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COMMUNITY WATER SUPPLY AND SANITATION

SUSTAINABLE OPERATIONS AND MAINTENANCE OF RURAL WATER SUPPLIES IN THE SUDAN

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SUSTAINABLE OPERATION AND MAINTENANCE OF RURAL WATER SUPPLIES IN THE SUDAN

Edited by:

H.J. McPHERSON
University of Alberta
A. LIVINGSTONE
World University Service of Canada
Y.A. MOHAMED
Institute of Environmental Studies, University of Khartoum
M. LIAO
University of Alberta

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List of Acronyms

AMREF	African Medical Research Foundation
CIDA	Canadian International Development Agency
DANIDA	Danish International Development Agency
ESA	External Support Agency
FINNIDA	Finnish International Development Agency
GOS	Government of Sudan
GTZ	Gerellschaft Fur Technische Zusammenarbeit
KFW	Reconstruction Loan Corporation, Federal Republic of Germany
KWAHO	Kenya Water and Health Organization
LBDA	Lake Basin Development Authority
IFAD	International Fund for Agricultural Development
IRC	International Reference Centre The Hague
MHPU	Ministry of Housing and Public Utilities
MOH	Ministry of Health
NGO	Non Government Organization

NCDRWR	National Corporation for the Development of Rural Water Resources (now NRWC)
NRWC	National Rural Water Corporation
NUWC	National Urban Water Corporation
PROWESS	Promotion of the Role of Women in Water and Environmental Sanitation Service
RWSG-EA	Regional Water Supply Group - East Africa
SIDA	Swedish International Development Agency
UNDP	United Nations Development Programme
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Childrens Fund
US AID	United States Agency for International Development
VLOM	Village Level Operation and Maintenance
WADS	Water Resources Assessment and Development in the Sudan
WASH	Water and Sanitation For Health Project
WHO	World Health Organization
WUSC	World University Service of Canada

PREFACE

The need to ensure the sustainability of water supply systems once built has become a priority issue for international organizations, external support agencies, developing country governments and everyone involved with the provision of water supplies.

Most of all it is a vital concern of the recipients whose faith in the development process may be destroyed if a much needed and valued water system breaks down after its installation and is not repaired.

Proper operation and maintenance of water supplies is the key to sustainability and local governments and external support agencies, alarmed at the high rate of failure and breakdown of water supply facilities are devoting considerable efforts and energies to finding solutions to the operation and maintenance problem.

Nowhere is the situation more urgent than in the Sudan. The lack of an effective, coordinated operation and maintenance programme combined with the natural aging of systems has resulted in a serious deterioration of rural water supply facilities. There are approximately 3000 wateryards in the Sudan and over 80 per cent require rehabilitation.

The Sudan does not have a policy or consistent operation and maintenance strategy. Over the years a variety of approaches have been tried with varying degrees of success. These attempts have resulted in a wealth of accumulated experience with the operation and maintenance problem.

From May 14 to May 17 1989, a conference on Operation and Maintenance was held in Khartoum. The objective of the conference was to bring together people from the water sector in the Sudan with representatives of external support agencies and individuals with experience in operation and maintenance from outside the Sudan to review the operation and maintenance issue for rural water supplies and to develop a plan of action for tackling the problem.

The conference was extremely well attended and included representatives from the National Rural Water Corporation and from all of the major external support agencies active in the sector in the Sudan. The importance attached to this conference by the Government of the Sudan was evidenced by the very supportive opening address given by the Minister of Irrigation and Water Resources.

The quality of the presented papers was so high and the contained information was felt to be so valuable that it was decided to publish them. This publication is a compendium of the papers given at the conference together with a summary of the major issues raised in the presentations and in the discussions.

The conference was jointly sponsored by the Canadian International Development Agency and the United States Agency for International Development and organized by the Institute of Environmental Studies University of Khartoum and the World University Service of Canada. Special thanks are due to Mr. Frank Gilbert, the US AID programme director in the Sudan and to Mr. Brian Grover, Head of the Water Sector, Canadian International Development Agency for their support.

The World Health Organization has long recognized the need for effective operation and maintenance programmes to guarantee the continued sustainability of water systems. The Community Water

Supply and Sanitation Unit of WHO is presently executing a programme to focus attention on the operation and maintenance issue and to develop more effective strategies.

The World Health Organization agreed to publish the proceedings of the conference and very special thanks are due to the Community Water Supply and Sanitation Unit at the Organization's headquarters and to the World Health Organization Regional Office for the Eastern Mediterranean.

OPENING ADDRESS

Mahmoud Bashir Gamaa
Minister of Irrigation and Water Resources

It gives me great pleasure to welcome you to this opening session of this very important Conference in which you will discuss one of the most pressing problems that faces our people in the rural areas - the problem of the management and maintenance of water supplies.

For a number of years, the greatest emphasis was given to construction and erection of new water sources while operation and maintenance was neglected or left to various initiatives by the authorities or by the local people.

In recent years and as a result of drought, traditional sources dried up and wateryards faced a great deal of pressure. This led to the stoppage of more than 50 per cent in 1985 while those which remained in operation operated at a much reduced efficiency. This created social and environmental problems including population migration, tribal conflicts and environmental deterioration around water sources.

As water provision is critical for rural development, there is a need for an integrated strategy to ensure its proper operation and maintenance and sustainability and the proper operation and maintenance of water systems.

Dear participants, allow me to emphasize the Government's concern about the problems of rural water supplies. We give it a very high priority because of its impacts on the social and economic life of the rural people. In this connection, allow me to put before your conference some points that I believe will help in finding solutions to the problems of rural water supplies in the Sudan.

1. Water provision should be considered as a catalyst for development. It therefore should be integrated and linked with other development activities such as initiatives to combat desertification.

2. We need to give much greater attention to renewable sources of energy.

3. We need to promote local involvement and participation in the management of water sources at the village level.

4. There is a need to strengthen and rehabilitate maintenance centres in the different regions to ensure proper operation and maintenance of the different water sources.

5. We need to revise the water rates so that the revenue generated will cover the costs of operation and maintenance, and also provide additional funds to achieve some margin for expansion and the development of new sources.

6. A revolving fund should be established to guarantee that funds are available on a sustainable basis for operation and maintenance.

7. Regional governments should be asked to collaborate with the NRWC to ensure proper management of rural water supplies.

8. To ensure active local involvement, the technology selected must be simple and appropriate to local conditions.

9. Funds need to be mobilized in order to rehabilitate the existing wateryards. I would like to thank the different donors and agencies who have helped us in these endeavours in the past. As you know, the country's financial resources are limited so any assistance given to us in this respect is very much appreciated.

10. For efficient operation and maintenance, there is a need for well trained personnel. For this purpose and with the help of the United Nations arrangements are now under way to establish a regional training centre in El Fasher as a first step. Later it is hoped training centres will be established in the other regions of the Sudan.

Ladies and gentlemen, allow me to thank the organizers of this conference and to wish you every success in your deliberations. I express my great gratitude and thanks for all those who have contributed to this workshop and especially to the steering committee. Special thanks are due to World University Service of Canada for its effort in organizing this workshop which will focus on a very vital problem facing this country.

OPENING ADDRESS

F.E. Gilbert
Director of The
United States Agency For International
Development In Sudan.

Good morning. It is a pleasure to be with you at the start of a Conference on such an important topic.

I do not often accept invitations to talk on technical subjects and my first instinct was that someone with real expertise should talk to you today at the beginning of this Conference on Sustainable Operation and Maintenance of Rural Water Supplies in the Sudan. But on thinking it over, I realized that sustainability is not really a technical subject at all. If it were a technical subject, I am quite sure that you people, or at least some of you, would have already solved it. Now it never hurts to start a speech by flattering the audience, and I certainly do not mind if I have done so in this case. But I also think there is a serious point here - one that we should bear in mind. Perhaps the main reason why sustainability is such a persistent problem is that it does not fall within any one area of expertise. Another related reason may be that assuring sustainability is certainly beyond the capability of any one actor, party or group involved in the development and operation of water supplies. Given these characteristics of the problem, it is at least arguable that a donor representative is roughly as qualified, or maybe I should say just as incompetent, as anyone else to talk about it. Having established my credentials, I will get on with the talk.

USAID has been engaged in water resource development and rehabilitation in the Sudan for over ten years. The aid that we have provided to the Government of the Sudan in the water sector has covered development, rehabilitation, research, and training. The cost of this assistance in appropriated funds alone is over USD 22 million. In addition, we have allocated over LS 50 million in counterpart currencies to water resource development and rehabilitation between 1982 and 1988. During this time we have rehabilitated over 100 boreholes and rehabilitated more than 50 wateryards. We have also assisted in the construction and rehabilitation of hafirs. Two of the biggest AID-funded water projects are in Gedaref and Port Sudan. These involve increasing the capacity of water supply and distribution systems in areas where previous capacities were over-taxed due to large influxes of refugees.

This very brief synopsis vividly emphasizes the importance of this Conference and its topic. I used the words rehabilitation and rehabilitated six times. Many other donors, NGO's and governmental agencies are engaged in developing water resources in the Sudan. A description of their efforts would mention rehabilitation just as frequently. Our judgement at USAID is that most of the water projects in this country have not contributed as expected in meeting the water supply needs of the communities they serve.

One reason for this is that design conditions change. For example, populations sometimes grow faster than had been anticipated.

However, another, perhaps even more important reason is that there has consistently not been enough funding for water supply operation and maintenance costs. However, basic as they are, funding problems are only part of the picture. Had funds been sufficient, other constraints would undoubtably have stood in the way of successful operation and maintenance of Sudan's rural water supply systems. At least in the near term there can be little doubt that skilled management and labour as well as foreign exchange for imports of equipment and spares would also have posed problems even if adequate local currency funding had been available.

At the bottom of all these problems lies the lack of an adequate government policy. Such a policy would need to take a realistic account of the needs, the capacities and roles of the concerned entities - most notably the rural communities themselves and the National Rural Water Corporation - and assure that their respective contributions complement one another to form a complete response to this need.

Developing such a policy is easier said than done. There is no single correct answer that can be adopted in principle and applied in the Sudan. The one that most of us at USAID, and possibly in other Western donor agencies, would be tempted to advocate is that users must be prepared to pay the true economic cost of the goods and services that they consume. That is the simplest way of ensuring sustainability. However, in the Sudan, as in other developing countries, there is room for honest concern that the terms of trade between city and countryside - which is itself largely a function of government policy - may be so unfavorable to the rural sector that communities may require subsidies in order to support the social services and infrastructure they need to remain viable. I merely acknowledge this point of view; I do not hold it myself. However, if this is so, what can be done to identify dependable sources from outside the communities? Other issues which such a policy must confront include questions of ownership and water rights and their implications for systems management. Experience has shown time and again that communities need to feel a sense of proprietorship in order for them to take adequate responsibility for water systems and other assets on which they depend.

The task of developing a government policy that realistically provides for sustainable operations and maintenance of rural water supplies is a large one. This Conference can mark an important beginning in the process of bringing together the interested parties and opening the dialogue that must form part of this process. I commend the organizers of this Conference for launching it. USAID is proud to play a part as a co-sponsor. We wish you every success in your efforts to define the issues, agree on the facts and reach for a consensus on their policy implications. Thank you.

OPENING ADDRESS

Guy Carrier
Canadian International Development Agency
Ottawa, Canada

It is with great pleasure that I welcome you to this important Conference. Jack Titsworth, CIDA's Country Programme Director for the Sudan, was requested to deliver this address. He sends his apologies for not being able to attend but he wishes the best of luck to all participants and sends his greetings to colleagues from the National Rural Water Corporation, the Institute of Environmental Studies, the United Nations Development Fund and other organizations.

This Conference, jointly sponsored by CIDA and USAID, demonstrates the importance that Canada attaches to sustainable operation and maintenance of rural water supplies in the Sudan. The funding of the WUSC project is a good example of CIDA's endorsement of the concept of sustainable development. CIDA considers that effective operation and maintenance is the key to sustaining systems and services in this critical sector.

The Inter-Agency Round Table on Water Supply and Sanitation, held in Harare on November 28 - 30, 1988, indicated a need for better and wider coordination in water supply and sanitation at the country level. It was also recognized that the initiative and responsibility rested with the respective governments themselves. In this respect, CIDA's development assistance to the Sudan has helped strengthen the water and sanitation sector in aspects of human resources development, women in development and integrated sector approaches.

Before starting the Conference, I would like to take the occasion to congratulate the National Rural Water Corporation, the Institute of

Environmental Studies, and the World University Service of Canada for this well-planned conference and to wish them every success with this meeting.

OPERATION AND MAINTENANCE OF WATER SUPPLY AND SANITATION FACILITIES.

José Hueb
WORLD HEALTH ORGANIZATION
Geneva, Switzerland

Introduction

The importance of operation and maintenance has been widely recognized by multilateral and bilateral agencies and governments, and concerns have been expressed in meetings involving external support agencies, in the reports on regional and international consultations and in a number of resolutions of the World Health Assembly.

The reports on the Regional External Support Consultations of Asia, America and Africa, and the report on the Interlaken Consultation have stressed this constraint as follows:

- The Americas Regional Consultation (Washington, D.C., 21-24 April 1986) identified six key constraints related to progress in the water supply and sanitation sector development in the Latin America and Caribbean Regions. Among them was found: "insufficient attention to operation, maintenance and rehabilitation of existing water supply and sanitation systems". (Page 2, item 1.7).

- The Asia Regional Consultation document (Manila, 21-25 October 1985 states on page 7, item 4.3, when referring to the sector's major constraints: "...while analysis has shown improvement between 1980 and 1984 in the percentage of people having access to safe water supply and sanitation, the functioning of water supply and sanitation systems was often disrupted by inadequate operation and maintenance..."

- The Africa Regional Consultant document (Abidjan, 25-29 November 1985) recognizes that "many installations were out of order soon after their implementation, mainly due to lack of local expertise to adequately operate and maintain them". The same document referring to the second half of the Decade strategies and approaches points out four major issues on which future sector inputs should concentrate. One of them is: "Rehabilitation and maintenance of existing water supply and sanitation installations, rather than investments in new capacity, to maximize the output of limited resources and to prevent recurrent project costs from soaring to unaffordable levels".

- The International Drinking Water Supply and Sanitation Consultation (Interlaken, Switzerland, 13-16 October 1987) has recognized that "operation, maintenance and rehabilitation receive insufficient attention, and the problem is aggravated by application of inappropriate and often too sophisticated technologies (which are neither affordable nor manageable)". In accordance with this Consultation, operation and maintenance represents one of the six major constraints to sector development.

Despite efforts exerted by WHO, other external support agencies and governments, the establishment of operation and maintenance in developing countries is not keeping pace with the huge investments for the construction of new facilities.

The lack of balance between the allocation of resources for the construction of new systems and the development of operation and maintenance capacities is a major constraint for an efficient use of existing water supply and sanitation facilities. Although there is insufficient information on the present situation of operation and maintenance, it is well known that a high percentage of the facilities in rural areas do not function as planned.

The following constraints are usually associated with the existing situation in rural areas:

- Institutional deficiencies;

- Lack of training programmes and adequate personnel development policy;

- Insufficient and poor use of financial resources;

- Lack of planning and programming;

- Lack of operational and managerial instruments for programming, evaluating and controlling activities;

- Inadequate information flow;

- Poor quality of information;

- Lack of community participation;

- Lack of manuals and inventories of technical information; and

- Recurrent mistakes in layout, design and construction of water supply and sewerage facilities.

The following are specific constraints for the proper use of existing facilities in rural areas:

- Deficient sector organization inhibiting the development of suitable operation and maintenance services;

- Lack of technological, institutional and financial support for local production of pumps, spare parts and tools;

- Lack of standardization;

- Selection of unsuitable technologies resulting in installations and equipment which are not in accordance with the capacity of nationals to operate and maintain them; and

- Deficient process of purchasing, stocking and distributing of spare parts.

WHO's LINES OF ACTION

WHO's present efforts to support countries in the improvement of operation and maintenance areas comprise the following lines of action:

1. Development of guidelines for operation and maintenance and optimization of water supply and sanitation facilities

Efforts at elaborating guidelines for implementing operation and maintenance programmes have been undertaken in past years. Despite this, the community water supply and sanitation sector lacks suitable guidelines which are based on a more active and broader involvement of recognized professionals representing external support agencies and governments from developing countries.

The development of operation and maintenance guidelines will be a valuable aid for policy makers, managers and sanitary engineers concerned with this constraint to sector development.

The development of this line of action will begin with the collection of existing case studies which describe the situation of O&M and related areas in water agencies of developing countries. Such case studies should cover, as fully as possible the variables which affect how the operation and maintenance of water supply and sanitation facilities is carried out in different regions.

The analysis of the case studies carried out by groups of consultants and professionals from the institutions which have presented them will allow the preparation of specific strategies for the improvement of O&M and related areas for the respective water agencies.

Simultaneously a library search to prepare an O&M bibliography will be undertaken. Out of this activity a document will be prepared which will contain a brief history of the state-of-the-art of O&M in the developing world and a list of bibliographic references on the matter.

A document which consolidates the case studies and the state-of-the-art will be elaborated. This will serve as a basis for the preparation of the guidelines on O&M. After preparation of the draft guidelines, a formal study group on O&M will be constituted to review the draft document and finalize the guidelines.

2. Operation and Maintenance Working Group

There is a need to coordinate efforts between External Support Agencies concerning O&M projects. Improved exchange of information on on-going and future activities and the possibility of developing projects shared by a number of ESA's have motivated WHO's actions directed towards the promotion of the constitution of a working group on operation and maintenance.

Representatives from WHO, IRC and WASH have worked out an approach for the Working Group. This approach will be discussed by representatives of the ESA's. This document proposes that the O&M group will be responsible for the execution of the following activities:

- Elaborate objectives and scope of coordinated actions;

- Develop proposals for joint and coordinated activities on O&M to be funded by UNDP and/or bilateral ESA's;

- Generate support for the implementation of cooperative projects;

- Organize cooperation in this field avoiding duplication of effort and poor use of financial resources;

- Facilitate and organize transfer of experience; and

- Support government in the formulation, implementation, funding and monitoring of O&M studies and programmes.

The goal of the working group would be to improve the status of O&M activities of organizations by increasing awareness, generating support and providing information on the magnitude and nature of the O&M problems.

Thus, the specific objectives of the group would be:

1. To prepare an overview of ESA efforts in support of O&M.

2. To establish a list of core problems that currently inhibit successful and sustainable O&M activities.

3. To establish working relations with relevant ESA's, specialized agencies and developing country institutions concerned with O&M.

4. To produce case studies. Case studies would include both existing studies from which lessons learned would be drawn and also new studies to be undertaken. Both a horizontal and vertical approach would be taken within a specified format which addresses the

themes indicated in (1) covering both rural and urban contexts in selected countries.

5. To sponsor a workshop on O&M to present and analyze results of case studies; to develop indicators in O&M and to identify gaps in experience and information.

6. To produce reports which would be a compendium of lessons learned based on case studies and workshop results and to provide guidelines on O&M policy.

7. To recommend follow up activities at the country and regional level for implementing O&M projects.

3. Support to the formation, implementation and monitoring of operation and maintenance programmes.

The complexity and quantity of activities comprised in O&M programmes require very well concerted efforts among the involved organizations at the country and international levels. The following are the major phases in the development of O&M programmes:

- Promotion of O&M programmes. The first important action to be taken at the level of national agencies is to generate an awareness of the significance of the programme and willingness to implement it;

- Formulation of O&M programmes. It should be undertaken once a political decision supporting such an initiative has been achieved. The formulation comprises the identification of a national coordinating agency, the organization of the sector to implement the programme, the assessment of existing community water services and the definition of priority programmes, projects, and activities respective costs and required resources (human, financial, equipment, materials, vehicles and installations);

- Implementation of O&M programmes. It should be undertaken with coordination of a leading national sector institution, initially in a few communities. Depending upon the country's experience of similar programmes, an external project manager may be required;

- Training activities. They should be supported by training packages. The training activities should be included in the programmes' implementation process. The courses/workshops/seminars/ will be directed to managers, engineers and technicians. This initial target staff is expected to become a core group for developing human resources including caretakers at the village level; and

- Monitoring, evaluation and adjustment. Mechanisms and procedures for monitoring, evaluating and adjusting the programme should be established and implemented.

