the region in the hope of extending the programme to as many communities as possible.

It is hoped that when the current GWSC restructuring process comes on stream, what has been a modest beginning in the rural sanitation delivery by the GWSC/GTZ/RODECO project will be sustained.

With the support of the Project, GWSC has shown in the Eastern Region that they could well guarantee sustainability of operation and maintenance of rural and urban piped born water supply systems if the necessary efficiency is performed and if access to needed spare parts is provided.

The financial input since 1982 was approximately 17 million DM from GWSC and the project. With a relatively low investment of 21.25 DM (8,000 Cedis) per consumer, the project showed that 800,000 consumers in the region could be supplied with 16.6 litres per head per day of potable water on average in 1992.

If the above described system for future development in small water supply systems with village maintenance is successful, it could be adapted as well to existing small piped water systems (but should
be limited to borehole systems and electrification) to guarantee sustainability.

BASIC ISSUES FOR SUSTAINABLE OPERATION AND MAINTENANCE OF RURAL WATER SUPPLIES IN THE SUDAN

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Introduction

Various studies and reports have indicated that both national governments and donors in developing countries have made huge investments in the field of rural water supplies but with disappointing results. Many of the constructed systems are not maintained and have been abandoned. Others are being used by few of the original target population. Expansion of the sources to meet the needs of the growing populations has been slow. This poor performance has been blamed on bad design and bad management (MacRae, 1987). It was found that inappropriate technologies were often selected that proved too complex and difficult to maintain, and insufficient attention was paid to issues of financial management, cost recovery, operation and maintenance and community involvement. Faced with poor performance, and recognizing these limitations, many agencies working in the field of rural water supplies began looking for new approaches which:

1. Consider consumer preferences and ensure that users want the supply, and that the organizational and institutional structures exist to maintain it.

2. Use the most appropriate technology that meets the service required.

3. Recovers costs to ensure sustainability and to enable expansion.

The consideration of these issues is essential for sustainable operation and maintenance. This paper will discuss these three issues of community participation, appropriate technology and cost recovery
as they relate to the establishment of a sustainable water system in the Sudan.

Community Participation

It is recognized that the degree to which a water supply system fulfils its function relates almost directly to the efficiency and effectiveness of its management. In general, the management of a rural water supply system is composed of three interrelated stages: planning, construction and operation and maintenance. To achieve effective and efficient management, appropriate structures and organizations must be established, linking national plans and objectives to the needs and requirements of the local community. Studies show that the success of the rural water supply programme depends on the extent to which beneficiaries are considered and involved in all stages of programme planning and implementation. In fact, recent approaches to rural development rely heavily on the involvement and initiatives of the rural people. Thus local involvement is seen as a very important prerequisite to local development, both for economic reasons and because the

process itself should increase the capability and self-reliance of the villagers. Hence water provision must not be seen as a donor-to-government operation but as donor-to-people (Windstrandt, 1978). This approach means that planning and implementing the supplies must start from below and consider the people's wishes. The whole process and the decisions tied to it are necessarily political if the people's participation is to be more than passive.

It is believed that villagers' contributions, in whatever form, reflect the desire for the project in question and are a response to a genuinely felt need. Accordingly, many developing countries have started assessing the appropriate arrangements for village level participation in the management of rural water supplies. The sustainability of these arrangements depends on local conditions. Sometimes there may be an existing institution which is well suited for undertaking the additional function of water supply management. In other cases government policy may dictate that certain persons or institutions in the village should (or should not) have this responsibility. In other instances the government may opt, in the face of obstacles to community involvement, to avoid local participation by directly administering the village water supplies through a government water authority. Hence the form of local participation by directly administering the village water supplies through a government water authority. Hence the form of local participation, and the degree of involvement and the responsibilities assigned to the local community depend on local conditions and the social organizations prevailing at the local level. Control over the water source gives some people a measure of control in the village community. However, local participation in whatever form is indispensable if village water supply systems are to work effectively.

Many developing countries found that the task of running village water supplies was beyond their capabilities and began efforts or creating for mobilizing existing local institutions to take over the responsibilities. In the Sudan, self-help in its traditional form (Naffir) is a very old and traditional part of rural life, but institutionalized participation in water provision is rather new. Self-help in its traditional or institutionalized form shows the people's level of involvement in domestic water supply (Mohamed, 1986).

In fact, with independence, the national government took over the responsibility of providing all the basic social services and this approach created a strong dependency on the government especially in the field of water provision and its management. Immediately following independence, local participation took the form of political pressure applied through influential leaders to press for water points to be located in their villages. Hence, the rural people were not efficiently mobilized or involved in the planning, installation or management of their water supplies. By 1970, the government considered self-help and local involvement as the appropriate mechanisms to provide more services to the rural areas. Thus a number of village organizations were formed to mobilize local resources and reduce reliance on the government. The involvement of these organizations in the field of water supply became very clear when village water supplies, especially wateryards, began to face problems of management and fuel provision. Still, this participation is not institutionalized but depends on local initiative and the cooperation of the wateryard administration. Participation through these organizations is mainly effected through self-help labour contributions or cash. In this respect, the ability and willingness of the villagers to pay depends on their economic standards, cultural and ethnic background. As a general rule, when the expenses are not beyond the capability of the community, and the work to be performed is less complicated, self-help tends to be effective. In a survey carried out in four communities in the Sudan in 1983, it was found that the most common type of self-help is through cash contributions (Mohamed, et al., 1986).

Involvement and consultations on site selection are very common in most areas of the

Sudan, but do not extend to the type of water supply system to be provided. This task is usually left to the implementing agency.

In recent years, many villagers have started to assume the responsibilities that used to be performed by the National Water Administration either through established village organizations or through newly formed "water committees". Communities for example look after the water source and assist with wateryard administration and operation. The normal procedure followed is that the committee gets the support of the villagers to levy an extra charge per tin of water sold to buy fuel, spare parts and perform maintenance. In fact, these committees have succeeded in ensuring the continuous operation of the wateryards in many parts of the country. Without their involvement, due to a lack of government operation and maintenance, these wateryards would have ceased operating. The committees obtain cash through three methods: (Mohamed et al., 1982).

1. Fixed amounts of money to be paid by each family monthly. This form is widespread in rural Khartoum and Gezira villages.

2. Fixed amounts of money collected when the need arises i.e. in case of breakdowns or shortages of fuel.

3. Extra charges on water taken from the source collected normally by the water clerk or the water committee, to be kept in a special fund to be used when the need arises. This method is the most common in Kordofan and Darfur. In a survey of 32 wateryards carried out in S. Darfur, by the Western Savannah Development Corporation, it was found that every single wateryard had a self-help committee established and these committees were in charge of running the wateryards. These committees arrange the purchase of fuel, oil, and spare parts on the open market. The same study found that the water committees arrange collection of money from the households of regular users of the wateryard. The amount to be paid by each household takes into consideration the livestock belonging to each household.

There are other versions of community participation in the country. In the Northern Region and in some parts of Khartoum there is a complete takeover of the water sources by the local community (Sammani, 1989). On the other hand, UNICEF and other international organizations have established local committees to ensure local participation. UNICEF in particular has instituted some degree of village level maintenance through the training of village caretakers.

From this brief review of the different approaches, it is clear that the principle of village participation is accepted with varying degrees of local involvement. Still the search for the appropriate village organization capable of providing efficient service to the villagers remain to be settled. When seeking a suitable organization, the traditional institutions might at first sight look attractive. Village sheiks or chiefs, as holders of a formally recognized office at the local level and recognized by the local government authorities would seem to be the most obvious people who should be responsible for managing rural water supplies. However, for political reasons, governments tend to regard traditional leaders with suspicion. This is because traditional leaders within their areas of influence represent the apex of an established order which a modernizing government wishes to reform. Thus the Sudan government instituted village councils, village development committees, etc., to allow new social elements to emerge.

These contemporary organizations may also provide a suitable system for village level

management to water supplies and can be easily adapted to perform the extra tasks required, but again, it may not be appropriate because of the tendency to increase village factionalism. For these reasons, in any particular village, there is no rule of thumb as to which group is suitable for managing the water supply. The choice ultimately depends on the assessment of the local conditions.

Appropriate Technology

In the field of water supply technology, as stated by Foster (1988), it is clear that in the Sudan we have passed through three phases. The first phase was represented by the introduction of imported technology which in many cases was found to be inappropriate to the realities of local conditions. The second phase was characterized by the search for low cost technology. The third phase defines the appropriate technology with respect to the individual requirement of each project by considering a broad range of issues. Accordingly, appropriate technology does not mean simple technology, but a technology specifically designed for the conditions under which it must function. Foster (1988) provided a list of elements to be considered in the selection of appropriate technology. These include:

1. Suitability to the local environment.
2. Cost effectiveness.
3. Durability.
4. Availability of spare parts.
5. Energy efficiency.
6. Acceptable from a social/cultural perspective.
7. Brings improvement to local ways of life.

It is possible to add to these major considerations elements such as the possibility of local manufacturing including the use of local materials, lessening the burden on women, and reduced negative environmental impacts.

The technologies used in the Sudan are a function of the type of water source. At the traditional sources such as hafirs, dams, and shallow wells, water is either collected directly or drawn with leather buckets and tins. Attempts to improve the water quality of these sources include fencing or digging side wells to prevent animals or people coming into contact with the source. The system of dug wells was improved and modified by the local people in the Northern Province. The procedures as described by Raziq (1987), involves first digging large diameter (3-4 m) wells to a few metres below the water level depth, known locally as "Matra". The increase in well diameter increases the storage capacity. Secondly to accommodate drops in water level, a 2-3 inch diameter pipe is driven inside the Matra to tap deep water horizons often under low artesian pressure. Thus the Matra becomes a combination of a borehole and a dug well. Thirdly, 3-4 inch diesel-driven centrifugal pumps are installed. Water from such Matras are used for both irrigation and drinking purposes.

The improved water sources include deep boreholes fitted with a system of reciprocating pumps with diesel engines or handpumps. The deep boreholes (wateryards) face many problems regarding sustainability. They experience frequent breakdowns, and often lack spare parts and fuel. For these reasons, the handpump seemed to be an appropriate alternative. In the mid-70's UNICEF, in collaboration with the NRWC launched an ambitious programme to drill boreholes fitted with

handpumps. It is worth noting here that through this programme thousands of villagers living in areas underlain by Basement Complex rocks were provided with clean and healthy water.

From this review, it is clear that some of the existing technologies are too complex and beyond the capabilities of the local communities. However, they can be involved in the administration and operation of the sources, particularly wateryards. Other technologies such as the handpump programme with its associated elements of village caretakers, health awareness and community mobilization are very appropriate to the conditions of rural Sudan.

Cost Recovery

The availability of financial resources in developing countries represents a major constraint to rural water development. There is a need to mobilize local financial resources to meet the costs of investment and to ensure a higher cost recovery and financial sustainability. To achieve this, attempts are made to find ways of generating more revenues and to emphasize user willingness to pay. Such an approach (Fano, 1988) requires:

1. Active local participation in planning, design, and operation and maintenance.

2. Creation of appropriate institutional mechanisms capable of mobilizing local resources and utilizing them efficiently.

3. Village level operation and maintenance which emphasizes the role of women and the recovery of recurrent costs.

4. Reconciling the community's needs and wishes with the ability and willingness to pay for the level of service desired.

5. Provision of a reliable and easily maintained technology.

The above outline shows cost recovery and financial sustainability are not applied in isolation, but have to take into account local realities, consultation with the community, and the establishment of a strong community organization capable of collecting and administering water charges and managing operation and maintenance.

Linked to cost recovery is the need for a realistic structure for water pricing to cover costs, to ensure efficiency, and to promote equity. The rate should reflect the true value of water.

Sudan's experience in this field is limited to a few cases initiated on an experimental basis. The Western Savannah Development Project (WSDP) in Southern Darfur instituted a revolving fund to enable the NRWC to be transformed from a subsidized corporation to a self-financing organization. The operation resulted in the increase of water charges and the extension of some degree of self administration to all wateryards rehabilitated by the WSDP, and the transferring of responsibility for day-to-day operations to the local community. Under this arrangement, the local community takes over the operation functions completely (paying both fixed and variable costs of operation and maintenance) while the NRWC is responsible for maintenance activities and all capital costs, which are to be paid by charging a monthly rent to the local community for the use of the wateryard.

Another initiative is now being implemented by the World University Service of Canada in

the El Fasher area where the structure for the establishment of a revolving fund has been created.

Other ways to finance recurrent costs are based on local initiatives. For example, in some parts of Eastern Kordofan, an arrangement was reached whereby the local community became responsible for the provision of fuel and spare parts while the NRWC pays the salaries of wateryard staff and performs the maintenance operations. To pay for these services the community pays 1/3 of the wateryard revenue to the National Rural Water Corporation.

Elements of a Proposed Strategy for Operation and Maintenance

This review has dealt with three main issues; community participation, appropriate technology, and cost recovery with respect to the operation and maintenance of rural water supplies. These issues were discussed in the light of the Sudan's experience and the initiatives of different organizations working in the country. From the above discussion two main conclusions emerge. The first is that there is a lack of clear policy in the Sudan towards the issues of community participation, appropriate technology and cost recovery. The second is that a variety of different and fragmented approaches to deal with these issues have evolved and are being applied in different parts of the country.

It seems clear that any proposed strategy for sustainable operation and maintenance of rural water sources must contain the following elements:

1. A policy and political commitment towards the issues discussed.

2. Decentralization of water supply planning and implementation to allow village level management.

3. An integrated strategy combining appropriate technology with the appropriate organizational support.

4. Outside assistance and government subsidies are essential to cover capital costs, while recurrent costs should be borne by the users.

The Sudan's experience in this field gives some indication of the course of action which needs to be followed in order to achieve sustainable operation and maintenance. In this respect, there are two approaches worth considering for adoption particularly in the management of wateryards.
These are:

1. Delegation of functions to a village level organization. This entails the formalization of the present system found in Kordofan and Darfur, whereby the local community becomes responsible for the administration of wateryards and responsible for costs of operation and maintenance, while the NRWC performs the maintenance, and trains the operators and gives general supervision and guidance.

2. Creation of a revolving fund. This involves the takeover of some functions by the local community and the establishment of a special fund. The fund is continuously replenished by monthly payments or a realistic water rate, to be used for operation

and maintenance, or for construction or rehabilitation of wateryards. Regarding other technologies such as handpumps, shallow wells and hafirs, the present system followed by UNICEF, with a little modification to suit local conditions, is appropriate.

In general, what is required is a strategy whereby the operation and maintenance decisions are made within the context of prevailing economic, social and environmental factors in the Sudan to produce solutions which are indeed appropriate.

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OPERATIONS AND MAINTENANCE IN THE NORTHERN REGION OF SUDAN - CASE STUDY OF COMMUNITY BASED OPERATIONS AND MAINTENANCE

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Introduction

The Northern Region of the Sudan is located between Lat. 16° and 22°N. The total land area of the Region is 477,074 sq. km. predominantly constituted of desert and semi-desert land, with the Nile crossing it and acting as the main axis around which the population is concentrated. According to the 1983 census, the Region has a total population of 1.07 million persons.

The widespread aridity of the areas has restricted population and economic activity to the Nile Valley and to the few basins linked to it where flood irrigation and the extraction of groundwater support perennial agriculture. Only a few small dispersed communities of pastoralists live away from the Nile in Wadis which carry some rain during the rainy season; mostly to be found in the southern districts of the Nile Province. The breakdown of population by mode of living, according to the 1983 census, is reflective of the general occupational pattern and form of residence in the Region. (Table 1)

Table 1
Form of Residence

Urban settled	%	Rural settled	%	Nomadic	%	Total Northern Region
230,341	21.45	793.414	73.8	50,269	4.7	1,074,024

Agriculture is the base of the economy and the economy and the source of the livelihood of the population. The prevalence of fertile soils, coupled with the availability of perennial irrigation and favourable climatic conditions have led to the growth of a diversified agriculture, with field and horticultural crops being produced. Wheat, faba beans, fasolia, lentils and clover are the most important field crops and dates, bersim and mangoes are the main horticultural crops.

The smallness of the cultivated area and its concentration along the banks of the Nile have resulted in the existence of a high population density, and a linear pattern of settlement, with a continued alignment of villages, small centres and urban places on both banks of the river. Settlement size ranges between 1,000 and 20,000 persons in the Nile Province and 850 and 15,000 persons for the Northern Province. The average settlement size for the Region is 6,000 persons.

These features of high population density and growth of settlements have provided favourable conditions for the provision and the development of an infrastructure of community

services, including water supplies. Administratively, the Region is comprised of two provinces; the Northern Province and the Nile Province. The first has a population of 424,391 persons, and the second a population of 649,633 persons.

The provinces are divided into Districts (Area) Councils, with each council divided into a number of Rural Councils. In total there are 4 districts and 10 rural councils in the Northern Province, and 3 districts and 11 rural councils in the Nile Province.

Water Supply Source

The Nile is still the main source of community water supply in the Northern Region with drinking water obtained directly and untreated from the river and the irrigation canals, or after some slow sand filtration. Tube wells are the other important source of supply, established at places where the geological conditions favour the drilling of wells. The water resources of the Region include:

1. Surface waters: The River Nile, Atbara River and seasonal Wadis, i.e. Wadi El Mugadam, El Hawad, etc.

2. Groundwater: The Nubian Sandstone aquifer (best aquifer in Sudan), the alluvial deposits (of minor importance), the weathered Basement Complex aquifer (of minor importance).

From data collected from a sample of 30 settlements in the Region, the water supply situation of the Region may be summarized as follows:

In the Northern Province, there exists 127 wateryards (of which 45 are incomplete), 13 slow sand filters, 1 raw water station, and 66 systems of house connections.

In the Nile Province there exist 176 wateryards (of which 49 are incomplete), 1 slow sand filter station, 39 raw water connections and 74 systems of house connections.

Open wells are dug in the Nile alluvium to tap the sub-surface waters which are directly recharged from the Nile. Alternatively they are dug at favourable geological locations to tap groundwater for domestic use and irrigation. Manual extraction of water and the use of the waterwheel (Mataras) were the traditional methods of water extraction. However, handpumps have now been introduced especially to shallow wells in the Central District of the Northern Province. Dependency on open large diameter wells for domestic supply has been undermined by the fluctuations in water levels and the pollution from pit latrines especially in densely settled areas.

Deep tube wells and slow-sand filters came at a later stage in the progress of water provision in the Northern Region. Tube wells are provided in areas that are geologically favourable, while slow-sand filters are installed at places which fall within the Basement Complex formation and where surface water is the major water source.

Drilling for water for domestic use started in the early 1960's in the Nile Province and in the early 1970's in the Northern Province. The drilling programmes are being implemented in the areas of Nubian Sandstones formation where groundwater is available in large amounts and the

quantity is excellent. For the areas falling within the Basement Complex where groundwater availability is generally poor, like Wadi Halfa, Abri, Dalgu, Abu Hamad, and Wad Hamid Rural Councils, the use of water began in 1966 and 1982 in the Nile and Northern Provinces respectively.

House connections came at a late stage in the water provision in the Region. It was introduced in the 1970's and has now become a basic request of the rural communities there as a result of the socioeconomic transformation that is taking place. Starting in the seventies, the people of the Region realized the importance of a reliable and hygienic drinking water supply. The change has come as a result of the fluctuations in the river's level, increased awareness that good quality water is a preventive measure against water-borne diseases and also because of improvements in the socioeconomic life in the rural areas, instigated by the adoption of urban attitudes.

Water Supply Technologies

The technologies in use are conditioned by the type of water resource utilized.

River water, sand-filtered or in raw form, is pumped to the filtration system (in case of slow-sand filters) or directly to the storage tanks. Water is usually obtained at the tanks which are fitted with taps.

Groundwater is tapped by 3 types of wells:

- Hand-dug well:
- Driven wells; and
- Boreholes.

Hand-dug wells are the oldest type of wells in the Region. They are easy to construct and operate and require no particular technology or instruments. This type is gradually disappearing and is being replaced by driven wells.

Driven wells represent a good example of the use of a simple technology, adopted and improved by people to fit local conditions. All wells constructed by means of driven iron pipes fit into this category. Tube-wells fitted with handpumps are very popular in the Northern Region for producing small quantities of water for domestic use only. Driven wells for agricultural purposes are usually equipped with lifting mechanical units.

Boreholes are constructed by means of percussion or rotary drilling machines. The boreholes are usually fitted with steel casing, screen, gavel pack and equipped with either turbine or reciprocating pumps powered by diesel engines.

House connections are a community-founded activity, in response to changes in ways of living, leading to an increase in household consumption. Local communities organize member-households in a settlement to support the water network project, throughout the various stages from initiation to project management. Distribution projects are usually carried out as a joint activity between rural communities and the national Rural Water Corporation.

Duties and Responsibilities of the National Rural Water Corporation

The main objective of the NRWC is to provide adequate and safe drinking water to the rural population. The NRWC realizes this objective through the following means:

- Drilling of boreholes and fitting them with pumping units in areas where groundwater is available;
- Construction of slow-sand filters and water pumping units from the Nile in areas where groundwater is not available;
- Maintenance of wateryards and slow-sand filters;
- Repair and maintenance of the Corporation's vehicles, machinery and equipment;
- Installation of house connections throughout the Region at the people's cost;
- Continuous monitoring and evaluation of groundwater; and
- Institution building in the area of water supply provision, and administration of the activities of the Corporation.

In order to achieve these functions the NRWC created the appropriate administrative structures in both the Nile and Northern Provinces.

In addition to the regional and provincial offices, the Corporation has succeeded in establishing maintenance centres with workshops. (Table 2)

Table 2
Maintenance Centres

Province and Name of Centre	Date of Establishment
1. Northern Province	
Abri	1982
Dongola	1982
Ed Debba	1988
Qoz Gorafi (Merowe Rural Council)	1983
Karima	1987
2. Nile Province	
Abu Hamad	1988
Ed Damer	1982
El Metamma	1987
Shendi	1983

The maintenance situation in the Northern Province is satisfactory. Only about 5 wateryards are out of order in the whole Region, and few mechanical units need to be replaced.

The National Rural Water Corporation faces a series of constraints in providing water to the Northern Region. These include:

- Shortage of spare parts;
- Shortage of transport facilities; mainly support trucks and reliable vehicles in the maintenance centres for the movement of personnel, equipment and spare parts;
- Lack of an appropriate system of procurement of supplies to raise the efficiency of field operations and maintenance;
- Shortage of skilled labour, mechanical technicians and daily paid labourers, especially in the Northern Province, as people prefer to emigrate or work in agriculture;
- The introduction of a myriad of new types of pumps and engines which complicates the maintenance situation.
- The continuous delay in receiving budget instalments to carry out the implementation of the development programme and the running and operation of the water sources; and
- The introduction of a myriad of new types of pumps and engines which complicates the maintenance situation.

Community Involvement

It has become almost a characteristic of the effort of water provision in the Northern Region that local communities are involved in one form or the other in the provision and management of domestic water sources. This widespread participation of rural communities in the provision and management of water sources arises from a growing awareness beginning in the mid-1970's by local communities that an adequate and reliable supply of domestic water is an essential requirement for the comfort of the household. Prior to 1970, little attention was given to the Northern Region in the national programmes of water provision as it was believed that the Region had an established dependency on the Nile as a permanent source of domestic water supply. Since the 1970's, the National Rural Water Corporation has supported water provision in the Northern Region, and the adoption and promotion by the Corporation of a self-help input from local communities in water supply has drawn public interest into the effort and strengthened community participation. It has thus become an established practice for communities to initiate water supply projects and approach the Corporation for joint implementation. However, there are certain socioeconomic factors common to the population of the Northern Region which have enhanced the community participation approach.

Population Homogeneity

Many factors contribute to give a homogeneous rural community in the Northern Region. From the ethnic perspective there is a dominance by the people of the same tribal origin in any specific locality. This has facilitated a common stand towards problems in general, and a cooperative attitude towards solving them.

Population Stability

Despite a continuous trend of out-migration from the Region to other parts of the country, the settlements there still have sizeable populations working on the land and managing the different forms of the agrarian economy. The stability of the population is a factor contribution to the economic stability of the area, based on irrigated agriculture with its low risk, in comparison to populations and settlements in rain-fed areas.

Enlightenment

Since early times the Northern Region has had close links with Egypt. The spread of migrants into almost all other parts of the Sudan and recently to the neighbouring petroleum exporting countries has added to the knowledge and experience of the population. At present the Region has one of the highest levels of primary education enrolment in the country. Enlightenment increases population awareness for a higher standard of life, and enhances their organizational capabilities.

Spirit of Cooperation

There is an observed spirit of cooperation among the population of the Region. The Nile has been a common enemy and people have come together to safeguard their property against its floods. Kinship and neighbourly relations call for reciprocation at different occasions. People cooperate in carrying out agricultural operations, in the use of machinery and in the sharing of irrigation water. The development of irrigation schemes under the Northern Agricultural Production Corporation, or privately, has strengthened and formalized the cooperative relationships. The spirit of cooperation extends to other facets of life, including the organization and management of the settlements' water supply projects.

Connectivity

The rural communities of the Northern Region are well-connected to their relatives residing in urban areas, to a large segment of government employees, to emigrants in the neighbouring countries, and to local and national politicians. This has aided the implementation of community water supply projects by providing financial donations, equipment; and the securing of government agencies for the execution of the project.

Emigration

In the majority of the settlements surveyed, the contribution of the emigrants to community water supply projects has been substantial. In nearly all of the cases studied, the emigrants assisted by collecting money and purchasing equipment and sending both home. The large diversity in diesel engines and pumping units mentioned earlier has partly resulted from emigrants' equipment donations.

Flow of Wealth and Capital

As previously mentioned there is a continuous flow of capital and investment into the Region. These funds are invested in agricultural activities, including reclamation of new areas and improvements of existing farms, and in housing. Investment in housing could be judged from the new extensions of settlements and the improvement of old housing. The availability of cash definitely helps in raising funds for the implementation of community development projects.

Competition Between communities

The closeness of rural settlements in location, the familiarity of people in neighbouring settlements with the on-going activities at each settlement, and the concern of the population about improving living conditions, has created a sense of competition between rural settlements to undertake community projects including rural water supply.

Knowledge of Technology

People in the Region have been familiar with technology for quite a long time. This started with the traditional peasant technology of the water wheel and animal traction for land preparation. These were gradually substituted for irrigation pumps and tractors. Other forms of mechanization in use are flour mills, trucks, small vehicles, simple factories, workshops, etc.

Management Experience

This is revealed by the involvement of individuals and communities in various management situations, for example in the Northern Region there is the Agriculture Production Corporation Schemes. In two cases the relationship between the farmer and the owner is organized through certain production relations. Cooperatives established for different purposes is anther forum which brings many beneficiaries together. Local Government Councils also provide organizational experiences from which management capabilities are drawn. These learning situations provide foundations for the management of community water supply projects.

Community Representation

Out of the surveyed 30 supplies, 27 water sources (90%) are community managed. Almost all of these sources stand as community initiated projects. Only in 4 cases was a strong individuals influence on the community mentioned. There is a common understanding that the implementation of water projects is a joint activity between the NRWC and communities, which entails a community representative body to approach the NRWC.

Once the community realizes the need for having a water project, whether it is the installation of a water facility or the construction of house-networks, a "water committee" is established by the community to look after the implementation of the project. Committees are usually elected in public meetings organized for this purpose. Only in 3 out of the 30 sites studied did no election of committees take place. In one instance the project is run by a group appointed by the management of an irrigation scheme, and in the other two cases by persons taking the initiative to act on behalf of the community.

The 30 supplies studied revealed that none of the communities have written laws to regulate the elections of members of their annual activities. Instead the activities of the water committees are regulated by community consensus. The terms of office of the committees were found to be 4 to 5 years. Twenty of the committees are operating within their elected term while the remaining 10 have exceeded their elected period by a number of years. In most cases, the same committee members are elected for successive terms of office for reasons related to efficiency.

The size of the committee varies from 5 to 10 members. In selecting committee members the main qualities required are the interest and ability of choice on prestige and status considerations, including education, wealth, leadership positions and a good family history, as was indicated in 8 of the sample communities. Each committee would be comprised of a president, a secretary and a treasurer with the rest as committee members.

Implementation of a Community Project

Whether the community water project is a wateryard, a lifting station for river water with or without a slow-sand filter unit or a house connection scheme project implementation follows certain steps, from initiation to completion with the responsibilities for execution of the project falling on the water committee. These steps include:

1. Meetings

Holding a series of meetings with the community members at the various stages of the project to review progress and report on the obstacles encountered and to agree on possible solutions. Twenty-five of the 30 cases studied reported convening regular meetings to address the above issues.

2. Fund Raising

Fund raising involves the collection of money to meet the contributions of the community to the project costs. The amount to be collected varies according to the size of the project. In some projects the community contributed to the initial drilling costs of the borehole/s or to the costs of the slow-sand filter/s. Amounts in the range of 300,000 Sudanese pounds were reported as being raised by committee for this purpose. In other projects the amounts required would be to cover the costs of the installation of the engine, pump, and tank; and the construction of the water network.

Fund raising may be staged, by a collection of a certain amount at the start of the project (the average was LS 50 per household) to be added to at the later stages of the project as the need arose.

3. Contact with Government Agencies

The authorities, usually the Regional offices of the NRWC, the Regional Ministry of Finance and Economic Planning and the Local District Council Headquarters give approval for the project, agree on community obligations towards project costs, agree on the operations to be carried out by each side, and schedule project execution. Twenty-four of the communities studied had gone through this approval process.

4. Travel to Khartoum

Project approval, the raising of funds from relatives residing in Khartoum, and the purchase of project equipment including engines, pumps, and pipes may entail travel of the committee to Khartoum. In some cases a bench committee for fund raising is formed in Khartoum to pursue some of these matters, and also in the countries where the emigrants work. Twenty-four of the 30 communities studied had applied these practices.

5. Organization of Manual Labour

Usually the NRWC would survey and design the network where house connections were to be installed. The water committees would provide help with the transport and the accommodation of the team. Executing the design would require manual digging for the laying of the pipelines, which is normally organized and paid for by the water committee. This activity was carried out in twenty-two of the settlements surveyed.

Management of a Community Project

Community involvement in the provision of water sources involves the management of the water source and its operation once it becomes operative. The management responsibility is carried out by the water committee. It involves many functions including working closely with the NRWC which caters for the maintenance of the source and the network, contacting the local council authorities to obtain diesel and lubricants at the official prices to run the pumping units, purchasing the spare parts and the other needed equipment including fittings and pipes, supervision of the staff working at the water source including payment of the salaries for some of them, collection of the water fees from customers and the daily supervision of the operation of the water source.

Community management of water sources is only effective through the roles played by the NRWC and the services rendered by it. A community managed water supply is a joint activity shared between the NRWC and the local water committee.

In essence, the task of the communities in the provision and management of the water source was initially engineered by the NRWC with the target of promoting self-help contributions by local communities in the field or rural water supplies. Hence, the way the process has evolved dictates maintaining a strong link between the NRWC and the water committees.

The NRWC provides most of the technical services required for the operation of the diesel engines and the pumping units, and assists in the major maintenance operations of the networks. It provides most of the engine operators (mechanics) and the guards, pays their salaries, and undertakes training of mechanics to upgrade their efficiently. The Corporation renders these services through its maintenance centres, located in the different districts.

The NRWC, as the caretaking body for rural water supplies in the Region, has the responsibility for maintenance. However, due to shortages in annual budgets, inadequate transport facilities, lack of spare parts and skilled manpower, the local committees often use the market mechanics and purchase spare parts to run the water sources. Judged on last seasons (1987/88) performance, 20 water committees depended on the NRWC for maintenance operations, while 10 committees utilized the NRWC as well as private workshops.

Regarding spare parts, out of the 30 sources surveyed, 10 depended solely on the NRWC, and 15 on the NRWC and local and Khartoum markets.

The water committees obtain a monthly fixed quota of diesel and lubricants at the official price rate from the Rural Councils for the running of their water source. However, it often happens that the local council does not receive their quotas in time, which forces committees to opt for the "black" market. At present the obtaining of their fuel requirements at official prices seems to be the only official link between the committees and the Rural Council authorities.

The Rural Council executive officers complain about the weak link presently existing between the councils and the water committees. The executive officers mentioned that the committees approach the councils in the early preparatory stages of the project for the approval of some of the matters related to project implementation and then disappear, and only reappear when the project is operated to be issued with fuel. While this weak relationship with the councils does exist, however, when conflict arises between the committees and the participants in the project, people approach the councils to settle these disputes as administrative and legal bodies.

The annual maintenance and the major maintenance operations for the tube wells and the slow-sand filter units are usually carried out by the NRWC. The water committees contribute spare parts for the maintenance operations, whether these are carried out by the NRWC or by a local mechanic.

As to which parts of the system (engine pump, tower or distribution system) require more frequent maintenance, the following responses were recorded from the 30 sites studied, which indicate that the distribution system, the engine and pump cause the main maintenance problems. (Table 3).

Table 3
Type of Equipment Requiring Frequent Maintenance

System	More frequent	Less frequent
Well	9	21
Engine	17	13
Pump	15	15
Tower	7	23
Distribution system	21	9

A limited number of staff are employed in the running of the water systems. The permanent staff includes the mechanics and guards. Their number per water source fluctuates between 1 and

5, in the case of mechanics, and 1 and 3 in the case of guards, depending on the number of pumping units, and whether the system includes a network or not.

Mechanics and guards are the two categories of the regularly salaried staff. Mechanics are usually young men chosen from the community, and trained for a short period by the NRWC to operate the diesel engine and the pumping units. The salaries of the mechanics and guards are mostly met by the NRWC. A few of them are paid by the water committees, which should not be the case, since in the policy of the NRWC it is stipulated that this component should not be part of the responsibility of the water committees.

The management of the mechanics and guards is divided between the NRWC and the committees. For the remainder of the management including daily supervision, the collection of water fees, the execution of new house connections, the procurement of fuel, spare parts and other inputs, and the keeping of accounts; the president, the secretary and the treasurer of the committee are in direct charge. They may also assign certain responsibilities to some of the committee members plus other individuals in the community. The collection of the water fees for example is carried out in some cases by the treasurer and in others by a person who is paid a fixed salary. A third method applied would be through certain shopkeepers, to whom customers would pay fees.

Collection of Water Fees

Of the 30 settlements surveyed, 26 have house connections, and 4 are without networks. However, except for 2 committees, the existing 26 networks do not cover all of the housing in the settlements. The following ranges of coverage reflect the situation. (Table 4)

Table 4
Percentage of Settlements Covered by House Connections

Percentage Coverage	Number of Settlements
Less than 10	3
10 - 19	4
20 - 39	6
40 - 59	5
60 - 79	4
80 - 99	4

The water rates vary between settlements and within the same settlement, depending whether water is obtained directly from the source or from the household distribution system. The following ranges reflect the current water pricing rates per household per month. (Table 5)

Table 5
Range of Water Rates

Range in LS	Number of Settlements
Free	3
Less than 5	3
5 - 10	22
11 - 15	1
16 - 30	1

The average paid by a household for the sample surveyed is 8.6 pounds.

No water meters are used to measure household consumption, either at the source or in the houses. All households in a settlement have equal access to water for domestic purposes, and pay the same monthly rate, irrespective of the amount each household draws for domestic use. Uses for gardening, or drawing of extra amounts for house construction are charged additional fees. Controlling the use of non domestic water is one of the day-to-day supervisory responsibilities of the water committees. This is commonly one of the areas of conflict between the committees and users.

Communities do not see a need for installing water meters. The reason for this, as gathered from the survey findings, centres around the belief that water meters are costly and require elaborate management; the expenses of which are beyond the resources available to the community, that there are no big variations in household consumption, and that there is scope for adjusting the rates any time through community consent.

As explained previously, water fees are collected directly for the water committees by an assigned member, the treasurer in most cases, or through paying at special shops. It is noted that adherence to month-by-month payment is not strictly followed by customers, resulting in arrears. However, committees usually try to have all arrears paid before closing the accounts for the fiscal year.

The success of the community managed water sources could be judged on many yardsticks. One of them would be the ability of the community to install the system and satisfy a felt need. Another would be the provision of domestic water to satisfy the daily requirements of the household. A third would be the financial performance and to what degree it is self supporting.

On investigating this last point, the following data (Table 6) provide a gold basis for the discussion of the financial performance of the water committees.

The information covers 23 out of the 26 settlements with networks from which the survey team was able to collect data on revenue and expenditures at the time of the survey. The missing data on the 3 settlements was either due to the committee member in charge of the accounts not being available, or that the accounts were not ready.

It is apparent from the data (Table 6) that the annual revenue collected ranged from 4,200

to 156,000 pounds, and the annual expenditure from 5,620 to 53,300 pounds. The size of the revenue is a function of the number of customers and the efficiency of collection. Expenditure covers the normal operation costs and the major replacement and development requirements of the water system.

Table 6
Revenue, Expenditure, Surplus/deficit (LS)
for 23 Water Sources with House Connections
1987/88

Settlement	Revenue	Expenditure	Surplus/deficit
Northern Province			
Dalgo	4,200	40,380	- 36,180
Akked/Sareg	13,800	17,680	- 3,880
Kerma El Balad	156,000	53,300	+ 102,700
Labab	13,800	10,800	+ 3,000
Dumbo	12,600	8,610	- 3,990
El Golid Bahri	12,260	12,230	- 0,030
El Gaba	18,000	12,080	- 5,990
El Debba	28,000	28,076	- 0,076
Genette El Onia	12,000	5,620	+ 6,380
Hissain Narti	7,800	6,780	+ 1,020
Korti	10,500	11,180	- 0,680
Qoz Gurafi	10,500	8,460	+ 2,040
Abu Dom	18,000	21,000	- 3,000
Merowe	78,600	22,200	+ 56,400
Nile Province			
El Bauga	10,800	8,260	+ 2,540
Gdalla	9,000	8,618	+ 382
Kedebas	23,040	14,480	+ 8,560
Sidon	3,540	9,480	- 5,940
El Hudaiba	6,000	10,000	- 4,000
Abu Seleim	9,600	5,312	+ 4,288
El Zeidab	45,000	26,400	+ 18,600
El Aigeida	3,240	7,840	- 4,600
Kelley	25,200	21,600	+ 3,600

On relating expenditure to revenue, 15 of the committees have a surplus income and 8 a deficit. The main reason behind the deficits is due to one of the following factors:

- Spending on major maintenance operations;
- Cost of replacement of machines; and
- Inefficient collection.

Financial deficits are usually made up for by subscriptions from the community which are collected as additional funds. Surpluses, on the other hand, are kept as reserves carried into the next years budget. Some communities, however, are contemplating organizing new community-funded projects (such as electricity connection to houses) and applying the surpluses from water revenues to these purposes.

In the final assessment of the financial performance of the community managed water sources, the picture would not be complete if the support given by the NRWC is not taken into consideration.

The field survey revealed that there are two types of subsidies provided by the NRWC:

1. Provision of all the fixed costs.
2. Sharing of the fixed costs between the NRWC and the beneficiary communities.

The share of the community is represented by the payment in the drilling phase (including transport of material to site) partial payment of the cost of the installation (engine, pump and tank) and full payment of the network cost. The running cost is shared between the community and the NRWC. The NRWC share appears in the technical supervision and the maintenance, besides the salaries of the mechanics and guards, at most wateryards.

In the 30 supplies analyzed, the water committees do not include the Corporation's expenditures on maintenance and the salaries of the mechanics and guards in their accounts. Costing the maintenance services of the Corporation by water source is not easy due to the lack of this kind of accounting. However, an amount of LS 5,000 per annum is estimated as an average maintenance cost per water source which is incurred by the Corporation. Added to that, an amount of LS 4,800 as the salaries of the mechanic and guard, it is estimated that on average, a community managed water source receives a subsidy of about LS 9,800 per annum from the NRWC.

Principle Findings

This final section aims at assessing the capabilities of community managed water sources, identifying the key lessons to be learned, making recommendations as to how their performance could be improved within the Region, and pointing to the possibilities and problems of replicating the Northern Region experience in the other parts of the country.

Data collected through a questionnaire given to 70 community members (Community Perception Questionnaire) and one given to 22 government officials (Official Perception Questionnaire) provided a basis for evaluating the success of these community managed sources.

The systems' capability is judged from the users' point of view, as to whether it provides adequate and timely water or not. Data from the 30 settlements reveal an average daily household consumption of 56 gallons, which is effectively provided by the community managed systems. All respondents confirmed that they obtain their daily requirements of water when the system is working. However, stoppages from time to time were reported, due to various kinds of breakdown, which resulted in either a complete failure or a shortage of supply. In both cases, people resorted to the Nile or to open diameter wells as a substitute. The irregularities of supply are a continuing source of dissatisfaction to communities. Overall, 47% of the respondents are satisfied with their systems and 53% are dissatisfied.

Whether the community managed water supply system is reliable or not was one of the issues put before the group of officials and resource persons interviewed and the users of the system. The responses gathered from the first category confirm that the system is judged to be 90% reliable.

Overall, users were positive about the performance of the management committees, with 71% satisfied with the performance of the committees and 20% dissatisfied. Answers received from the officials and the resource persons confirm similar results: good (66%), obstacles by friction (17%), and inefficient accounting (17%)>

Frictions due to competition over leadership, mostly stimulated by political rivalry (a factor which emerged recently with party politics) was mentioned in many settlements. Inefficient accounting was also raised; sometimes elevated to an accusation of the committee members of financial violations of the cash resources under their disposal.

A number of obstacles to community managed systems were raised. Some of the constraints are physical, and others are management. The ones most frequently mentioned include: lack of spare parts (32%), shortage of fuel and lubricants (sometimes bought at "black" market prices) (27%), low quality and capacity of engines (13%), continuation of committees beyond their terms of office (12%), inefficient design and poor construction of networks (8%), and the non-legal and non-institutionalized status of the water committees (8%).

The solutions to the above problems are indicated by the answers to the question: "what are the best conditions required to run an efficient community managed water system", which was asked of officials, resource persons, and users. The answers suggested the following solutions:

- Improvement of the designs and the laying of the network (26%);
- Better availability of spare parts (21%);
- Financial support by the government to replace inefficient engine and pumping units (20%);
- Legalizing and institutionalizing the status of the committees (19%);
- Introducing a system of official/public monitoring of the work of the committees (11%); and
- Minimizing the conflicts arising from political rivalry (3%).

The main findings of the study can be summarized as follows:

1. Domestic water sources in the Northern Region used to be provided by the NRWC but recently and increasingly, their provision has become a joint activity between the NRWC and the beneficiary communities.

2. The management of the water sources, as well as the development of the network, is fully the responsibility of the local communities with the Corporation assisting in some of the technical matters such as the maintenance of the source, the engine and the lifting units.

3. There are certain socioeconomic factors that are characteristic of the Northern Region which provided the preconditions for the success of community managed systems in the Region.

4. Through the approach of management by the communities was initially introduced and encouraged by the NRWC, communities are presently taking the lead and are promoting the approach, while the NRWC lags behind in matters relating to the institutional development of the system.

5. In implementing projects, people have relied on their system of social organization of relationships in organizing the participants and raising funds, borrowing from the modern systems the election of committees, without realizing a need for any written laws.

6. Though the system, communities have succeeded in obtaining adequate water for their domestic needs. Water from the tube-wells is of good quality, while that from the Nile is potable and its quality was not identified in the survey as an urgent priority at present.

7. The cost of running the system is reduced by the free-of-charge management and supervision responsibilities carried out by committee members and the other assigned individuals in the community. The subsidy given by the NRWC enhances the capabilities of the system. The revenues collected generally meet expenditures in the majority of cases and when there is a deficit the community is prepared to make up for it through subscription and donations.

8. Generally people are satisfied with the performance of the system and see no alternative to it. The major problems encountered by community management centre around shortage of spare parts, irregularity of fuel supplies, poor quality engines in some cases, limited capabilities of engines in others, inefficiency and inadequacy of housing connections, and lack of controlling laws on the activities of the committees.

Recommendations

Based on the study the following recommendations are proposed to improve the provision of water supply in the Northern Region.

The system of community managed water sources in the Northern Region seems to have developed under a laissez faire atmosphere. It requires to be controlled through definition of responsibilities and roles, and the linkages with the related agencies, namely the NRWC and the Local Government councils. This would entail legislating the activity through the issuing of a departmental law or Local Government Ordinance.

So as not to be a top-down official move, local communities through their representative water committees should be consulted about any proposed legislation. The purpose of the legislation is not to undermine the efforts of the communities in improving their water supply situation, but to enhance these efforts by enabling both communities and the government agencies (that have dealings with water provision and the welfare of the local communities) to effectively monitor the performance of the system.

The legislative move should be followed by an effort to improve the institutional and the management capabilities of the water committees through timely elections, training in accounting, budget preparation and record keeping.

Despite the market limitations regarding the availability of the right kind of machines for the pumping units, the NRWC should work towards implementing a scheme for the standardization of the mechanical units (mainly engines and pumps) in use and should assume a leading role in this.

This scheme of institutional development should consider creating an association which would bring together the water committees of each province. One of the tasks of the association would be to develop a revolving fund for the procurement of spare parts. The fund should be built from fixed contributions by the water committees, and subscriptions by the NRWC and the Regional Government. The spare parts should be sold at market price to the committees.

House connections present one of the drawbacks of the system due to the fact that they are poorly designed and, over time, networks expand beyond the capacity of the system as a result of uncontrolled connections. This is an area which require attention and revision by both the water committees and the NRWC.

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COST EFFECTIVE WATER AND SANITATION IN THE SUDAN

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Introduction

UNICEF support to water and sanitation in the Sudan spans a dozen years. During this time several phases can be identified. From a geographically dispersed programme involving a wide variety of technologies, ranging from "hafirs" (man made reservoirs) and hand-dug wells to small water treatment plants, the UNICEF programme in the Sudan has evolved into a highly efficient community-based handpump and VIP latrine programme.

Despite extremely difficult circumstances and harsh climatic conditions, the programme has managed to complete unprecedented numbers of successful boreholes at dramatically lower unit costs. This has been facilitated through production bonuses being paid to NRWC (National Rural Water Corporation) staff and through a significant community involvement. Conditions are attached to the installation of handpumps. These conditions include the setting up of health committees, the construction of latrines, and community responsibility for handpump repair and maintenance. UNICEF has found that when handpump ownership rests with the community rather than with the government much more awareness, involvement and community participation is stimulated.

Background (1975-1986)

UNICEF's involvement in water and sanitation in the Sudan began in 1975 when a handpump programme was planned for southern Sudan. Implementation began in 1976 with drilling in Equatoria Region. However, in mid-1977 the programme area was moved to Bahr El Ghazal Region with its base located in Wau town, the capital of the Region.

A second programme was started in late 1978 in South Kordofan Province. Programme activities included: the exploitation of ground water by borehole drilling and handpump installation; the improvement of surface water sources, including rectification of hafirs of 5,000 to 50,000 cubic meter capacity; and the construction of treatment plants adjacent to those hafirs serving significant populations.

In 1979, a three-pronged approach consisting of the provision of potable water, sanitation and health education so as to maximize the health impact was implemented. While sanitation and health education were introduced in 1979 they did not attain sufficient integration with the programme to have the desired effect in reducing waterborne diseases.

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During 1980, 1981 and 1982, hafirs, power pumps, dug-wells, water treatment plants and small earth dams were added to the programme. This was undertaken in response to the government's preference for these technologies compared to the uncertainty of the newly introduced handpump technology. At the same time these activities were geographically dispersed in response to political pressure to spread development assistance over a wider constituency. UNICEF's limited resources were therefore dissipated over large geographical areas of this vast country. This had the effect of diluting the available assistance.

In 1983, community participation in, and responsibility for handpump maintenance was included in the programme. By 1983, there were sufficient pumps installed for the NRWC to see clearly that breakdowns were a major problem. This aspect has been increasingly stressed ever since. Despite community emphasis, many pumps were still maintained by the NRWC.