4. Training Packages on Operation and Maintenance

Critical areas regarding operation and maintenance activities have been identified. Training packages directed towards the improvement of managerial and technical areas are being prepared. The objective is the prior preparation of material in such a flexible manner that it will be possible to assemble a complete set of training packages which will meet the requirements of developing countries. The respective courses/ workshops/seminars will be directed to trainers in accordance with a problem analysis for each situation. An initial target population in each country is expected to integrate a core group of human resources which would exert a multiplying effect in disseminating the proposed knowledge.

Conclusions and Recommendations

Operation and maintenance has not usually been considered a priority in developing countries. A coordinated effort involving ESA's and governments from developing countries should be exerted to restore the balance between construction and O&M on the basis of better knowledge of how resources for O&M can be most effectively utilized.

The initiative concerning the organization of a Working Group on O&M is of great importance for better coordination and interaction between ESA's and developing countries and should be supported and further developed by both the ESA's and developing country governments.

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

Yagoub Abdalla Mohamed
Institute of Environmental Studies
University of Khartoum
Khartoum, Sudan

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 (Widstrand, 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, 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 of creating or 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 remains 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 of 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 UNDP/World Bank handpump programme represents a major effort in the search for a suitable appropriate technology. This effort stresses village level management and responsibility. Thus it combines technical improvements together with social, cultural and environmental concerns. Hence appropriate technology can be defined as that type which can be integrated in the social, economic, and institutional fabric of the community.

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 investments 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 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 economic, social and environmental factors to produce solutions which are indeed appropriate

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GOVERNMENT POLICIES AND STRATEGIES IN THE WATER SECTOR

Omer Abdel Salam
Energy Sector
Ministry of Finance and Economic Planning
Khartoum, Sudan

Introduction

Increasingly, experts in the water sector at both the national and international levels have begun to call for integrated and comprehensive planning for the development, protection and use of water and other renewable natural resources. Such plans should thus be incorporated within the broad framework of social and economic restructuring and environmental reforms in order to achieve sustainable water resources.

In the Sudan, however, at present there is no comprehensive and integrated policy for the protection, development and maintenance of resources on a scientific basis. Further environmental health factors have not been given proper attention. This paper reviews the status of the water supply and sanitation sector in the Sudan and describes the government strategies and policies in this important area.

Water Supply and Sanitation Coverage

One of the most serious difficulties encountered by the government in the preparation of the 4-Year Programme for the water sector was the problem of obtaining the necessary information needed to assess the position of this important utility and to estimate the magnitude and nature of its problems. The information used in developing the programme is not entirely accurate but needs further verification. It does not include for example the recent changes and population movements which are occuring in both the rural and urban areas.

National water supply and sanitation service coverage is presumed to be much lower than the minimum standards called for by the World Health Organization. Estimates of the coverage given in the four year Salvation, Recovery and Development Programme (1988/89-1991/91) and World Bank Report (1988) are as follows:

Rural water supply	30% (coverage);
Urban water supply	40% (coverage);
Rural sanitation	10-20% (coverage); and
Urban sanitation	N/A.

However, the designed capacities of the water sources do not give an accurate estimate of the actual coverage and water produced. This is due to the aging of the water facilities and their generally poor state of repair.

In the Sudan it is estimated that there are :

- 3600 wateryards;
- 1100 hafirs and small dams;
- 170 slow-sand filters;
- 5000 handpumped wells; and
- 62 urban water facilities.

Almost all of the wateryards and all hafirs/dams and urban water facilities need major rehabilitation. This is a formidable task.

Sector Investments

The water supply and sanitation sector received an annual average of 3-5% of total public investments during the period of 1981/82 to 1985/86. Estimates for 1987/88 are that it was about 12.4% of the total public development budget. The 4-Year Programme gives an increasing prominence to investment in the sector leading to appropriations of more than 20% of the total budget for the period.

An annual investment of about USD 30 million is envisaged during the 4-Year Programme period for rural water supply, and USD 13 million for urban water supply.

History of Sector Organization, Management and Development

The occurrence of cyclical periods of drought early in the present century led to a national concern with the provision of drinking water for the increasing number of people and animals. Exploration drilling for groundwater was initiated at the beginning of the century by the Geological Department. The Public Works Department at the same time, undertook the task of installing, operating, and maintaining water works in all regions of the Sudan except Khartoum (the capital city) and Wad Medani (the regional headquarters of Gezira at the time) where water services were provided by the Electricity Company. During the 1930's water supply was considered in conjunction with soil conservation and land use. A special committee was established in 1942 to make recommendations on the conservation of the country's natural resources and to draw up guide-lines for their exploitation. The committee presented its report in 1944. It included recommendations for the development, protection and the exploitation of natural resources, the planning of villages and the effects of providing drinking water on social development. It recommended the levying of special taxes as a measure of reducing the pressure of livestock on grazing areas. The report also identified projects in various parts of the country with an emphasis on soil conservation around villages and towns, land reclamation and the preparation of an annual survey to determine the degree of deterioration of the soil. Based on the recommendations of the report an executive organ was formed in 1946/47 for soil conservation within the Department of Agriculture. A permanent advisory committee was then established to supervise the implementation of the policies on water supply and soil conservation. However, both the committee and the executive organ which had been set up tended to concentrate solely on the provision of rural water supplies from groundwater sources neglecting the other aspects of the recommendations which aimed at conserving and developing the land through an integrated approach. To remedy this short-coming, two committees were set up in 1952 to revise the terms of reference of the previous committee for water supply and soil conservation. They produced a second report with the following major reccommendations.

1. There should be adherence to the report of the soil conservation committee of 1944. The report recognized that the measures which had been agreed to in the first report had not prevented the continued deterioration around certain water sources because the people had not changed their land utilization behaviour.

2. The importance of studying and planning for land use. The committee warned against giving excessive attention to the provision of rural water at the expense of planning for land use. It emphasized the importance of study and organizing land use around water sources in an attempt to restore vegetation cover and to preserve soils. The potential capacity of the land should be determined with the help of aerial photographs.

3. There should be an institutional reorganization of involved agencies including the regrouping of surface and groundwater with research and engineering sections.

In 1956 the water and land use committee was established comprising members from several fields of specialization. It established regional sub-committees with water and land use executive organs. This stage of institutional development was characterized by many positive achievements embodied in an increased awareness of the value of an integrated planning of water, land use and soil conservation. There was also an expansion in water provision in connection with land use. However, this expansion in water supply created a division of responsibilities between the ministries involved but a rivalry between the agencies prevented the necessary preparation of wide-ranging plans. This in turn caused a lag in the development and protection of water resources.

In 1966, the Corporation for Water Supply and Rural Development was formed as an independent executive body comprising most of the relevant technical components to ensure coordination and prevent overlapping of responsibilities between departments. The Corporation's task was defined as planning and executing a programme (Anti-Thirst Campaign) within 3 years. The Corporation Act defined the task as follows:

> "Provide water and define agricultural and grazing areas, to conserve the soil and develop all aspects of rural areas". The powers of the Corporation's board of directors stipulated "the setting of policy and devising means by which rainfed lands are utilized, the development of rural water resources within a comprehensive and integrated plan, the setting of priorities in the programmes of rural water and land use, introducing measures to prevent the deterioration of water and agricultural land resources as well as grazing lands and forests".

In subsequent developments in the late 1960's, the range and pasture section was returned to the Ministry of Animal Resources, but was reunited with the Corporation again under the Ministry of Cooperation and Rural Development in 1971. Shortly thereafter the Ministry of Cooperation and Animal Resources combined into the Ministry of Natural Resources and Rural Development. In a further development in 1974, the new ministry became the general administration for natural resources within the Ministry of Agriculture, Food and Natural Resources. This last move was intended to separate the responsibility for planning from the execution of water supply programmes.

In 1975 the Department of Soil Conservation, Land Use, and Water Programming was separated from the Corporation for Water Supply, which became an independent body. The Corporation's functions were to play a lead role in the search for sources of water in coordination with other administrations in the field of natural resources. The Corporation began to provide water services for rural and small urban areas.

When the system of regional governments was introduced in 1981, a decision was taken to decentralize the administration of water supply. In 1985, the National Corporation for the Development of Rural Water Resources and the National Urban Water Corporation were set up, thus centralizing again water resources administration. The two Corporations remained part of the Ministry of Energy and Mining but each of them remained independent from each other. In 1987 the NCDRWR was attached to the Ministry of Irrigation.

These frequent changes and confusion about the responsibilities of ministries responsible for water ,the decentralization and centralization of authorities, the rivalry which exists between the various units managing the water sector and the resulting administrative instability has adversely affected water supply coverage and quality, and has hindered the Sudan in developing a sustainable policy for managing its water supplies and water resources.

Mandates of the Water Corporations

Following the decision to re-centralize the administration of water services, the National Corporation for the Development of Rural Water Resources (NCDRWR) Act was issued in April 1986 to provide rural water service. Also in February 1986 the National Urban Water Corporation (NUWC) Act was enacted. These two Acts are based on the following water rights:

1. Urban water sources are all considered to be sources of water in towns whether surface or ground or running water in a river or valley.

2. Rural water sources are all sources of water which lie outside the scope of urban water. However, the proposed amended Act of the NCDRWR defines rural water as all sources - whether surface or ground- except the Nile water which was defined in the Nile Agreement. It forbids the use of water sources unless a license is obtained from the Corporation which has the right to limit the amount of water drawn from the different sources.

These Acts also contain the following general provisions:

1. No body or person may purify or bring water into a town for commercial purposes unless licensed to do so by the NUWC.

2. The NCDRWR may prohibit the establishment or utilization of water installations in rural areas if in its view this contradicts the public interest.

3. The provision of a safe water supply for all categories of consumers.

4. The efficient administration and management of water resource utilization with a reasonable financial mark-up in more prosperous centres, with the aim of cross-subsidizing poor areas as far as possible in the case of urban water supply.

5. To carry out operation and maintenance of water points, and manufacture spare parts, equipment and the other materials required.

6. To improve the efficiency of manpower by means of training.

The Acts also provide that:

1. The Land Use, Soil Conservation and Water Programming Department shall:

    - Carry out economic and social studies for rural communities with the aim of advocating an awareness of the most suitable means of utilizing natural resources in order to conserve them; and

    - Help in the formulation of policies, legislation and programming intended to regulate the use of land and water to ensure the necessary conservation of natural resources.

2. The National Corporation for Geological Research (NCGR) involvement in this field is confined to groundwater research in coordination with other bodies concerned with water supply.

3. The Ministry of Irrigation which has the three departments of general administration for the Nile Waters, Dams and Nile Regulation, and the Nile and River Studies shall be responsible for the Nile Waters.

Review of Mandates

The 4-Year Salvation, Recovery and Development Programme involved a general review of the legislation governing water resources and its utilization. Also, further studies have recently been conducted with the support of the United Nations Development Fund.

Issues

In the Sudan, a clash developed between the growing need for drinking water for humans and animals, and the need to utilize and conserve "renewable" natural resources. However, the need to provide water became so urgent that this took precedence over problems of environmental conservation and "renewable" natural resources. Attempts made by various organizations to curb environmental and natural resources deterioration, particularly in rural areas where severe land degradation occurred, failed. Immediate needs were thus satisfied at the expense of the longer-term perspective. In the Sudan, there developed no form of integrated planning nor the establishment of policies aimed at the rational use and conservation of water resources. Instead the whole issue of water supply was dealt with according to the predominant professional departmental specialization available. This constituted one of the main reasons leading to the dispersal of the units concerned to the Ministry of Energy and Mining, the Ministry of Agriculture and Natural Resources, and the Ministry of Irrigation.

In planning, supervision and execution there is a clear conflict between the NCDRWR Act and the functions of SCLUWP Department. The NCDRWR Act covers all aspects of the linkages between water, environment, renewable energy and other ecosystem components. It also sets up a technical advisory committee with three professional experts in environmental issues as members, as well as representatives from the regions affected by drought, appointed by the minister. Also, all heads of sections in the Corporation are represented in the committee. However, the NCDRWR Act granted a wide range of power to its executive organ, leaving the task of coordination with other organizations to the board of directors. This naturally led to water related problems such as land use and environmental quality being treated in isolation from water supply. The proposed amended Act for the Corporation focuses more on financial and commercial aspects. It states that the productive capacity of the Corporations manpower should be raised through training and appointing any worker it sees fit to operate, administer and maintain water installations. The Corporation was also empowered to set up companies or participate in the establishment of companies and organizations with similar objectives on a commercial basis. The danger in this action relates to the high cost of remedying the deterioration in the environmental ecosystem. If a commercially-oriented attitude prevails within the Corporation, its technical and research functions may be adversely affected. This is in fact clearly depicted in Chapter One of the Corporation's recurrent budget and in the bias towards new high capital investments as well as private work outside the Corporation's approved programme. The same is true for the SCLUMP Department which has gradually moved away from planning. The Department has begun to expand its activities in the execution of water projects as a component of rural natural resources programming. The consequence of this situation is competition over financial resources and a worsening of ecosystem problems, as well as an increase in the costs of providing water.

All water acts and regulations excluded monitoring and follow up with the exception of the SCLUWP Department, which refers to conducting the necessary research and studies relevant to land and water resources in coordination with other organs.

Within the field of water research there is an overlapping between agencies. However, all Acts refer to cooperation except the NCDRWR Act. After the transfer of most hydrologists to the NCDRWR, the NCGR has become incapable of playing its role in spite of its long history and experience in groundwater research.

Although there is no specific reference in the NCDRWR legislation to the relationship with the Ministry of Health (MOH), considerable cooperation between them does exist in practise.

Sources of water have been defined geographically as rural water or urban water. The purpose of this definition is to show which body is responsible for managing the water sources. This may create many problems particularly in connection with the definition of "town" and "villages". However, certain recognized criteria are used in distinguishing between urban and rural water services. Towns should have at least ten thousand inhabitants, a planned residential area, hospitals, schools, etc. The transfer of village water service to urban requires the approval of the Minister. Under the present legislation regarding water there is no overlapping or conflict between the functions of the Ministry of Irrigation and the other water authorities.

Recommendations

The 4-Year Programme concluded its review of the water sector with the following recommendations which can be summarized as follows:

1. The General Objectives and Strategies for Water Resources Development.

    1. The assessment of water resources with a view to develop and conserve them within a framework of a long-term perspective of integrated and sustainable rural development. In the short and medium-term, measures for the provision of water supply to meet the most needy areas using low -cost solutions, with micro-agricultural activities using excess water or run-off, and with environmental health activities i.e. rural sanitation and health education should be the pillars on which projects should rely.

    2. The reconciliation of the provision of an adequate and safe water supply with ecological balance and ecosystem protection and development.

    3. Water supply should be linked with environmental quality improvements. Water-borne and water-related diseases which constitute more than 90% of epidemics should receive urgent attention through environmental health services. Such measures would reduce both mortality and morbidity levels.

    4. To attain water decade targets in water supply and environmental health by the end of the 4-Year Programme period (1991/1992). The most needy areas are assigned special priority in water and sanitation programmes.

2. The Policy Issues.

The national policy statements contained in the 4-Year Programme have addressed the organization, and management, operation of water resources facilities, and financial and manpower resource mobilization with the following statements:

1. The organizational instability and the dispersal of water agencies has led to weaknesses in administration and management, a lack of cohesiveness, scattering of necessary information required for planning, competition over resources and overlapping and a conflict of responsibilities. To reverse this trend an inter-agency coordinating body has been proposed. Regional government authorities are expected to resume participation in planning and execution in the regional organizational structure of the NCDRWR.

2. Community participation in operation and maintenance as well as in identifying their needs for water supply and related services is a long-term objective of the water resources management policy. Community involvement is justified in order to:

   - Ensure the adequate and continued supply of water;

   - Reduce the cost of administration and cost of water services borne by the government;

   - Stimulate both the physical and financial capability of indigenous populations; and

   - Widen the coverage of water supply and environmental quality improvements.

3. Cost recovery systems are introduced for review and consideration by the government in order to broaden the national economic base.

Water charges are presumed to be large enough to cover the costs incurred in operation, maintenance and minor replacements of water facilities. However, financial and accountancy systems and procedures require extensive reviews to identify the real cost of water services.

4. Low-cost appropriate technologies based on adaptive research are the desired options. Adoption of renewable energy techniques are also required for small communities particularly in remote areas where the availability of operational inputs (i.e. fuel, spare parts) are in very short supply.

5. Encouragement of local manufacture of inputs such as spare parts, handpumps, water tanks, etc. to reduce the heavy dependence on foreign financing and to stimulate indigenous capabilities. Both public and private investments in the field of manufacture of water capital inputs and related industry could have favourable financial terms and credit schemes whenever feasible.

6. Promotion of local consultancy services and the involvement of national expertise in the water sector with a view to attaining cost effectiveness of technical assistance inputs for water projects and programmes. Upgrading of local training institutions such as the Wad el Magboul Institute (an affiliate of the NCDRWR) to retrain the redundant personnel in the Corporation and to enable water staff to acquire the vitally needed skills to operate and maintain water facilities.

OPERATION AND MAINTENANCE OF RURAL WATERYARDS IN NORTHERN SUDAN.

Andrew Livingstone[1] and H.J. McPherson[2]

Introduction

Perhaps the most serious problem facing the water and sanitation sector in the developing world is the lack of adequate operation and maintenance for existing water systems.

A high percentage of facilities in Africa, Asia and South America are either completely broken down or are functioning at very much reduced capacities. Estimates vary from 30 per cent non-functioning systems world-wide to locally higher values in some developing countries.

The problem is becoming more acute as more systems are being built to meet the water needs of expanding or even exploding populations and as previously built systems age. External support agencies are increasingly supporting projects to rehabilitate existing facilities and in some countries rehabilitation has become a form of operation and maintenance.

Why is operation and maintenance proving so difficult? There are several reasons:

The tendency has been for the responsibility for operations and maintenance to be vested in the central government. This was based on the historical model of utilities management imported from the developed world. In some countries this has worked reasonably well for urban areas. However, for the rural and smaller urban centres, quite often the central

[1] Word University Service of Canada.
[2] Department of Geography, University of Alberta, Edmonton, Canada.

government does not have the financial or human resources or the institutional infrastructure to sustain viable operations and maintenance systems. This is especially true in Africa.

The difficulty in obtaining spare parts, especially imported ones, requiring scarce foreign exchange is another serious issue. The generosity of donors has resulted in a myriad of different types of imported equipment and having to service and maintain tens of different varieties of pumps places unreasonable demands on the operation and maintenance abilities and capacity of national water authorities.

The consequence of all this is that in many countries, especially the poorer, operation and maintenance has been neglected with the consequent rapid decline of facilities.

The Sudan is a good example of a country which is experiencing severe economic hardships and where operations and maintenance has become a serious problem, especially for rural wateryards. There are various estimates as to the number of non-functioning wateryards in the Sudan and of the percentage requiring either major or minor repair.

Currently, there are about 3,500 boreholes in the Sudan in approximately 3,000 wateryards. Some of these wateryards in Darfur and Kordofan are 40 years old. The NRWC estimates that some 20% of the yards need complete replacement while another 53% require major rehabilitation. All in all some two thirds of the wateryards require moderate to substantial work. The traditional centralized operations and maintenance procedure of the National Rural Water Corporation has not proved adequate to ensure long term, sustainable operation and maintenance and the National Rural Water Corporation has recognized the need to look at alternative strategies; possibly involving more direct participation of the beneficiaries.

This paper reviews the historical development of wateryard operation and maintenance in the Northern Sudan, identifies the issues contributing to the difficulty of sustaining wateryards and describes a possible alternative strategy presently been experimented with by the World University Service of Canada in cooperation with the National Rural Water Corporation in Western Darfur.

Typical Rural Wateryard

In many areas of the Sudan due to lack of surface water resources the population relies on groundwater pumped from considerable depths. The average depth is 150 metres although deeper boreholes, up to 300 metres occur in the west. The name wateryard is given to the water extraction and distribution complex which includes one or more boreholes, storage tanks, animal watering troughs and tapstands.

The wateryard facilities are contained within a rectangular walled or fenced compound, normally 50 by 70 m, under the control of a wateryard clerk and pump operator who reside within the compound. Some attempt is made to separate livestock troughs from the tap stands for human consumption by internal cross-fencing.

Each borehole is equipped with a pump, powered by a diesel engine. A wide variety of pumps are installed, including Edeco and Scholler reciprocating types and more recently Monolift helical rotor types. A wide variety of diesel engines are utilized; the Lister, Torpedo and Perkins being the most common.

Water is pumped into one or more elevated storage tanks, usually constructed from prefabricated steel sections. The average nominal tank capacity is 50 m^3 (10,000 imperial gallons) From the storage tank, water is distributed by gravity to tap stands for filling containers for human consumption, and to metal troughs for watering livestock. A water meter is installed on the outlet of the storage tank.

Water yields are normally in the range of 1.5 to 3.8 L/S (20 to 50 imperial gallons/minute). The water quality from the Nubian Sandstone Formation, the dominant aquifer, is good, with Total Dissolved Solids frequently less than 1,000mg/litre (Mohamed, 1982). The borehole is cased with standard 170 mm diameter (6 5/8 inch) nominal steel casing, with slotted casing within the production zone (NRWC, 1987).

Livestock are watered directly at the wateryard. Goats and sheep are watered every 3 days, consuming 6 to 10 litres/head/day and cattle are watered every 3 days, using 16 to 30 litres/head/day. The water consumption of donkeys and horses approximates that of cattle. Camels are watered every 7 to 11 days, consuming 15 to 26 litres/head/day. The above estimates include an approximate 20% allowance for water loss and wastage (Mohamed, 1982, 1986).

Water for human use is hauled from the wateryard to the home by a variety of means. Jerrycans of 18 litre (4 imperial gallons) capacity are commonly used and are carried to the home if the distance is short. For the longer distances, the jerrycans are loaded on donkey carts or alternately, goat skin saddle bags, or used fuel barrels. Larger metal tanks on carts hauled by donkeys are also used. Children and men are the primary water providers in the Northern Sudan, transporting nearly 90% of the household water, and spending an average of 1-2 hours/day at this task (Mohamed, 1982). Women only assume the role of water carrier when the male household head is absent. Human water consumption varies with distance from the wateryard. In remote areas, average use is frequently less than 10 litres/person/day. For those households close to the wateryard, an average water consumption of 33 litres/person/day, including irrigation of the family vegetable garden is usual (Mohamed, 1986).

The National Rural Water Corporation (NRWC)

The National Rural Water Corporation (NRWC) is responsible for the construction, operation and maintenance of public funded rural supplies (primarily wateryards) throughout the Sudan. The NRWC has been in existence in one form or another for approximately 60 years, having its current, separate distinct corporate identify since 1966. The Corporation has an extensive network of regional offices and district sub-offices, but in reality functions as a centralized organization. Financial, planning and implementation activities are controlled from Khartoum by the Director General and Executive Director.

Bureaucratically, the NRWC is part of the Ministry of Irrigation and Water Resources and its budget and hence most of its activities, are controlled by the Ministry of Finance and Economic Planning. The latter ministry is highly politicized, and responsible for all official development planning and implementation in the Northern Sudan.

Within the NRWC, there are erection (construction) sections, drilling and geology sections, hafir (surface water) and shallow wells sections, and administration (operations) and mechanical service sections. Like other government agencies, the NRWC has a limited annual budget and is burdened with a large permanent staff and aging physical plant and facilities. The NRWC is under considerable political pressure to continue constructing new rural wateryards. In recent years, the NRWC approved recurrent budgets for wateryard operation and maintenance have been only 10 to 20% of the budget that is needed.

A considerable number of bilateral and multilateral sector development projects are channeled through the NRWC, resulting in yet more new wateryards annually. The NRWC welcomes foreign development aid, since it provides work for its construction staff through secondment arrangements, and helps upgrade the NRWC's physical plant and facilities. However, with the increasing number of rural wateryards in existence and faced with an inadequate recurrent budget and other significant operational constraints, the NRWC is doing less and less operations and maintenance.

The first drilled and cased borehole was constructed in 1912 at Umm Ruwaba in Western Sudan. Up until 1955 boreholes were constructed under the supervision of the drilling division of the Department of Works, with the construction of wateryards managed by rural water supply groups within the provincial and district governments. During the period from 1956 to 1966, the drilling division of the Department of Works was merged with the Soil Conservation Section to form the Land Use and Rural Water Supplies Department. Wateryard construction proceeded as the responsibility of this new department. Annual construction programs were undertaken, and by 1966, there were approximately 450 wateryards in existence (Mohamed, 1986).

Commencing in 1967 and lasting until 1977, the Rural Water Development Corporation which succeeded the Land Use and Rural Water Supplies Department embarked upon a large-scale borehole drilling and wateryard construction program referred to as the Anti-Thirst Campaign. Most sites that exhibited favourable hydrogeological conditions were developed with little regard for the environmental impact of the wateryards. Land use planning criteria were applied to most new wateryard sites, but there was no government body responsible for the wateryard. As a result, environmental degradation in Northern Sudan accelerated at a phenomenal rate during this period (Ibrahim, 1984. Mohamed, 1982). By the end of the Anti-Thirst Campaign, approximately 2400 wateryards had been constructed.

From 1977 until the present day, wateryard construction has proceeded at a slower pace, due primarily to budgetary constraints. New wateryards are being constructed through development projects funded by UNDP, IFAD, USAID, CIDA, and DANIDA for example, or by the NRWC directly or through subcontracts. To date, the problem of operating and maintaining these wateryards, together with the large number of existing wateryards, has not been seriously addressed.

Issues in Operations and Maintenance

Several key issues can be identified which constrain and hamper the operation and maintenance of wateryards. These can be summarized as:

- Transportation and communications;
- Availability of diesel fuel;
- NRWC infrastructure and resources;
- Aging of facilities;
- Spare parts availability;
- Tariffs and cost recovery; and
- Environmental degradation.

Transport and Communication

Sudan is the largest country in Africa and has a widely scattered, low density rural population outside of the River Nile valleys areas. Combined with a very poor road system and an ineffective railway system, access and transportation to and from rural communities is very difficult. This constraint is exacerbated by frequent, chronic fuel shortages which effect both the public and private sectors of the country.

With ineffective postal and telephone systems, rural communities are isolated from one another and from contact with the major urban areas. Within urban areas, poor communication severely affects the functioning of the government and the private sector. Coordination of activities in the field is virtually impossible and this seriously restricts the efficient functioning of a centralized operations and maintenance system.

Diesel Fuel Availability

Diesel fuel is required to operate the wateryard pumps, which often pump continuously in the dry season. With an average fuel consumption of one litre per hour, each pump requires approximately four barrels (800 litres or 176 imperial gallons) of diesel per month when continuously operating. Diesel fuel is available in Khartoum, but subject to rationing by the General Petroleum Corporation. It is expensive to arrange for its transport to NRWC regional centres, and to distribute from regional centres to individual wateryards. Most NRWC regional centres are unable to purchase sufficient diesel for their construction operations due to budget constraints and so are reluctant to release any for wateryard use. Consequently, a major problem for wateryards is obtaining the necessary fuel to keep the pumps going.

Spare Parts

The availability of spare parts is another problem. Under prevailing economic conditions, the importation of any new equipment, and urgently-needed supplies and spare parts is extremely difficult and the Sudan has a very limited capacity to manufacture equipment, supplies or spare parts needed for the operation and maintenance of rural wateryards.

Infrastructure and Resources

A further constraint is the infrastructural organization of the NRWC and its serious shortages of both human and material resources, particularly vehicles. Most government departments in the Sudan are decentralized along regional lines and while regional offices exist, most decision-making and and budget allocation are centralized in Khartoum. The anomaly exists where NRWC regional directors are responsible and report to the regional government where they are located, but their activities are controlled by NRWC headquarters in Khartoum. The NRWC management in Khartoum responds to direction from the central government, whose sector plans and financial priorities are often at variance with the regional government's.

Aging of Facilities

Most of the wateryards in the Sudan were constructed during the Anti-Thirst Campaign of 20 years ago. The equipment is old and in poor condition due to a general lack of preventative maintenance. The design life for wateryard equipment is 20 years and most of the equipment is nearing that age in Darfur and Kordofan. In some cases it is even older.

Tariffs and Cost Recovery

Ideally, tariffs should be sufficient to pay for long term operation and maintenance including major equipment replacement. However, the disorganized and sometimes corrupt tariff collection system is not providing adequate funds for cost recovery and long term operation and maintenance. The problem is not the absence of a willingness to pay by the users for as Mohamed, Abu Sin and El Tayeb (1986) have shown, the beneficiaries are willing and able to pay for good service.

Environmental Degradation

The uncontrolled explosion of wateryard construction during the Anti-Thirst Campaign has had severe environmental consequences and has contributed to increased desertification especially in the west. Most of the settled Northern Sudan outside of the River Nile valleys area is within the semi-arid Sahel. The Sahel ecosystem is very fragile, subject to frequent severe droughts (Ibrahim, 1984. El Afiri, 1982) and operating rural wateryards in this environmentally sensitive area has contributed to widespread desertification adjacent to the wateryards (Mohamed, 1982. Ibrahim, 1984). The negative environmental impact of rural wateryards is a major concern of the government and must be mitigated through environmental education and rehabilitation.

NRWC Operations and Maintenance Practice

The operation and maintenance of all rural wateryards in the Sudan is the responsibility of the NRWC which has administration and maintenance sections for this purpose.

Water is sold by the NRWC from the wateryard to the community but water rates vary from area to area. In a few locations, water is provided free, but the usual water rate ranges from 1 to 6 piastres per jerrycan (18 litres), equivalent to 0.12 to 0.36 U.S. Dollars/m^3. The water rates are collected by the wateryard clerk, who is an NRWC employee. Individual clerks are supervised by senior clerks responsible for a number of wateryards in a district. Since the wateryard water meter is rarely functioning, individual water withdrawal is estimated by the clerk on a per container or per head of livestock basis. Tickets are sold for this purpose. The clerk accumulates the water revenues and remits them periodically to the NRWC regional centre, which then forwards them to Khartoum. The headquarters in Khartoum in turn provides each region with an annual wateryard operations and maintenance budget.

A wateryard (pump) operator is also employed by the NRWC at each wateryard. The operator's job is to start and stop the pump, perform routine and preventative maintenance to wateryard equipment, and to notify the NRWC regional centre when a major overhaul or repair of equipment is required. NRWC maintenance and repair teams are based in all regional centres and the maintenance section is responsible for scheduling wateryard preventative maintenance and major overhaul, so that the incidence of equipment breakdown and subsequent repair is minimized - at least in theory.

In practice, the NRWC wateryard operation and maintenance programme does not function. Financial record-keeping by the wateryard clerks is minimal, and in the absence of any reliable measure of the amount of water pumped at each wateryard, the water revenues collected and the revenues remitted to the regional centre are often at variance. A monthly remittance of 1,000 to 2,000 Sudanese Pounds (225 to 450 USD) per average wateryard appears to be acceptable to the NRWC, when in reality the actual amount of water sold is probably at least several times this amount.

The wateryard operator is frequently unable to perform routine and preventative wateryard equipment maintenance, since he is not supplied with the necessary spare parts, lubricants and tools and it is not uncommon to find a rural wateryard which has been inoperative for several years with the NRWC clerk and operator still living at the wateryard with nothing to do. Further, most wateryard operators are poorly trained and are unable to perform their jobs even with adequate supplies. The NRWC considers that lack of preventative maintenance and lack of operator training are the major reasons for the breakdown of many rural wateryards.

Community Based Operations and Maintenance

The need for water is paramount in the Sudan and it is not uncommon for people to travel 20 km or more to collect it or hundreds of kilometres to water their animals.

In the wet season contaminated traditional sources are available but during the dry season or the periodic droughts which affect the region the wateryards are the only source of water and their reliable and continuous operation is critical for the community served.

In the Sudan what has evolved out of necessity is an essentially community based operations and maintenance system which operates almost entirely independently of the NRWC in over half of the rural wateryards. At one stage, the NRWC delegated wateryard operation and maintenance to the rural councils. However, this experiment failed as the rural councils tried unsuccessfully to duplicate the practises of the NRWC.

Most communities perceive that lack of diesel fuel is the major impediment to the operation of the wateryards (Mohamed, 1986). In reaction to the lack of fuel, the village headmen or water committee will collect funds from each household in the community, to purchase diesel on the "black" market. The official price of diesel in 1988 ranged from 3.50 to 9.50 Sudanese pounds per gallon (0.80 to 2.16 USD) depending upon the location and the "black" market price which is often three or four times higher. Normally enough funds are collected to purchase one or two Jerrycans of diesel, which allows the wateryard pump to operate for about 15 to 35 hours. This process is repeated several times a month, resulting in an intermittent supply of water. This extra fuel cost is in addition to the NRWC water rate charged at the wateryard.

In some communities, a surcharge is agreed on among the village members, to be added to the NRWC water rate and to be collected by the wateryard clerk. This surcharge is used to purchase fuel from the "black" market on a more regular basis. Sometimes, the village members agree to surcharge the price of some rationed commodity, such as sugar or tea, and again use this revenue for fuel purchase (Mohamed, 1986). Each of these three revenue generating enterprises are conducted on an unofficial basis since NRWC policy does not permit these practices. In some areas this community management is actively encouraged and supported by local authorities which is contrary to NRWC policy.

Equipment breakdown and delay in the repair of the equipment is the second major impediment to wateryard operation perceived by the communities (Mohamed, 1986). The reaction to the lack of maintenance has been similar to the reaction to the lack of fuel, in that funds are collected within the community, usually by the village headman or water committee as repairs are required. Spare parts and skilled labour are then obtained locally or sometimes from the NRWC regional centre. This is an unsatisfactory maintenance procedure, since it results in the repeated disruption of water supply while funds and parts are obtained. Also, with little or no preventative maintenance, wateryard maintenance, wateryard equipment life and performance is reduced.

In some areas, notably the River Nile valleys and the eastern Kordofan areas, communities have tried to solve the operation and maintenance problems by contracting out the wateryard service to private commercial concerns (Mohamed, 1982, 1986). However, this has tended to be a viable alternative only in the relatively more affluent areas.

A Proposed Alternative Operations and Maintenance Strategy

Increasingly in the rural areas of developing countries it is being realized that central governments or even regional ones do not have the capacity to undertake sustainable operations and maintenance programmes. The traditional government run utility company may still be appropriate for cities, however, it is not a realistic approach in the rural regions. Here it is clear that the beneficiaries must assume the major responsibility for the operation and maintenance of facilities.

In many developing countries community based operations and maintenance programmes are successfully underway and are being promoted by external support agencies. In East Africa well organized initiatives have been incorporated in projects in Malawi, Zimbabwe and Kenya where village level operation and maintenance is actively supported and promoted by the government. Many governments have come to accept that they cannot realistically carry out centrally controlled comprehensive operation and maintenance for rural water supply systems.

The Sudan offers a unique opportunity for a successful community based operations and maintenance programme for two reasons. First, in much of the Northern Sudan water is such a vital need that the people are willing to do almost anything to obtain a reliable supply and second, an unofficial informal community based operation and maintenance system is already operating quite successfully in over 50 percent of the rural wateryards.

During the past two years, the authors in collaboration with the NRWC and the Ministry of Finance and Economic Planning have developed an experimental operations and maintenance strategy to be tried out in the CIDA and US Aid funded Northern Darfur Water, Sanitation and Hygiene Education Project being implemented by the World University Service of Canada. The test wateryard which is going to be operated entirely by the community guided by WUSC is the Sharafa wateryard in Northern Darfur.

The strategy calls for cooperative management between the NRWC and the community. Each party can assume the responsibilities for which it is best suited, and can benefit from the other's assistance so that the management task is not so onerous. Since the community directly benefits from the wateryard and is in a position to supervise its use on a daily basis, it is proposed that the community be responsible for water revenue collection, daily pump operation, and routine preventative maintenance of the wateryard equipment. The NRWC possesses trained technical personnel, and the infrastructure to procure supplies, equipment and spare parts. Therefore, it is proposed that the NRWC be responsible for major wateryard equipment repairs and periodic equipment overhaul, on a fee-for-service basis. Most communities would favour a cooperative approach to wateryard management, and the NRWC would definitely benefit from this approach.

Key elements in this proposed strategy include:

- The development of local water committees;
- The establishment of a community based revolving fund and the setting of realistic water tariffs;
- Hiring of local community members as clerk and operators;

- Establishment of a supply of maintenance parts at each wateryard; and

- A reporting system for major breakdowns.

Local Water Committees

Most rural communities already have some form of community organization, such as a village council committee, cooperative or youth association (Mohamed, 1986, 1987. El Mangouri, 1985). These organizations may already be involved in water provision, or may be active in the fields of education or health care. With assistance and guidance from community workers, an effective water committee will be formed in each community, with representation from each segment of the community's population. The tradition of self-help is strong in rural Sudan, and with a flexible approach this social resource can be mobilized for management of the wateryards.

Revolving Fund and Tariffs

Rural residents in the Northern Sudan expect to pay for a reliable supply of clean water and a large number of rural and periurban residents in Northern Sudan without reliable water supplies are currently paying up to 75 piastres per jerrycan for water purchased from mobile commercial vendors. Water rates should be formulated to cover the full cost of wateryard operation and maintenance, with a reserve for future equipment overhaul or wateryard improvement. It is generally accepted that the maximum amount an individual can pay for potable water is 3 to 4 per cent of the individual's disposable income (CIDA, 1988). In the Northern Sudan, this translates to an approximate maximum water rate of 8 to 12 piastres per jerrycan. Current maximum wateryard water rates are 5 piastres per jerrycan (Northern Darfur) and approximately 8 piastres per jerrycan (at the official NRWC rate of 3 piastres plus a 5 piastres community surcharge for fuel and repairs) in some communities. Since water rates based upon recurrent cost recovery will vary from one area to another, the government may wish to subsidize water rates in remote areas. Alternately, intra-community subsidization of poorer members by wealthier members might be implemented.

Water revenues generated at each community will be deposited into a revolving fund, administered cooperatively by the communities and by the NRWC. Individual community credits and debits to the revolving fund will be coded so that the individual community wateryard account balance can be ascertained at all times. The revolving fund is designated solely for wateryard operation and maintenance purposes, to prevent revenues passing into the NRWC's general revenue.

The major credits to the fund would be the water revenues and major debits would include wateryard clerk and operator wages, fuel costs, routine and preventative maintenance costs, and major repair costs. After some experimentation with water rate setting, a surplus should accrue in the revolving fund that can be used for major equipment overhaul or wateryard improvement at the individual community wateryard.

Wateryard Clerks and Operators

Local clerks and operators will be hired from within the community and paid by the water committee out of community water revenues in the revolving fund. This will permit direct and effective supervision of the daily operations of the wateryard and routine preventative maintenance of the equipment. At least one volunteer understudy will be appointed to both the clerk and operator, so that continuity of service can be assured.

The clerk will be trained in basic bookkeeping and report preparation and the operator in pump and engine operation, lubrication, preventative maintenance, and pipe repair. The community health workers assisted by NRWC staff and consultants from the Institute of Environmental Studies University of Khartoum will present short training courses for clerks, operators, and water committee members in hygiene education, the health benefits of water and sanitation and wateryard care.

Spare Parts

A stock of lubricants such as oil and grease, and other supplies such as pump and engine gaskets and seals, filters, nuts and bolts, pipes and pipe fittings will be kept at each wateryard. This will allow the pump operator to maintain the equipment and perform minor repairs. These items are hard to obtain at the community level, but will be procured in bulk by the NRWC in Khartoum, and supplied to each wateryard at cost, and debited from the revolving fund. Supplies for the clerks such as paper, record books, a cash box and a tool kit for the operator will also be provided.

Diesel requirements at each wateryard will be estimated on a regular basis and a bulk order for fuel placed by the NRWC in Khartoum. Once transported to the regional centre, fuel is to be distributed to individual wateryards by NRWC vehicles performing major repairs at wateryards, or by commercial trucks. It is estimated that diesel fuel can be supplied to wateryards at a cost of fifteen Sudanese pounds per gallon; allowing for all transport costs and a NRWC ten per cent administration fee. This cost is substantially lower than prevailing "black" market rates.

Reporting System

The water committee will be responsible for reporting any serious breakdowns to the NRWC regional centre. The NRWC will react by dispatching a repair team. The costs of providing this service, including vehicle operating costs, personnel costs, costs of spare parts and supplies will be paid for by debiting the community's account within the revolving fund. The NRWC will also provide periodic wateryard equipment inspections for a fee.

A portion of the revolving fund will be given to the NRWC to procure an adequate supply of wateryard equipment, spare parts and replacements.