In response to the worst drought and famine in a century, in early 1984, UNICEF extended its handpump programme to Sinkat, Haya, Durdeib construction of a dam for "water harvesting". However, in 1987, the handpump programme was closed down due to high ground water salinity. The programme is presently rehabilitating dug-wells, a more appropriate solution for the supply of water for the population of Red Sea Province.

Late in 1984, UNICEF diverted drilling rigs to El Obeid, North Kordofan Province, to alleviate the severe water shortage resulting from the influx of people fleeing the drought. These displaced people put a considerable strain implemented to support the El Obeid water supply by installing engine-driven pumps and handpumps. By late 1985, this emergency programme was integrated into the regular NRWC programme for North Kordofan Province.

Problems Encountered

By the mid-1980's the programme was technically diversified and geographically dispersed. Logistic delays, problems with technical specifications for equipment, procurement of materials, and technical supervision emerged. Programme management difficulties also came to the fore. During this period a wide variety of makes and models of vehicles and other equipment were procured by, or donated to the programme which resulted in maintenance and repair bottlenecks. As the vehicles aged the programme had to purchase spares for all these different vehicles which resulted in the over-stocking of spare parts. This tied up considerable amounts of capital, leaving the overall programme with insufficient liquidity.

The full impact of working in too large a geographical area, employing too many different technologies and having a variety of equipment was finally realized in 1987.The programme was redesigned that year to reduce geographic dispersal and to concentrate on boreholes with handpumps latrines and health education. Hafir construction, power pumps, embankments and treatment plants were found to be expensive and impractical to maintain. Transport and equipment were standardized in the 1987-91 programme with the full support of NRWC.

However, the major enduring problem in these early years was inadequate government commitment to handpump technology. While there are a number of crucial factors influencing the success of the low cost approach to water and sanitation, the first and possibly most important is government commitment. While donor supported water programmes have resulted in an estimated 5000 handpump installations throughout the country, the government has only recently expressed serious interest in handpumps.

Over the past decade the NRWC has had to devote most of their limited resources to a continuous rehabilitation programme of comparatively high technology rural water supplies. As early as 1930, but accelerating in the 1950's and 1960's over 3,500 wateryards were constructed which consisted of deep boreholes fitted with power pumps, elevated tanks and reticulation. Without asking the obvious question: "Why do these wateryards fall into disrepair and require repeated rehabilitation?", the government in recent years has merely continued to rehabilitate them. While there are many reasons for this, the longstanding constraint is lack of adequate financial resources for operating and maintaining these relatively sophisticated systems.

One must ask whether there is any reason to believe that the conditions that led to wateryards falling into disrepair in the past have changed. It must be concluded that the only change is that the economic situation in the country has worsened rather than improved, thus further impeding good maintenance. As a result, government money is increasingly absorbed in wateryard upkeep, hence siphoning off much needed donor assistance. Rehabilitation of wateryards has thus become a cyclical process of breakdowns and ill-affordable rehabilitation.

A policy review is urgently needed to more adequately and realistically address the problems of rural water and sanitation, so that new water facilities can be developed to at least keep pace with population growth.

UNICEF Programme Reorientation

Up to 1986, UNICEF concentrated its WES (water and environmental sanitation) support to NRWC activities in Kordofan, Red Sea Hills, Bahr El Ghazal and western Equatoria. It reflected a strong commitment to drilling in as many communities as possible and frequently in remote rural areas. These areas were not easily visited by government officials or politicians. In mid-1987, when the rural El Obeid District again faced a serious water shortage caused by localized drought, UNICEF mounted an emergency handpump programme. Between September and December 1987, 286 handpumps were installed within easy reach of the Kordofan Regional capital, El Obeid. For the first time handpump technology achieved a highly visible profile. In the space of just 3 months, over 50,000 villagers were provided with clean water. The speed with which the programme was implemented and the "saturation" effect resulted in a dramatic increase in the popularity of handpumps. All the neighbours in the adjacent areas began clamouring for handpumps. This sudden rise in handpump popularity helped to convince senior government officials, politicians and donors of the viability of handpumps due to this easy "show and tell" advocacy. This advocacy has been made easier since both BBC and Sudan T.V. made documentaries showing villages which possessed a good concentration of handpumps, household latrines, active health committees, and trained local villagers for maintenance and repairs.

At the village level, there is no need for any persuasion. The low cost approach is already preferred over more complicated and unreliable systems, although, in villages where there are too few handpumps and where breakdowns force people to draw water from unprotected sources, the handpump is mistrusted. In turn, this can prompt the community into petitioning for a motor-driven wateryard. Since handpumps are now owned by the community, maintained by local residents and installed with back-up capacity they are increasingly preferred over wateryards. The latter are frequently broken, or lack fuel which leaves the community without continuous potable water. However, this is not to suggest that wateryards are less important than handpumps but rather to assert that handpumps are readily accepted for domestic household water supply. Wateryards are indispensable in some locations when there is a very deep water table.

Cost Effectiveness

The cost effectiveness of handpumps VIP latrines and health education programmes are of primary concern and a prerequisite to further programme expansion. The three elements must be delivered at approximately USD 25 per capita in order for donors to grant aid to the Sudan for WES projects. In order to contain costs, a number of preconditions must be met.

Equipment

Appropriate drilling rigs and support trucks to allow for efficient implementation. Too big, too heavy and too costly drilling equipment has been used in the past. Similarly, over-specified rigs are not appropriate for drilling shallow small diameter boreholes and have resulted in an unnecessarily high initial capital investment cost. Heavy rigs bog down more easily in both sandy and alluvial conditions which are found in much of the Sudan. They consume more fuel and are more expensive to maintain. Lighter rigs with the precise technical capacity appropriate to the geological conditions of Kordofan have simplified the technical aspects of the programme and allowed the NRWC to reduce the number of rigs in operation. Hence, they can concentrate all their efforts on a few rigs which are more easily operated and maintained.

Bonuses

Government staff responsible for programme execution must be adequately rewarded. Considering the gradual erosion of government salaries over the past decade due to inflation, it is estimated that the real purchasing power of NRWC staff has declined to around 10% of what it was when the programme started. (This is based on an International Labour Organization study "Employment and Economic Reforms" published in September 1986). General salary top-ups or per diems were paid until 1986, but these payments proved to have little impact on production. During the first decade WES budgets were always spent but targets were never met. A production based bonus system was experimented with in late 1986 and the decision taken to switch over completely to production bonuses in 1987. These are paid on the basis of good quality work and shared on a predetermined pro-ratio basis between managers and field crews alike. Since the introduction of production bonuses, output has doubled or even tripled in some areas thus reducing unit costs dramatically. There are a number of problems inherently associated with production bonuses in order to achieve ever increased output. These include negligence of vehicle and equipment maintenance, poor workmanship and the general lowering of quality. These problems need to be decisively addressed through close supervision, quality control and across the board payment cuts where standards are not maintained.

The bonus scheme, though limited by design to less than 5% of total programme expenditure, has proven to be both an excellent incentive and management tool. It simultaneously reduces per unit and per capita costs by increasing output and efficiency.

Technical Assistance

The need for long term contracts for technical assistance personnel so as to provide

consistency is now appreciated. In the past, the frequent rotation of such staff impeded programme implementation. It is also important that technical personnel believe in the appropriateness of the equipment employed.

The UNICEF technical assistance staff cannot be held responsible for planning, supply specifications and meeting targets unless they spend several years with the project. While they always work in close collaboration with their government counterparts they nonetheless have a greater influence on rig, equipment and vehicle specifications than their government counterparts. In order to achieve agreed targets it is necessary to provide the following technical assistance for each project:

1. A project coordinator with overall responsibility for working as a counterpart to the government executive manager to plan and implement the programme. This person needs to be a good senior manager preferably with a background in hydrogeology. The two projects in North and South Kordofan respectively employ one expatriate and one Sudanese in these posts.

2. A driller responsible for supporting his NRWC colleagues with borehole construction techniques and handpump installation and with special responsibility for quality control of initial installations. Again, in one project there is an experienced UNV (United Nations Volunteer), who has 5 years experience with a similar UNICEF assisted project in Uganda, and one experienced Sudanese.

3. A mechanic specialized in the type of equipment operated by the programme for training local staff, monitoring maintenance schedules and "trouble shooting" when a breakdown occurs. Given increased drilling targets this post is essential for keeping vehicles and equipment in operation. Two expatriates currently fill these positions, both of whom are, interestingly, former employees of the rig manufacturers and from developing countries. One of them is a United Nations volunteer.

4. A community mobilizer with responsibility for sanitation, health education and village training. The mobilizer ensures involvement of the whole community and the various government ministries responsible for extension work. The mobilizer's post needs to be filled by a Sudanese national who is fluent in Arabic and acquainted with the culture of the country.

Most of the above staff can be found in the Sudan, thus minimizing the need for expatriates. This further reduces costs and avoids the many inevitable problems which expatriates experience with the harsh environment and climate of the Sudan. Locally recruited technical assistance personnel should have the following qualifications:

- be Arabic speakers;
- be familiar with local customs and traditions;
- be acceptable to government staff and the local community; and
- be willing to work in the same location for several years.

The Sudanese professional in the post of coordinator has nine years of UNICEF experience in the Sudan and 2 years as an international professional in the Yemen. The driller has 10 years experience with UNICEF. Both have relevant overseas training, have worked for the NRWC before joining UNICEF and started at lower management levels and worked their way up to their present positions.

Plans

Pragmatic programme plans have been drawn up and agreed upon by all involved parties so as to facilitate efficient implementation. One of the principles followed religiously to maintain efficiency is that each geographic area must be fully covered before drilling is moved to a new area. This minimizes unproductive movement of vehicles and equipment and makes close supervision possible. With this method, logistics are much more easily managed. Prior to 1987, rigs were moved frequently in response to political pressure and hence valuable production and management time was lost. The planning cycle includes a five year master plan, an annual review and work plans plus monthly monitoring.

Standardization

Vehicles and equipment should be standardized as far as possible. Ideally, the programme should have only one make and model of truck, light vehicle and drilling rig. Such standardization drastically reduces staff training costs, down time on equipment and minimizes the investment in spare part stocks. Utilizing numerous models and makes of vehicles and equipment requires the programme to carry too much "dead" stock and places a burden on the programme's financial liquidity. Some nine different makes of trucks were used at one stage in the programme, though this has now been reduced to four and will be further reduced to one in the coming year.

The actual choice of handpump is less important than the decision to standardize, although it is essential that the pump can be readily maintained at the village level. Manufacturing the pumps locally is not essential but is desirable because it assures a more reliable supply of spare parts that importation would allow Even pumps other than the very best will perform satisfactorily when installed properly and in sufficient quantities to provide a "critical mass whereby everyone involved is thoroughly familiar with the pump. Planners, procurement staff, and installation crews right down to the village mechanics must be familiar with the spare parts, installation, maintenance and repair procedures.

While the Government of Sudan has decided to standardize on one handpump (India Mark II) despite fragmented donor recommendations, the local manufacturer has, as yet, not been established. The main reason for this delay is the low level of interest shown by Sudanese entrepreneurs. Businessmen have better options for their investment capital which will yield a more immediate and higher return. Nonetheless, in the long term there are great advantages in having locally made pumps and spare parts, and this is why it is supported by UN agencies whenever feasible.

Designs

The design of latrines, boreholes, and handpump installations have been standardized. This assures more effective supervision and minimizes the decision making process related to construction specifications. With good standard designs virtually all decisions can be made in the field by construction crews. Such standardization also facilitates supply planning, ordering and stock management of construction materials. However, it must be recognized that there are limits to standardization as there are a variety of situations arising in the field which require different approaches and solutions.

"Critical Mass"

The importance of "critical mass" is imperative to success and effective advocacy. This critical mass has been calculated as never less than one pump per 200 villagers and a minimum of at least 2 handpumps even in small communities of less than 200 people. Pumps must be installed close enough to one another to provide a back-up capacity when any particular pump is out of action, whatever the reason. In parallel, an adequate number of village mechanics must be trained, spare parts made readily available, tool sets supplied and with NRWC staff at all levels being fully aware and supportive of handpump technology. Only with this "critical mass" will handpump water supply truly work and be kept working. A few pumps in dispersed villages are unlikely to have the same impact, as a breakdown will force people to use distant or polluted sources, thus discrediting handpumps. Only when a back-up capacity is provided, thus assuring an uninterrupted supply of water, will the villagers develop the confidence in handpumps necessary to sustain their upkeep and maintenance.

If the programme planning and design is not technically precise it is very difficult to achieve cost effective implementation. All of the above components contribute to reducing costs while simultaneously increasing production. In order to achieve universal water access they must, however, be implemented in all areas of the country. In trying to reach that goal and reach optimal programme efficiency, a number of constraints are encountered such as tied funding, political pressure and varying geological conditions.

Criteria for Coverage and Critical Mass

Reasonable handpump service levels must include back-up capacity so as to provide water even when pumps break down. This criterion must be built into the programme plan to give the community-based maintenance system a fair chance of success. All functional water supplies world-wide have a back-up capacity to avoid disruption of services when pumps undergo repair or overhaul. This same criterion must apply to a village handpump in rural Sudan. This has not always been the case, formerly, even when the population of a village was as high as 500, only one handpump was installed per village. Such an inadequate water supply cannot provide sufficient water even with a good maintenance system. The 1987 work plan specifies that "one handpump per 200 people maximum and never less than 2 pumps per village regardless of how few people reside in the village will be installed". Handpump water supplies designed in this manner can be expected to function efficiently provided a village based maintenance system can be established, because it allows for a percentage of pumps to be out of action at any given time without reducing access to potable water.

Community Participation

While it is widely acknowledged that villagers should be involved in water programmes from the outset, it has nevertheless been difficult to put this into practice. For the Sudan, the process starts when the community is asked whether they would like handpumps. They are then told that they must form a health committee. The community mobilizer and government staff sit with the community to explain what the programme entails, what they can expect from it and what is expected from the village in the form of time and money This process allows the villagers to make an informed decision on whether they want to participate or not.

If the community decides to participate, the following steps must be taken:

- The health committee must be formed. This involves the recruitment of 5 men and 5 women from the ranks of traditional leaders, health workers and teachers. This committee if given a one week training course, where all aspects of the programme are thoroughly explained with a concentration on health education;

- Two of the committee members, a woman and a man, must be selected for a two week handpump repair and maintenance training course;

- The villagers must contribute 50% of the cost of the handpump, maintenance tools, and 100% of the pump spare parts; and

- The villagers must also make a commitment to sanitation through the procurement of slabs and vent pipes for construction of household latrines, sold on a subsidized basis.

After these requirements are met, the drilling rig arrives and the village handpumps are installed. This takes only one or two days for drilling and a week for the handpumps to be installed. This quick action reinforces and stimulates community involvement when seen against a background of unfulfilled development promises and lengthy planning. The Sudan approach means installing the handpumps immediately after the community decision of acceptance has been made.

Village Level Maintenance

It is relatively easy to train villagers in handpump maintenance and repair even when they only have a familiarity with hand tools and simple machines. Bicycles are a common feature of rural Sudan and are routinely maintained and repaired locally. Since handpumps are less complex than a bicycle, it is logical that local rural expertise is adequate to maintain handpumps. Training begins with maintenance procedures including the more complicated aspects such as threading of pipes and rods. Subsequently, more detailed training is undergone, and finally practical training is completed through common repair tasks.

The NRWC and UNICEF were "forced" to train women as pump mechanics in early 1987 somewhat by accident when the wife of a mechanic was seen trying to repair a broken pump by the staff of Kadugli Youth Training Centre (who subsequently trained five women). Since then over

130 women have trained. Presently, (early 1989) an equal number of women and men are trained i.e. one from every community.

Rarely does the village maintenance system fail due to the mechanic's inability to perform the repair. When problems are encountered, these have more to do with managerial, administrative and organizational problems such as remuneration of the mechanic, having the right tools at hand, advance procurement of spare parts, collection of funds and availability of transport.

It is through good training of the village committees and alerting them to these potential problems that the key to a well functioning maintenance system is found. The pre-requisites for a village maintenance system are:

- Community ownership;
- Good quality initial installations;
- National standardization of handpump equipment;
- Local manufacturing of handpumps where possible; and
- Constant regular and reliable supply of spare parts.

Another reason that the NRWC promotes village level maintenance and repair is that the Government of Sudan can not afford to cover the cost of maintaining village water supplies. Consequently, maintenance costs are borne directly by the beneficiary communities. This is why it is imperative that local committees fully understand and accept the system before the boreholes are drilled. The programme must be in a position to provide accurate information to the villagers on annual maintenance costs, probable breakdown frequencies and other problems. If there are any doubts as to the village's capacity or willingness to cover these costs, then it is better to delay installation until they are well enough organized and motivated to look after their handpumps. Since the programme attempts to saturate the project area with handpumps it is possible to schedule drilling in the most enthusiastic and well organized villages first. This sets an example and allows time for more fragmented communities to organize themselves. In this way all communities are provided with handpumps as the entire area is caught up in the momentum of the drilling programme. In turn, this allows for greatly increased drilling efficiency.

Momentum

The momentum of the drilling programme has been an important factor in the overall popularity and acceptance of handpumps and latrines. High rates of acceptance of the conditions attached to handpump installation is supported by quick follow up by the installation teams. Drilling takes only one or two days while handpump installation is optimally completed within a week, thus generating an atmosphere of great activity. This is used to gain community interest which is later translated into their commitment to the project. At first, many villagers are initially sceptical from years of hollow promises and unfulfilled development plans. Drilling technology with the potential for rapid construction should be harnessed to create a momentum which allows the creation of a "critical mass" necessary to achieve universal water supply.

The Role of the Government

In addition to undertaking programme implementation, the NRWC must provide a back-up maintenance system for dealing with those aspects of maintenance which cannot be handled at the village level. These should be limited to "fishing" out dropped pipes and occasionally cleaning the borehole. However, these services are paid for by the pump users and financial accountability therefore rests with the community with the government providing the service.

The NRWC also establishes sales outlets through the rural councils for spare pump parts, latrine slabs and vent pipes. The same administrative set up is also used to monitor village health committees and the village pump maintenance system. So far 42 villages in 5 rural councils have established this system and it seems to be working effectively.

Scientific Investigations Versus Cost

When hydrogeological studies and geophysical work are undertaken for improving success rates of the drilling operations it must be done in a cost effective manner. The cost of the investigations must pay off in increased success rates and the lowering of the overall cost of a borehole with a handpump. An ideal borehole site from a hydrogeological viewpoint, which is located several kilometres from the village it is intended to supply, is inappropriate for a handpump supply. It may never be used if it is further away than alternative water sources, even if those are contaminated. In addition, the quantity of water required for a handpump is minimal, and incurring additional costs for investigations and borehole construction for the sake of obtaining yields beyond what is required for a handpump cannot be justified.

Laboratory analysis of samples from formations penetrated during the drilling operations, borehole logging and comprehensive test pumping procedures are not compatible with a handpump water programme which has as its main objective the supply of water to as many people as possible for as low a cost as possible. This does not mean that basic data should not be collected in the field or that the value of scientific data collection is not fully appreciated. It does, however, reflect the priorities of the programme.

While water quality tests are necessary the degree to which such an analysis should be carried out is a mater of some controversy. To undertake bacteriological analysis on all boreholes as a matter of course is not justifiable. Total coliform counts have been shown to give a large percentage of false positive results in tropical regions, while with faecal coliform the indicator organism dies off quickly while pathogens may survive, thus making false negative results possible. A positive faecal coliform test is an indication of recent contamination, suggesting an improperly sealed well. Rather than solve the problem of contamination post factum it is considerably more cost effective to have adequate supervision at the time of drilling and installation. Additionally, alternative water sources are normally sites of gross bacteriological contamination.

Total dissolved solids should be checked on site during drilling in areas where salinity may be a problem. Borehole construction can therefore be aborted at as early a stage as possible. Initial chemical analysis should be restricted to a few harmful elements like heavy metals, fluoride, nitrate and arsenic in areas where these are known to be present. Routine chemical analysis on every borehole is generally unwarranted.

The Three-Pronged Approach

It is widely believed that the combination of water supply, sanitation and health eduction is required in order to have an impact on health. However, there are sceptics who believe that even with this three-pronged approach that the health impact is not measurable. Indeed many studies show very low measurable impact compared with interventions like immunization or oral rehydration therapy. The comparatively high cost of water programmes is cited by these sceptics to "prove" that they are not worthwhile. Because rural Sudanese put water as their first priority such sentiments are both impossible to understand or accept, and indeed it is hard to see how health benefits will permanently improve unless clean water is readily accessible.

The high priority "felt need" for a good water supply provides a unique opportunity to introduce other elements such as sanitation and hygiene education (the conditions attached to handpump installation) into villages. The strategy of water supply and sanitation combined with health education is therefore translated in practical terms into "no water supply without both latrines and a trained health committee". Communities are so highly motivated to improve their water supply that a number of conditions can be attached to the programme and a high degree of compliance will still be achieved. While the long term effect of such conditions is not known and it is realized that long standing habits must change so as to have the desired health impact, it is equally recognized from a decade of experience that latrines will not be built without conditions. It is one thing to construct a demonstration latrine and sit through a one week training session but quite another to ensure that every family builds a latrine and uses it. However, the results of a recent survey of latrines installed over two years in 121 households revealed that more than 90% are presently used. This indicates a high degree of acceptance of latrines among villages in Kordofan.

Latrine construction has, until 1988, lagged behind the set targets. Although the programme has accelerated notably in the last twelve months, it must be recognized that the past shortfalls need to be made up and the construction output further increased.

A comprehensive and richly illustrated manual has been developed to assist staff in explaining all aspects of the programme's three-pronged approach to the various people involved. This includes village leaders, pump mechanics, latrine builders, health educators, government officials and senior management. The roles and responsibilities of all involved is explicitly spelled out. The manual is generic and written so that it can be easily used by any organization or government department involved in rural water and sanitation.

Monitoring

Progress needs to be carefully monitored on a monthly basis in order to provide a clear picture of how this relates to targets, and to identify constraints. To effectively monitor progress it is necessary to have well defined criteria which are understood by all involved. For example, a comprehensive definition should be given for a completed latrine, a successful borehole and a trained and functioning health committee.

Field staff should not be burdened with requests for reports and other information which are used in the national capital by either UNICEF or NRWC. To facilitate quick and easy monitoring of "output" there is a pretested form for monthly reporting, which provides all necessary information in a clear and coherent manner (see annexes 1 and 2 for definitions and monitoring forms).

New Ideas

The Requirements for Success

Many interdependent components must be in place for achieving and sustaining an efficient and low cost water and sanitation programme. The most prominent are:

- Government commitment. It took a decade to realize the importance of an effective, accessible high concentration "demonstration" area to use for advocacy to develop and nurture commitment (i.e. rural El Obeid where over 50,000 people benefitted within three months);

- Cost effective implementation i.e. an efficient implementation capacity has reduced the cost of a borehole fitted with a handpump from over USD 9,000 to 3,000;

- Realistic design criteria: i.e. never more than 200 people per pump and never less than two pumps per village. All communities must have a back-up water supply system;

- Community ownership to assure proper community participation and acceptance of responsibilities;

- Attaching conditions such as sanitation to the provision of water while stating concisely what the village community is expected and required to do;

- The combination of water supply, sanitation and health education in a hard-hitting, target-oriented and quantifiable programme;

- National standardization of handpumps to facilitate the ready availability of parts and to simplify training, maintenance and repair;

- An efficient "saturation" approach to drilling which builds momentum on its own success, thus proving to village communities that the NRWC is serious about the rapid provision of clean water;

- Women's involvement in the village health committees as a precondition, i.e. 5 women and 5 men plus an equal number of women trained as village mechanics; and

- Closely supervised production bonuses in conjunction with quality control which together ensure high output and consistently good results.

These elements must mesh well in order to ensure success. The programmes in the Sudan have yet to reach their full potential and aims, but are headed in the right direction. Successful boreholes, their unit cost and total expenditure are analyzed over time, and the results have given all involved considerable confidence in the programme despite the increasingly difficult conditions experienced in the Sudan.

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Appendix 1

Definitions of Various Aspects of the Programme

A Successful Borehole for Handpump

- Deeper than 90 feet.
- Final inner diameter not less than 4 inches.
- Yielding more than 200 gallons per hour of sand free water at all times.
- Water quality to conform to national standards.
- Completely cased and screened in loose formation, or casing cemented into stable formation for hard rock with open hole in stable rock. In both cases the casing is to be sealed for sanitary purposes with cement or bentonite.
- Dynamic water level pumping with 200 gallons per hour must not exceed 150 feet.
- Borehole depth should not exceed 250 feet if not otherwise instructed by supervising hydrogeologist.

A Correctly Installed Handpump.

- Cylinder installed to between 75 and 155 feet.
- Pedestal installed plumb, with tops of legs embedded half an inch into partially reinforced, 1x2x4 mix concrete with maximum gravel size of half an inch, cured for 7 days under one foot of soaked sand. All specification and concrete details to be as per India Mark II installation manual with the addition of reinforcement between the drain and the apron as per issued specifications.

A Successfully Constructed Latrine.

- Circular pit with a minimum depth of 12 feet.
- Maximum depth must be at least 3 feet above ground level.
- Diameter must not exceed 3 1/2 feet and should not be less than 3 feet.
- Pit should be lined with brick masonry when walls of the excavated pit is unstable. This may only be necessary for the first two or three feet.
- Slab installed as per manual.
- Superstructure completed with the inside being dark.
- Screened vent pipe extended above the roof.
- To be used by everyone in the family.
- Minimum distance between latrine and handpump or other water source must be at least 150 feet.

A Functioning Health Committee

- Consists of 10 people, five female and five male including:
  - traditional leaders
  - school teachers
  - health workers
  - pump mechanics
  - Is trained in the use of the programme manual.

- All pumps under the committee's responsibility are fenced, clean and working.
- Latrines are being used and new ones being constructed.
- Waste water from the pumps is being utilized.
- Has an up-to-date list of children under 1 year of age.

A Trained Mechanic

- Is certified by the project.
- Is capable of repairing all aspects of the pump.
- Has access to all required spare parts, special and standard tools.
- Is a member of a Health Committee.

Appendix 2
Monthly Monitoring Report

For: ..... Programme: ..... Month: ..... Year:

	Reporting Month	This Year	Since start of Project
BOREHOLES			
Number of successful b/h drilled	.....	.....	.....
Number of unsuccessful b/h drilled	.....	.....	.....
Total feet drilled	.....	.....	.....
Success rate in percentage	.....	.....	.....
Number of b/h redrilled or deepened	.....	.....	.....
Total feet redrilled or deepened	.....	.....	.....
Success rate in percentage of rework	.....	.....	.....
HANDPUMPS			
Number of handpumps installed	.....	.....	.....
Number of installation re-done	.....	.....	.....
LATRINES			
Number of latrines completed	.....	.....	.....
Number of slabs cast	.....	.....	.....
Number of slabs sold	.....	.....	.....
Percentage of latrines used	.....	.....	.....
HEALTH COMMITTEES			
No of committees formed & trained	.....	.....	.....
Percentage of committees functioning	.....	.....	.....
PUMP MAINTENANCE			
Number of pump mechanic trained	.....	.....	.....
Number of tool kits sold	.....	.....	.....
Number of repairs done by govt team	.....	.....	.....
Percentage of pumps functioning	.....	.....	.....
WATER QUALITY			
Number of b/h testes chemically	.....	.....	.....
Percentage fit chemically	.....	.....	.....
No. of b/h tested bacteriologically	.....	.....	.....
Percentage fit bacteriologically	.....	.....	.....
No. of b/h closed due to water quality	.....	.....	.....

OPERATIONS AND MAINTENANCE OF RURAL WATER SYSTEMS IN ZAIRE

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Introduction

Zaire, located on both sides of the equator between 50° 20' latitude north and 13° 27' latitude south and 12° 31' longitude west and 31° 16' longitude east, is the largest country in Central Africa.

Zaire, stretching over 2,345,409 km^2, has a narrow window on the Atlantic Ocean to the west which coincides with the mouth of the Zaire River. It is bordered to the northwest by the Congo, to the north by the Central African Republic, to the northeast by Sudan, to the east by Uganda, Rwanda, Burundi and Tanzania, to the South by Zambia and to the southwest by Angola.

The central basin is bordered on all sides by areas of high relief. In the north, plateaus range between 600-800 m and in the south, between 1,000-2,000 m. To the east, the relief is created by the collapse of the occidental Rift Valley and by massive volcanoes reaching 4,500-5,000 m.

The geographic setting of Zaire between 5° latitude north and 13° latitude south and its distance from the sea in the middle of a vast continent determines the basic characteristics of the Zairian climate. There are four distinguishable climates.

The equatorial climate is hot and humid. Annual rainfall everywhere is greater than 1,500 mm an don rare occasions exceeds 2,200 mm. Temperatures vary little and humidity is permanently above 85 percent.

The humid tropical climate extends on both sides of the equator. Annual rainfall is between 1,200 mm and 1,800 mm and nowhere do temperature ranges exceed 3°C. Humidity is between 70 and 85 percent.

The dry tropical climate is characterized by an annual rainfall which is between 1,200 mm and 1,500 mm, temperatures variations of up to 8°C, and low atmospheric temperatures and humidities.

The mountain climate is characterized by declining temperatures at increasing altitudes. At 2,000 metres, temperatures are between 15-16°C. At 4,500 m, at a temperature of 0°C, only mosses and lichens are able to survive.

The population of Zaire is presently estimated to be 35 million; 65 per cent of whom live in rural areas. The growth rate is estimated to be 2.7 percent; however, the rural growth rate is 2 percent due to rural out-migration and to a very high child mortality. Population density is around 13 inhabitants per km^2 (Figure II).

Water Supply

The tectonic movements which affected the African continent resulted in the creation of a basin in the centre of Zaire which drains the entire country. This basin is underlain by porous rock capable of retaining subterranean water and forms a natural underground water reservoir.

Generous rainfall, substantial water flows, and the geological structure of the country are such that Zaire does not face a shortage of water resources for domestic use. Problems are related rather to water quality and its availability for domestic use.

Public Health problems in Zaire are complex and numerous, including the prevalence of diseases such as malaria, diarrhoeal and respiratory diseases, infectious diseases (tuberculosis and leprosy), and parasitic diseases (bilharziasis and tripanosomiasis). Measles is especially devastating among small children.

Recent health statistics revealed a very high number of diseases directly or indirectly related to water quality and poor sanitary conditions.

"Health for all by the year 2,000" is the objective adopted by the Executive Council to remedy this situation. "Primary health Care" is the strategy which will enable Zaire to achieve this objective.

The country has been divided into 306 rural and urban health zones; 100 of these zones are already functioning. A health zone consists of:

- a reference hospital for treatment of diseases which cannot be treated at health centres.
- about 20 health centres, each serving about 5,000 people in rural zones and 10,000 people in urban zones.
- development committees led by volunteers chosen by the community.

Rural Water Supply

Activities to provide potable water to rural inhabitants of Zaire began around 1948 when "le Fonds
du Bien-être Indigèe" (FBI) was created in order to implement "all activities able to enhance material and moral development of "la Société Traditionnelle Indigiène" of the Belgian Congo.

This agency pursued such activities until 1964, although most water construction projects were discontinued in 1959. The FBI capped and improved 1,355 springs, installed 1,634 hand pumps and constructed 138 km of water adductions thereby serving 771,372 people. In addition, the FBI financed 385 spring cappings, 441 hand pumps and 5 small water adductions. During this period, the FBI was directly responsible for maintaining water systems. Later, beneficiaries were given this responsibility. However, they were given no preliminary training by the technical division of the agency and thus were unprepared to carry out this operation and maintenance task.

The financing of maintenance costs were assured by a "water tax" included in the income tax. With the withdrawal of the FBI there was no longer any agency to maintain these installations and since the local populations were unable to do so, the systems deteriorated. There were a few scattered efforts, supported by religious, non-governmental organizations, and REGIDESO (the national water company), to continue installation and maintenance of potable water systems.

In 1977, the Department of Rural Development resumed the activities of the FBI including provision of potable water to rural zones.

In 1978, in reaction to endemic diseases and drought in some areas of eastern and western Zaire, rural water brigades were created with financial assistance from UNICEF.

Strategies and objectives were only vaguely defined at this time. It was not until the 1980s with the advent of the International Decade for Water Supply and Sanitation that objectives to reach 70 percent of the urban population and 35 percent of the rural population were set. The percentage of the latter was increased to 50 percent under the most recent seven year plan.

The strategy to achieve the above objectives was not defined until the middle of the decade during the National Symposium on Rural Water and Sanitation organized in 1985 by the National Action Committee for Water Supply and Sanitation. This strategy was revised in 1987.

The past decade has witnessed an increase in potable water service to 20.5 percent; this figure was realized in late 1989, whereas at the end of 1987, it was 16.3 percent. Implementation of water system activities received an impetus in early 1985 due to generous financial inputs mostly from USAID and to the creation of the National Rural Water Service (SNHR). SNHR was established to complement activities of the REGIDESO (Water Supply Agency) and non-governmental organizations (NGOs).

To date, 5,068 springs have been capped 1,115 wells drilled and equipped with handpumps and 80 water adductions, (90 percent gravity fed) constructed. These installations provide potable water to nearly 4.1 million people.

Funding for the implementation of the rural potable water supply programme in Zaire is assured by a combination of the following agencies.

- The government of Zaire
- The beneficiaries
- Bilateral cooperation:
- United States Agency for International Development (USAID)
- Belgian Cooperation
- Japanese Agencies for International Cooperation (JICA)
- Multilateral cooperation:
- United Nations Children's Fund (UNICEF)
- United Nations Development Program (UNDP)
- African Bank for Development (BAD)
- European Funds for Development (FED)

Community Participation

In Zaire, community participation is considered to be the means by which communities which are going to benefit form developmental assistance actively participate in all aspects of planning, implementation, and evaluation to solve problems which they have identified.

Zaire believes that active participation allows communities to better solve problems and provides them with the necessary means to continue solving problems with a decreasing dependency on outside assistance.

The experience in Zaire is that projects are only successful if the community served participates actively in project design and implementation and that projects are only sustainable if inputs, motivations and activities are related to resources already existing in the community.

Communities must participate in every aspect of project development including:

- analysis of actual situation
- identification of problems
- analysis of targeted problem
- choice of action plan to solve targeted problem
- design of plan of action
- implementation
- follow up and evaluation

Community participation means entirely entrusting the management of water systems to the benefitting community.

The various agencies involved seek to motivate the community and instill a sense of self-management with activities conducted through existing community organizations. Several indicators are used to measure community participation:

- Acquisition and transportation of construction materials (sand, stone, gravel, etc.)
- Financial contribution of beneficiaries in relation to village income and required operating costs
- Self-organization for operation and maintenance of water systems
- Participation in construction
- Logistical support of technical team at the construction site
- Establishment of a water committee.

Operations and Maintenance of Water Systems

The WASH (Water and Sanitation for Health) Project recently assisted the SNHR in defining an operations and maintenance programme for rural water systems. This strategy has now been implemented in an organized fashion in rural areas.

A nation wide forum regrouping all parties concerned met under the auspices of the National Action Committee for Water and Sanitation to formulate guiding principles for a common national approach to operations and maintenance of water systems. After much discussion, the group was able to agree on the following principles:

- responsibility for maintaining water supply systems rests with the community;
- a financial contribution prior to construction is a key indicator of the local community's willingness to assume responsibility for maintenance of water systems;
- community participation in the design, construction, and operations of potable water systems is essential to ensure sustainability.

The following are currently involved in the operation and maintenance process:

- Technical service
- Beneficiaries

1) The technical service is responsible for animating and sensitizing the villagers through development committees; for construction and follow-up of water systems; for ensuring proper functioning of systems which may require maintenance beyond the competence of the local repairman; and for establishing a reliable supply chain of spare parts.

2) The beneficiaries are responsible for establishing a committee to manage water systems; maintaining cleanliness of water source, designating individuals to receive technical training, appointing person to be responsible for maintenance, and assuming any recurrent maintenance costs.

A comprehensive "programme d'animation", taking into account the specificity of the most common systems in a given region (province), must be developed in order to accomplish the above.

One example of the programme which is worth describing is the installation of pumps.

In the south-western Lualaba region, where there exists an intensive programme of drilling and spring capping, the following procedure is used:

Each village slated for the installation of one or more pumps or spring cappings receives the visit of an animator who organizes a series of 6 preliminary small group meetings with the villagers.

1) Informal Presentation Meeting: The animator notes the problem and importance of water as well as possible solutions.

2) Formal Presentation Meeting: He/she explains the different options and probable costs.

3) Acceptance Meeting: He/she focuses on the necessity of contributions from the villagers and on the choice and placement of the pump.

4) Committee Constitution Meeting: Discussions are held concerning the role of committee members, the committee's nature as a voluntary organization, elections, and the contract to be signed between the technical agent and the village.

5) Construction Meeting: The animator reiterates the villagers obligations; ensures that the basic maintenance kit (containing high mortality spare parts) has been purchased; describes briefly drilling and pump installation procedures including a few comments on local maintenance. Once the basic maintenance kit has been purchased (Z20,000 or $40 per household), the animator advises the village of the

probable drilling period and informs the technical team.

Three months following the installation of the pump, the animator returns to the village to ensure that the pump is functioning correctly and that it is being used properly. The animator also checks to be certain that the designated caretaker is maintaining the pump as instructed. This inspection visit is undertaken in collaboration with the health zone staff.

The animator also examines financial records.

In addition to animation activities which take place before, during and after installation of the pump, training of different levels of personnel is also undertaken:

- Regionally: training animators
- Locally: training of artisan-repairmen, committee members, storekeepers, treasury clerks

Another important point concerns the spare parts supply chain (basic tools and maintenance kits). The tools and spare parts are distributed by the National Headquarters to the Rural Water Stations (Regional), Rural Water Station: - Health Zone, Religious Organizations, NGO or other Community Organizations and to Health Centres or other NGO and to Artisans and Repairmen.

Another example of the programme and process is a gravity fed adduction. Since 1978, several water systems have been established in North Eastern Zaire, North and South Kivu, and many other systems are now being constructed. To date, these systems continue to provide water for local communities without the technical assistance of the agency which installed them, i.e. SNHR (the National Rural Water Agency) and various NGOS. How can the maintenance of these systems be organized? The response to this question is found in the procedures adopted by SNHR to ensure the operation and maintenance of these installations.

During the design of the water system, the community actively participates via the Development Committee which exists in the village or is created by the health zone or other parties concerned. At this time two or three people are appointed by the community to work with SNHR in the installation of the adduction system. They participate in the entire construction phase and are familiar with all systems. These individuals, often volunteers, are trained to repair leaks and replace faucets. Generally, the villagers all contribute to cover the cost of a breakdown which is repaired by the local repairman. The repairman often has his own water supply point in his yard and is thus motivated to promptly repair breakdowns. This is often also true of the village chief and other key persons.

The operation and maintenance system in effect is estimated to be approximately 90 percent satisfactory as evidenced by cleanliness of water supply sources, number of pumps functioning, motivation and promptness of villagers in contributing to maintenance costs, villagers' social organizations and needs expressed by other villages.

However, despite these achievements, there are specific constraints to full success. These include:

- Lack of attention to community priorities

- Inadequate funds allocated exclusively to activities related to the maintenance of systems

- Very rapid fluctuation in price of spare parts, and handpumps

- Pursuit of Project objectives within a fixed period while ignoring the time necessary to change the beneficiaries traditional attitudes and practices. This is very often due to a lack of communication between the technical service and the animators.

Conclusions

In Zaire, the strategy and system for maintenance of gravity fed adductions and spring cappings works well; however, for pump installations it is still too early to tell. Furthermore, it has been realized that the overall success of rural water projects depends less on the technical success of water installations and more on the absolute necessity of operations and maintenance of water systems being assumed by the beneficiaries themselves and this is being increasingly emphasizing in projects.

Future activities to enhance the operations and maintenance capacity are to:

- Interest local enterprises in the production of handpumps and spare parts adapted to rural conditions in Zaire by encouraging informal sector small entrepreneurs interested in repairing pumps to expand

- Continue training animators, artisan-repairmen, development committee members and treasury clerks and

- Encourage external support agencies to fund the operation and maintenance of water systems.

FINANCING OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS IN ZAMBIA AND MALAWI

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Introduction

The last ten years (1981-1990) has witnessed the significant development of water supply for the urban and rural populations in Zambia and Malawi. The benefits of improved services have been, in many cases, short-lived as the facilities quickly failed to function. One of the major reasons why services could not be sustained is the generally poor performance of operation and maintenance. A contributing factor is inadequate funding.

This paper discusses how Zambia, and Malawi are approaching the problem of improving the funding of operation and maintenance (O & M) of water supply facilities. Examples will be drawn from the urban water supply sector in Zambia, and from the rural water supply sector in Malawi.

Sector Objectives and Institutional Framework

The objectives of the water supply sector in both Zambia and Malawi echo the goal of the International Drinking Water Supply and Sanitation Decade (IDWSSD). Paraphrased, the objectives can be stated as "to ensure permanent supplies of water of acceptable quantity and quality to as many users as possible". The underlying justification is improved health and economic development.

There are many similarities between Zambia and Malawi with respect to the institutional framework. In both countries governments have prime responsibility for providing water supplies to the urban and rural populations. These responsibilities are carried out through government technical departments, statutory bodies or parastatal organisations. The government, and social services are the major sector organisations.

In Zambia the Department of Water Affairs has the major responsibility, among others, for water supplies to rural areas and to small townships. In Malawi the corresponding institution is the Water Department. Large urban centres have their own departments responsible for providing water and sanitation services. In Malawi the two largest urban centres of Lilongwe and Blantyre have autonomous statutory boards responsible for water supply services. In Zambia, the Lusaka Water and Sewerage Company, a subsidiary company of Lusaka Urban District Council, has full responsibility for providing water and sanitation services to the capital city which has about one million people. Other large towns are in the process of establishing organizations similar to the one in Lusaka.

Support for the Sector

Several external support agencies (ESA's) provide investment support and technical assistance to the water sector in Zambia and Malawi. These include: multi-lateral agencies such as

the World Bank, African Development Bank, UNDP, WHO, and UNICEF; bilateral agencies (for example NORAD, USAID, DANIDA, GTZ/KfW, Japan, Netherlands Government); non-governmental organizations such as Lutheran World Federation, Save the Children, Christian Services Committee, and Africare. Bilateral and UN agencies have provided the bulk of support for rural water supplies in Zambia and Malawi.

Coverage and Service Levels

In Zambia it is estimated that about 60 per cent of the total population have access to safe water supplies. In the urban centres (about 48 per cent of total population) more than 75 per cent of the population are served with water supplies through house connections and individual or communal standposts. In the rural areas some 40 per cent of the population has reasonable access to safe water supplies provided through boreholes, protected dug wells, and piped water schemes.

In Malawi current estimates indicate that some 4.5 million rural people (about 64 per cent of the rural population) are without improved water supplies. In the urban centres, where 14 per cent of the total population of Malawi live, about 75 per cent of the urban population is provided with safe water supplies.

Major Constraints to Operation and Maintenance

In the urban water sector in Zambia all operation and maintenance of water schemes is the responsibility of the technical departments of the city or township authorities. In the case of Lusaka, the Water and Sewerage Company has the mandate to provide water and sanitation services to the one million inhabitants, about 50 per cent of whom live in the periurban zones. In the rural areas, the Department of Water Affairs and rural district councils have the major responsibility.

In Malawi all maintenance of small townships and rural water supplies is the responsibility of the Water Department. Thus all boreholes, dug wells, township schemes, and some 55 gravity-fed piped water schemes are under the responsibility of central government. The statutory boards for Lilongwe and Blantyre have maintenance responsibilities for their schemes.

The main constraints to effective operation and maintenance include inadequate funds (mainly from government allocations and user contributions), shortage of adequately skilled manpower, inappropriate technology and institutional weaknesses of sector organizations.

The shortage of funds for capital development and for operation and maintenance has been caused by inadequate financial allocations from central government and the poor financial performance of sector organizations. Contributing factors include high levels of non-revenue water; low levels of revenue collection; unrealistic water tariff structures exacerbated by the slow process of tariff reviews and adjustments; and poor maintenance of installations. In addition, levels of financial contributions from the users have not been set to realistically reflect either the real value of the services or the user's willingness to pay for the services provided.

In the rural areas, whether in Zambia or Malawi, there are many examples indicating that the technology adopted for some of the installations can only be maintained by central government. The target communities have neither the skills nor financial resources to manage the installations.

The technology being used is beyond the technological capabilities of the benefiting communities.

Solution Strategies

Problems of financing O & M of water supply facilities exist in varying degrees in the urban and rural water supply sector in Zambia and Malawi. Solution strategies adopted to address the major constraints reflect differences in levels of service provided, the extent of coverage, technology in use, sources of funding of the project, and institutional weaknesses of sector organizations. These strategies are discussed below, firstly for urban water supply in Lusaka, Zambia, and secondly for rural water supply in Malawi.

Example from Lusaka

Following a series of institutional assessments carried out between 1977 and 1984 with technical assistance from the Federal Republic of Germany, Lusaka set up a framework for a long-term solution to its operational problems. A comprehensive approach was adopted which would eventually set the basis for more effective coverage of water services to the inhabitants, and enhance sustainability of installed facilities. The city authorities therefore began to put into effect a comprehensive development plan that included not only physical rehabilitation and extension of the water system, but also human resources development, and institutional reorganization that has led to the establishment of an autonomous Lusaka Water and Sewerage Company.

An important aspect of the institutional development plan was the drawing up and implementation of a man-power development plan. It provides for group and individual training programmes which are meant to improve group and individual management skills and upgrade technical, professional and supervisory levels of competency in the organization.

The city has been divided into service areas, and different strategies are being implemented so as to provide supply levels which are appropriate to each service area. In the metropolitan area, with conventional multiple tap house connections, there is more effort aimed at improving metering, reducing water wastage, and improving revenue collection. A combination of user education, and disconnection policy is used to encourage timely and complete settlement of water bills.

A strategy adopted for the low cost high density periurban areas is the development of "Satellite Water Schemes". These consist of a borehole, elevated storage tank and distribution mains serving individual or communal standpipes. These water schemes will be operated as separate supply units where the source will be maintained by the company while the user community will be responsible for operation and maintenance. Plans are under way to develop procedures and activities to promote active involvement of the users in the planning, implementation and management of the satellite water schemes. Such an approach would, in due course, lead to self-financing sustainable schemes in the periurban zones.

Example from Malawi

Since the beginning of the Decade Malawi has had some notable successes in implementing rural water supply programmes involving groundwater and gravity fed piped water schemes. Through the Piped Supplies for Small Communities (PSSC) programme, funded by the Netherlands

Government through the International Water and Sanitation Centre (IRC) some community based management approaches have been developed and demonstrated at several sites including rural and periurban areas.

Community participation has been promoted during the planning, implementation and management of the water schemes. Efforts were directed at maximizing the involvement of communities, especially women, in decision making, as a basis for sustainable development. In addition a sense of ownership was built up with a view to improving responsibility in operation and maintenance. The communities were encouraged to appreciate that they were in partnership with the development agency. The multi-disciplinary nature (water, health, social development) of project teams enable more open and active participation by the communities.

Community organizations (water or tap committees) were assisted with training in simple accounting and financial management. They set up their regulatory mechanisms for utilising the funds collected from the communities. Agreements were also drawn up between the development authority and the communities on division of responsibilities. For piped water schemes, for example, there was agreement that the Water Department would carry out repairs, but the spares would be provided by the communities.

Greater emphasis was placed on sharing information and experiences through workshops and study tours at a national level between sector organizations and projects and at regional level with related projects from neighbouring countries.