These will be kept at the regional centre stores, *where appropriate stores* control and disbursement procedures will be established.

Conclusion

Sustainabilty of systems is a prime concern for external support agencies in the water and sanitation sector. It is pointless to build water supplies if they fail and need replacement in a short period of time. Repeated rehabilitation as a form of operations and maintenance is also an unnecessary waste of scarce resources.

The simple truth has now been recognized and accepted by many governments and sector support agencies that the model of a centralized water utility which works reasonably well in urban areas is not appropriate for the operation and maintenance of rural water supplies. For the rural areas the benefiting communities must assume as full a responsibility as possible for the operation and maintenance of their own water supplies.

However, community based control and operation and maintenance of systems should not be developed in parallel or in competition with the government. Rather, village level operation and maintenance (VLOM) should constitute government policy and strategy for rural water facilities and the government should develop an operation and maintenance programme based on community participation.

The community does not have the resources to obtain supplies or undertake major repairs and of necessity will require some support including training from government agencies. However, this assistance will be much reduced from the present high level of assistance, thus alleviating the stress on limited government financial and human resources.

The rural areas of the Sudan present an excellent opportunity for the the establishment of a community based operations and maintenance programme. Several important preconditions already exist. The people have a real need for water and are anxious to obtain and ensure a reliable supply. There is a strong tradition of community participation in the rural Sudan and an informal community based operation and maintenance system is already present in over 50 per cent of the rural wateryards.

The strategy outlined in this paper and being tested in Northern Darfur will hopefully prove viable so that it can be adopted as national policy to achieve the realizable goal of long term sustainability for wateryards in the rural Sudan.

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AN OVERVIEW OF RURAL WATER SUPPLY IN THE SUDAN

Abdel Raziq Muktar
Director, Groundwater Research Department
National Rural Water Corporation
Khartoum, Sudan

Introduction

Sudan is the largest country on the African continent with an area of 2.5 million km^2 and a population of 22 million (1983 census), which is increasing at an average rate of 2.9 per cent per year. The population of the Sudan is estimated to be around 26 million by 1989. About 70 per cent of the population (18 million) live in the rural areas. Their minimum annual water requirements are calculated to be in the order of 130 million m^3 at a per capita consumption rate of 20 litres per day.

More than 60 per cent of the country lies in the desert, semi-desert or low rainfall savannah woodland zones. Although the country is transected by the river Nile and its tributaries, 80 per cent of the population live away from the Nile.

The economy of the country is mainly agro-pastoral and the development of its rural areas depends very much on the availability of reliable sources of good quality water.

The recent drought which struck the Sudan, combined with a lack of proper management has resulted in a sharp deterioration of rural water supplies. The health implications of this lack of sufficient water, both in terms of quantity and quality, are significant. The most important water related diseases in the Sudan are the diarrohoeal diseases; malaria, bilharzia and trachoma.

Traditional Set Up

During the colonial period, the responsibility for rural water was shared by several different and diverse departments including the Railway Department, Ministry of Works, Geological Survey, the Soil Conservation Section (in 1945), and the Land Use and Rural Water Department.

These disparate sections dealing with rural water were brought together for the first time in 1966 to establish the Rural Water and Development Corporation (RWDC) as a government organization to deal with the rural water supply mandate.

Between 1976 and 1986 the Corporation passed though several different stages of organization and reorganization, decentralization,and centralization before the existing National Corporation for the Development of Rural Water Resources (NCDRWR) was established in 1986 as a central Corporation. This organization is responsible for the planning, construction, operation and maintenance of all rural water supply systems in the Sudan. At the national level, the Corporation is managed by a board of directors and headed by a director general, and includes a number of specialized departments.

At the regional level, the Corporation is headed by a regional director assisted by executive managers at the provincial level and regional officers at the district level.

In support to the NCDRWR, various bilateral and multilateral institutions are providing financial and technical assistance. Among the most active donors are UNICEF, World Bank, Italy, CIDA, Netherlands,Japan, West Germany, and USAID in addition to many NGO's like CARE, World University Service of Canada, Save the Children, OXFAM, ADRA, Plan Sudan and Action Aid.

Rural Water Supply Sources

Rural water supply is generally obtained in one of four ways, from:

1. Traditional sources which utilize both surface and groundwater.

2. Hafirs, earth dams, and Nile water schemes which utilize surface water.

3. Wateryards which utilize groundwater.

4. Handpump wells which utilize groundwater.

1. Traditional Sources.

Traditional sources of water supply vary in their quality and reliability, but do not usually provide safe drinking water. The quality of the water from traditional sources is very much a function of the type of the source and the method of exploitation. Surface water sources include perennial streams and rain water collected in natural depressions (Rahad, Turdas and Rugab). Historically the population has concentrated along perennial water sources like the Nile where water is drawn manually and is often contaminated (bacteriologically) and turbid, especially during floods.

Away from the Nile, people depend on surface pools which are both contaminated and short-lived. Under certain topographical and hydrological conditions, perennial source are found in the form of Turdas or Rugabs such as Turdat Er Rahad, Abu Zabad, Umm Badir and Lakes Keilak and Abyad in Kordofan, and Lakes Kundi and Enzili in Darfur. Water from these sources is used both by animals and humans and is often subject to contamination. Recently, these sources have become increasingly threatened by siltation and sand encroachment. These sources can be improved by deepening, fencing and pumping water for domestic and other purposes.

Groundwater sources include temporary or permanent dug-wells equipped with windmills or suction pumps and springs. Temporary dug-wells have different names in the Sudan such as Meshish, Idd, Tamad, and Gamman. Such wells are manually dug through loose sediments along water courses when surface sources dry-up in the dry season. To prevent collapse during digging, the wells are lined with millet stalk hoops and filled with timbers. They provide limited amounts of water both for drinking and animal watering and are often subject to contamination.

Permanent dug-wells have been known in the Sudan for centuries. They vary in depth from a few metres to more than 100 metres. They were dug manually by boring or hammering, with the cuttings removed by Dalu (metal or leather bags tied to a rope) and drawn manually or with the use of animals and windlasses. These wells were lined with stones or bricks or left unlined when penetrating hard rocks. A famous type of well are the Anag wells which date back to the 16th Century. These wells were dug in Basement rock without the use of modern techniques such as explosives, jetting and hammering. They still exist and provide an all-year water supply. To avoid dewatering, they were dug during the dry periods. The ownership of such wells is communal.

This system was later improved on by the NCDRWR through the use of explosives to facilitate digging in hard rocks, and through the use of windlass systems. The NCDRWR together with the rural councils so far have dug more than 2000 wells. Some of the wells were affected by the recent drought when water levels dropped or when they were filled with blowing sands. With the assistance of the Netherlands government, the Corporation is working on improving dug well design to provide water all year round and also to provide sanitation facilities.

The system of dug-wells was improved and modified by the Northern Province farmers by digging a large diameter (4-5 m) well and driving a 2 inch pipe to penetrate deeper horizons. Centrifugal pumps were then installed and the water obtained used for irrigation as well as for domestic purposes.

Windmills were introduced into the Sudan in the middle of this century by the Gezira Board. Pumps were installed in boreholes to pump water from depths varying from 5 to 40 metres. As villages grew and diesel driven pumps with high discharges and high heads were introduced and became popular, the use of windmills was abandoned.

From the early 1940's people in the Northern Province traditionally obtained their drinking water through the use of suction pumps that were manufactured locally in Atbara. These pumps were manufactured first in railway workshops and later in private workshops. Pumps were either installed in dug-wells or driven into the ground to tap the shallow groundwater. Their maximum suction head could not exceed 10 metres. Recently due to the lowering of the groundwater table and shallow aquifer pollution resulting from pit latrines, the whole system has fallen into disuse.

Springs originating from mountainous areas have provided water for a long time in the Sudan, especially around Jebel Marra in Darfur and Ematong in Equatoria. Groundwater appearing at the surface and forming spring fed lakes used to be the main water source along the old Darb El Arbaein route between Egypt and the Sudan.

2. Hafirs, Earth Dams, and Nile Water Schemes.

Hafirs are artificial excavations into which surface runoff is diverted during the rainy season. They are mechanically excavated in impervious clay soil in the shape of an inverted pyramid. The hafir depth is usually in the range of 3 to 8 metres while the capacity varies from 5,000 to 60,000 m^3. Twin hafirs have often been constructed for large capacities, partly to facilitate rectification, and partly to reduce evaporation losses by means of pumping from one hafir to the other as the water levels fall. Many hafirs are provided with a settling basin at the intake to control the amount of sediment entering them.

Water is drawn from a masonry well connected to the hafir by a gravity pipe. At several hafirs, steel or concrete troughs are provided for watering animals. Most hafirs are fenced and access is through a single gate. Fencing is often in a poor state of repair and the animals enter freely, accelerating bank erosion, increasing turbidity of the water and adding to the pollution hazards. Many extraction wells are blocked and supplies have to be drawn directly from the hafir.

The first hafir was constructed in 1947/48. By now there are a total of 850 hafirs and 50 earth dams. Siltation is a problem for all hafirs and many are approaching the end of their useful life. Sand encroachment is a serious problem especially in Northern Darfur and Northern Kordofan, where hafir inlets are blocked and are completely buried under creeping sand. Due to a lack of rectification, seepage and evaporation losses, the available hafir waters for use available throughout the year are usually only about 30 per cent of the design capacity.

To reduce contamination, slow sand filters and fencing were installed at some hafirs to safeguard the quality of the drinking water. Also to reduce seepage losses in sandy soils, lined hafirs were introduced at some sites.on an experimental basis

Earth dam capacities vary from 300,000 to 2,000,000 m^3. These dams, besides providing drinking water, recharge the shallow aquifers and provide some opportunities for flood irrigation cultivation. For drinking, dam water can be pumped through slow sand filters and distributed with or without additional treatment. Minor maintenance of hafirs and dams can be carried out by labourers but major maintenance requires heavy equipment.

A new system of using slow sand or mechanical pressure filters was adopted by the Corporation for providing drinking water along the river Nile and its main tributaries, and along irrigation canals in the Gezira, New Halfa and Rahad Schemes. Raw water is pumped by centrifugal pumps to coagulation tanks, then through filters to distribution tanks. The system, especially the construction of slow sand filters ensures the community's participation in construction, operation and maintenance. A system using horizontal roughing filters is presently being tested by the Engineering unit of the Blue Nile Health project.

3. Wateryards.

A wateryard is composed of one or more boreholes with reciprocating turbine or electrical submersible pumps with engines and enclosed by a 80x60 m fence. The borehole and the pump are normally housed in a prefabricated galvanized steel pump house, which can be dismantled easily for well development. A storage tank of between 22.5 and 45 m^3 capacity is installed at a 3 metre height in the wateryard.

A 50 to 75 millimetre gravity-fed main conducts the water to a distribution area. Domestic requirements are met first through a tap stand connected to six taps. Water is then led to two or three standard animal troughs.

Drilling of boreholes in the Sudan started in 1919. Up to now about 11,000 boreholes have been drilled for rural water supply with a success rate of about 70 per cent. Today 5,600 of them are equipped with pumps, engines and storage tanks and are located in some 3,500 wateryards.

A system of reciprocating pumps, mostly Edeco, with diesel engines, mostly Lister was adopted in the late 60's for rural water supply systems. This system was chosen for the following reasons:

- They provide small amounts of water (5 m^3/h) thus preventing animal overstocking around wateryards;

- They are easy to maintain, durable and can be installed to greater depths without serious problems; and

- They are relatively cheap (a complete unit cost was LS 1,300 in 1970).

To ensure continuous water supply and to allow for mechanical breakdown, at least two wells were drilled at each site. Today in some villages there are more than 4 wells but which together produce only 15 to 20 m^3/h. Each well should in fact be able to produce 15 to 20 m^3/h. The reciprocating pumps are currently the most expensive pumps, and for the price of one reciprocating pump 3 to 4 turbines with an output of 20 to 50 m^3/h each can be purchased. Turbine pumps have now replaced the reciprocating pumps in the Northern Region, Khartoum, and most of the Central and Eastern Regions.

4. Handpumps.

In the mid-1970's UNICEF, in collaboration with the NCDRWR launched an ambitious programme for drilling slim boreholes fitted with handpumps.

The objectives of the programme can be summarized as follows:

1. To improve the general health and the socio-economic conditions of the rural population by providing sufficient and safe water for drinking, personal hygiene and other domestic purposes.

2. To improve the general situation of rural women by relieving them of the burden of carrying water for long distances and often from polluted sources.

Wells are drilled using a lorry-mounted hydraulic down-the-hole hammer drilling rig which tap the fissured zones in the Basement Complex. Normally a well can be drilled in one day and a pump installed the next. Today there are more than 4,000 wells fitted with handpumps concentrated in Kordofan, Bahr El Ghazal and the Eastern Regions. A pump with a yield of around 1 m^3/h is sufficient for 300 people.

There still exists a good potential for additional wells in Darfur, Blue Nile and the Red Sea areas.

The advantages of this system can be summarized as follows:

- It is a quick method;
- It is cheap and easy to maintain;
- It ensures community participation in all stages of planning, implementation and operation and maintenance; and
- It provides reasonable amounts of water in the Basement areas where no other techniques are appropriate.

This system has been adopted as an appropriate technology for areas underlain by Basement Complex rocks and where favourable climatological conditions allow aquifer recharge.

Rural Water Cost

The actual cost of rural water varies depending on hydrogeologic and hydrological conditions, the method of development and the pumping systems. The following are rough estimates:

A hafir of 50,000 m^3 capacity with a lifetime of 20 years will cost about 2.5 million Sudanese pounds for construction. The hafir will supply about 15,000 m^3/year (300,000 m^3 in 20 years). Thus the production costs will be around LS 8 per cubic metre of raw water without pumping or treatment and excluding even operating costs.

A wateryard with a single borehole on average will cost about 1.2 million pounds for construction only, including the cost of a reciprocating pump. It costs annually around 70,000 pounds for operation and maintenance. On the assumption that the lifetime of the borehole is 20 to 30 years and the mechanical units last 10 years, the annual cost will be about 80,000 (initial) + 70,000 (operating) for a total of 150,000. The water production of such a wateryard will be about 30,000 m3/year at a cost of LS 5 per cubic metre or 10 piastres per 4 gallon tin. The same well with a turbine pump will cost about 800,000 pounds for construction and 100,000 pounds for annual operating costs to produce about 100,000 m^3/year with a production cost of about LS 2 per cubic metre.

Conclusions and Recommendations

The Sudan used to have good traditional water supply systems but these have deteriorated over time and are now in need of improvement and rehabilitation.

In the Sudan, the improvement of the rural water supply wateryards and hafirs initially employed mid-to-high cost technologies but later, due to economic reasons, there has been a tendency to go back to low cost technologies.

To maintain and operate 3,500 wateryards and 900 hafirs and dams places a heavy financial and administrative burden on the government. In the future, existing systems which are rehabilitated will have to be operated and managed in such a way as to ensure the user communities participation in their upkeep.

The existing water pricing system in the Sudan should be revised to meet the operating and maintenance costs and to provide a marginal profit for improvement and system extension.

Use should be made of renewable energy for water pumping whenever feasible. For example solar and wind are possible alternatives to diesel engines.

It is clear that the the water resources in the Sudan are tremendous except in a few exceptional areas and that the technology exists to solve rural water problems. The major constraints are primarily managerial and in the future, efforts must be directed to involve the beneficiaries in a greater management role.

MAINTENANCE AND OPERATION OF WATERYARDS IN THE SUDAN

Mohamed Abdalla Sabeel and
Abass Hamaza Abdalla
National Rural Water Corporation
Khartoum, Sudan

Introduction

The National Corporation for Development of Rural Water Resources (NCDRWR) started as a small unity within the Ministry of Works and Public Utilities. It was then promoted to a Department within the Ministry of Agriculture, composed of the two main units of Drilling and Land Use and Soil Conservation.

In 1960 a decree was issued identifying the relationship between the Department of Land Use and Soil Conservation and the local government. The Department of Land Use and Soil Conservation was to be responsible for:

- Ground and surface water research studies;
- Socio-economic studies;
- Construction of rural water supply systems; and
- Operations and maintenance.

The local governments were to undertake:

- Recruiting of wateryard clerks and guards and training of clerks;

- Supply and control of fuels and lubricants; and

- Revenue collection.

In 1976 a decree was issued reorganizing the authorities of the Corporation and of the local government. The Corporation was to include in its budget all the maintenance staff while the wateryard staff (clerk-pump operator and guards) were to continue to be paid by local governments.

In 1980 the Corporation was transferred to the Ministry of Energy and Mining and was decentralized. In 1986 the Corporation was recentralized and in 1988 was transferred to the Ministry of Irrigation and Water Resources.

Organization and Activities of the Corporation

The NCDRWR headquarters is in Khartoum and consists of a number of different departments contributing to the activity of rural water supply. One of the main departments is the Mechanical Engineering Department which includes a section for the maintenance of wateryards. This section has the following responsibilities:

- Planning and programming for maintenance and rehabilitation of wateryards;

- Establishment of administrative policies and technical standards;

- Preparation and control of the maintenance budget;

- Supervision of the execution of the national plan on a regional basis;

- Provision of technical assistance;

- Preparation of requirements for spare parts, equipments, materials and working tools; and

- Training of personnel at all levels inside and outside the country.

In each region there is a Regional Director and a Deputy Regional Director for Mechanical Engineering, who is in charge of the mechanical engineering activities in the region, with particular emphasis on maintenance and operation and the implementation of rehabilitation programmes.

All mechanical engineering activities within the province are under the supervision and responsibility of senior mechanical engineers with aparticular focus on the following:

- Supervision of maintenance centres;

- Operation and maintenance of wateryards;

- Administration of wateryards; and

- Promotion of revenue collection.

During the early sixties the number of wateryards were few and mainly concentrated in Kordofan and Darfur Regions (formally provinces) and the equipment generally was in good condition. Consequently wateryard maintenance was not a serious problem.

Later as the number of wateryards increased and different types of pumping units were introduced, an operation and maintenance plan and strategy was required to match the number and diversity of pumps. Operation and maintenance of existing wateryards is proving a costly undertaking.and now considerable international technical and financial support is urgently required to rehabilitate the systems. The number and geographic distribution of wateryards is given in Table 1

Available Facilities for Operation and Maintenance

In order to perform operation and maintenance on wateryards the Water Corporation has established a number of maintenance centres throughout the country.

These were established mainly with Yugoslavian aid support between 1979 and 1988. There are 36 maintenance centres (type C) (Figure I) 5 main workshops and a training centre at Wad El Magboul. Each maintenance centre is equipped with a workshop, machinery and servicing tools. However, these centres lack major machinery and equipment and transport and communication facilities. The maintenance centre staff generally includes a mechanical engineer, technicians, foremen, skilled labourers and labourers. There is a vital need for intensive training and accommodation for all staff.

Table 1
Wateryards and Boreholes in the Sudan

Region/Province	No. of Wateryards	No. of Boreholes
Kordofan		
Northern	402	565
Southern	131	171
Darfur		
Northern	131	199
Southern	239	332
Central		
Gezira	854	959
White Nile	190	204
Blue Nile	294	323
Northern		
Nile	88	97
Northern	67	76
Eastern		
Kassala	114	154
Red Sea	-	-
Khartoum	209	253
Total	**2719**	**3333**

Rehabilitation and maintenance processes are categorized as follows:

Rehabilitation.

Rehabilitation of a wateryard starts by rectification and drilling or replacement of the borehole as required. This is carried out by the relevant departments within the NCDRWR. The rehabilitation programme is usually prepared by the regional office based on the technical reports from each maintenance centre.

The approved budget and available funds to meet implementation of rehabilitation programmes are far below the actual needs, so it is very important to obtain international support in this respect.

Figure 1

Routine maintenance.

This is carried out by pump operators on a daily, weekly and monthly basis in accordance with a maintenance chart. Also during tours of inspection by the maintenance engineer, supervisor or maintenance team leader, some routine checks and necessary repairs are made.

Emergency maintenance.

In the case of a major breakdown at the wateryard the clerk in charge sends a message to the nearest maintenance centre to make the necessary arrangements for an urgent repair.

Although the NCDRWR is utilizing all the available potentialities for maintaining an effective and efficient operation of wateryards, it is faced with a lot of difficulties that are hindering the achievement of adequate operation and maintenance standards.