Results Achieved

The implementation of the appropriate strategies for the provision of water supply services already shows promising results. In Lusaka as a result of improvements in billing, collection and rehabilitations in the water systems, actual water revenue increased tenfold between 1982 and 1987, and still continues to increase although at a slower rate.

The existence of a clearly defined water development plan for Lusaka with short-term, medium term and long-term goals, has begun to attract ESA support. Lusaka Water and Sewerage Company is implementing a US $36 million rehabilitation programme with funding from the African Development Bank.

The reorganization of water supply services in Lusaka is being emulated by other large urban centres in Zambia. Thus Lusaka is providing a practical, viable model for the sector.

In Malawi the approaches developed through the IRC supported Piped Supplies for Small Communities Project have found wider application in the rural water supply sector. Malawi has begun implementing a UNDP-funded project (MLW/88 - Support for Community-Based Management in the Rural Water Supply Sector) aimed at coordinating, and promoting community management of rural water supplies.

The information sharing activities, through workshops and seminars, have engendered a more comprehensive outlook to rural water projects. It is increasingly being appreciated that successful rural water projects involve a partnership between the development authority and the target community for all phases of a project. There is also open debate on how to ensure

sustainability of water and sanitation facilities. Case studies have been undertaken which have yielded valuable insight regarding the basis for sustainability of some of the existing community water supplies.

Conclusions

Experiences from both the urban and rural water supply sectors in Malawi and Zambia show that solutions to problems of funding operation and maintenance can best be solved in a framework involving improvements in several areas including community participation, institutional set-up, human resources development and technology. These factors all require resources in terms of funds, time and skills. Thus a more comprehensive approach for addressing O & M problems is the basic model for resources coverage. Operations and maintenance should be viewed as one of the important and essential elements of sustainable water supply development if systems are to operate over the long term.

TECHNOLOGY SELECTION FOR LESOTHO'S RURAL WATER SUPPLY PROGRAMME

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Introduction

Lesotho is a small mountainous country with a population of 1.6 million. It is landlocked and completely surrounded by the Republic of South Africa. The total area of the country is 30,350 square kilometres of which two-thirds is high mountains and hills with elevations ranging from 1500 to 3500 metres. Due to its varying topography the country is divided into three characteristic regions, namely the lowlands, the foothills, and the mountains.

Significant development of the rural water supply subsector in Lesotho only occurred after independence in 1967. Prior to this there was no rural coverage. The new government gave top priority to the rapid installation of new water supply systems and embarked on a campaign inviting villages to undertake joint ventures. The villagers were to collect and contribute some funds to the Government and provide free unskilled labour, while the government for its part would top up the funds to cover the capital costs and provide the necessary technical expertise.

With limited technical and institutional capacity and experience, the Government installed several rural water systems. The technology was chosen on the basis of simplicity of installation and installation time. The technologies selected included windmill systems, polyethylene pipe and the use of corrugated iron tanks for storage. These systems collapsed quickly as the windmill systems were inappropriate, the polyethylene pipe was not suitable for the topography and the tanks rusted.

Having realized these problems, the Government in 1975 established the Village Water Supply Section (VWSS) in the Ministry of Rural Development and sought out external assistance to strengthen the institutional capabilities of the section. Swiss technical assistance was provided in 1978 and the Swiss developed standards for planning, design and construction of rural water supply systems. The major objective was to reduce operation and maintenance costs and requirements.

Systems Type

The technology in use by VWSS includes four different water supply facilities. Depending on the availability of water sources and the population size of the given village(s), the system is chosen on the basis of its operation and maintenance requirements. The preferred order of preference is:

1. Waterpoint (Spring protection): This facility comprises a spring collection completely sealed against direct human and animal pollution and a collection pipeline (1 to 2 pipe lengths of 6 metre length) leading to a storage tank which feeds a public standpost. The system is

most common in the mountain areas where springs are readily available and are in close proximity to the village (average distance for people to walk is 300 metres) and population sizes are small (ranging from 50-200 people) Per capital cost of construction is about U.S. 8.00 in 1990 prices. Operation and maintenance requirements are almost zero as all that is required is an occasional flushing of the system. However, if leakage of the spring catchment occurs this may require recapturing the spring and reconstruction. This happens very rarely and is not really a major concern.

2. Gravity system:: This system is an expansion of a waterpoint. It often includes multiple spring protection, several storage and distribution tanks, a distribution network and multiple public standposts. It has effectively no running costs and requires a minimum of maintenance as the quality of the structures is high and durable. However, it does demand a high level of management by the community, especially if several downstream villages are connected. The cost of maintenance is often not a financial one but rather requires a large input of community participation for regular inspection and preventative maintenance.

3. Handpump system: this is the third option where springs are not available. It is less expensive, having a per capita cost of US$ 16.00 as compared to a power-pumping system which costs US$ 32.00 per capital (1990 prices). Also, it provides flexibility in that when one pump stops functioning, others are still available for use. Concentrated efforts to install this system began in 1982 and now there are over 2,000 handpumps installed. Initially, the pumps were the American made Moyno largely because the programme was supported by USAID. Recently, South African Monos have been installed. Fortunately, as both pumps are progressive cavity with a rotor and stator they have interchangeable major components. VWSS has standardized on the Moyno pump although the Mono is preferred because of the ease of availability of spare parts. Neither the Moyno nor Mono are VLOM as they require special skills and equipment to repair.

The VWSS has realized the heavy maintenance requirements for handpumps and has adopted the following maintenance strategy.

- Although the villagers are not able to carry out actual repairs, they have the responsibility for reporting to the VWSS pump breakdowns and must ensure the proper use of the handpump (i.e. keeping pump surroundings clean and preventing children from playing with the pump).

- VWSS has overall responsibility for maintenance and stocks spare parts and maintains an adequate level of trained maintenance staff.

- The VWSS is striving to get private sector involvement in maintenance to the maximum extent possible.

- VWSS continues to implement a system of cost recovery which at this stage aims to recover 50% of the direct costs of maintenance.

4. Power pumping system: It is VWSS policy to avoid power pumping and windmills whenever possible. These systems are very few in number (no more than 10% of the total VWSS existing systems) and the experience so far is that they breakdown frequently and have high running costs. Power pumps require a high level of organizational capacity for

collecting the needed cash contributions and a more complex financial accounting by the villagers.

Standardization

Village Water Supply Section standards for level of service, design and construction of structures, choice of equipment and construction materials have all been developed in order to minimize operation and maintenance even if these initially require high capital investment costs.

The overall standards of service are designed to meet the people's needs for 10-15 years without requiring a major expansion of works.

Gravity systems are designed for 30 litres per capita consumption, a maximum walking distance of 150 metres to the nearest public standpost and a maximum of 150 people per standpost. The VWSS only installs public standposts and discourages the installation of private (yard or house connection) taps. Handpumps are designed to serve 75-100 people per handpump. They are located within a 200 metre-radius around the village.

These design standards were developed to help overcome operation and maintenance problems and include the requirement that piped water systems should not connect an excess number of villages. However, when this is unavoidable every effort is taken to provide each village with individual distribution chambers and separate main distribution lines.

The Village Water Supply Section enforces a very high quality of construction and workmanship. Standards are well elaborated for construction masons, foremen and supervisors through construction manuals. Standard plans have been prepared for all structures such as storage tanks, siltboxes, valve chambers, public standposts and handpump slabs.

The Village Water Supply Section installs basically one type of handpump (Moyno or Mono). In addition the Section uses only galvanized iron piping for its pipelines and pump riser mains. This is a result of the ruggedness and rocky terrain of Lesotho No exceptions are made simply to avoid problems of maintaining a variety of spare parts and fittings. All structures are either of stone or brick masonry work.

Conclusion

Gravity water systems which require the least degree of operation and maintenance are the primary technology choice in Lesotho. Where this not possible handpumps are the second option. When handpumps are used the VWSS undertakes to organize, with community support an adequate operation and maintenance system and strives to recover 50 percent of the costs of this maintenance. Power pumping systems are avoided if all possible as they require a high level of village organization, management and financial organization.

OPERATION AND MAINTENANCE ASPECTS OF KIBWEZI WATER PROJECT, KENYA

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Background

At the request of the Ministry of Health, Kenya, the African Medical Research Foundation began the Kibwezi Rural Health Scheme in 1978. With the establishment of AMREF's Environmental Health Unit in 1983, one of its first activities was to support the Kibwezi Rural Health Scheme with the formation of the Kibwezi Water Project at the end of 1983.

Kibwezi is a division of Machakos District of the Coast Province. The Division is centred some 200 km south east of Nairobi, and covers an area of 8,000 km^2 and has a population of 150,000. The region is dry with an annual average rainfall of 612 mm and evaporation of 2112 mm. The local Akamba people are agriculturalists.

The project objective is to support the local people in the construction and maintenance of their own water supplies. Thus the project is designed to be community based. Local conditions dictate that the most suitable water sources are obtainable from shallow wells. However, in a few cases roof catchment systems have been built.

The project has two full time employees; a driver and a site supervisor, with part time input from an engineer. To date, 60 supplies have been constructed, training courses for all groups organized and a maintenance and operation structure established. Each supply serves an average of 424 consumers. At present the project is being evaluated using the Minimum Evaluation Procedure of the World Health Organization. The evaluation is a self administered one and is being carried out by the communities themselves. This evaluation will enable the future interests of the project to be quantified and planned by the community.

The project has had to tackle many of the usual problems facing the establishment of community based water supply projects and has been to a large extent, successful in finding and implementing solutions. This success is attributed to the philosophy that the agency is participating in the communities' project. AMREF's financial inputs to the project will cease in mid-1990. In the remaining period, the AMREF field team is concentrating upon strengthening the local management structures, and completing construction and training activities.

Issues in Operation and Maintenance

Community Resources

There are many factors in the background of the Akamba people of Kibwezi which contribute to the success of a community based water project. Firstly, water is a scarce commodity

which has a high value (in remote areas, water vendors using tractors charge up to USD 12 per m^3) and consequently there is a real felt need. This has contributed to high levels of motivation by the recipients and clear ideas as to the requirements for their supply. Secondly, the area has only recently been settled, (the people moved in essentially as squatters) and they have had to work closely together in order to tackle the problems they encountered. Consequently, their social organizations are strong and the introduction of a water project has not required the importation of any exogenous social structures.

It was clear fairly early on that the water project groups were ready not only to tackle the hardware for water supply but also the software for operation and maintenance. Regular meetings were held with the group committees until their number grew so large that a "central" committee was elected to represent all wells in the Division. The Kibwezi Divisions Wells Committee has 9 members, all chairmen of local wells committees and chosen to give representative coverage of the area. The committee has been recognized by the sub District Development Committee representing the Government of Kenya administration. The committee has designed the maintenance system for the water project.

When the AMREF water project team leaves Kibwezi, the Kibwezi Divisions Wells Committee will be responsible for supporting well groups both new and old, managing the pump store and serving as the liaison with relevant organizations at least at a local level. The AMREF field team has now begun a gradual process of withdrawal.

Expertise Required

Basic practical skills for repair and construction are taught at the village level. Since by the end of this year some 60 groups will have received practical and classroom instruction, it is hoped that the knowledge will be retained by the people.

The management skills required for overall operation and maintenance rest with the Divisional Wells Committee. They have been supported by the AMREF field team and responsibilities are now shifting from the AMREF field team to the Divisional Committee.

There are other inputs of "expertise" which still remain with AMREF. These are the input of new ideas and technical updating, fund raising for the present project and the physical link to get spare parts from the manufacturers to the Divisional Committee.

The Divisional Committee and AMREF intend to continue to maintain strong links in the future. The Committee is currently drafting its ideas for the basis of this future relationship. This institutional link is important as a complete severing of relationships would be disastrous. The link will allow the Divisional Wells Committee to have access to information and new ideas and will allow it to use AMREF as a spare parts supplier. Fund raising for future project development is now being addressed by the Divisional Committee. The committee is able to raise and manage funds from the community but the possibility of attracting external funding will be looked into.

Technology Employed

The first year of project operations enabled a number of well construction technologies to be tried out. The emphasis was upon locally available materials and replicability. A final design

was adopted which balances actual local cost with service level and the possibility of replication. In fact locally made bricks are being used in the construction. The well design is such as to enable access for deepening and water drawing during pump breakdown periods. The importance of good design is stressed and this helps reduce the operating and maintenance difficulties.

The choice of pumping equipment was made in consultation with the UNDP/World Bank project but at a time when the AFRIDEV had not been developed. However, the pump employed is giving excellent service although pumping depths average only 9.4 metres. The average annual repair bill for a pump and well is less than USD 70 and pump purchase is approximately USD 400. Breakdowns are rare and a real danger exists that individual groups may lose the knowledge of how to repair the systems. Each well group has trained mechanics with a simple tool kit and the pump store maintains a complete tool kit which can be loaned.

A one year guarantee is issued on each pump. This enables communities to begin fund raising in advance of repair bills and to be fully trained before accepting full responsibility. As the choice of pump was made largely by AMREF it would have been extremely difficult to expect a community to service the system if the equipment turned out to be substandard.

Well groups use bank accounts for safe keeping of membership fees and for the purchase of spare parts from the pump store. Guideline figures of annual repair costs were obtained from other projects using this pump, hence committees had an idea of what suitable membership fees should be. The Divisional Committee operates two further accounts; one for pump spare part transactions and the other to hold the Divisional membership fees of the individual groups. The latter is to cover the expenses of the Divisional Committee and to form a cash buffer. Thus each well group contributes USD 0.16 per member per year towards the running costs of the Divisional Committee. The wells which do this can then purchase spare parts at a minimum price. The minimum price is calculated at cost, transport and inflation factors. A handling fee is added to purchases by non member groups.

To further assist the management of individual wells, committees are requested to calculate the water output of their own well. This is done by a container count. This enables pricing levels to be worked out and the long term outputs to be monitored. It also provides useful "yield" data which, where possible, are supported by pumping tests and temporary meter readings.

Summary of Operation and Maintenance Activities

Water projects have their own committees responsible for the supply. They raise funds to cover maintenance and membership of a Divisional Wells Committee. The Divisional Committee oversees on-going project activities including the supply of spares to a central store together with maintaining a liaison with the Government.

Individual groups are responsible for the financing and repair of their own water supply. The Divisional Committee supplies the spare parts via a central store.

Using current figures, the average group of 424 consumers will spend USD 70.00 on maintenance and USD 20.00 on operations per year. The average daily (over a year) yield of a well is 5 m^3 per day. The capital investment cost in construction and installation is USD 2,500 per well, all inclusive.

Discounting over 10 years at an interest rate of 12%, the capital cost can be reduced to an annual figure of USD 443.00. After including the operation and maintenance cost of USD 90,00 per annum the annual cost becomes USD 0.29 per m^3 of water or USD 1.25 per user.

Experiences

Due to the active participation of the Divisional Wells Committee, it is possible for the existing operation and maintenance procedures to be changed in the light of continuing experience. Thus what is presented here are current ideas which may well change. Also it must be stressed that many of the ideas come from the community themselves in response to very specific problems.

Several key factors and issues relative to experience with the Kibwezi project are worth mentioning.

- Community leaders have a high profile in project management which enhances sustainability and consumer satisfaction;
- Project activity and policy has remained constant for the project duration which encourages motivation and understanding;
- The project has a finite time span forcing early decisions on the project future and management;
- Limited capital input enhances community involvement emphasizing community development and not project productivity;
- Collaboration with Government and NGO's strengthens the peoples' capacity to undertake operation and maintenance;
- After withdrawal of the implementing agency it appears that an Institutional connection should be maintained in the long term, to mutual benefit;
- A good technological design is central to effective operation and maintenance;
- In the case of handpumps, a 1 year guarantee enables users to establish a repair fund and become familiar with the equipment;
- Safe keeping of funds raised is essential; and
- Project evaluation by the community themselves is a valuable exercise to support development operation and maintenance activities.

As a result of the project the following general issues have emerged which need to be addressed in the future.

- Are rural communities able to raise enough capital to replicate "low cost" supplies? If not, is cost recovery possible or can local communities arrange funding directly

with donor agencies?;

- Even strong representative committees may have difficulties in relating with the Government and politicians;

- Will the motivation of groups and committees still exist after construction of the supply?; and

- The handpump market is more and more diverse than ever, thus making standardization or even choice a difficult task. Some effort needs to be directed to settling for a limited choice of handpumps which are particularly suitable for Kenya.

OPERATION AND MAINTENANCE PRACTICES IN WATER AND WASTE WATER SYSTEMS IN CENTRAL AND SOUTH AMERICA

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Introduction

This paper presents an overview of operation and maintenance practices in water and wastewater systems in Central and South America. It also includes the various solutions proposed and being implemented by the regional organizations of Water Companies, CAPRE in Central America and ANDESAPA in South America.

Constraints

Some Central and South American water companies have survived under the unsatisfactory economic and financial situations that have severely affected the provision of urban and rural water and sanitation services in these countries.

The major problems facing the companies can be summarized as follows:

1. Management Under Public Service Criteria

Usually management of the water and waste water systems is by local authorities. The assumption is that only the government is capable of managing so important a social service.

This approach has resulted in the neglect of key management principles such as the need to increase profits, reduce financial losses, increase efficiency, involving the workers in the decision making process and the need to consult and involve the beneficiaries. This approach inevitably results in poor service with the consequence that the users will not pay and the better workers finding more profitable employment.

2. Factors External to Water Company

There are external factors which hinder the correct management of the companies. A major issue here is the involvement of the central government in establishing tariffs. Tariffs are often established for political reasons and not to guarantee the financial security of the company.

3. Lack of Knowledge by Management and Workers

Another problem is that both workers and management often are not properly trained for their positions. This results in poor management, poor performance of the system and expensive and unnecessary costs in operations and maintenance.

A further issue hampering proper operation and maintenance is that operations and maintenance personnel may not be adequately trained to carry out repairs and plan an operation and maintenance strategy. In addition it is common for operation and maintenance to be under the planning section in the company and planning personnel may not be very knowledgeable on O & M.

4. Lack of Community Participation

Traditionally water companies have not consulted or involved the users in operation and maintenance. This is a mistake as the users need to be involved in operations and maintenance and can play a major role in contributing to improved O & M.

5. Use of Inappropriate Technologies

A major problem is that the technology being used may not be the most appropriate. The installation of sophisticated technologies for which spare parts are not readily available and which cannot be repaired by local technicians is a further problem.

These sophisticated technologies also have very high financial O & M costs which is another concern for the company.

Regional Organizations

In 1979 the regional water companies in Central America concluded after analysing their common problems that there was a need for a regional organization of water companies to share experiences on common problems.

The Regional Coordinator Committee of Water and Sanitation Institutions of Central America, Panama and the Dominican Republic (CAPRE) was formed and received initial support from GTZ. Participating countries in CAPRE include: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama and the Dominican Republic.

The Committee has an executive body composed of the senior officials in the water companies of El Salvador (ANDA) Costa Rica (AYA) and the Dominican Republic (INAPA). The commission has an executive manager whose office is in San Jose, Costa Rica.

CAPRE receives support from other regional organizations such as AIDIS, The Sanitary and Environmental Engineering Interamerican Association, WHO, The World Health Organization and ANDESAPA which is CAPRE's equivalent in South America. Financial support is provided by FINNIDA, GTA, and OPS.

Within the national water companies belonging to CAPRE national technical committees (CTN) have been established to deal with specific topics. There are 8 CTN's:

1. Development of Human Resources
2. Loss Control Programs
3. Community Participation, Sanitary Education and Personal Hygiene
4. Commercial Systems and Financial Management
5. Materials and Products Normalization and Certification

6. Water Quality
7. Information Systems
8. Institutional Strengthening

To foster cooperation between water companies on the same 8 topics, Regional Technical Committees, CTR's have been set up.

An organization similar to CAPRE is ANDESAPA which includes the water companies of South America. Countries belonging are Venezuela, Colombia, Peru, Ecuador and Bolivia. This organization has its office in Quito Ecuador and has an executive manager and a rotating president.

ANDESAPA differs from CAPRE in that not all of the water companies are government bodies. However even the non government agencies have similar problems to the government water companies of CAPRE.

Planning Development Projects in the Region

To ensure a logical and solid planning for projects, CAPRE AND ANDESAPA have used a method called ZOOP, which has produced a work plan with a duration of 4 years. This plan includes the solution to the majority of problems mentioned in the first part of this paper.

The components and results proposed in the work plan are the following:

1. Reinforcement of CAPRE at Regional and National Levels

   1.1 CAPRE is an organization with legal support able to represent its members.

   1.2 CAPRE has an information system able to know the activities of the members to facilitate interchange and help between the countries.

   1.3 CAPRE has an organic structure, budget and a good physical infrastructure.

   1.4 CAPRE has policies, strategies and is developing more regional programs.

2. Better Quality of Personnel at all Levels in the Water Companies of CAPRE

   2.1 Good recruiting systems and career structure for CAPRE staff.

   2.2 Adequate budget for career structure

3. Application and Diffusion of Appropriate Technologies

   3.1 A system has been established to develop and diffuse knowledge about appropriate technologies for urban systems.

   3.2 A system has been established to develop and diffuse knowledge about appropriate technologies for rural and peri urban areas.

4. Support to Countries in the Formulation and Execution of Loss Control Programs

   4.1 The Institutions are able to formulate and execute appropriate Loss Control Programs.

5. Promotion Andesapa

   5.1 ANDESAPA is accepted by the sectorial organizations as a competent representative at the Regional level.

   5.2 The technical competence and influence of ANDESAPA has improved for the members of the organization.

   5.3 There is cooperation between CAPRE, ANDESAPA, and other institutions.

6. Improvement of the Quality of Materials

   6.1 The water companies use certified materials which meet acceptable standards of quality

   6.2 Appropriate chemical water treatment is applied in treatment plants throughout the region

THE UNACCOUNTED FOR WATER REDUCTION PROGRAMME IN SAO PAULO BRAZIL

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Introduction

The metropolitan region of São Paulo (RMSP) is the second biggest urban conglomerate in the world with some 16.2 million inhabitants. The metropolitan region includes in addition to São Paulo, 35 towns which are supplied by the RMSP Water Supply Integrated System.

The total production of drinking water is 56 m^3/s which comes from 8 water treatment plants. Guarau produces 33 m^3/s, ABV 11 m^3/s, Rio Grande 4 $m^3\backslash s$, Rio Claro 3.6 m^3/s Alto Tiete 1.5m^3/s, Alto Cotia 0.9 m^3/s and Baixo Cotia 0.4 m^3/s.

The Cia de Saneamento Basic do Estado de São Paulo (SABESP) is responsible for providing treated water to cities and towns in the RMSP. The integrated system has 1200 kilometres of large diameter pipes and 23,100 kilometres of distribution pipe.

Water Losses

From 1985 to 1992 unaccounted for water losses rose from 25 percent to 40 percent. This represents a total loss of 17 m^3/s, a flow sufficient to service 6 million people.

SABESP has developed a strategy to reduce unaccounted for water losses. This includes:

- The installation of improved meters
- Pilot studies in specific sectors to confirm data

and - Review of customers files.

In addition SABESP has contracted Lyonnaise des Eaux Services Associes (LYSA) a French firm specializing in reducing water losses to investigate ways of reducing unaccounted for water losses. LYSA has implemented a three phase programme including:

	Phase 1	Initial Diagnoses
	Phase 2	Field Research and Complementary analyses
and	Phase 3	Establishment of a two year action plan.

Initial Diagnosis

The initial diagnoses analyzed all probable causes of losses. The initial diagnoses was based on an examination of relevant statistics and an analyses of the water companies organization and its procedures.

A significant conclusion of this work was that the present data system does not easily

provide information to identify the causes of losses.

The diagnosis revealed that water losses increased from 25% in 1985 to 40% in 1992. In 1989 losses were 29%.