Community Participation

In the early seventies the Government established self-help committees at all levels throughout the country. In the rural areas in particular, the main objective for the formulation of these committees was community participation for rural development.

The principal activity of the rural committee was often directed towards the operation and maintenance of wateryards. The rural committees usually struck a water committee composed of a suitable number of members with the responsibilities of:

- Imposing reasonable water charges to cover the costs of fuel and lubricants, to contribute in providing spare parts and to forward the Government portion of water tariffs to Khartoum; and

- To assist in minor repairs and general maintenance for fencing within the vicinity of wateryards.

In the absence of close supervision from the Government and a high percentage of illiteracy within the village community, these committees often carried out illegal activities. Some of these illegal practices which the water committees undertook were:

- Increasing the water charges;

- Intervening in pump operator responsibilities; and

- Interfering with maintenance teams.

There were several disadvantages with water committees being responsible for the wateryards. For example, there was no proper bookkeeping or regulations to control the implementation of water charges, revenue collection and auditing. Further in some cases the committees consisted of people chosen on a tribal basis who did not represent the whole community. Consequently, these factors often resulted in excessive hours of operation of the pumping equipment which in turn led to frequent breakdowns and to an overall deterioration in the general condition of the wateryard equipment.

Training

To enable its staff to better undertake their operation and maintenance responsibilities, the NCDRWR has a training programme. The training for the NCDRWR personnel is carried out within the framework of the Sudan National Training Programmes and is classified for both academic and practical training at national and international levels. However, lack of funds has severely limited the number of approved training programmes for NCDRWR staff.

The NCDRWR policy is to train newly appointed engineers and technicians for a period of 6 months in its central workshop in Khartoum before being transferred to one of the different regions in the country.

Under the agreement for the construction of maintenance centres by the Yugoslavian Company Geotechnica, thirty technicians have had 3 month training courses in Yugoslavia to gain different skills for the efficient operation of the equipment and machinery in the newly constructed workshops. Also under the same agreement Yugoslav experts carried out a local training programme for 10 people at the training workshop at Wad El Magboul Training Centre.

The training courses undertaken by the Yugoslav project have included:

- Crankshaft grinding;

- Boring and honing;

- Milling; and

- Shaping.

In addition, courses on the testing and calibration of fuel pumps, the testing and repairs of fuel injection and on electrical equipment, including general electricity and automobile electrical systems have been given.

The NCDRWR has constructed training classrooms in some regions for the purpose of training wateryard pump operators. It is felt that these classrooms should be established in all regions of the country in order to produce more competent pump operators.

The pump operator is in charge of the pumping unit/s and other components related to water pumping at the wateryard. His main function is to carry out daily, weekly and monthly routine maintenance in accordance with the maintenance chart. This includes checking for engine oil, and gearbox oil, greasing the moving parts of the unit and keeping the pump engine room clean and tidy. He also carries out possible repairs and assists maintenance teams when carrying out major repairs in the wateryard.

Cost Recovery and Pricing

When water prices were first set for wateryards, the tariff was 2 mms/tin (4 gallons) which later increased to 10 mms/tin. For animal watering, the owners are charges according to the standard amount of water each animal drinks. This system of pricing was adopted in some areas but still in other regions water was not charged for but was taken free.

In 1983 a study was carried out in Southern Darfur which led to an agreement between the governmental and the non-government implementing agencies and the beneficiaries. The study was carried out jointly by the NCDRWR and the Western Savannah Development Project (WSDP) and was based on a random sample of 32 wateryards in the area.

The objective of the study was to set a suitable water price which could be accepted by the users and would generate enough revenue to cover the operational costs and a return on the capital investment in the project.

The water price recommended by the study was reached according to the figures of the actual cost of water pumped from every borehole during one season in addition to a 5% interest surcharge.

The yearly total cost was calculated taking into account:

- Cost of fuels and lubricants;

- Salaries and allowances for maintenance staff;

- Spare parts;

- Salaries and allowances of administrative staff in the wateryards (clerk, pump operator and guard); and

- Depreciation of equipment.

The quantity of water was based on the number of beneficiaries and was calculated on a daily basis and the per annum total was found to be 440,000 (tins). The cost of equipment depreciation was obtained by estimating the capital investment for the following:

- Borehole - average lifetime of 25 years.

- Pumping unit and other components - average lifetime of 10 years.

- Buildings - average lifetime of 20 years.

Based on these calculations, a final price of 31.4 mms per tin of water was obtained (Table 2)

Table 2
Water Pricing

Item	Cost per annum (LS)	Cost of (1) tin of water (mms).
1. Fuel and lubricants	875	2.0
2. Salaries and allowance for wateryard staff	1000	2.3
3. Maintenance	3200	7.3
4. Depreciation	4700	10.7
5. Interest	4000	9.1
Total	**13775**	**31.4**

This price was then applied after being passed through the required legislative procedures.

This system was first implemented in 16 of the rehabilitated wateryards in Southern Darfur after the provision of sufficient quantities of fuel and lubricants and the securing of spare parts. The price was readily accepted by the villagers as it was much lower, in fact almost half the 50 mm/tin being charged by the village water committees.

These water charges can be applied in other areas provided that the preconditions that contributed to its success in Southern Darfur are met. These include:

- Rehabilitated wateryards in good condition;

- Availability of sufficient stock of fuel, lubricants, spare parts and materials; and

- A well serviced fleet of cars for maintenance operations distribution of fuel and for wateryard inspection trips.

It is worth mentioning that this system of pricing needs to be assessed and updated on a regular basis so that the collected revenues are sufficient to permit the NCDRWR to become a self-sustaining service organization.

Revenue Collections

Water sales are controlled through the sale of water tickets and by checking water meter readings to obtain the quantity of water consumed.

Due to frequent breakdowns of water meters, another procedure for obtaining the quantity of water consumed was introduced. This involves a field test based on calculating the actual fuel consumed over a specific time during which the quantity of water pumped is closely monitored. Then based on the quantity of fuel used the number of gallons of water pumped per gallon of diesel can be obtained. Subsequently, by monitoring diesel consumption water production can be approximated.

By adopting the new water prices in 1983, and applying full administrative and checking regulations and control the revenue generated in 1985/86 was high compared to previous years as shown in Table 3

Table 3

Revenue Collected from Different Wateryards

Category (A) Wateryards Operating 12 Months/Year El Deain Maintenance Centre Wateryard	Revenue 1984/85 (LS)	1985/86 (LS)
1. Abu Matarig	8,149.33	35,548.12
2. Kario	15,183.26	33,529.41
3. Abu Imma	22,153.30	42,097.26
4. Abu Karinka	13,223.90	42,632.60
5. El Dain El Batary	28,883.60	53,897.33
Category (B) Wateryards Operating 8 Months/Year		
1. El Asal	7,146.15	33,847.30
2. El Tabat	10,956.36	21,694.51
3. El Rut Rur	10,969.88	20,574.00
Category (C) Wateryards Operating 6 Months or less/Year		
1. Um El Hatoo	4,146.00	12,181.75
2. Kowrachi	2,815.00	17,709.45
3. El Mabag Baglool	5,507.00	15,731.00

Experience With Various Technologies

Reciprocating pump or piston pumps with diesel engine drives were the first type of pumps installed in wateryards. This was the only make available at the time. The NCDRWR has continued to install these pumps and now due to their long experience the NCDRWR maintenance staff have acquired the skill to properly maintain and operate these units.

By the early 1970's vertical shaft turbine pumps were introduced and installed in boreholes where the yield exceeded 5000 gallons per hour and recently, submersible pumps have been introduced but on a very limited scale.

Handpumps which are a low cost technology have been in use in large numbers in the Northern Sudan where it is estimated that perhaps 2,600 have been installed. Other possible technologies utilizing wind and solar energy have not been implemented for rural water supply to any extent.

The selection of a pump is critical and must be made taking into consideration the following:

- The daily output required which is dependent on the population, the number of livestock, etc;

- The yield of the borehole which is usually expressed as proven yield in gallons or cubic meters/hour;

- The total head; and

- Borehole diameter.

As the demand and borehole characteristics dictate pump selection, the NCDRWR uses a variety of different pumps in its wateryards.

Summary and Conclusion

1. Since its establishment, the NCDRWR has been an unstable organization due to its transfer from one Ministry to another and also due to changes in mandate, structure and authorities. This has created difficulties and problems in the system affecting the planning and implementation of programmes.

2. International technical and financial support needs to be provided to strengthen the NCDRWR's potential and to improve the operating efficiency of wateryards.

3. Community participation cannot be ignored but needs to be organized so as to be consistent with NCDRWR regulations and plans.

4. A study is required to evaluate the on-going intensive handpump installation programme to evaluate its performance and to ensure the future efficient performance of these pumps. In particular, attention needs to be directed to the problems expected to face handpump caretakers.

5. Using the experience obtained from the cost recovery and pricing system in Southern Darfur, consideration should be given to implementing this system in other areas.

6. A revolving fund account should be established and controlled by the NCDRWR to promote community-sustained water services and to secure a reliable water supply for the rural communities.

7. A comprehensive wateryard rehabilitation programme needs to be prepared and implemented by the international community.

RURAL WATER SUPPLY OPERATION AND MAINTENANCE AS PART OF OVERALL RESOURCE DEVELOPMENT

Rural Water Supply Group-East Africa
UNDP/World Bank Project
Nairobi, Kenya

Elements of Overall Water and Sanitation Sector Development

Rural water supply operation and maintenance (RWS-O&M) is one part of the water supply and sanitation sector which can be divided into the four sub-sectors:

- Rural water supply;
- Urban water supply;
- Rural sanitation; and
- Urban sanitation.

The sector development activities can be further broken down into three phases: planning, construction, and operation/maintenance as shown in Figure 1. The definition of what constitutes the rural water supply sub-sector will vary from country to country and any classification will be temporary as some rural villages become growth centres and eventually towns or cities. Nevertheless, several criteria are often used, for example:

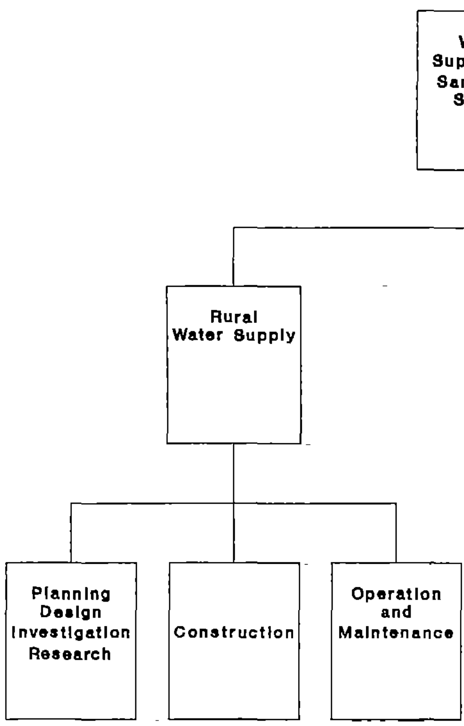
- Communities below a certain size and/or population density may be scheduled as rural;
- Communities having (or lacking) certain organizational and governmental structures may be considered rural;

- As ability-to-pay is often lower in rural areas this may be a factor in the type of system to be considered (thus poor people in peri-urban areas may be scheduled for rural type systems or rural levels of service); and

- The type of economic activity and life style may be considered rural (i.e. agricultural activity would be rural, whereas trading or industry would be more urban).

Insert Figure 1 here

Figure 1



Scarce financial, human and water resources often leads governments to see the advantages of rural and urban water and sanitation being coordinated within a sound policy framework. In order to carry out the policies and monitor progress and adherence to rules and norms it is necessary to have worked out details on such matters as:

- Objectives and strategies;
- Water and pollution control laws;
- Institutional and organizational arrangements;
- Administrative procedures; and
- Technologies appropriate for the various conditions.

A comprehensive review of the whole sector will bring to light opportunities for and constraints against development and progress in the sector. Based on this an action plan can be drawn up and implemented. The greater the existing level of investment, and the greater the anticipated level of future investment, the greater will be the benefit of preparing and working within a sound framework of policies, plans and procedures for the development of the sector.

The resources available for planning, constructing, operating and maintaining rural water supply systems are:

- Water resources;
- Human resources;
- Financial resources;

- Physical facilities; and

- Organizational systems.

Some of these resources may be found in the village, some in the public service and some in the private sector. The optimum mix and the degree of centralization or decentralization will vary from country to country and from time to time. Within large countries with great climatic and ecological variation the details of the systems may vary somewhat from region to region.

Share of Rural Water Supply Operation and Maintenance

In sub-Saharan Africa about 70% of the population lives in the rural areas, although this percentage is decreasing. In the Sudan, the respective figure is about 77%. It is estimated that 40% of the people in Africa (78% of urban and 25% of rural) and 34% in the Sudan (47% of urban and 30% of rural) have access to adequate water supply.

At present, the total investment in water supply is about USD 400 million per annum in the sub-Saharan Africa and USD 42 million per annum in the Sudan, out of which USD 33 million is directed towards rural water supplies. The recurrent expenditure in the rural water supply sector in the Sudan is LS 69 million per annum at present. Out of that about 80% is used for personnel expenses (salaries and allowances) and only 20% for fuel and spare parts.

The share of manpower of RWS-O&M is relative to its financial share, although the nature of the operation does not emphasize requirement for highly skilled personnel. It can be estimated that in the Sudan out of the total work force of 15,000 in the NRWC, about 12,000 are directly involved in the operation of public rural water supply systems. In addition, there are numerous community or privately owned supply systems which employ a considerable number of people.

The facilities used in rural water supplies in the Sudan include, apart from the water supply systems themselves, administrative buildings, stores workshops and transport facilities. The number of the public rural water supply facilities is as follows:

wateryards	3,600
filtration plants	142
small roughing filters	27
hafirs	1,100
dams	126
handpump wells	5,000

The value of these facilities can be roughly estimated at USD 150 million. The present (1987) annual allocation through NRWC for RWS-O&M is approximately LS 30 million. The estimated maintenance requirements of the existing facilities (5% of value) is LS 33 million which shows that there is a considerable deficit in RWS-O&M financing. This type of situation is common in Africa where priority has been given to the development of new facilities and where governments have provided the main share of RWS-O&M costs.

Linkages of Rural Water Supply Operation and Maintenance to Other Sector Elements

Being part of the water supply and sanitation sector the RWS-O&M is linked to and dependent on other sector elements and other parts of the society as shown in Figure 2:

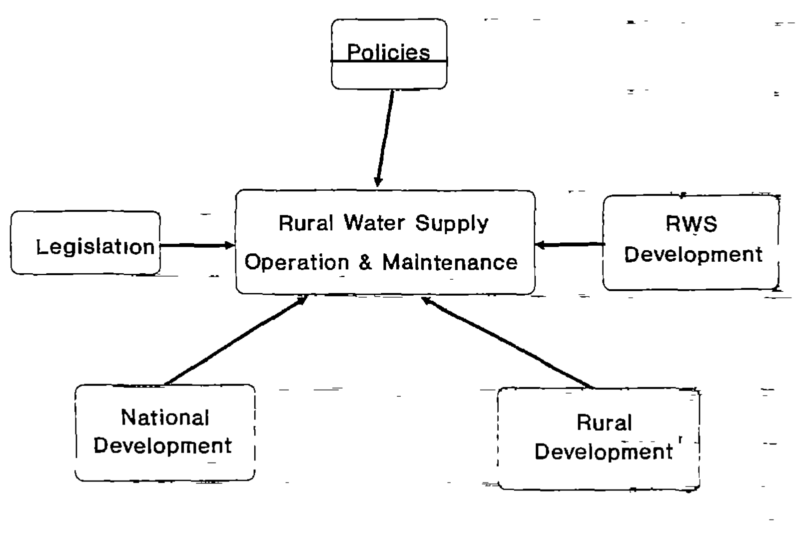
- legislation provides for the legal framework for sector functions and institutional arrangements and gives possibilities for flexibility in operating and maintaining rural water supplies.

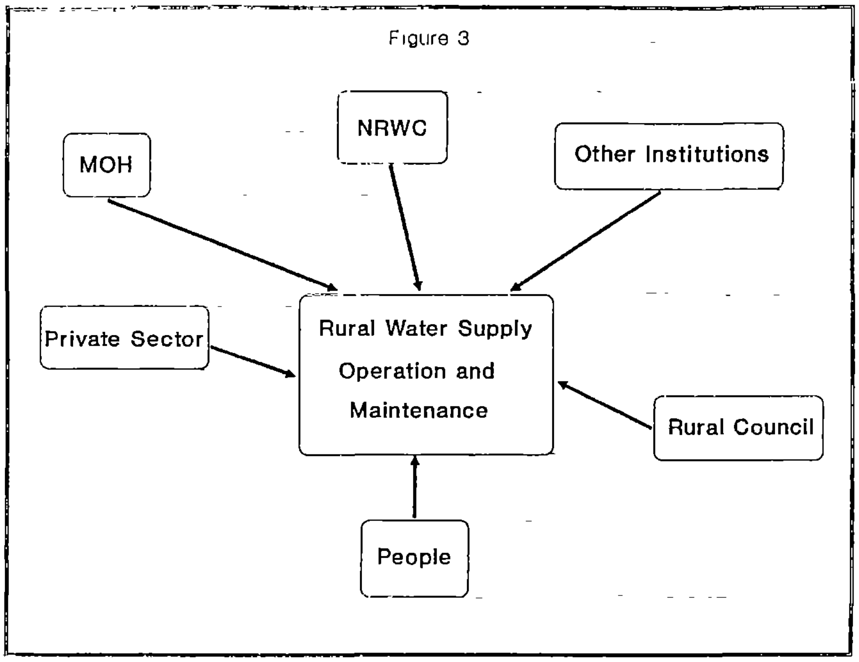
- rural water supply development determines the scope and characteristics of RWS-O&M (the general national development and, more especially, rural development have strong and direct influence in the development of rural water supplies and their operation and maintenance).

- in the Sudan RWS-O&M is normally the responsibility of NRWC but MOH, educational institutions, donor agencies, local councils, private sector and the consumer communities also have their role in the sub-sector as shown in Figure 3.

rural water supply development and thus RWS-O&M also depend on the resources available: water resources, financial resources, manpower resources, technologies and facilities (environmental aspects also have, or should have, influence on operation and maintenance of rural water supplies).

Figure 2





Aspects to be Taken Into Consideration In Rural Water Supply Operation and Maintenance at the Sectoral Level

The following aspects should be taken into consideration in the development of RWS-O&M:

- The operation and maintenance of rural water supplies cannot be considered in isolation. It is part of rural water supply development, general sector development, rural development and national development;

- Sustainable operation and maintenance of water supplies can only be achieved by beneficiaries taking the main responsibility. This means that consumers should pay fully for the operation and maintenance and in the long run also for the development;

- Planning of water supply development so that there is a balance between provision of new facilities and capabilities to operate and maintain the existing and new systems (in other words, when deciding on the new development, it should be known already how the operation and maintenance will be arranged and financed):

- In planning of water supply development, choosing the level of service and technology which is appropriate, affordable and can be operated and maintained with the available technical and financial resources;

- Develop and standardize technologies which are easy to operate and maintain and are available in the country;

- Plan and implement manpower development so that a sufficient number of qualified and motivated personnel will be available (this includes providing training at the national and local levels);

- Water supplies have to be operated so that water produced is safe and fit for consumption and so that the operation does not cause undue stress and damage to the environment;

- Communities play an important role in rural water supply planning and development. When communities are given responsibilities for O&M they should be fully willing to take those responsibilities and have, or be provided with, corresponding technical, financial and administrative capabilities;

- If communities are to take over O&M responsibilities there has to be sufficient supporting infrastructure i.e. Government or private sector providing technical assistance, spares, fuel, etc; and

- In developing RWS-O&M and rural water supplies in general the aspect of an integrated approach in rural water supplies, sanitation and health education should be practiced, because the benefits of improved water supply do not fully materialize if sanitation and the general hygiene are not improved at the same time.

Observations Based on Current Efforts to Obtain and Sustain Affordable Rural Water Supplies

Efforts to develop sustainable operation and maintenance programmes are underway in anumber of countries. In Kenya, Tanzania, Malawi and India there are projects which emphasize operation and maintenance, low cost technologies and community participation. There are lessons to be learned from the experiences gained in these projects which will be useful for the Sudan.