The losses were differentiated and classed as physical and non physical. In 1992 18% of the losses were physical and 12% non physical

The major causes of physical losses were identified as

- Branch lines losses, due to use of galvanized iron pipe
- Distribution network losses: Initial data indicated losses in the distribution network varying between 0.7 and 1.6 m^3/h x km. In phase 2 of the project this information will be mapped to permit identification and correlation of the losses with network age, pipe materials and existing pressures.
- Metered volumes. Problems with meters was identified as a cause of losses. There are 2, 286,056 meters in the RMSP. Of these 98.8% are between 1.5 and 3.0 m^3/h, 0.91% between 5 and 30 m^3/hr and 0.16 between 1,100 and 6,500 m^3/hr.

A further cause of unaccounted for water is the water supply to the squatter settlements or favelas.

In São Paulo the population of the favelas increased from some 375,000 people in 1980 to 650,000 in 1991. According to a state of São Paulo regulation each household is supplied with 10 m^3/ water per month.

There are 77,000 registered connections and the total metered consumption is 4.7 million m^3 per month. However revenue is only obtained for some 1.08 million m^3/month.

The preliminary analysis indicated that problems in the favelas included poor metering and the existence of clandestine connections. Poor people on the periphery of the RMSP illegally hook up a water supply. These clandestine areas instal their own connections and operate their own distribution networks. The number of clandestine connections is estimated at between 40 and 100 thousands and their elimination is almost impossible.

Phase 2. Field Survey

For field survey LYSA formed a team of 40 trained technicians and surveyed 50, 000 connections or about 3% of the total number in the RMSP. The areas surveyed were chosen to reflect a wide range in levels of income, types of service and social and economic status of the consumers.

The field survey involved:

- the field and office training of the surveyors
- development of software packages to enter data in PC's. Part of this involved

transfer of data from mainframe SABESP computers.
- installation of specific hardware on the PC's

and - training of computer operators.

Phase 3.

Phase three of the programme will involve the elaboration of a 2 year action programme. This will aim at:

- the development of a management information system for unaccounted for water

and - the implementation of a programme to reduce unaccounted for water losses. This programme will be phased and short, medium and long term objectives and tasks will be established.

The management information system will identify the causes for water losses, whether physical or non physical, and the geographic occurrence of these losses in the RMSP. Data will be generated to show the total volumes of produced water, the volumes supplied to the various sectors in the system and to the towns. Losses indexes will be computed for different sectors in the distribution network.

The programme will implement specific activities such as pipe replacement, pipe repairs, meter replacement, meter repair etc. to address the losses due to physical causes. In addition organizational and financial changes will be introduced to reduce the losses from non physical causes.

In the loss reduction programme special attention will be paid to:

- the problem of water supply in the squatter towns and slums
- the organizational structure of the company
- meter reading problems
- fraud and irregular administrative actions
- leak detection
- improvement of domestic supplies
- illegal connections

and - the development of accurate customer files.

OPERATION AND MAINTENANCE OF URBAN AND RURAL WATER SUPPLY AND SANITATION SYSTEMS IN NEPAL

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Introduction

Nepal is a landlocked mountainous nation of some 19.5 million population. It borders in the North with the People's Republic of China and in the South, East and West with India, covering an area of 147,000 sq.kms. There is a wide variation in both climate and physiography with the plain of the Terai in the South, the Siwaliks and the Mahabharat range of the midlands, followed by the high mountains and the high Himalayas of the mountainous region to the North. The climate varies from sub-tropical to alpine and tundra as a result of great elevation variations, ranging from 70 m in the Terai to 8,848 m in the Himalaya.

Nepal is an agricultural country with 94% of the population engaged in agriculture, primarily subsistence farming. The population is predominantly rural with only 10% living in urban areas. The national population growth rate is 2.1% per annum, while population growth in urban areas is around 5%. Annual per capita income varies among geographic regions and the average is estimated to be US $180.

The health profile of Nepal reveals a high incidence of illnesses related to water, sanitation, and household/personal hygiene. Diarrhoea and dysentery are leading causes of morbidity (40 per 1,000 cases) and child mortality (16.5% of total deaths). Typhoid, hepatitis and parasitic infections of the intestine are very common. Inadequate access to safe and reliable water supplies and sanitation facilities, combined with unhealthy personal, household and community hygiene practices are known to be exacerbating the continued prevalence of these diseases.

The Ministry of Housing and Physical Planning (MHPP) has lead responsibility for water supply and sanitation sector development, formulating and steering implementation of overall policies and strategies. Within MHPP the Department of Water Supply and Sewerage (DWSS) is the lead government implementing agency for the sector. DWSS is responsible for development of water supply and sanitation in rural villages and 19 smaller urban areas of the country. The Nepal Water Supply Corporation (NWSC), also under MHPP, is an autonomous body responsible for water supply and sanitation in 14 larger urban centres. Other Ministries involved in the sector, but to a much smaller extent, include Ministry of Local Development and Ministry of Health.

Though the country did witness a spurt of activities during the International Drinking Water Supply and Sanitation Decade (1981-1990), national water supply coverage is presently only 42% and that of sanitation is even much lower at 6%. A substantial proportion, probably exceeding 50% of rural water supply systems are in need of repair or renovation and are not presently providing adequate services. Similarly, most urban water systems suffer from poor operation and maintenance, leading to excessive water losses, intermittent and contaminated supplies and large expenditures of public sector funds.

Sector Policy, Strategy and Approach Related to O&M

To improve the health status of the people, the elected government, after the restoration of democracy, has taken many initiatives, one of which is to provide all the Nepalese people with access to safe drinking water supply within the next decade. To achieve this lofty target, existing policies and strategies will have to be readdressed. Resources needed and the utilization of the beneficiaries potentialities in project implementation and operation and maintenance will have to be explored. The traditional system of project implementation has been re-oriented and streamlined through a community-based approach to fulfil the democratic norms of decentralization.

A policy directives on implementation of water supply and sanitation was initiated in 1990. The main objectives of the directives, among others, are to run water supply and sanitation on a sustainable basis with "partners in progress" approach such as:

- identification/formulation of water supply and sanitation projects will be based on the demand from the community;
- establishment of community water user committees will be obligatory from the feasibility stages;
- due priority will be given to projects with relatively high levels of community participation and substantial contribution of local inputs i.e. labour and materials;
- formal agreement will be signed between the supporting agencies of HMGN and water users' committees, defining each others responsibilities and authorities during construction and operation and maintenance;
- sanitation programmes will be integrated with water supply and 7.5% of water supply project costs will be earmarked for sanitation;
- community institutions will be authorized to function as an autonomous institution in terms of fixing and collecting water tariffs/revenues;
- to enhance the capabilities of community organization and water users' committees, Village Maintenance Workers will be given appropriate levels of training before the project is formally handed over to the water users committee for operation and maintenance.

The philosophy of community participation is to develop a sense of ownership as "partners in progress" and is identified as:

- cost sharing in the project implementation by the local people;
- voluntary contribution (cash or labour);
- effective use of the decision-making authority of the people's representative; and
- involvement of the local people in project identification, implementation, evaluation and sharing of benefits.

Following a critical assessment of sector performance during the past decade, it has been established that:

- the new approach giving additional responsibilities for construction and O&M to User Committee will obviously strengthen community involvement in the programme;
- a planned and institutionalized "preparatory phase" for each project, between budget allocation and release, would improve programme implementation;
- although O&M would be the responsibility of the Users Committee, there is a need to develop a system of regular field monitoring by DWSS;
- core staff with appropriate social science skills would be useful in DWSS staff structure to guide, assist and motivate Users' Committee in construction, O&M, and promotion of health education in the communities.

O&M Practices, Constraints and Issues

Since the early years of the programme there has been a requirement for water systems to be handed over on completion of construction to the local government and benefitting communities for O&M. However, when this arrangement was not found to be practicable due to lack of local financial, managerial, and/or manpower resources, DWSS also assumed temporary responsibility for the O&M of completed system for an initial 2-3 years, pending the completion of appropriate arrangements for O&M by the local government. In practice, however, this "temporary" phase has continued beyond the initial 2-3 year period to become a permanent arrangement. This has created a dependency syndrome among the users. There is a strong feeling in the community that the drinking water projects belong to the Government and the users do not have the responsibility for O&M.

With the experience gained during the past decades, the need for setting more pragmatic O&M programme has been better understood. One of the strategies, amongst other equally important ones, specifically required that benefitting communities were to be responsible for the O&M of their systems and the users to pay at least for the O&M costs.

Surveys were conducted during 1989 and 1990 to determine the operation and maintenance status of DWSS constructed projects. Based on the surveys, a proposal for a rehabilitation programme has been finalized and is under implementation. The survey results indicate that of the 306 piped systems surveyed, 268 rural systems and 14 urban systems need repair/rehabilitation to varying degrees. Some of the repair/maintenance problems identified were: intake - lack of routine cleaning, damage due to natural causes or by people; storage reservoir - leaks; pipelines - cutting of exposed pipes for extracting waters, poor jointing, displacement from landslides; valves/chambers - damaged taps/tap stands, poor flow, poor drainage. The high percentage of completed water systems included in the proposed rehabilitation project is indicative of poor operation and maintenance practices, and a lack of user concern or assumption of responsibility for the systems.

Presently there are about 2000 on-going water and sanitation projects and about eight hundred plus completed projects. The size of the projects range from a few hundred to about

several thousand beneficiaries. The varying size of the projects makes it difficult to generalize maintenance policy. Operation and maintenance of completed projects alone is taking a big chunk of the government budget currently leaving little for new projects and causing impedance in target achievement. Although the major portion of the budget for this sector is from external support, it has been necessary to find new ways to relieve this burden. Guided by a new implementation policy as well as by the policy of decentralization, a programme has been initiated to mobilize beneficiaries potential in implementing and maintaining water supply and sanitation projects. Up till now about 50% of the completed projects have already been handed over to the beneficiaries committee officially called Water User's Committee. More completed and rehabilitated projects are in the process of being handed over to Water User's Committee for operation and maintenance. The water users have been supported by necessary training in management, as well as in technical aspects, which will be continued as and when this type of support is needed. This strategy has limitations in the sense that users are willing to take over small and medium sized projects only. Plans are underway to make even bigger sized projects sustainable for local maintenance by forming clusters of water users committee with the sector agency taking the responsibility for source and trunk mains.

All relevant studies have shown that the status of O&M of drinking water and sanitation facilities is beset with several problems which can be summarized as follows:

- Budget made available for O&M is inadequate to maintain the system. Budget allocations for operation and maintenance are done on an ad-hoc basis.

- The O&M work is done mostly by untrained and temporary staff such as plumbers, watchman, and labourers.

- Users are not involved in O&M due to poor planning in the programme, in constructing the systems in areas where a felt-need does not exist, lack of information/gap of communication, non-involvement of users from planning and construction stages, all of which lead to a lack of sense of ownership by the users.

- Training and back-stopping support for Users Group from Government agencies to ensure that the Groups are capable of operating and maintaining the systems are generally not adequate.

- Communities are not adequately assisted in establishing or maintaining Users Committees resulting in inconsistent establishment of the committee; membership turnover tends to be high leading to inactive and ineffective committees.

- There is no properly established cost recovery scheme for O&M in rural areas, consumers either cannot afford or are not willing to pay for water charges.

Proposed Measures to Improve O&M Programme

The key concept for proper functioning of water projects is to ensure sustainability of project supply in designing, building and managing improved water services in such a way that they continue to function reliably to provide the intended services to the people of the area, and the funds for keeping them functioning continue to flow from the beneficiaries regularly and without interruption.

The pre-conditions for reliable functioning of water supply systems will be exercised before and at all stages of design, supervision and construction. The use of quality materials in the construction will be monitored; community participation to develop sense of ownership will be encouraged; spare parts made available when needed and training of required manpower will be undertaken.

In rural areas, user involvement in all aspects of WSS system development to inculcate a sense of system ownership will be enhanced in order to increase the likelihood of community assumption of responsibility for O&M. A systematic back-up support from Government will be developed. The O&M costs of projects will be ascertained at the beginning of implementation and regularly monitored to assist User Committee in planning and budgeting for these costs, and to determine community capacity to finance O&M.

In urban areas major tariff increases may be necessary for NWSC and DWSS to be able to afford to maintain urban systems. Prevailing Government policy pointing toward the establishment of semi-autonomous bodies for management of municipal water supplies may facilitate improved tariff collection.

The following essential elements will be taken into account in the O&M Programme.

Planning: The overall plan for O&M will be developed starting from the time of the community's request for the project and continuing through out the life of the project.

Training: Proper training will be provided to both sector and community based personnel responsible for O&M including User Committee members.

Manpower: O&M is a labour intensive activity and the programme will be supported by an adequate number of trained manpower.

Funding: Budget will be allocated for proper functioning of O&M staff and programme activities.

Implementation: The maintenance Unit in the District WSS Office of DWSS will be strengthened.

Community Participation: Community will be mobilized to participate actively in all stages of project implementation through extensive health and hygiene education promotion and the participatory approach.

Follow-up: Routine follow-up by monitoring, evaluation and back-up support from HMG agencies concerned will be provided.

Institutional Arrangement:

In order to manage the operation and maintenance programme effectively, a modified institutional structure and distribution of responsibilities have been proposed. The programme consists of three levels of tiers; Regional Level, District Level, and Village Level.

Regional Level

The responsibilities of regional level includes implementation of O&M policy, monitoring and evaluation.

Regional Maintenance Section

The Regional Maintenance Section will be supervised by a Divisional Engineer of the Regional Director's staff. The function of this section shall include the following:

- provide clear O&M and repair policy for the District Offices.
- request for changes in policy & programme that a DE may propose.
- allocate adequate funds for the district maintenance programme.
- accumulate and compile the maintenance reports from the DESOs for the regional maintenance reports.
- provide the DWSOs with the standard forms necessary for the maintenance activities.
- provide the annual operational status to MHPP/DWSS.
- organize training and orientations to the maintenance unit staff of district offices.
- create systems in order to provide incentive to maintenance staff.

District Level

The responsibilities of DWSO are
- implementation of community based maintenance programme,
- monitoring of water supply schemes,
- technical and financial assistance,
- running of training programmes,
- making available of spare parts (at Ilaka level),
- posting of maintenance technicians (for Ilaka level).

Maintenance Unit at the DWSO

This unit will assist all communities in the district to maintain and repair their water supply schemes and sanitation facilities.

The DE's responsibilities are:

- generating interest within the DWSO for maintenance.
- organizing the MU and provide administration support in terms of personnel, finance and supplies.

- supervise and support the Maintenance Unit-in-Charge.
- insure that the MU staff receives training on maintenance.
- approve status survey & repair schedules.
- approve MST and MST's TA/DA claims.
- review and approve Repair Estimates if Users' Committee meet the preconditions for repair.
- conduct monthly MU meetings: discuss maintenance progress, problems and how to improve the programme.
- submit maintenance/repair reports to Regional Director.
- prepare Scheme Completion Report.
- request Maintenance Budget and Major Repairs Budget.
- provide arrangements for availability of spares required for small repairs at Ilaka level.
- provide arrangements for providing the technical support at the Ilaka (Sub-district) level.

The responsibilities of District Development Committee (DDC) are to:

- assist DWSO for overall maintenance programme in the district.
- assist DESO and VDCs to establish a system to make availability of spare parts.
- provide directives to VDCs in mobilizing Users' Committee for O&M.
- prioritise rehabilitation schemes.

Village Level

The responsibilities of VDCs are to:

- request for small/major repair.
- pass in the general assembly for rehabilitation scheme to request DWSO and DDC.
- provide overall support to Users' Committee for O&M including formation of Users' Committee.
- coordinate with DDC.
- support for minor repair.

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UNACCOUNTED FOR WATER MANAGEMENT IN GREATER KATHMANDU

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Introduction

Nepal is a small, landlocked Himalayan kingdom divided into three east-west bands: the northerly "Mountains", the middle "Hills" and the southerly plains called the "Terai", with a present population of about 18.5 million which is expected to grow at about 2.7% per annum over the next decade or so. Rainfall varies but is typically about 1500 mm annually with 80% falling in June to September (the monsoon season) which is out of phase with the seasonal water demand which generally reaches a maximum in the dry months of April and May.

Lying in the middle "Hills" of Nepal is the Kathmandu Valley with an approximate circular diameter of 30 km and surrounded by hills rising to 2000 m in altitude and with a floor elevation of 1300 m above mean sea level. The Kathmandu Va''ey towns include Bhaktapur (which has a separate water source and distribution system), Kathmandu and Lalitpur.

Kathmandu-Lalitpur (also known as Greater Kathmandu) has a present (1990) population of 460,000 which is projected to increase to about 879,000 by the year 2005. Greater Kathmandu presently faces a severe and steadily deteriorating water crisis with leakage and wastage estimated at about 60 percent.

Water Supply - Leakage and Wastage Control

The history of piped water systems to Greater Kathmandu dates back to 1895 A.D. when the Bir Dhara system was constructed. Subsequently there have been various additions to, and extensions of the system, particularly, under three World Bank (IDA) assisted projects.

Evolving from a UNDP assisted "Master Plan for Water Supply and Sewerage for Greater Kathmandu and Bhaktapur" prepared by consultants in 1973, the "First Project" commenced in 1974 to include water supply and sewerage improvements to Kathmandu-Lalitpur, and water supply to Bhaktapur and Pokhara. A "Second Project" started in 1979 to strengthen and extend the distribution components of the water supply and sewerage systems initiated under the First Project. Water supply improvements to Birgunj and Biratnagar and an update of the 1973 Master Plan were also included under this project. Subsequently, a "Third Project" was commenced in 1980 to include further water supply and sewerage improvements in Kathmandu and Lalitpur and water supply to Bhaktapur, Pokhara, Birgunj, Biratnagar, as well as Nepalgunj, Bhairahawa, Butwal, Hetauda, Janakpur and Dharan. This project was officially closed in June 1988.

Additionally, an important objective of all three IDA projects was to assist the development of the Water Supply and Sewerage Board (WSSB), (which was created in 1974 to execute the First Project). into a self-sufficient public utility able to improve and extend water supply and sewerage services to other urban areas in the country.

However, like other Boards in Nepal, WSSB was a temporary creation to implement projects. Hence in July 1984 the WSSB became the Water Supply and Sewerage Corporation

(WSSC), a semi-autonomous government corporation with a broader responsibility and greater responsibility in the management of water supply and sewerage.

The legal powers of WSSC were also found inadequate to enable the water/sewerage system to be managed efficiently, as a result, under a new Act, WSSC became the (autonomous) Nepal Water Supply Corporation (NWSC) in February 1990. Under this Act, NWSC has responsibility for urban water supply and sanitation in all 33 town councils in Nepal. Presently, NWSC has taken over operations of only those 12 towns administered by its predecessor. The NWSC operates under a Board of Directors and falls under the Ministry of Housing and Physical Planning. NWSC enjoys greater autonomy with powers to set its own tariffs and take action against defaulters. In practice, however, the government of Nepal exercises control on NWSC's activities.

Leak detection and repair was given very little attention prior to 1974 when the estimated leakage in the system was reported as 75%. Between 1974 to 1977 under an Overseas Development Agency - UK assistance the (then) WSSB staff were trained to actively search for leaks quickly and efficiently. Two inspectors of the WSSB were trained in the United Kingdom; one in leak detection and the other in metering. At the end of the project WSSB was left with a considerable amount of equipment such as stethoscopes, pipe and leak detectors, valve locators, two mobile wastemeters and the like. However, WSSB was not able to sustain any programme of leakage control and the equipment deteriorated out of service. In 1987 a German government (GTZ) assisted leak detection and repair study was carried out in two pilot areas in Kathmandu: Baneshwor and Maharjgunj covering an area of 260 hectares (about 4% of the supply area).

In spite of past efforts the water supply system of Greater Kathmandu has deficiencies in water quality and service levels. High levels of iron, manganese and ammonia in groundwater and pollution through infiltration of contaminants due to low pressure, intermittent supply, rapid urban growth, depletion of sources of water in the valley and excessive amounts of unaccounted for water are of grave concern.

To address the deficiencies in a comprehensive manner, His Majesty's Government of Nepal (HMGN) embarked on a Fifteen Year Development Program (FYDP) for NWSC. In Greater Kathmandu the FYDP proposes to extend the present 6-hour per day water supply to 24-hours by 2005. It is expected that the shortfall of supply would be achieved through rehabilitation of, and extensions to the existing water supply facilities, and development of new outside the valley, water sources. Improved operation and maintenance becomes imperative to manage the additional resources effectively. Improved and expanded wastewater facilities would be provided concurrently.

HMGN/NWSC recently negotiated with IDA a credit for US$ 60 million for a Water Supply and Sanitation Rehabilitation Project (WSSRP) to cover part of the first phase of the FYDP. The WSSRP focuses on activities to achieve managerial, financial and operational improvements and rehabilitation, extensions and improvements to the water/sewerage systems.

The water and sanitation sector efforts have been governed by HMGN's urban water supply and sanitation sector objectives to provide:

1. a 24-hour supply of affordable and safe drinking water to all the urban population by 2005;
2. affordable sewerage/sanitation facilities to the urban people by the year 2005; and
3. strengthening of NWSC's operational capabilities and financial viability.

Water Supply

At present, about half of the water supply to Kathmandu-Lalitpur comes from surface sources and the other half from tubewells (groundwater) from within the Kathmandu Valley. The supply is stored in four reservoirs servicing the two cities and distributed through a network of 50 mm to 800 mm diameter pipelines extending to about 300 km to cover an area of about 50 square kilometres and to serve a 1989 population of about 430,000 which is expected to rise to some 870,000 by the year 2005 and around 1.3 to 1.5 million by 2011. Water is currently being released from the reservoirs for only 3 hours each morning and evening, which provides many consumers, particularly those living in higher areas with water for only about half an hour during each period. There are approximately 55,000 connections in Kathmandu-Lalitpur of which 85% are metered; but 45% of the meters in Kathmandu and 30% in Lalitpur are believed to be defective and not functioning correctly. The original distribution system, about 100 years old, has been extended over the years and consists mainly of cast iron (CI) and ductile iron (DI) pipes with diameters of 80 mm to 800 mm and galvanized iron (GI) pipes for diameters less than 80 mm. The system has serious deficiencies and a very high proportion of unaccounted for or "lost" water which coupled with the inadequate supply from the existing sources creates a wide variation in pressures and levels of service. The intermittent supply causes water pressure in the mains to fall during non-supply hours and even to become negative allowing infiltration of contaminated groundwater into the mains through leaks in pipes or joints thereby posing a potentially serious health hazard.

Groundwater is being mined due to non-availability of surface sources within the valley. The surface waters being tapped at present are treated in four treatment plants while most of the groundwater, containing iron levels up to 6 mg/l and ammonia, receives only chlorination. When borehole water is mixed with treated surface water, iron flocculation occurs causing serious operational problems like choking of meters, reducing pipe sizes, odour and staining, consumer resistance to paying and meter tampering. Deficiencies in the distribution system result in some areas receiving less than the twice daily three-hour supply while a few locations enjoy a continuous 24 hour supply. The current demand is 54 mld and the supply 65 mld of which about 26 mld (40%) is unaccounted for water through losses in the system, wastage and theft. The "lost" water is estimated to increase to over 60% in the event that water is supplied 24 hours per day. The inadequate supply is augmented for public standpost users through tankers supplying water to small tanks located in areas of low pressure. The higher income residents have installed ground level and over head tanks to assure themselves of a de facto 24 hour-supply. Current procedures and practices for pipe laying, ferrule specification, testing and service connections are thought to contribute significantly to water losses.

NWSC's operation and maintenance (O & M) performance has been far from satisfactory. The organization lacks sufficient personnel adequately experienced in managing a water/sanitation utility. On-the-job training or formal training for middle and junior level staff to improve efficiency are lacking. NWSC has not yet developed standard practices for operations e.g. preventive maintenance, pipeline laying and maintenance, treatment and contract supervision. Despite past assistance, NWSC continues to repair only passive leaks, and much of the leak detection equipment is out of service and/or under utilised.

Major Constraints to Operation and Maintenance

The Nepal Water Supply Corporation currently suffers from serious financial and operational weaknesses, and is in need of widespread improvements in all departments. The organization is

expected to finance its operating expenses from tariff revenues. NWSC's annual revenues, currently about NRs. 34 million (US$ 1.36 m) falls far short of the present operational budget of about NRs. 66 million (US$ 2.64 m). This deficit has forced NWSC to make short term savings at the expense of quantity and quality of water and needed maintenance. The result has been a steady deterioration of service levels and growing customer dissatisfaction reflected in illegal connections, tampering with meters to avoid payment, blockage of meters due to poor water quality, other abuse of facilities by users, and large arrears in revenue collection, adversely affecting NWSC's cash flow.

Apart from financial resources, NWSC is weak in management, construction supervision, and operation and maintenance. Poor personnel management has resulted in overstaffing and low morale among the staff for whom proper training to develop their skills is not provided. Supervision by poorly motivated staff and poor procurement practices (based on lowest bid) and selection of materials for use without proper assessment have led to an inferior quality of the water/sewerage systems. This has been aggravated by increasing public demands on the system which has led to the laying of Spaghetti service connections buried at shallow depths with poorly jointed galvanised pipes. Substandard internal plumbing has also added to wastage of water as the low tariff structure, shown in Table I, does not provide an incentive to conserve water.

The situation continues to deteriorate as the groundwater sources in the Valley are being mined and the intermittent supply causes health hazards. There is an urgent need for improved utility management; to introduce sound groundwater management; address the reduction of unaccounted for water; augment the supplies; and improve water quality.

TABLE I

NWSC PRESENT AND PROPOSED TARIFFS

Tariffs for Metered Connections

Size of Connection (mm)	Minimum Quantity ('000 litres/month)	Minimum Charge (NRs.)		Rates for Additional Units (000 litres)(NRs.)	
		Present	Proposed	Present	Proposed
15	10/	7	7	1.20	2.50
20	27	28	88	1.20	3.25
25	50	56	200	1.20	4.00
40	140	168	665	1.20	4.75
50	235	280	1,293	1.20	5.50
75	700	840	4,200	1.20	6.00
100	1,400	1,680	8,400	1.20	6.00

1/ The minimum quantity in the proposed tariff is 5,000 litres for 15 mm connections only.

Tariffs for Unmetered Connections

Size of Connection (mm)	Tariff (NRs/month Present	Proposed
15	13	30
20	45	195
25	90	480
40	270	1,425
50	450	2,640
75	1,350	5,760
100	2,800	11,520

Operation and Maintenance Strategy

It is extremely important for Greater Kathmandu that proper management for water losses be instituted in NWSC. The past efforts in this respect have not been sustained. Leak detection and repair has always received less attention with greater emphasis being given to construction activities. This has resulted, as discussed earlier, in NWSC maintaining a passive leakage control policy relying on leaks spotted by inspectors or reported by beneficiaries. A gang, consisting of 3 to 4 persons (a plumber and labourers) is sent to repair the reported leaks and, presently repairs about one to two leaks per day. This is due mainly to lack of transportation. The Leak Detection and Repair Study provided under the German government assistance programme clearly showed that the skills learnt and practised during the programme did not continue to the same degree after the end of the project. Lack of incentive payments to leak repair gangs appear also to contribute to a marked deterioration in repair productivity.

The German assisted leak detection and repair study in two pilot areas in Baneshwor and Maharajgunj (divided into three sub-areas: Chandaul, Dhumbarahi and Ring Road - 1) show that with the twice daily intermittent supply about 20% of the supply is wasted, while about 40% is attributed to leakage. Because of intermittent supply and low pressure in the mains (0-10 m) an electronic leak detection project was not successful in the pilot areas. The study found (i) a low state of personnel training; (ii) poor organization and motivation; (iii) problems of transportation; (iv) difficulties procuring spare parts; and (v) lack of essential tools.

The Fifteen Year Development Programme stresses that the water supply to Greater Kathmandu can be improved only by adopting a programme approach that addresses both the physical rehabilitation and extension of existing water supply networks together with some sewerage and sanitation as well as augmentation of the systems and the software part that emphasizes management improvements and cost recovery. The Water Supply and Sanitation Rehabilitation Project (WSSRP) for greater Kathmandu includes management support to assist NWSC in improving management; operation and maintenance; a consumer education programme; training for

NWSC staff; assistance in future project preparation; detailed design and construction supervision; water supply rehabilitation, treatment; design of new sources for future water supplies in the Kathmandu Valley; sewer system rehabilitation and sanitation and the provision of central facilities such as vehicles, plant, equipment; and effective unaccounted for water management.

However, conventional leak detection and repair are not feasible for intermittent supplies and it will be some time before Greater Kathmandu can have a 24-hour supply. Therefore, NWSC has prepared a proposal to conduct a leak detection and control programme by pressurizing sub-zones in Greater Kathmandu. This strategy has already been carried out successfully in Madras, India where Metrowater has conducted a leak detection/repair survey. The results of this work have revealed significant leakages averaging 180 litres/connection/hour at 5 m pressure mainly at unsatisfactory ferrule connections and service pipes which account for 90% of the identified leaks. Repairs and retesting of selected areas indicated significant leakage reduction, up to 50% to 80% in some cases. This was achieved at a repair cost averaging US$ 42 per leak repair point resulting in a significant cost benefit for Metrowater.

In order to prevent excessive wastage of water, NWSC plans to establish a consumer education and community participation department as well as to develop programmes to install ballcocks on ground and roof storage tanks.

Results Achieved

It is obvious that no significant achievements in the way of operation and maintenance and management of unaccounted for water have been seen so far in the Greater Kathmandu water systems. However, the realization by the government and the Nepal Water Supply Corporation of the problems faced in the urban water sector and the endorsement of a comprehensive programme under the FYDP beginning with the IDA financed WSSRP is a positive step which it is hoped will bring about changes in NWSC to make it a competent water utility and that the leak detection effort will result in a sustained methodology appropriate for leak detection and repair for intermittent supplies.

OPERATION AND MAINTENANCE OF WATER SUPPLY AND SANITATION SYSTEMS IN BRAZIL

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Introduction

Sanitation services in Brazil are the responsibility of three different levels of government; Federal, State and Municipal. After the promulgation of the new Brazilian Constitution in October 1988 and when the new President took office in March 1990 these services were reorganized. There is a National Sanitation Secretary, subordinated to the Ministry of Social Action which is responsible for the definition of policies, guidelines and goals and the direction of the funds for this area. There is also a Financial Agency in the Ministry of Economy which is responsible for applications for funds.

The design, construction, operation and maintenance of the water supply and sanitation services is the mandate of the States and the individual Municipalities. There is a Company in every state which is responsible for the water supply and sanitation service for the various municipalities. In addition to these, in each state several municipalities operate and maintain their own services. In total there are twenty-six State Companies in Brazil which serve approximately 4500 towns and there are 2500 Municipal Services. The States Companies cover about 80% of the served population and the remaining 20% is served by the Municipal Services.

Levels of coverage for water supply and sewage vary throughout the country and the percentages of the population provided with water and sanitation services are presented in Table I.

The necessary investment to achieve the projected service level increase in water by the year 2000 is 8.3 billion US dollars while 2.6 billion US dollars will be required for sewage.

Table I

Region	Water (1989)	Sewage (1989)
North	80.7%	6.7%
North East	72.3%	8.1%
Middle West	75.2%	23.9%
South East	93.2%	60.0%
South	88.8%	16.2%

During the last twenty years only State Companies have received funds from the Federal Government. The Municipal Services relied on Municipal funds which were generally insufficient. This situation resulted in a marked difference in the quality of the service offered to the population. The State Companies had more technical and managerial resources than the Municipal Services and so provided higher levels of service. The new Federal Government is modifying this policy and intends in future to distribute funds directly to the municipalities to help improve their service levels. Currently privatization of facilities is being tested in Brazil. One of the sewage treatment plants in

São Paulo state is now totally operated and maintained by a private company and other states are considering similar experiments.

This privatization of water and sanitation systems has a lot to recommend it and may well be the most effective means of achieving more efficient operation and maintenance for water and sanitation facilities.

The Operation and Maintenance Programme

Traditionally, investments in water supply and sanitation in Brazil were made for system extensions and new construction. Large systems were constructed, mainly in water supply, to satisfy the great increase in urban population. When the facilities were completed it was necessary to develop an operation and maintenance structures, to sustain the services. The operation and maintenance programmes developed by the water and sanitation companies have the following overall goals.

- The improvement of established systems in order to postpone new construction.
- The reduction of operational expenses through the elimination of unnecessary wastages.
- The application of a uniform planning system to all the areas of the Companies involved in operation and maintenance.
- Reduction in unaccounted for water.
- To set a high level of preventative maintenance in order to increase the reliability and the regularity of the services.
- To establish operational standards that include designs incorporating local criteria.
- To develop new, more efficient and cost effective technologies.
- To improve operational security to reduce the number of accidents.

A new technical and management structure was created to achieve the improvements in operations and maintenance. This structure is directed by a general manager, assisted by a consultative council which comprises all the managers of the areas involved in operation and maintenance.

In order to institutionalize operation and maintenance programmes in the Companies as a permanent activity a number of steps were taken:

1. The programme was given priority in the Companies as one of the main activities.
2. A managerial structure was created for the programme.
3. An awareness campaign was established to demonstrate the benefits to the Company, Employees and Customers of the new O/M programme.
4. A training programme was initiated for the employees involved.

Unaccounted for Water and Los Control

Unaccounted for water is a major problem in operation and maintenance and an objective of the Brazil operation and maintenance programme is to reduce unaccounted for water. The experience of São Paulo site, the largest and most populous of the states is an example of how this

problem is being approached in Brazil. SABESP (The São Paulo State Water Supply and Sanitation Company) is responsible for operation and maintenance both in the metropolitan area of São Paulo and in other areas of the state.

In the metropolitan area of São Paulo current losses for 1992 are 40% compared to 36% in 1976, which was the year in which the loss control programme was initiated. The losses to the distributing system are as follows:

-	Total produced water	100,0%
-	Effectively used	80,0%
-	Accounted for	71,0%
-	Unaccounted for	9,0%
1)	Not registered by meter	6,0%
2)	Illegal connection/others	3,0%
-	Water not effectively used	20,0%
1)	Leakages/breakages from pipelines	6,0%
2)	House connection leakage	12,0%
3)	Overflow	2,0%

SABESP in the Metropolitan region of São Paulo covers an area of 8,500 km^2, treats up to 50 m^3/sec of water, operates 1000 kilometers of supply lines, and services 2.2 million metered connections. The urban population served is 15 million dispersed in 35 towns.

The water and sewage network is complex and in order to reduce losses the operations and maintenance programme is adopting a new strategy. The first step was a study which collected accurate data on the areas covered, system parameters such as pipe age and types of pipes, existing pressure ranges, leakages and geotechnical information.

Based on this information the following activities were undertaken:

1. Detection of non visible leaks in critical areas with high pressures, (more than 60 MCA) water distribution network age (more than 30 years) and zones with above average leakages and breakages.

2. Cleaning and cement mortar lining of pipelines older than 25 years which are non-coated and have low roughness coefficients.

3. Replacing galvanized iron house connections older than 10 years with high density polyethylenium

4. The replacement of pipelines in certain critical areas where age or pipe diameters made it prohibitive to rehabilitate by cleaning and lining.

To accurately determine losses, breakages and leakages in the São Paulo metropolitan area the company is employing a range of techniques and equipment.

1. Micrometers that were operating inadequately were replaced resulting in increases in measured water production up to 500 litre per second (1% of the measured volume in the metropolitan region of São Paulo).

2. Eighteen large meters were repaired and reactivated resulting in a gain of US 46,470 for the company.

3. The operational control system was made more efficient through the acquisition and reutilization of primary elements and pressure transmitters.

4. In order to improve pitometry for determining flows and pressures new prototype units were manufactured that provide for a greater accuracy and security for field workers. Metering of users' consumption was also improved.

5. The metering system was improved and a better reading accuracy was enforced.

   - Meters with capacities of 5, 7 and 20 m^3/h were eliminated thus reducing the costs of maintaining these items in stock;

   - It is proposed to manufacture, and test 1.5 m^3/h capacity meters in order to minimize manufacturing costs and guarantee the functioning of the instruments within their optimum range of nominal capacity;

- New selective criteria were established for meters maintenance. Currently the following criteria are used for replacement times.

  - up to 10 ^{3}/month... no replacement
  - 10 m^3 to 20 m^3/month... replacement every 13 years
  - more than 20 m^3/month... replacement every 10 years

The adoption of these new criteria have resulted in a gain of approximately US$4.335.000 a year, as compared to the former policy where meters were automatically replaced every five years.

In order to ensure material standardization and standardization on service connections, the programme:

- has purchased and established follow-up procedures for the replacement of 15,000 segments of galvanized iron in meter shelters with PVC and PAD ones.

- planned for the replacement of 36,000 galvanized iron house connections by PAD connections over a 10 year period.

In order to decrease water losses the company:

- has initiated a campaign asking the population to phone in reports of leakages. This has resulted in an increase of 20% in reports over the last 4 years.

- has repaired visible leakage faster through better usage of material and personnel. In 1986, 87,280 leakages occurred and the average time per repair was 33.5 hours. An operation called "LEAKAGE HUNTERS' has been established in the company. This group has 24 well equipped vehicles which are used to repair leaks in connections and pipelines of up to 100 mm diameter. The use of these vehicles has resulted in a reduction in the repair time to less than 24 hours in 95% of the registered cases.

- has searched for non visible leakages. There are 680 leaks reported per month and the programme has repaired 490 leakages a month on average. In order to detect and locate leaks acoustic and correlational detector and electronic and mechanic geophones are employed. French equipment DFO from METRAVIB and German DK 2000 from SEBA Dynatronic are the two most commonly used equipment units.

- The hydraulic performance of systems has been improved through a rehabilitation programme of cleaning and lining which allows for a better hydraulic capacity. The improvements measured by the coefficient "C" of the Hazen-Willian s formula, have been, on average in the range of 64 to 129, thus reaching values similar to those in new pipelines. Sixty kilometers of pipelines (diameters 200 to 1000 mm) were rehabilitated under the auspices of the programme by the end of 1989.

A number of general non-technical measures have also been undertaken to improve operational efficiency and cut down on losses to the system.

- The works at the Centro de Controle CCO (Operational Control Center) were improved. This Center has operated with the same lay-out, two COBRA 700 computes for 9 years. These computers have been replaced by two COBRA 1200 units with the inclusion of new video terminals, printers, software thus enabling the increase of 48 more telemetric points, predictable month consumption models etc.

- A study is underway on the feasibility of updating the telephone answering service system through automatization of its operation. By doing so we expect to deal faster with leakage information thus reducing the repair time and providing better services to the population and improving the company's image with the public.

- The programme to alert consumers to avoid water losses has been initiated.

- The company has been alerted to the fact that it is experiencing losses in sales of up to 3% due to special social tariffs which are being applied in squatter areas.

OPERATION AND MAINTENANCE OF URBAN AND PERI-URBAN WATER SUPPLY SYSTEMS

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Introduction

Strategically planned, systematic, and well organised operations and maintenance (O & M) afforded a high management priority, is an integral and essential factor in the successful operation of any water supply system. Failure to recognise its importance and consequent lack of attention to this function is a principal cause for the defective performance of many water undertakings throughout the world.

This paper reviews the major issues affecting operations and maintenance performance and presents the results of a survey of operation and maintenance practices in 9 Asian cities.

The paper concentrates on the situation in urban and peri-urban areas, largely because it is based upon information derived as the result of a questionnaire circulated to city water undertakings within the Asian region. The approach in urban areas, although similar in principle to rural, is governed by very different technical and physical considerations, and to try to deal with the two environments in tandem would have required continuous qualification in comments and conclusions. The paper recognises, however, the complementary and influential relationships between the effective management example of urban areas and improvement in the larger but less populated rural districts.

The paper emphasises the essential relationship between all disciplines of management; none can be effective in isolation. Therefore O & M is dependent upon Executive will in providing financial resources; management commitment to training skilled staff and applying its resources consistently to planned objectives; and effectiveness in obtaining reliable income from its customers to finance, wholly or partly, the carrying out of that management policy.

Well managed undertakings are dependent upon adequate resources and appropriately skilled staff at all levels. There is evidence that although management is of a high calibre at senior and middle
management levels, in many cases standards are far from consistently maintained throughout the lower strata where the 'hands on' work needs to be carried out.

Operation and Maintenance Practice and Development

Operation and maintenance are essential in safeguarding adequate drinking water supply. Most people recognise that in developing countries the operation and maintenance practice does not warrant priority. Fortunately, there is growing recognition that operation and maintenance is essential, both by planners and the financiers, as well as by the designers and operators of the water supply systems. Over the past decades many projects, achieved through very major financial and technical efforts, have performed insufficiently or broken down after only a short period of time.

Factors which may cause inadequate operation and maintenance include:

- insufficient awareness of the necessity of efficient operation and maintenance;
- inadequate management;
- lack of definition of responsibility for certain operation and maintenance tasks;
- inadequately educated and trained personnel;
- lack of operational information;
- shortage of spare parts;
- lack of funds;
- use of inappropriate technology which is difficult to maintain.

An additional cause of inadequate operation and maintenance can be that a system design has been inappropriately geared to the local circumstances and conditions. In many cases this results from insufficient consultation between planners and designers on the one hand, and the operators on the other.

Operation and maintenance practice must be systematically developed one step at a time. The policy and strategy of all bodies involved in protecting drinking water supply projects will need to concentrate increasingly on the importance of that aspect, as much as on the system itself. Managers will have to recognise the adverse effects of inefficient operation and maintenance. This may lead, directly or indirectly, to:

- serious faults in the water supply system;
- threats to public health;
- drop in income from water sales;
- high costs of renovation of the system or the need for additional investment;
- an adverse effect on public opinion;
- demotivation of the personnel involved.

The policy of authorities responsible for drinking water supply should aim at creating circumstances which are conducive to the development of efficient operation and maintenance.

General Approaches to Operation and Maintenance

It is customary for 'Operation' and 'Maintenance' to be discussed in combination, demonstrating that maintenance is an integral part of successful operations. The reason why efficient operation and maintenance are vital is simple: only in this way will supply systems function satisfactorily and continue to do so in the future; and equally, satisfy quality and quantity standards, meet guidelines including those of reliability and economic return, and comply with the overall policy laid down by a particular water supply company.

The definition of appropriate requirements is in itself a difficult question. In many industrialised countries the obligations of water supply companies are statutory and therefore outside their control. Each company is required to ensure that consumers receive an uninterrupted supply of drinking water 24 hours a day, in sufficient volume and under a stated pressure. Equally water quality must be maintained to nationally agreed-standards. This is reasonable and straightforward by definition, but far more difficult to satisfy in everyday practice. A number of important issues which affect the operation and maintenance of water supply facilities can be identified.

1. Reliability

In order to comply with requirements, a water supply system must be reliable from source to consumer. Only then can management satisfactorily meet its obligations, and this is one of its most important responsibilities.

But what is the correct assessment of 'reliable'? As in most management decisions, technical standards are important but are invariably influenced by financial considerations. Naturally also, the policy of the water company involved substantially determines the level of reliability required. The more consumers depend on the reliability of parts of a system, the higher the degree of reliability needed for those parts. The acceptable degree of reliability decreases from source to tap.

2. Costs

It is technically impossible to achieve 100% reliability even if finance were no object; however, inevitably finance is always a factor to take into account. Management has the responsibility to operate a company with financial prudence, no matter whether it be public or private. Water tariffs must be accepted as reasonable and fair by consumers, but set at a level to enable management to operate effectively and plan for long-term investment.

The desired degree of reliability largely influences how operation and maintenance are executed. The higher the standard, the more money must be spent on design as well as operation and maintenance. Simply, total investment costs and the costs of operation must be optimised. Economy in maintenance generally results in higher costs ultimately. Equally, sound design can substantially reduce maintenance costs.

3. Design

When planning a water supply system, the method of supply is determined by the available source and on the basis of a number of fundamental requirements - capacities, quality, catchment area, population to be served.

On the other hand, operational performance and concept allow scope for broad range of alternatives. The selection of system components must be made with great care, particularly in relation to maintenance requirements. Equally the selection of pipeline materials is as important as the choice of pumps or the decision on the overall operational system itself.

The essential basis for long term and smoothly operating supply systems is good initial design.

4. Preventive Maintenance

It is self evident that maintenance involves much more than merely making emergency repairs in the event of faults or malfunctions. Systems and installations will only perform reliably and consistently when preventive maintenance is carried out regularly.

Preventive maintenance involves carrying out a programme of work according to a predetermined schedule for each section of the water supply system, and on a regular calendar basis.

The design of an effective maintenance schedule requires experience and practical expertise. This means that the practical operators of the system should have a considered input into, and influence on, the design of a schedule and on its re-assessment; it should not be static, but must be varied with experience, being tested regularly against practical circumstances. For this reason it is impractical to provide standard set rules in perpetuity.

Naturally the directions for maintenance provided by the suppliers of systems components, for instance, mechanical and electrical equipment, will be incorporated in any maintenance schedule. However, even these need to be tested in practice and consequently the schedule must be dynamic and flexible.

The important criteria for evaluation of any schedule is simply, the level and number of faults in production and distribution. This requires accurate recording and analysis of malfunctions; no more so than in the case of technically complex and sensitive purification systems with a multiplicity of components and expensive metering devices which are prone to operational defects.

Preventive maintenance to achieve optimum operational efficiency of an installation is a precondition for success.

5. Rehabilitation

Maintenance and repair of systems can prolong their operational life but only for a finite period. Ultimately the cost of maintenance will become uneconomic because of frequency of faults, and replacement will be necessary. Thus cost evaluation is important, but the most efficient and planned maintenance and replacement policies which keep systems in working order over extended periods, should not preclude, if appropriate, the replacement of a system that has become dilapidated, although still functional.

This radical assessment needs to be made periodically, for in many cases the practical and technically functional span of a system exceeds its economic relevance. This happens particularly where maintenance has been carried out diligently and correctly. Systems may become obsolete earlier than expected because of quality requirements or reliability needs, and management must always be sensitive to the balance between technical and economic considerations.

6. Quality

Water quality monitoring is a comprehensive and vital element in operations. Surface water supplied by means of extensive distribution networks demands that numerous samples are taken and that a wide range of parameters are monitored. Chemical, bacteriological and biological testing must be widely executed. Water quality can easily deteriorate in a distribution system and systematic testing is essential if the most important aim of bacteriological reliability of water supply is to be safeguarded.

Water quality investigation needs fully equipped laboratory resources and qualified personnel. Normally water supply companies maintain their own laboratory services, although some are shared with other utilities. It is important that water quality monitoring is organised on an independent managerial basis so that its objectivity is absolute in assessing the needs and requirements for the protection of consumers.

7. Spare Parts

Without a planned and comprehensive supply of the required spare parts and repair sets, effective, timely and technically correct maintenance is not possible. The quantity of spare parts available for each of the countless technical components which are part of the water supply system must be assessed so that they are always available at the time they are needed and that stocks are kept at a sensibly larger level than immediately required.

The stock should be determined by the frequency of the occurring malfunctions of a component and the delivery period of spare parts. Excessive stock occupies space and is expensive. It goes without saying that not only quantities must be assessed correctly, but that quality also demands close attention. Spare parts and repair sets can be stocked either centrally or strategically, or in a combination of the two. This must depend on the size and the organization of the water supply company. With large companies, the purchase of materials, and stock management, are often the responsibility of a separate section within the organization, to achieve proper economics of scale in purchasing.

An important aspect of materials supply is standardization. The number of spare parts can be reduced substantially when less dissimilar components of the water supply system are chosen. Standardization is most effective when applied to components of the distribution network, which are large in quantity: pipes, water-meters, valves, hydrants. Standardization of system components means reducing costs, higher quality of service, and increased reliability. Material and spare parts management is therefore a specific and important activity in operation.

Water Supply Quality

The quality of the water supply source is an important factor influencing the operations and maintenance process and programme. If the water at source is clean and free of impurities then the required treatment will be minimal reducing the costs and complexity of the treatment system and thus reducing O & M requirements.