Three Examples from Kenya

Community participation in projects such as schools, clinics and improved water supply has a long history in Kenya and the local word "harambee" conveys a sense of all pulling together towards a common objective. In the case of rural water supply there has been a policy of requiring beneficiary contribution even before the establishment of a Ministry for Water Development (i.e. when this subject was administered by a department in the Ministry of Agriculture). Another important policy is one which is called the District Focus for Development. Although not a new policy, the procedures and guidelines for implementation are revised periodically and many older projects launched 5 or 10 years ago were developed with much less attention and emphasis on this than those currently being developed. The ideal of this policy is that the expressed need and the idea for a development project will come from the village level and then be subjected to scrutiny by professionally qualified staff at the divisional and district level in order to assess impact, feasibility, etc. At the district and national levels, projects must be prioritized and must be positively responsive to national policy and strategy for the particular sector and sub-sector such as rural water supply.

Despite the policies mentioned above which can favour local action to get involved and contribute to planning, implementing and sustaining improved water supply systems, the lack of a clear operational framework to guide planning and implementation often results in rather slow development of programmes and lack of standardization in equipment and consistency of approach. Some of the examples given below illustrate attempts to develop affordable and sustainable systems, but there have also been some schemes which were expensive to build and too expensive and difficult to keep running. The policy of cost recovery or cost sharing is not disputed as a principle; however, it is only natural that there can be much debate on how much should be contributed and how best to make this operational.

Typically in rural systems the donor finances about 80 per cent of the construction costs, the government finances about 10 per cent and the community provides local materials and labour worth about 10 per cent (this latter contribution is often neglected or underestimated because it is so often in kind rather than in cash and thus harder to quantify). Rural water tariffs have long been published, but how consistently and effectively these are applied and monitored is not clear. What is clear is that the government is subsidizing recurrent costs in most systems and such subsidies have, on occasion, come from external donors as well.

1. Kwale Project

Kwale district is on the Indian Ocean and to the south of Mombasa. The government selected this area, and in 1981 the UNDP/World Bank handpump testing activities in Kenya were launched in both dug and drilled wells near the coast. The Swedish International Development Agency supported these efforts and has continued to support the continuation and expansion of the project (now called the Kwale District Community Water Supply and Sanitation Project). It should be noted that water and soil conservation as well as primary health care activities are also being implemented in the District with SIDA support.

Following the handpump testing there was the development of handpumps in which high priority was given to the concept of Village Level Operation and Maintenance (VLOM). The design which emerged and which is now being manufactured in Kenya and elsewhere (Malawi, India and Pakistan) is called the AFRIDEV handpump. A prototype direct-action version for shallow wells (down to 12 metre) has also been designed and is undergoing initial field testing. The AFRIDEV only requires a single spanner plus a fishing tool (for footvalve extraction) for all routine maintenance. This means that village level maintenance is greatly facilitated and local production of standardized parts makes them accessible as well as affordable. The current phase of the project (1985-1990) has been subjected to a mid-term evaluation in 1988. Furthermore PROWESS/UNDP has also prepared a case study of this and earlier phases of the project (published in late 1988) as part of their technical series on involving women in water and sanitation. Many of the points made below are drawn from these reports.

In the early stages of the project many of the technology issues were satisfactorily settled. These included improved siting and drilling techniques and better screening and gravel packing of boreholes, as well as the development of a VLOM handpump. A study by the African Medical Research Foundation (AMREF) in 1983 noted the inadequacy of the community participation both in terms of definition of objectives and in terms of resources allocated to this vital component. The project responded by changing course. A Kenyan NGO, Kenya Water for Health Organization (KWAHO) was brought into the project to fill the need for better community and women's involvement in all stages of planning, implementation, operation and maintenance.

In this case study the role of the NGO was to help organize and provide training to community groups so as to adequately involve men and women and ultimately to ensure that the facilities were properly used, cared for and sustained. The NGO also helped to synchronize the construction activities with the work on community organization and preparedness. It could be used in different ways to reach the same objective. For example, the assistance of an NGO could also be used to train district, divisional or locational staff from a Ministry like Culture and Social Services to carry out community organization, training and liaison with the technical or specialized departments. Another possible role for a national NGO would be to work with existing local NGO's in order to train them to carry out the community work needed for sustained participation in improved rural water supplies.

All those involved with the project have had to interact in new ways so that course corrections could be made as feedback from the field indicated need for change. These changes applied to almost all aspects of the project, from handpump design to the interaction between Ministries and the NGO, between traditional community leaders and the men and women working as water committees members and as handpump caretakers. These changes took time as problems were identified, solutions proposed and proved. The basis for this relatively successful project has been the persistent pursuit of a common goal by the Ministries, the communities, the NGO, and the donors to launch and sustain community owned and operated water systems. Community participation is also being developed for the other types of water supply in the district (i.e. protected springs, gravity schemes, rainwater catchment, etc.).

The project has completed about 200 wells (mostly boreholes) with handpumps. About half of these wells and handpumps have already been handed over to water committees for all routine operation and maintenance. All of these water committees have raised money and put this in bank accounts for procurement of spare parts and eventually for pump replacement. At the present time the spare parts are purchased from the project store in the district headquarters; however, it is envisaged that as local production of handpumps increases in Kenya, from the present few hundred per year to the necessary several thousand per year, spare parts distribution will be possible on a commercial basis.

The spare parts kit for the handpump costs Kshs. 200.00 (equivalent to USD 10.50) and these parts are recommended to be changed at least once per year. The average per capita cost of the borehole with handpump is about Kshs. 1,000.00 (USD 52.50) and about 10 to 15 per cent of the cost is spent on community development and training of water committees and caretakers. The per capita cost of some other means of water used in some parts of the project area such as rehabilitation of the piped water schemes and rain catchment is very similar to that of boreholes and handpumps; however, in the areas where spring protection is feasible, this is somewhat less at about Kshs. 645.00 per capita (the recurrent costs for protected springs are also estimated to be lower than for handpumps).

2. Lake Basin Development Authority (LBDA)

This project is active in four districts (Kisumu, Kisii, Siaya and South Nyanza) which drain into Lake Victoria. LBDA is a regional development authority which has been assisted by the government of the Netherlands in a Rural Domestic Water Supply and Sanitation Programme. A shallow wells project was begun in 1982 and it proved the feasibility of groundwater supply extracted by means of handpumps. Two types of detailed surveys were undertaken in all of the districts and their divisions. One type was a socio-economic survey of the communities. The other was a comprehensive survey of existing water supplies and of opportunities for the development of new and improved water supplies (especially groundwater).

The specific handpumps chosen were SWN 80 and 81. Although these pumps give an adequate discharge and have good abrasion and corrosion resistance, they are not easy to maintain especially for lifts greater than 12 metres. Local assembly and manufacturing of pumpheads (SWN 80) is going on at a small scale (about 100 pumps per year). Repairs of handpumps are carried out by maintenance officers on bicycles; however, heavy tools are transported by other means in advance of the repair work. The most common repair problems relate to broken pump rods and rising mains (cylinders also become disconnected or blocked).

In the initial phases of the project all work was planned and supervised from the regional headquarters; however, following review mission recommendations there has been considerable decentralization towards the district level. District implementation units now have staff specialized in the technical aspects of water resource development, extensionists trained to carry out socio-economic surveys and community development work, and sanitation foremen. The regional headquarter staff now act more as survey and design consultants on technical and social aspects and also perform overall monitoring and reporting. The headquarters staff also provide advice and assistance to a considerable number of other bilateral and NGO assisted projects in the region.

The community development work starts with the socio-economic survey which includes household questionnaires (a sample of 3 households per village), key informant questionnaires and formal discussion questionnaires agreed during formal meetings ("barazas") chaired by an Assistant Chief. This initial work is done in close consultation with the local authorities and results in selection of priority sites. As the objective is to place ownership of the water points in the hands of the community of beneficiaries, the extensionists have to see that:

- Land is formally set aside for the water point;
- A registered water committee is formed and trained;
- A pump attendant is chosen and trained; and
- That money (Kshs. 2,000 minimum) for maintenance is put in the committee's account.

Similar requirements are made of communities involved in spring protection. Of the total budget 19 per cent was allocated for community development work which includes the socio-economic survey work. Additional budget allocations totalling 13 per cent were made for training (both higher level technical and community level education).

As in the Kwale Project, the community development workers must assist in synchronizing the community work with the construction activities.

The LBDA Project has also done a lot to train local contractors to do as much as possible of the construction. This has been very successful and most well digging, platform construction and pump installation is done by local contractors (who also do rain catchment and latrine construction). Machine drilling is also contracted; however, handpumps maintenance is still to a large extent done by the project staff.

By late 1987, the programme had completed about 244 water points and was able to do another 200 points in 1988 and has the capacity to equal or exceed this in 1989. The average cost of a 70 metre deep drilled well complete with handpump is Kshs. 138,250.00 (USD 7,200.00). A typical 18 metre dug well installation costs half as much as the drilled ones. The variation in cost for dug wells deeper than about 20 metres is much greater than drilled wells in the same depth range. The estimated annual maintenance cost per handpump is Kshs. 1,930.00 (USD 100.00) Villagers pay for spare parts, but do not pay for any breakdown or defects which occur within the first six months of installation. Considerable staff and transport costs for maintenance could be saved if more routine maintenance and repair were done at village level; however, this will require some changes in the design of the pump especially the down-hole components.

3. Finland Western Water Supply Programme

This programme works in an area covering parts of four districts (Kakamega, Bungoma and Busia in Western Province and also a small part of Siaya District). The investigation and planning was largely done from 1981 to 1983 and implementation has been going on since 1983. The improvements include spring protection, rehabilitation of piped schemes and handpumps installed on both dug and drilled wells. A FINNIDA supported primary health care project is also being implemented in this region.

Although this programme is a regional one, it has moved towards the district focus ideal in responding to district priorities and coordinating with district and lower level development committees. The programme also contracts within each district for as much of its required goods and services as possible. The programme has tested many types of handpumps and worked with the supplier and the UNDP/World Bank programme in developing a VLOM direct-action pump (NIRA AF-85) which performs well in shallow wells with a lift of up to 12 to 15 metre. For deeper wells other NIRA handpumps, AFRIDEVS and India Mark II's pumps are being used. Currently the programme has expressed the need to standardize on VLOM handpumps and have these produced locally in order to move closer to the goal of locally sustainable operation and maintenance.

The programme has developed a training and community development section which works with communities in planning, siting, constructing and maintaining their water points. Typical activities include:

- Formation and registration of water committees and land easements;

- Seminars for community leaders and extension workers;

- Training of women handpump attendants;

- Education of consumers and promotion of hygienic use of water; and

- Obtaining feedback from consumers regarding their water points.

The budget for these activities is about 10 to 11 per cent of the programme costs.

Since the start of the implementation in late 1983, the programme has completed some 2,550 new water points. About one third of these are protected springs, one third dug wells and one third boreholes. The unit costs are similar to those in the LBDA region. Dug wells with handpumps cost about USD 3,300.00 and boreholes with handpumps about USD

7,300.00 Handpump maintenance is eased by the use of a VLOM direct-action pump in many of the wells (this is possible because of relatively shallow groundwater in much of the region). Annual maintenance costs of handpumps depends on the type and depth and whether it is a VLOM (i.e. NIRA AF-85). Deep well handpump maintenance can cost from USD 150.00 to USD 200.00 per year; whereas, shallow wells with VLOM pumps can be maintained by the villagers themselves for USD 20.00 to USD 30.00 per year. The down time for maintenance and repair of VLOM pumps is also reduced correspondingly.

An Example from Malawi

This country is well known for its very successful rural gravity water supply system based on community participation. Malawi has also promoted the use of water committees for operation of standposts in peri-urban areas where house connections are not financially feasible. Health education and sanitation have also been promoted with the gravity feed schemes. The community based schemes were started by NGO's and the government's community development workers. From the start communities also contributed for minor maintenance such as replacement of taps and repair of tap stands.

The history of rural water supply by means of boreholes with handpumps has not been so straightforward. Early on, dispersed drilling activities led to high costs and the maintenance responsibility was shifted from the district level to the central government without an improvement in results. Fortunately drilling efficiency has been improved by concentrating the work and by improving communications and logistics (by greater use of the private sector, drilling has also boosted production rates). Development of VLOM handpumps has opened the way for more effective and affordable maintenance.

RWSG-EA is working with the government on several levels. One has been to prepare a position paper and action plan for water supply and sanitation. As part of the effort to encourage practical plans in the sector and its subsectors, UNDP/ World Bank and UNICEF assisted the government to organize a workshop on National Strategies for Operation and Maintenance of Rural Groundwater Supplies in late 1986. Subsequently, a project was developed to implement the recommendations of this workshop. This basically calls for decentralization of handpump maintenance and creation of support and monitoring mechanisms for the new system. Local production of VLOM pumps (AFRIDEV) is also being supported by the UNDP/World Bank Project. As more systems of all types are installed and as they age, the cost of maintenance will go up; therefore, the ability and willingness of people to pay, not just for routine maintenance, but also for major repairs and replacements must be reassessed. Based on these findings, improved systems of cost recovery will have to be developed.

An Example from Tanzania

RWSG-EA has helped Tanzania prepare a sector development plan to deal with the institutional and other constraints found there. It will also follow-up with projects to implement strategies laid down in the plan. With regard to rural water supply a workshop on National Strategies for Operation and Maintenance of Rural Water Supplies was held in 1988. The key conclusions of the workshop were:

- Operation and maintenance of rural water supply schemes are local responsibilities to be met at the village level;

- The village capabilities for preventative maintenance need to be strengthened;

- Local and central government bodies shall continue for the time being to provide backstopping support services;

- Standardization of procedures is called for;

- A reporting system shall be developed covering village, ward, district, regional and national levels;

- The government shall vigorously pursue local production of handpumps; and

- To help the standardization process, a more extensive local production of equipment and materials shall be pursued.

An Example from India

The UNDP/World Bank Project has worked with the Government of India and with UNICEF to apply the VLOM concept to the India Mark II handpump. The minimum number of necessary changes were made to the India Mark II to facilitate maintenance. The main changes were:

- increasing the diameter of the rising main to 2 1/2 inches (using the same material as before which is galvanized steel) to permit extraction of the plunger and footvalve without removal of the rising main;

- slightly modifying the pump head to facilitate faster removal for access to the down-hole components;

- use of an open top cylinder through which the plunger and footvalve can be extracted.

This modified Mark II pump is now called the VLOM Mark III. The major cost difference between the Mark II and the VLOM Mark III is that the cost of the 2 1/2 inch rising main is more than double that used in the Mark II. This extra cost is offset by major savings in maintenance costs and reduction in down time. One of the costliest items in maintaining India Mark II's is the transport of maintenance personnel and equipment. This is expected to be cut by 50 to 75 per cent with the Mark III; however, each country should obtain actual field data on this as it could vary significantly from country to country depending on field conditions and on the way maintenance is organized. Even in India, costs vary from state to state depending on maintenance systems (two tier, three tier, etc.), on the distribution of pumps and on how well the state government institutions are organized to cope with this and related sector issues.

In addition to an improved and easier to maintain handpump, Indian experts meeting in Nagpur in 1988 also stressed the need for action to :

- Mobilize local resources because central and state government services are overloaded with demands;

- intensify training programmes (especially training of trainers) for preventative maintenance and for repairs;

- Encourage participation of voluntary agencies in rural water supply (especially those with skills in community organization and health education);

- Employ more qualified sociologists and economists in the water department to better deal with community and cost recovery issues; and

- Involve and train women for work on water committees and as handpump caretakers.

Approach in the Sudan

1. Introduction of the Proposed UNDP Technical Assistance Project

In 1987-88, the Government of Sudan with assistance from the Regional Water and Sanitation Group - East Africa, carried out a water supply and sanitation review. This review discovered several serious problems and shortcomings in the sector; several related to intersectoral division of responsibilities and coordination and institutional capacities. The review report included an action plan containing proposals for immediate measures for strengthening the sector institutions. The report further recommended that implementation of the action plan be supported by a UNDP technical assistance project.

The general objective of the UNDP funded project is to improve the general performance of the sector. The more specific immediate objectives are:

- Rationalize functions and responsibilities for the various sector institutions with the identification of intersectoral interactions;

- Strengthen the following sector institutions: NRWC, NUWC, MOH, MHPU and establish linkages with DSCLUWP of MOA: and

- Develop investment planning and project/programme preparation systems and procedures and aid in the formulation of investment plan and project/programme packages for donor financing.

To achieve the objectives, the general strategy of the project is:

- To consolidate the sector responsibilities for water resources management and for land, soil and water utilization taking environmental issues into due account;

- To define functions and responsibilities for concerned sector institutions with identification of interministerial and intersectoral interactions;

- To establish systems for an integrated approach in water supply, sanitation and health education project implementation;

- To develop the sector institutions to enable them to comply with objectives set on service coverages;

- To develop procedures for investment planning taking into account prioritizations, appropriate technologies and financing resources, and other development activities linked to water supply and sanitation; and

- To develop financing and cost recovery procedures in order to achieve financial self-sufficiency on a long term basis.

To implement the above strategy, the Project has been designed to assist the sector institutions to gradually overcome their weaknesses and shortcomings as identified. Specific tasks, both short and long term have been identified for the achievement of these objectives which are as follows:

- Preparation of a water supply and sanitation sector strategy paper;

- Identification of duties and responsibilities for various sector institutions and of systems and procedures for required interactions;

- Preparation of plans for organizational and manpower resources development;

- Preparation of financing, accounting and cost recovery policies, systems and procedures and operation and maintenance manuals;

- Preparation of national programmes for rural and urban water supply and sanitation;

- Preparation of sample regional rural and urban projects/programmes; and

- Continuation of studies on water resources assessments.

The above tasks are proposed to be implemented through:

- The Water and Sanitation Co-ordination Committee (WSCC) to be established under the Ministry of Finance and Economic Planning to monitor the Project and to assume the interministerial and intersectoral coordinating and policy making role. The WSCC will be composed of representatives of the concerned sector authorities; and

- The Sector Advisory Team (SAT) to be established and to be composed of:

- A Project Coordinator (PC) to be located in MFEP and to be assisted by a technical assistant (TA) specialized in sector organization and manpower development;

- Two TAs (engineer and financial analyst) to be assigned to NRWC and NUWC respectively (two in each organization;

- One TA (sanitation specialist) to be assigned to MOH;

- The SAT will be supervised and guided by the WSCC; and

- A consultant assistant to complement the SAT will also be required for specific activities.

The execution of the project will be carried out by the World Bank through RWSG-EA, Nairobi.

The inputs of the project consists of 7 experts (5 expatriates and 2 local experts) and 4 short term consultancies with provision of necessary equipment. The estimated total cost of the project is USD 3.8 million, of which the financing still has to be finally agreed to.

The main outputs of the project are:

- Water Supply and Sanitation Strategy Paper;

- Definition of functions and responsibilities for various sector institutions through an Interministerial and Intersectoral Study;

- Detailed organizational structures for sector institutions, estimates for manpower requirements and training through an Organization and Manpower Development Study;

- Accounting, financial and management information systems and procedures, tariffs and requirements for financial self-sufficiency through a Financing, Accounting and Cost Recovery Study;

- Operation and Maintenance Guidelines and Manual which include proposals for administrative and procurement procedures, operation guidelines for various types of water supplies and stores and transportation manuals;

- Improved database for water resources management and general knowledge on the water resources in the country through a Water Resources Assessment Study;

- National Programmes for rural water supply, urban water supply and sewerage, urban sanitation and rural sanitation. These 5-year programmes will provide the framework for the development and investment planning of each sub-sector. The aim of these programmes are to optimize the impacts of the proposed investments, enable lending activities to take place in a more uniform and controlled manner and to promote an integrated approach in water supply, sanitation and health education. The National Programmes will also provide the basis for the preparation of Regional Programmes;

- Sample Regional 5-year Programmes for rural water supply, urban water supply and sewerage, urban sanitation and rural sanitation will be prepared with identified development projects, investment and implementation programmes. These programmes will be used as models when preparing similar programmes in other Regions; and

- Implementation of the above proposals and programmes in the sector institutions which means introduction and installation of the systems and procedures in the organizations, training the staff and provision of further support in implementation of the systems and programmes. (To enable this part of the Project to proceed the necessary decisions have to be made by the authorities concerned to adopt the improvements and the programmes).