Water sources are fundamental to any water supply system and must provide the highest degree of reliability. This is why protection of sources against pollution is vital. Frequently, however, sources are not owned by the water company and management's control over them is therefore circumscribed. In such cases national or even international agreements are required to provide the necessary protection.

Surface water sources are particularly vulnerable. Where a river source flows through industrial or densely populated areas, maintaining quality is a continuous problem, accentuated by the risk of incidental pollution whose likely effects must be anticipated and planned against. When pollution does occur it may be necessary to suspend the intake source for a period.

Monitoring of surface sources is particularly important, not only at the intake point, but by regular inspections upstream. This is necessary so that quality problems can be assessed and if deterioration has occurred, action can be taken to protect supply, by whatever appropriate means, possibly by suspension of water abstraction. This demonstrates the need for adequate storage provision which is a basic requirement in the situation where water comes from surface supplies. Storage may be achieved in open reservoirs or underground by means of artificial infiltration. Protection of these storage resources and quality control are major management responsibilities.

The importance of protection and quality also applies in the case of reservoirs even when they are located in remote areas. Quality must be the criterion of whether or not, or to what extent, leisure activities are permitted on reservoirs.

Groundwater sources are less vulnerable to pollution than surface water. Catchment pollution is only likely to infiltrate abstraction wells after a protracted period. Nevertheless, protection zones around wells are necessary in which certain activities are prohibited or regulated. The flow of water in the direction of supply sources must be consistently monitored.

Some potential damage to groundwater supplies is very long-term, and in this respect even more serious, because once adverse effects are detected, there is no immediate counter solution. The concentrated use of nitrates for agriculture, for instance, has an accumulative effect on groundwater sources. It may take years for harmful build up of nitrates in the soil to become sufficiently obvious to be detected, but one this has happened, there is no method of protecting sources. The neutralisation of nitrates in water supply by treatment from an affected source is extremely costly, and brings into question whether it is right that a water supplier, and therefore its customers, should have to bear the cost rather than agriculture which causes the problem. It is a vexed question, but clearly prevention is preferable, and more economic, than cure. For this reason monitoring and control in the catchment area of an underground sources is of the utmost importance.

Underground sources may be extensive, but if they are to be exploited effectively and without detriment to other environmental factors, their levels and flow patterns should be monitored to gain knowledge of their character and fluctuations over a period of time.

If the water at source is not potable then some form of water treatment is required. Generally, a purification process comprises a number of successive steps. However, groundwater supplies may require little more than limited aeration and rapid sand filtration. In the case of a chemical-physical purification process, there may be elements such as flocculating, sedimentation, ozonization, activated carbon filtration, rapid sand filtration, disinfection and dosing with various chemicals.

In all circumstances it is necessary to guarantee that the clean water satisfies quality requirements in a continuous and consistent manner, and that production is uninterrupted. To achieve satisfactory results in a purification system it is necessary to ensure that supply to it is provided in a consistent volume and flow. Intermittent fluctuations in flow to the installation disrupt the purification process and consequently affect the end quality of product.

In general, the aim is to purify the daily demand over a 24 hour period. To meet hourly fluctuations in demand, drinking water is stored in clear water reservoirs overnight. Even when the designed capacity of the installation is not in demand, the daily output must be achieved in a consistent and even manner. In a non-automated system this will require the attention of the operator who should not be tempted to keep the clear water reservoirs filled to capacity. The problem in these circumstances is that demand has to be estimated, and accurate assessments are normally the result of experience in manual systems, although where fully automated systems are in use they can be calculated statistically.

The aims of balancing quality and quantity cannot be achieved without sufficient and proper insight into the course of the process. Consequently, process control must stem from proper data collection. The frequency of various measurements may vary widely, from continuous through to

the periodic of hourly, daily or weekly checks. Whatever the schedule, however, it must be very carefully designed.

Where a process is not fully automated, an installation is controlled by the operators on the basis of primary measuring data. This requires sufficient data about the automated parts of the process to enable the operator to monitor the operation and take any corrective action required.

As the process becomes more sophisticated, the range and variation of process data increases, sometimes to the point where it cannot easily be interpreted. In this situation there is a surplus of data that remains unused. This is an unsatisfactory, although not uncommon situation, and clearly it is necessary for all data to be processed if the performance of the installation and the effectiveness of the purification process is to be properly assessed. It is particularly important that any malfunctions or deviations in quality are catalogued and analyzed. Automation and information systems play an increasingly important role in optimising operations as the demands upon a system increase.

Special care and diligence is required when using chemicals in a purification process. Chemicals may be purchased 'off the shelf' from suppliers or as semi ready products. In the latter case, requiring blending by operatives, there are clearly increased dangers of mistakes, and it is not recommended other than where there are significant financial advantages and staff are qualified to produce the end product, or where there is no alternative because the required chemical composition is unavailable on the market.

The chemicals supplied must be checked against quality specifications for purity and composition. Adequate stocks to meet treatment demand must always be maintained, with sufficient surplus to maintain uninterrupted treatment in unforeseen circumstances, such as delivery problems with suppliers. Inevitably, the size of stock maintained will be governed by the suppliers' delivery capacity.

The principal problem in using chemicals is to meter accurately any dosage. Strengths must be adapted to achieve desired quality, and to maintain that quality in relation to quantity. The installation of reliable and accurate measuring and metering equipment is the precondition of sound operation, complemented by rigorous performance control and regular and intensive maintenance of equipment.

Whenever chemicals are used, there is always problem of potential hazard to staff. Often chemicals may be injurious to health and this should always be taken into account when designing a system. Strict safety regulation should be enforced, backed by educational material to bring attention to the handling risks and to minimise accidents.

Supply and Distribution

The method adopted in operating a pumping and distribution system is largely determined by the size and configuration of the distribution system and the variations in level in the service area. Consequently, a wide variety of operating systems can be employed, ranging from simple manually controlled to fully automated and computer operated. The demand for water in any service area fluctuates from hour to hour. Generally the minimum hourly use is not less than 1% of the daily use, while the maximum hourly use can be as high as 10%.

Optimum performance of a system - reservoirs, pumping stations, distribution networks - is needed to react to and meet these fluctuations. By optimisation is meant the ability to meet demand under predetermined pressure and to quality standards, but in the most economical way in terms of cost. These factors should be fully taken into account in the design of a distribution system. Nevertheless there is always scope for maximising results through sound operational control by staff. Where operational systems are manual, or only partly automated, the operator must be given clear guidelines on the methods of adjusting the pumping regime on the basis of available data. In the case of large pumping stations and extensive distribution networks, a vast amount of data is needed relating to volume and flow levels and energy consumption. Automation, computer aided operation and centralised control are increasingly applied to achieve the most effective and economic control of such large systems. It remains the operator's responsibility to monitor production and distribution, interpret the data, and adjust the system if necessary to keep within operating parameters.

When pumping stations rely upon electric pumps provided with power by outside agencies, it is necessary to make contingency plans for a possible breakdown in power supply. Standby generation independent of electricity is needed so that service can be maintained in the event of power failure, although this may be at a diminished level.

The necessary output capacity of such an emergency power system is determined by a number of factors: these include safety, availability of water from other sources, alternative pumping installations, and the economics of providing and maintaining such standby arrangements. In any event it would be unusual to provide cover to produce 100% back-up, and some 80% of normal hourly delivery is a more realistic target for emergency operation.

The distribution network of any water supply company normally represents some 75% of its total capital investment. In itself this statistic provides an obvious reason why it is prudent management and financial practice to maintain the network in the highest possible state of repair. It is equally important from the technical reasons of minimising leakage; containing interruptions to supply; and ensuring that quality is not affected during distribution.

Maintenance of distribution networks encompasses a wide variety of tasks. Apart from regular inspection of the network, including periodic checks of valves and hydrants, maintenance includes routine cleaning, rehabilitation and repair.

The regular cleaning of pipes is critical to efficient operation. Water being transferred through pipes, and the pipes themselves, may become polluted in several ways. Corrosion in old cast-iron pipes is common, resulting in a loss of capacity from rust formation, and rust particles being present in water through the tap. Other pollution arises from organic or bacteriological causes, or over long storage in the network. Various techniques can be applied to clean pipes: flushing with water; with water and air; by the use of foam balls; or by mechanical methods.

Normally, cleaning is carried out intermittently according to need, but some policies involve systematic flushing on a regular basis where conditions demand such attention.

Pipes may also require replacement for technical, financial or qualitative reasons. If the reason is corrosion, a suitable alternative may be relining. This is usually applied where serious growth has occurred in old cast-iron pipes as a result of rust formation and lime deposits. Cement lining is widely used and can provide a pipeline with many years of additional serviceable life. The

decision between replacement and relining requires careful study, and must take into consideration costs balanced against operational and technical factors. It is rarely a straightforward or self evident choice.

Repairing pipes through leaks or bursts is the most usual on-going maintenance activity. These faults develop as a result of many different internal and external stresses, and occur frequently in all networks, both new and old. The first reaction is always to repair the fault as quickly as possible. Every company must operate an emergency system with standby crews available day or night with a back up of necessary equipment and materials. Advanced means of communication and specially fitted transport are invaluable in these circumstances.

Contractors are often engaged to deal with major bursts or leakages in larger mains which require the use of heavy equipment. In every repair there is a risk of pollution, and strict hygienic and operational codes for the workforce are needed to prevent or minimise this problem. The disinfection of pipes should be standard procedure after any repair.

Well functioning pipeline management is impossible without reliable pipeline registration: it is fundamental that management must know where its network runs and have details of its technical character. Registration records the geographical location of pipes, the valves, the hydrants, the connections, the sources of supply. It should also give topographic references and make it possible to show the location of pipes relative to the topography.

Pipe registration is still predominantly carried out by conventional methods requiring detailed plans and maps. However, increasingly it is being automated by means of digital mapping, giving instant and more accurate information than ever before.

Computerization

Computers play an increasingly important role in drinking water supply management. For many years they have featured in the administrative and financial management of water companies.

Nevertheless their employment in the technical and operational spheres of management has been slower in becoming established. Only over the last fifteen years has the use of computers for operational management been widely accepted.

There is no doubt that this trend will develop at a very rapid pace in the years ahead, for a number of reasons:

- demand for better quality, operational efficiency and reliability;
- the need for up-to-date reliable information to achieve those ends;
- the increasing complexity of purification systems;
- the need for simulation models for supply and distribution systems;
- centralisation, telemetry and remote control;
- laboratory data management;
- digital mapping of distribution networks.

The case for increased use of computers in new supply systems is difficult to dispute. However, it is much more difficult to assess the merits of introduction to existing systems, and this can only be done after thorough evaluation of individual circumstances, taking into account financial

and technical considerations. But not only these, for computerization has considerable impact on personnel management and staffing in general.

It is important to remember that computers and computer systems are expensive. Any system must be geared in its degree of sophistication to the job it has to do. It is easy for management to become over enthusiastic and introduce systems with capacities far beyond the immediate needs of the role they are to perform. This can be a very costly error.

Organizational Aspects

Operation and maintenance not only require the appropriate technical resources, but also trained and qualified personnel. The management framework of the organization depends on the size and the complexity of the water supply system. The direct responsibility for operation and maintenance lies with the company's technical department. But the administrative department also has an important function. Administrative sections such as Personnel, Budgeting, Purchasing, Accounting, Consumer Relations, Public Relations, Billing, Administrative Automation have functional links with operations and maintenance units.

Generally the technical department is subdivided into at least two sections: Operations and Engineering. In that case Operation includes production, distribution, quality control and maintenance. Often these activities are organized in separate sections with their own responsibilities and competencies.

Equally as important as a good organization and a clear distinction between disciplines, is the availability of highly qualified and motivated people. The number of employees of different levels of education must be well-balanced. The best top management cannot fulfil its task if the middle management is under-staffed. Middle management needs sufficient and qualified personnel. Often external training is not sufficiently geared to the job requirements of a water supply company. Personnel have to acquire experience as well as knowledge within the company. Many companies have in-house training facilities or use jointly organised external training.

Most functions are carried out by in-house employees, particularly in the case of operational requirements. Certain maintenance activities are sometimes contracted out to third parties, for instance, the maintenance of specific electronic equipment. But the main consideration in the choice between internal and external maintenance must always be the aim of continuity and quality of the water supply. It is a situation where the cheapest is not always the best, nor the most economic in the longer term.

Practice of Operation and Maintenance Practices in the Asian Region

To obtain an assessment of the operational situation in the Asian region related to public drinking water supply, a questionnaire was sent to water authorities involved in 12 Asian regions. Completed questionnaires on 9 urban service areas from 7 countries were received. These concerned the drinking water supply of Shanghai, Taipei, Bangkok, Hong Kong. Singapore, New Delhi, Bandung, Semarang and Surakarta.

A summary of the answers received from questions aimed at obtaining indications of the operation and maintenance situation is set out below:

- The percentage of 'unaccounted for' water lies between 20 and 43 (with two exceptions: Singapore 11% and Shanghai 7.7%). The lowest most favourable figure relates to the Shanghai water supply and can be regarded as related to that City's specific circumstances.
- All companies have metered terminals and all implement meter exchange programmes. In eight companies maintenance is carried out in-house; only one company contracted out these activities.
- Eight out of the nine companies have some form of corrosion control programme.
- All companies have laboratories. Eight of these laboratories are equipped with advanced analysis facilities.
- All nine companies observe the water quality standards of the WHO, national standards, or both.
- All companies operate maintenance schemes and carry out preventive maintenance. Five companies answered positively to the question about standby teams for operation and maintenance of treatment and pumping installations.
- Standardisation of spare parts for distribution systems has been introduced in all companies. This applies equally to treatment and pumping systems in all but one company.
- All companies clean pipeline systems periodically by flushing with water.
- All companies have renovation programmes for distribution networks.
- One company is involved in carrying out maintenance of household installations.
- All companies have active leak detection programmes.
- All companies use computers for technical and administrative purposes. Five out of nine companies use computers for pumping control. Computerised water treatment control systems are operational in four companies.
- All companies have emergency planning programmes.
- Meter reading periods range between one and four months.
- All companies organise internal and external training courses in operation and maintenance for their personnel

The overall impression of the operation and maintenance practices of the companies which responded to the survey is one of positive commitment. Certainly there is clear evidence of efficient management at the higher levels; there is perhaps some suspicion interpreting variations in statistical return, that this efficiency may not be translated into the lower management levels. Clearly there are favourable indications of continuing development in all companies which individually indicate positive prospects for the region as a whole.

Recommendations for Improving Operations and Maintenance

A water supply company is usually a public utility. More than in any other industry, a public utility has to give service to the people in the literal sense of the word. In this respect service from a water supply company means a continuous supply of drinking water in sufficient quantity, of safe quality and at reasonable cost. To meet those targets, four basic requirements are necessary:

- appropriate design of the water supply system;
- optimised operation of the system;
- intensive maintenance of the system;
- qualified human resources to manage the system.

None of these conditions is less important than the others. A water supply system designed with utmost care, but ineffectively operated or insufficiently maintained, will fail sooner or later.

Operation and maintenance are continuous activities which need qualified personnel and special and everlasting attention of the management.

The following recommendations are made as necessary prerequisites for the successful operation and maintenance of a water supply facility.

- The first step towards an effective operation and maintenance policy must be taken by the management. If the management does not accept a high priority for operation and maintenance, the quality of the water supply will inevitably deteriorate. Sooner or later, technical apparatus is bound to fail and water supply standards will fail with it. For that reason alone management must give their undivided attention to this aspect of their responsibilities. This is not so much a recommendation, as an absolute precondition.
- Operation and maintenance should have a recognisable and individual function with appropriate management status and support staff of qualified levels within an organization's management structure. An effective policy recognising O & M is impossible without management which is totally in sympathy with the company's task. Executive control should decide and establish policy and them allow managers to carry out the task.
- As a function Personnel is no less important than any other arm of the organization. Personnel should be competent; well trained; understand their task and authority and be motivated.
- Management should create a situation which enables them to employ competent and motivated personnel. The methods to achieve this include:

    - education and training; technical skill development;
    - clear definition of tasks and delegated authority to carry them out;
    - clear instructions and job description;
    - clear administrative procedures;
    - availability of technical means;
    - progress consultation;
    - suitable working conditions;
    - internal company guidelines.

- Management and personnel must maintain dialogue to ensure compliance with defined rules and regulations and to effect modifications as and when appropriate.
- The financial and administrative management should be closely involved in the operation and maintenance tasks. Sound company operation depends upon a comprehensive and accurate registration and appraisal of all technical responsibilities and activities.
- Water charges should be geared to a level necessary for returns to cover the total annual capital costs and operational expenses. It is important that this income should be used exclusively for water projects and expenditure.
- Financial policy should take into account that initially new systems may cost more to operate because of teething problems. These exceptional costs should be included as part of capital installation expenditure. Once established, the operating costs of new systems should decrease with experience. They will however, start to rise again with the age of the plant and resulting need for increased levels of maintenance.
- The operational functions of a water supply company should embrace public relations and consumer relations responsibilities. These are required to keep the public properly informed about the company and its policies, as well as to establish a good rapport and reputation. The latter depends on the company supplying a good and reliable product, and important

precondition of which is that operation and maintenance are carried out effectively to ensure minium interruption of service and consistent standards.

- The importance of operation and maintenance should be taken into account at the design stage of a water supply system. This will influence both the choice of system components - abstraction, purification, transport and distribution - and the materials to be employed. Saving on initial outlay may increase maintenance costs subsequently. A basic aim should be to make the system as uncomplicated as possible and to use materials for components of first class 'maintenance friendly' quality. Experience supports the need to keep individual components and functional units separate from each other for ease of maintenance or repair. Initial costs should not be the sole or most important criterion in the selection of units.
- Genuine consultation between planners, designers and operation and maintenance management is needed to realise a design which is optimally geared to economic use, practical operation and financial return. Gravity systems are preferable in general, but if not feasible, electrical supply is preferred to other alternatives.
- Generally speaking it is recommended to apply 'the best available technology' in order to achieve an optimum blend of 'appropriate' and 'advanced' technology. A choice should reflect an assessment based on practical experience of O & M requirements from different countries and under varying conditions.
- An analysis of all technical components of the water supply system and their reliability and life expectancy should be drawn up to ensure which and what quantity of spare parts should be available in order to guarantee the continuity of water supply.
- Management should pay specific attention to collecting and processing relevant data on the full range of company responsibilities and its performance. In the specific field of operation and maintenance a clear insight should be obtained into the performance of:
- Water purification process;
- Production;
- Water supply;
- water quality;

The assimilation data should be processed into easily understandable periodical reports for various levels of management and executive personnel. Dependent on need, these could be daily, weekly or monthly reports.

- Each company should have at least one laboratory with appropriate facilities and qualified personnel required to adequately manage and control purification process and to periodically test the water quality against the set primary quality standards.

- The water should be sampled regularly both at the source of the distribution system and in the distribution system itself. For this purpose schedules are required indicating the sampling locations, sampling frequency and the parameters to be analysed.

Conclusions

The following most important considerations should always be taken into account when developing a sustainable O & M policy:

- the essential basis for long term and smoothly operating supply systems is sound initial design;
- good design should not be assessed on the basis of initial financial outlay. Many other factors should be taken into account including the important aspect of ease of future maintenance at reasonable cost;
- positive support at executive level in allocating necessary funds and enthusiasm at the managerial level for devising and implementing O & M policy are vital to its success;
- a precondition for the protection of a water supply system is good operation and maintenance practice;
- operation and maintenance tasks require a well structured organization with trained and qualified personnel;
- preventative maintenance to achieve optimum efficiency in a supply system is essential for its continuous success;
- comprehensive water quality monitoring is a vital element in operating efficiency;
- data collection on the day to day production and distribution process is a basic need for good operation and maintenance;
- effective maintenance of the distribution system is not possible without network mapping;
- adequate spare parts and appropriate equipment are a prerequisite of proper maintenance;
- effective operation and maintenance are not attainable without financial and administrative support and supervision;

Information obtained about the level of drinking water supply in 9 urban areas in the Asian region gives reason for optimism for future development. It is expected that in the long term this situation will have a stimulating influence on the development of service levels in rural of areas of the countries involved.

Operation and maintenance should have well defined aims and objectives and be established as a management function in its own right. Nevertheless it should be an integral part of the overall management strategy of the water undertaking, complementing other management responsibilities. Its function is to contribute to the effective and economic management of the organization with the result of providing a safe consistent water supply service at the most economic price, to as many consumers as possible.

The practical operation of maintaining service, monitoring standards, and providing water at consistent levels is greatly facilitated by regular and planned maintenance. The level and degree of this maintenance, the policy of replacement of new parts, the assessment of when the cost of maintenance reaches uneconomic levels compared with replacement expenditure, are management decisions requiring experience and technical knowledge.

It is important for the success of any policy that the best available technology is selected: not necessarily the cheapest; not necessarily the most expensive; not necessarily the most technically advanced. But the most appropriate to prevailing local conditions and to the task that it has to perform.

This requires consultation between managers of technical and financial disciplines, and also those who will have responsibility for operating the system. It means being able to consider all available alternatives, and not being restricted to any particular recommended solution.

The growth in urban cities world wide is an unrelenting problem. Experience proves that improvement in facilities to ease existing problems tends to attract an even larger population through immigration from rural areas, and increased birthrates and lower mortality through better health and hygiene. Consequently planned improvements quickly become inadequate. This trend is increasing and negates the theory that improving rural facilities in itself discourages movement into urban areas.

Management strategy should adopt the complementary aims of improving and more efficiently utilising existing facilities and resources including manpower, and where necessary, expanding services and systems to improve inadequately served areas and to bring supplies to new ones.

These aims demand the interaction of a wide range of individual management responsibilities and technical skills, since none in isolation can achieve significant improvement. The development of technical capacity will not be possible without sound financial policy and management. Such development on an institutional scale depends on these two spheres - technical and financial - being treated with equal emphasis and priority.

The management thrust to achieve improvement and development should be directed towards:

- institutional development capacity improvement, both technical and financial;
- information exchange and dissemination of country-wide experience, research and models to reach all levels;
- undertaking applied research, especially in the areas of reducing after loss, conservation and recycling, and developing suitable models for delivering basic services to low income communities;
- user involvement, community participation and partnership with other interests, including the private sector;
- choice of technology and level of service based on willingness and ability to pay rather than lower cost;
- the underlying defect in many areas is weakness of management capability, although as already stressed, the returns show that in the Asian cities which responded, management at the higher levels was impressive. Nevertheless training of staff should be a consistent and important exercise and is fundamental to achieving the required management goal.
  Within the context of institutional planning the following are important:
- the establishment of programmes for improved, systematic operation and maintenance practices;
- improving metering, billing and collection;
- developing and strengthening of units for water quality surveillance including setting up laboratories;
- development and strengthening of units for setting standards, promotion of local materials and methods and quality certification through testing;
- setting up special units within water supply utilities to work with community organizations;
- setting up systems for exchange and communication of country experiences and practices and sector information in general at all levels and the promotion of in-service training.

Policy objectives within an overall strategy are important, but their success or failure will depend on the correct technical selection of equipment and systems to achieve these ends economically and with minimum recurring problems.

Management strategy should also take into account the growing environmental considerations which are becoming increasingly important world wide. Designs should be chosen which minimise waste and are most economic in the use of chemicals whose disposal could affect the environment.

In the context of broad environmental management there is little doubt that the future will require an integrated management approach embracing the problems of water supply, sewage disposal, sanitation, and solid waste disposal. This is inevitable if the problems of pollution are to be contained and the world is to enjoy a more wholesome living environment.

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STRATEGIES FOR SUSTAINABILITY

1) A project proposal has since been prepared by the Provincial and District Water and Sanitation Sub-committees to run for 5 years.

2) Emphasis will be put on the training of extension workers using participatory methodologies in an effort to facilitate replication of CBM and also to reduce costs.

3) DDF through its normal supervision activities should also visit and follow up on trained mechanics and not view CBM as a separate endity.

4) With funds now channelled to the RDC it will be easier to plan more effectively.

5) The RDC should now seriously think of taking the management of village mechanics.