Project Implementation Schedule

The implementation of the Project is planned to start at the beginning of 1990 and to go on for 3 years.

2 Proposed Project for Support for Local Production of Handpumps

Background

In late 1988 RWSG-EA was asked to assist the Government of Sudan and UN agencies concerned to review the situation with regard to requirements for India Mark II type handpumps and to review proposals for local production of such handpumps. Accordingly, two handpump missions were made and a draft project document was prepared in March 1989 for consideration by GOS, UNDP, UNICEF and other interested donors and by potential manufacturers.

Requirements

The medium deep borehole pump can be used in many parts of the Sudan. One estimate is that as much as 60 per cent of the population are living in areas that could be served by such handpumps. UNICEF alone has been installing as many as 1,000 such pumps per year. In order to keep up with population growth and to provide replacement for worn out pumps, the number of required pumps could be anywhere between 3,000 to 5,000 handpumps per year, depending on field conditions, funding and implementing capacity.

Srategy

Local production of handpumps aims to facilitate sustainable rural water points by improving access to pumps and spare parts and by increasing local employment and improving skills. There are many potential benefits, but they can only be realized if there is good quality control. Therefore all concerned must give high priority to establishing this during the project and make provisions to continually monitor it in the future.

The draft project document proposes to employ underutilized capacity in both the public and the private sector in the manufacture of handpumps by encouraging them to each make those components which they feel most suit their existing equipment and staff. However, technical assistance and some equipment (i.e. patterns, jigs and fixtures) would be provided as part of the project. The manufacturers are required to freely share the knowledge concerning the India Mark II pump, its specifications, production and quality control procedures as these have been developed in the public interest and cannot be patented or restricted.

The project is proposed to be implemented in two phases. Phase I would require 12 months and during this period production of all necessary spare parts and special maintenance tools would be established. Phase II would be launched on the successful completion of Phase I and would establish the production of complete pumps over an 18 month period. UNICEF and the GOS are proposed to procure the first few years' production of tools, spares and complete pumps at prices to be agreed on in advance. The sustainability of the plant requires that it has access to foreign exchange in order to procure raw materials and this requirement can be met by following the pattern successfully used elsewhere (i.e. India); that non-Sudanese agencies active in supporting handpump programmes will be required to procure pumps in hard currency.

With the long term in view, in addition to the main aim of establishing production of Mark II pumps, tools and spares, the project will experiment with abrasion and corrosion resistant stainless steel lined cylinders and with the VLOM or Mark III version of the handpump in order to gain experience with its performance and to establish the local costs of maintaining such pumps. These components and pumps are highly compatible with the Mark II, but may in the long term provide easier and cheaper maintenance. However, these promising developments can only be assessed over several years of trial and demonstration after which economic, social and other implications can be adequately defined.

Project Organization

The project is proposed to be executed by the World Bank. The Khartoum Central Foundry (KCF in which the GOS has the largest share) has been proposed as having the leading role in pump production, but it is encouraged to involve small scale enterprises in producing various components. The exact division of labour is to be worked out in advance to the mutual satisfaction of all the parties concerned. UNICEF is to assist with procurement of any finished components from India; this can be as direct aid to the project or as reimbursable procurement. UNICEF is also to contract for third party inspection of finished products.

Inputs

These include technical assistance of 54 man-months, production and quality control equipment. Both raw materials and some finished components will be imported. The technical assistance component is estimated to cost USD 555,000.00 and the total funding required to start the project and procure the first 2 1/2 years production is about USD 2.5 million.

Outputs

The main outputs are:

- Operational production units in KCF and in other enterprises producing components;
- Established quality control procedures in the foundry and in the workshops;
- Reasonable assessment of the benefits and costs of the VLOM version of the handpump (i.e. Mark III); and
- Assessment of the feasibility and advisability of using abrasion/corrosion resistance elements in the handpumps.

COST EFFECTIVE WATER AND SANITATION IN THE SUDAN.

Lufti Wahadan[1], Cole P. Dodge[2], Thomas Ekvall[3], and
Mohammed A. Yousif[4].

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 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.

1 Director General of National Rural Water Corporation. Khartoum, Sudan.
2 UNICEF Representative. Khartoum, Sudan.
3 Chief, Water and Environmental Sanitation (WES) Section, UNICEF. Khartoum, Sudan.
4 Project Coordinator, UNICEF. South Kordofan, Sudan.

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. Implemention 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.

During 1980, 19881 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 responsibilty 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 and Toker Districts in Red Sea Province. This programme included 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 on the water supply of El Obeid town. An emergency programme was 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 rehabilitaion 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 rehabiltate 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 neighbors 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 indispensible 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. Similarily, 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.

Figure 1
SUCCESSFUL BOREHOLES

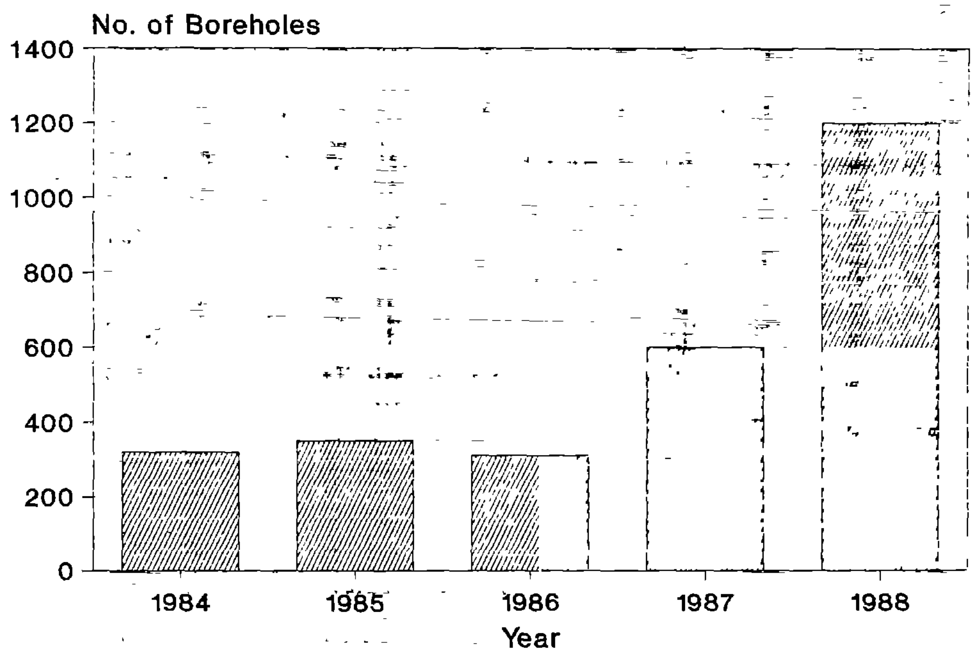


Figure 2
OVERALL EXPENDITURES IN US $

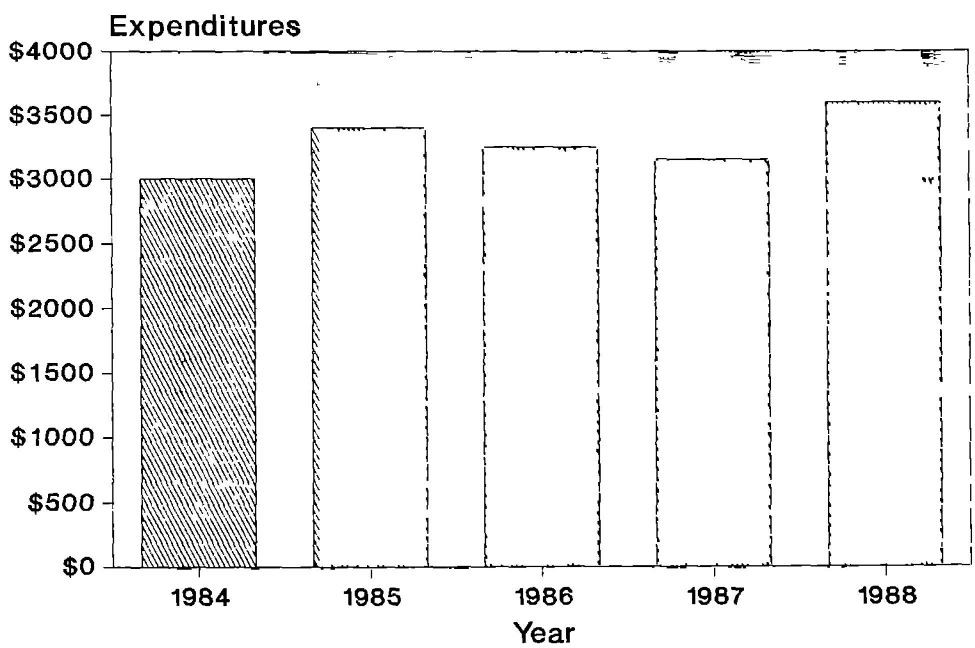
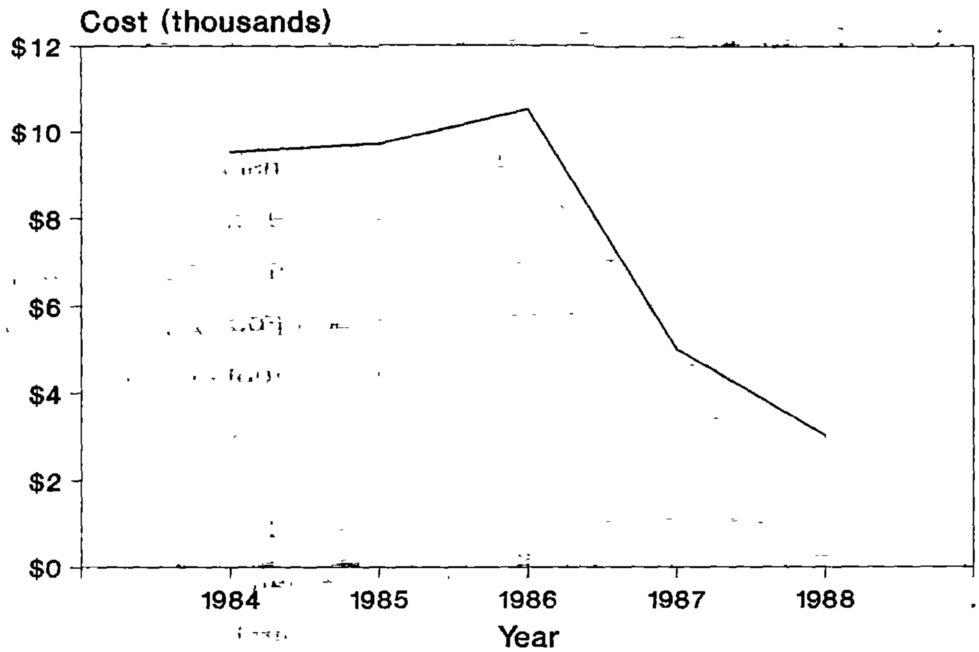


Figure 3

COST PER SUCCESSFUL BOREHOLE IN US $



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 responsibilty 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 andSouth 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 responsibilty 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 eqipment 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 responsibilty 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 desireable because it assures a more reliable supply of spare parts than 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 familar 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 entrepeneurs.

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 adequte number of village mechanics must be trained, spare parts made readily avilable, 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 is 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 committment 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 been 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 renumeration of the mechanic, having the right tools at hand, advance procurement of spare parts, collection of funds and availabilty 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 ill 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 willingnes 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 skeptical 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 kilometers 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 matter 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 fecal coliform the indicator organism dies off quickly while pathogens may survive, thus making false negative results possible. A positive fecal 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.

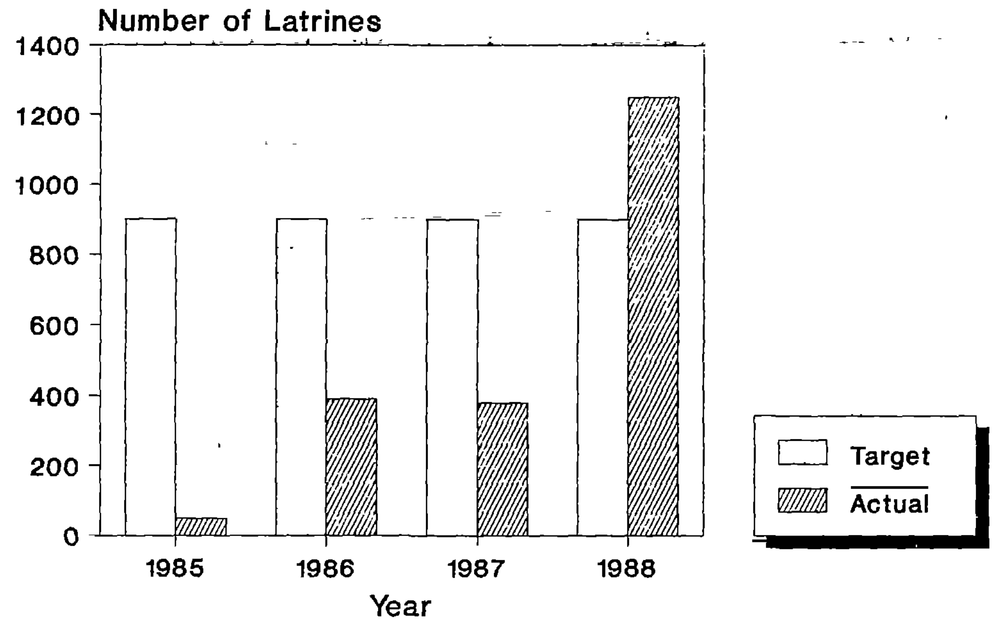
Total dissolved solids should be checked on site during drilling in areas where salinity may be a problem. Borehole construction can therefore be aborted at as early a stage as possible. Initial chemical analysis should be restricted to a few harmful elements like heavy metals, flouride, nitrate and 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 education is required in order to have an impact on health. However, there are skeptics who believe that even with this three-pronged approach that the health impact is not measureable. 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 skeptics 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 experiece 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.

Figure 4
LATRINE CONSTRUCTION
KORDOFAN REGION, SUDAN



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 responsibilties 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 pre-tested 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 pre-condition, 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. Figures 1,2,3 and 4 illustrate the commitment to target-oriented monitoring. Successful boreholes, their unit cost and total expenditure are analysed 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 benonite.
- 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 rrof.
- 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 responsibilty 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 Committe

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 unsucessful 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 per centage 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			
Per centage of latrines used			
HEALTH COMMITTEES			
No. of committees formed & trained			
Per centage of committes functioning			
PUMP MAINTENANCE			
Number of pump mechanic trained			
Number of tool kits sold			
Number of repairs done by govt team			
Per centage of pumps functioning			
WATER QUALITY			
Number of b/h testes chemically			
Per centage fit chemically			
No. of b/h tested bacteriologically			
Per centage fit bacteriologically			
No. of b/h closed due to water quality			

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

M.O. El Sammani
Department of Geography
University of Khartoum
Khartoum, Sudan

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 area 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 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 estimated total cultivable area is 1.5 million feddans, out of which about 0.5 million is presently utilized under different forms of management. (Table 2)

Table 2
Forms of Land Management

000's feddans	
95	Public sector schemes, under Northern Region Agriculture Production Corporation
272	Private sector and companies
65	Cooperative sector
70	Basins and Wadis (private)
26	Mataras (private)
528	

For the irrigation of the above areas about 1.75 milliards of Nile water and 0.16 millards of groundwater are presently utilized.

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 socio-economic 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 socio-economic 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, gravel 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.

A wide variety of engines and pumps are in service in the area. There exist 8 different makes of engines and 9 makes of pumps. This diversity is a function of market availability and the provision of equipment from many sources. The contribution of local communities to the installation of water supply systems, by providing the accessible units in the market is a major factor behind the diversity in make. This complexity in pumping technology has created problems for operation and maintenance.

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 9 maintenance centres with workshops.(Table 3)

Table 3
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 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 socio-economic 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 contributing 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 enrollment 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 reclaimation 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.

This technological familiarity is utilized in other fields including water supply projects.

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 another 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 samples, 27 water sources (90%) are community managed. Almost all of these sources stand as community initiated projects. Only in 4 cases was a strong individual's 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 samples studied revealed that none of the communities have written laws to regulate the elections of members or their annual activities. Instead the activities of the water committees are regulated by community concensus. 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 the individual to serve the community. However, this does not exclude 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.

The age structure of the committee members shows the following ranges, as furnished by the survey results from the 30 samples. (Table 4)

Table 4
Age of Committee Members

Age Group	%
19 - 24	3.6
25 - 34	25.2
35 - 44	27.1
45 - 60	39.3
Over 60	4.4
100.0	

This indicates clearly that the majority of the committee members come from the age groups 25 to 60 which represents the bulk of the active working population.

The level of education of committee members was computed from the survey results of the 30 samples.(Table 5)

Table 5
Education Level of Committee Members

Level of Education	%
Illiterate	18.3
Khalwa	12.7
Primary	26.3
Intermediate	18.0
Secondary	19.4
University	5.3
Post University	0.0
	100.0

Illiterates represent 18.3% of committee membership. The rest of the members have received some formal education. This tallies with the previously mentioned fact about high levels of enlightenment and education in the Region. Occupation-wise, the committee members are engaged in the following occupations as reflected by the survey results.(Table 6)

Table 6
Main Occupation of Committee Members

Occupation	%
Civil Servant	34.4
Farmers	41.0
Traders/Merchants	14.8
Others (including workers)	9.8
	100.0

The two principle occupations are farmers and civil servants, which indicates that representation comes from the core of the settlement population of the farming elements, assisted by those in government service, with the preparedness to push community objectives for improving living conditions.

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 contribute 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 branch 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 management 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 then, 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 of 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 guards, pays their salaries, and undertakes the training of mechanics to upgrade their efficiency. 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 operative 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 7)

Table 7
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 8)

Table 8
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 9)

Table 9
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 supervisary 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, centers 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 10) provide a good 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 10) 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 10
Revenue, Expenditure, Surplus/deficit (LS)
for 23 Water Sources with House Connections
1987/88

Settlement	Revenue	Expenditure	Surplus/deficit
<u>Northern Province</u>			
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
<u>Nile Province</u>			
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 year 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, which in a way is a form of subsidy.

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 samples covered, 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. Its reliability is attributed to the fact that it matches the peoples' needs and resources (54%) and that the alternative of having the government shoulder the responsibility of water provision is not attractive to the consumers. The evidence pointed to for reliability are good performance (52%), effective management (34%), and low cost (14%). It is therefore evident that the local communities of the Region view the present system of community managed water sources as reliable and see limited alternatives to it.

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%), obstacled 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 socio-economic factors that are characteristic of the Northern Region which provided the preconditions for the success of community managed systems in the Region.

4. Though 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. Through 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 center 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 legislatiive 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.

Acknowledgements

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VILLAGE WATER SUPPLY IN SOUTHERN DARFUR
THE WADS APPROACH AND EXPERIENCE

Ton Neggeman
Water Resources Assessment and Development Project In The Sudan

Introduction

To underline the subject of the Conference, I will quote some statements from the report "Maintenance, the Headache of the Decade " by Mr. J. Bron.

> "Sustainable operation and maintenance of rural water supply systems implies primarily that facilities constructed or supplied during the implementation of the project are being operated and maintained in a way that they continue to function as intended or desired, especially after government and/or donor support is withdrawn from the project.
>
> During the International Water Supply and Sanitation Decade, handpump and well construction technologies were developed to acceptable standards. Construction crews were trained and available funds created efficient construction programmes which allowed an increase in production rates. However, an increase in production alone has not been enough to alleviate the drinking water problem. Failing maintenance systems has turned out to be the greatest obstacle in reaching the goals of the Decade. Maintenance has required much more financial input than anticipated. For economic reasons, maintenance tasks have been delegated to the

> beneficiaries. The supporting institutional framework has been, in most cases, inadequate. However, solutions are being sought in concepts such as community participation and appropriate technology and these methodologies should reduce the reliance of the community on institutional organizations".

The negative effects resulting from a failing maintenance system are of crucial importance. WADS feels that any new water supply project without a sound and fundamental solution for the maintenance aspects of the project should be disallowed.

The WADS Approach for Village Water Supply

During the last two years, the WADS project was in a pilot phase. The objectives of this phase were:

- Field testing of solutions in order to select the appropriate technology;

- To demonstrate the viability of the participatory approach to village water supply so as to produce sustainable systems with reduced health risk at an acceptable level of production; and

- To create the institutional capacity within the NRWC to carry out this approach in a sustainable manner.

The technology for Rural Water Supply that WADS is introducing in Southern Darfur is in fact a relatively simple improvement of the traditional village well. In its most elementary form, it consists of an open hand-dug shallow well of some 15 to 25 metres deep, with a 1.50 m diameter, a lining of concrete rings or masoned bricks, an elevated concrete drain around it on which to stand while drawing water, and a concrete drain for spilled water (that ultimately ends up in a soak pit) that also serves as a trough from which the animals can drink. To avoid contamination, well users are supposed to use special containers (not their own) for hauling water, and to keep the slab and the drain clean. Animals are kept away from the well by putting up a fence around its immediate area.

A well can be equipped with a windlass if the village desires one. The construction capacity that can be reached is one well per construction team per month. The project has constructed 50 wells during one and a half construction seasons.

Implementation

The following steps are taken in selecting project villages and in implementing the well construction programme:

1. WADS informs the Rural Councils and the Administrative Officer then informs the Village Councils. Interested Village Councils report to the Administrative Officer who sends a short list of interested villages to the WADS Project.

2. All short-listed villages are surveyed hydrogeologically and socio-economically.

3. The WADS Project team prepares a priority list of villages and contacts the first 20 villages on the list in each Rural Council.

4. Three extension meetings are held in each village. These should result in the signing of a contract between the village and the project. This contract covers the payment for the well, the provision of labour during construction, the appointment of two caretakers per well, their payment after construction, and the installation of a Village Health Committee and a Village Water Committee.

5. Selection of possible well sites in consultation with the village communities and test augering before final selection.

6. Actual construction of the well by village and project labour.

7. Inauguration, follow-up and monitoring and evaluation.

To implement the Village Water Supply, the project has set up three sections:

1. The Groundwater Exploration Section.

2. The Village Project Section.

3. The Well Construction Section.

Construction, Community Participation and Technology

The WADS concept is based on the involvement of the villagers from the beginning; including the siting and construction of the well. If a village wishes to have a well, it should agree:

- To pay LS 1,000 for a simple well or LS 1,250 for one with a windlass;

- To provide labour (12 men) for well siting and construction;

- To appoint two caretakers per well who will see to it that the well and its area are well kept and maintained once the well is in use;

- To pay for the salaries of the caretakers and for the maintenance of the well (minor repairs, ropes, buckets);

- To appoint an all male Village Water Committee that will be responsible for the collection of the village contributions and the organization of the labour; and

- To appoint an all female Village Health Committee that can serve as a future channel for health education work.

The WADS Project has found that the conditions related to the siting and construction of the well generally did not cause any problems. The money for the contract was always raised and the labour and the meals for the construction teams were always provided. The Village Water Committee usually had no problems in collecting the money and organizing the labour. This supports the conclusion that there is an apparently high demand for the construction of wells from village populations and a willingness to contribute money and labour to obtain them.

The design criteria used for WADS wells are: water quantity, water quality, sustainability, reliability, durability, preference of the villagers, ease of use, ease of construction and environmental impact.

The most important improvement that the WADS well provides in relation to the traditional well is the deepening of the well below the lowest groundwater level in the dry season. The source of the well water is mainly found along "wadis" which fits in with the traditional settlement patterns of the tribes of Southern Darfur. The project can provide ring lined wells with a single shaft, telescopic wells of reinforced concrete blocks and rings and telescopic wells of rings with several diameters.

The design criteria for the waterlifting devices are: waterlifting capacity, water quality, VLOM, sustainability, durability, reliability, preference of the villagers, ease of use, possibilities of complete local manufacturing,and the link with traditional lifting devices and costs.

The project can provide as required communal ropes and buckets attached to hooks on the rim of the well, windlasses with spokes, windlasses with handles, windlasses with spokes and handles, and windlasses with a storage tank.

The use of windlasses, operated by the water users themselves, appears to be a success, especially when the water demand from the well is not overly high. In nearly all the villages, this system has been adopted. There seems to be a strong preference for a windlass with handles as compared to the other types available. If the windlass breaks down, the shallow open dug well has the advantage that the water drawers can fall back on the use of the rope and bucket system.

Monitoring and Training

So far the project has not had much experience with the operation and maintenance side of the wells programme because of the short period it has been in existence.

In view of the project characteristics related to appropriate technology and the participatory approach, a monitoring system has been developed to learn from the on-going implementation. The monitoring issues include:

- Functioning of facilities;
- Use of facilities;
- Hygiene; and
- Population participation and organization.

In November 1988 a review of all WADS wells constructed until then (20 wells) was undertaken.

It was found that some of the wells needed construction improvement. This, however, was limited to the deepening of wells (in 3 cases) and slab construction. These construction improvements are contractually the responsibility of the project. Other maintenance duties like fence repair, digging drains and cleaning the well surrounding have to be undertaken by the villagers. From the monitoring it appears that a properly maintained cattle fence improves the hygienic appearance of the well surroundings, although it could not be proved that the bacteriological quality of the water is better at sites with a fence as compared to sites without a fence.

With the windlasses there seemed to be problems with the bearings. The design of the windlass is still under development and more monitoring and field testing will be necessary. The windlasses are made in the project workshop and the actual costs are about LS 1,500.00. It is anticipated that windlass maintenance will be restricted to fastening and replacing bolts and nuts, although sometimes a handle may have to be replaced.

It was found that the bacteriological quality of the water was bad in wells where no windlass was installed. The main cause of this was that community members were using a variety of dirty private containers to abstract water.

Although no conclusive information is available it seems from preliminary data that the appointment of the caretakers will not prove successful in the long run. This may be (1) because of the high salaries these people are demanding and (2) because their function and behaviour is causing resentment among the women in the village.

The training in community participation at the project and village level is considered to be very important in the WADS project and the Village Project Section has been trained in community extension work, management skills and the development of a monitoring system.

Further a health education programme has been developed. This programme is as practical and as pragmatic as possible; and redundant theoretical medical knowledge and health topics not directly related to water are omitted. The programme concentrates on three topics directly related to the hygienic treatment of water, i.e. "clean well", "clean water transport" and "clean water storage". The training method is based on the concept of adult education in a context of group work.and involves the Village Health Committee and the Village Water Committees, as well as groups of village women.

Conclusions

During the pilot phase of the WADS project, it has been discovered that the technological concept as developed by WADS has proven to be appropriate for the shallow aquifer zones of Southern Darfur. This is because:

- The technology developed guarantees water throughout the year as long as digging occurs below the lowest groundwater level;

- It is expected that the concept will guarantee a sustainable supply of water as operation and maintenance are simple and can be done by the villagers themselves;

- The concept is based on the involvement of the villagers from the beginning (from siting and construction onwards);

- The improved open hand-dug well concept with a windlass as developed so far makes further improvements of traditional wells possible, i.e. hand or diesel pumps, financed and managed by the villagers;

- Hand-dug wells are decentralized water supply systems which, it is believed, have less negative impact on the environment than more sophisticated systems which have a higher capacity and therefore attract more users (people and animals). Hand-dug wells leave the original trekking routes and patterns more or less intact;

- The viability and sustainability of the participatory approach to village water supply in well construction has been demonstrated. It still needs to be demonstrated in well operation and maintenance; and

- The institutional capacity has been created in manpower and equipment. The proper integration within the existing structure has yet to be worked out.

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MAINTENANCE AND OPERATION OF THE HAWATA WATER SUPPLY PROJECT

Mohamed Said Nasir
National Rural Water Corporation
Khartoum, Sudan

Introduction

This paper describes the maintenance and operation of the Hawata Water Supply project which was financed by the German government through KFW. The paper focusses on the important question of water pricing and cost recovery.

The present water supply system at El Hawat was constructed in three phases:

I. An emergency phase (June 1984 up to April 1985).

II. The main phase (January 1986 up to June 1988).

Both phases were combined and the systems commissioned by the end of April 1988. A phase III for the project was approved and the project was extended to cover Qala en Nahl. This is now under construction and the project is expected to be completed in March 1990.

For the project, the financing agency (KFW) and the recipient (Government of Sudan) made an agreement specifying:

- That appropriate water rates would be introduced in order to cover all current costs and build adequate financial reserves for the procurement of spare parts; and

- That the collected rates would be accumulated in a special account and this money would be utilized exclusively for the operation and maintenance of the project systems.

A consultant report by German Water Engineering (GWE) in March 1987 recommended a water price of a minimum of 1 pound per cubic metre. For consumers taking water from kiosks, the proposed rates were as follows:

cost per 2 tins:	0.05 LS (LS 1.39/m^3)
cost per cart:	0.50 LS (LS 2.50/m^3)

These rates are to be revised periodically based on actual production costs and water demand. A recent analysis of water production costs is shown in Table 1. The table displays the amount of water consumed per month, actual income, and actual expenditure for the year 1988.

Production Costs

For the calculation of the production costs the following elements have been taken into consideration:

1. Energy and Operations costs. These include fuel costs for the production of energy to operate the power station as well as the fuel and lubricants for vehicles. Costs are estimated at LS 280,000.

2. Personnel costs. These include wages for the management and operational personnel which are as follows:

wages	LS 304,662
incentives	LS 270,000
Total	LS 574,662

Table 1

HAWATA PROJECT

A SUMMARY FOR THE MONTHS OF THE YEAR 1988
THE FOLLOWING:

1. Quantity of Water Sold
2. Revenue Supposed to be Received
3. Summary of Monthly Expenditures
4. Expected Revenue by Applying different selling rates for Due Comparison

YEAR 1988

Month	Water Consumed Cubic m	Actual Income for 1 25 LS/cu m	Actual Expenditure in 1988	Recommended 2.75 LS/sq m 5 P.T./Tin	New Water Price 5.5 LS/sq m 10 P.T /Tin	6.8 LS/sq m 12.5 P.T./Tin	8.25 LS/sq m 15 P T /Tin
January	21,130	25,515.71	36,949.24	58,107.50	116,215.00	145,267.75	174,322.50
February	22,154	25,335.58	45,064.57	60,923.55	121,847.00	152,308.75	182,770 50
March	30,475	47,226 97	20,005.10	83,806.25	167,612 50	209,515 62	251,418.70
April	51,180	62,625 87	48,315.54	140,775.00	281,490.00	351,862.50	422,235 00
May	57,291	69,710.87	118,373 63	157,550.25	315,100.50	393,775.62	472,650 00
June	35,773	43,660.02	49,768.53	98,375.75	196,751.50	245,939.37	295,127 00
July	21,480	26,135.72	40,642.42	59,070.00	118,140 00	147,675 00	177,210 00
August	14,665	17,438 77	21,379.37	40,328.75	80,657 50	100,821 87	120,986.20
September	12,729	15,027.74	48,779.01	35,004.75	70,009.50	87,511 88	105,614 20
October	19,614	23,441.85	33,195 92	53,938 50	107,877.00	134,846.25	161,815.50
November	24,447	30,097.03	28,832 43	67,229.25	134,458.50	168,073.12	201,687 80
December	26,368		35,568.60	72,512 00	145,024.00	181,280 00	217,536 00
TOTAL	337,306		526,874.36	927,621.55	1,855,183.00	2,318,877.73	2,783,373.40

3. Costs for Maintenance and Repairs. This includes the cost of spare parts and/or major repair works of cars and kiosks.

cars	LS 630,000
small repairs	LS 527,877
Total	LS 1,157,8774.

4. Reinvestment costs for Vehicles. There are 5 cars and 1 tractor which need replacing in 5 years for the cars and 10 years for the tractor.

Conclusions

When the project costs were compared with the established price for water, it quickly became apparent that the rate of 1.3 pounds per cubic metre was much too low and would not enable operation and maintenance costs to be recovered.

Accordingly, the project management met with the Qala en Nahl town council and the villagers in the area who accepted a new rate of 6.50 LS/m³. This rate will allow sufficient monies to be accumulated to satisfy the requirements for effective cost recovery.

EVALUATION OF RURAL WATER PUMPING TECHNOLOGIES

Siddig Adam Omer[1] and Jonathan Hodgkin[2].

Introduction

The seriousness of operation and maintenance problems with rural water supply systems in the Sudan was first brought to public attention at the Water Resources Supply Seminar in 1982 and reiterated at the National Economic Conference in 1986. The Renewable Energy Research Institute (RERI) of the Energy Research Council (ERC), in conjunction with the USAID-funded Sudan Renewable Energy Project (SREP), established a water pump testing and evaluation programme as a contribution to finding solutions to these problems. RERI postulated that renewable energy pumping systems could be cost effective ways of addressing some of the elements contributing to operation and maintenance problems of these systems. Fuel costs and availability and the lower projected recurrent costs for wind and solar pumps were factors which led to examination of these technologies.

However, the fuel displacement and reduced maintenance requirements are only two factors defining the potential role for renewable technologies. Other elements include reliability, technical capacity, capital as well as recurrent costs and the institutional arrangements which provide operations and maintenance service. As a result, an applied research effort which includes not only the performance testing and evaluation of wind and solar pumps, but a full examination of diesel pumping systems as well, is now underway. The ERC/SREP water pumping programme will provide useful data to agencies directly seeking to address the issue of sustainable

1 Energy Research Council of the National Council of Research.
2 Associates in Rural Development INC. Burlington, USA.

operation and maintenance of rural water supply systems. This paper discusses current project activities and objectives as well as defines future roles for ERC/RERI in assisting NRWC and other organizations to provide sustainable rural water supplies.

Background

RERI was established as part of the ERC in the early 1980's with the mandate to identify, test, evaluate and disseminate renewable energy technologies. The institute began its work with a series of renewable resource data collection efforts and the establishment of a research facility at Soba. The work has expanded since that time to include applied research, development of renewable technologies, and promotion of the commercialization of viable ones. RERI had begun work with wind and solar pumping systems prior to its incorporation into the ERC. However, it is only within the last several years that bilateral donor support has led to a series of related water pumping projects.

Because the performance of the renewable energy technologies depends on the energy resource availability, it is important to measure these resources. Several studies have been conducted into the wind potential of the Sudan. These show that there is a good wind energy resource. Historical Meteorological Department data analyzed for twelve sites indicate that roughly half of the country has average wind speeds above 3.5 meters per second. In these areas wind energy pumping may well prove a viable alternative to diesel pumps. In the northern part of the Northern Region and along the Red Sea coast average annual wind speeds are estimated to be above 4.5 meters per second, indicating an even greater likelihood of viability in these areas (Eisa). Preliminary indications are that these surveys may underestimate the real wind energy potential in the Sudan.

Sixteen meteorological stations throughout the country have collected solar radiation values for periods of 5 to 24 years. These data show that the Sudan enjoys a considerable solar energy resource with most areas north of

12 degrees reporting radiation levels above 20 megajoules per square meter per day on a horizontal surface. The exception is the eastern part of the Eastern Region. Half of the 16 stations report figures above 22 megajoules per square meter per day (Sudan Meteorological Department). This represents a a very favourable solar resource for the Sudan.

To complete the energy availability picture, diesel fuel used for conventional water pumping is currently sold at government-set rates of about LS 240 per drum or roughly 50% of the world price. Recent estimates are that the economic cost of diesel fuel is closer to LS 525 per drum. However, fuel is not always available at the official price and often must be purchased at the going street rate which may be 5 to 10 times the official price. In more remote locations, fuel may not be available at all during some periods. The disparity between the financial and economic cost of fuel, as well as concerns about its availability, along with the level of wind and solar resources, has prompted interest in use of renewable energy.

During the last several years, a number of different renewable energy pumping systems have been installed in the Sudan. For the most part, these systems have been provided as gifts and grants to the Government of Sudan from international multilateral and bilateral donors to help demonstrate the potential for these technologies. To date, no wind or solar pumps have been purchased at full cost by the government or the private sector.

Perhaps the best known efforts in wind energy utilization took place during the early 1950's with the installation of a large number of Cross windmills in the Gezira area. All these units were replaced by diesel pumps during the 1960's when diesel fuel was readily available and inexpensive. Other more modest attempts to introduce imported windmills in the Sudan have not led to widespread acceptance due, at least in part, to the lack of spare parts and limited promotion of the technology.

However, the potential financial and economic benefits of local fabrication along with the benefits of available locally made spare parts and service capability led to a Dutch-funded wind programme established in 1985. The goal of this project is to develop within a local firm the capacity to build and service the CWD 5000 windmill. At the present time there are 11 CWD 5000 wind pumps installed in the area around Khartoum. These are being examined for their potential use and acceptability in irrigating small agricultural plots. The programme is now set to begin a second phase with the fabrication of a number of windmills for sale to private purchasers. The work is planned to include technical assistance to one or more private sector manufacturing firms. The ERC/SREP pumping staff will conduct field test monitoring and evaluation of these windmills.

A parallel activity was intimated under the Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ) - assisted Special Energy Programme (SEP) begun in 1984 with the rehabilitation of three Southern Cross windmills and the purchase of two Kijito wind pumps from Kenya. Several more wind pumps have been ordered for installation and evaluation with plans to place at least one of these pumps in a village setting. Other purchasers of Kijito wind pumps include the Northern Agricultural Production Corporation which intends to install several wind pumps near Shendi.

Some years ago the ERC evaluated the potential of solar-thermal pumping systems. The unreliable solar-thermal technology and advances in photovoltaic (PV) technology began to focus research efforts on PV pumps during the 1980's. A United Nations Development Programme (UNDP) solar pumping project which began in 1978 included the installation and evaluation of the first generation of photovoltaic solar pumping equipment.

In the early 1980's the ERC collaborated with the University of Gezira and the Hodieba Research Centre in the installation of solar pumps in Wad Medani and Ed Damer. These PV pumps have been operating without major difficulties for almost five years now. More recently, several solar pumps were provided for evaluation and testing by the SEP programme. The purchase of two configurations of solar pumps (Grundfos borehole and KBS floating pumps) has now been followed by the procurement of three more

Grundfos systems. Presently there are more than 20 solar pumps, provided by half a dozen donors, operating or planned for installation in the near future. These PV solar pumps are being used in potable water supply, irrigation, and forestry application.

Other non-petroleum based pumping systems include handpumps which have been installed in great numbers by the the United Nations Children's Fund and the National Rural Water Corporation in Bhar Al Gazal, Kordofan and Red Sea Regions. At this time the India Mark II is the standard for these installations. Several non-governmental organizations are installing other makes and models in small numbers in areas in which they work. In addition, several thousand lift-type handpumps of a local design have been fabricated by artisans in Atbara over the past 20 to 25 years and have been installed for pumping from shallow wells along the Nile from Shendi to Dongola.

The ERC is also supporting the development of a river-current turbine which uses the energy in moving water of the Nile to pump water to the banks for irrigation purposes. A second generation prototype is just now being completed.

Goals of the SREP Programme.

The goal of the water pumping programme is to field test a number of currently installed diesel, wind and solar pumping technologies in order to determine the technical feasibility, performance and comparative cost of these technologies under typical operating conditions. The analysis focuses on collecting the data necessary to characterize performance and determine the relative costs per unit water pumped over the lifetime of the specific design of diesel, solar, and wind systems in various configurations and recommendations for appropriate use. It will also provide data on factors which effect water pumping costs and sustainable operation. This in turn should help guide future work to establish sustainable water supply systems.

Programme Activities.

Current programme activities can be divided into four areas. These are:

- Both long- and short-term technical data collection for operating diesel, solar, and wind pumping systems;

- Data analysis and pump output modeling;

- Collection of information on operation and maintenance requirements and costs; and

- Financial and economic analysis of pumping systems using the technical, financial, and economic data collected.

The solar and wind pump technical testing utilizes microprocessor-based data-loggers. Diesel testing is performed during short visits to pumping sites. Performance models are verified with field data. The models can be used to predict pump performance under operating conditions (i.e. head, average wind speed, or solar radiation levels). The results can be used to design pumping systems, predict performance of given systems, and identify pumping systems which may not be operating properly.

A base of information on maintenance and repair costs for diesel, wind, and solar pumps is also being assembled. This work includes a review of currently available information, data collection at the RERI test sites, and selected surveys of village and farmer systems. This information will expand current knowledge concerning longer-term requirements and costs of pumps in the Sudan. Such information is critical to projections of long-term logistical and budget requirements which are so vital to sustainable water pumping systems. Financial and economic analysis focuses on present value unit water cost derived from life-cycle analysis techniques. The use of computer models for this analysis allows the rapid identification of the financial and economic factors which have the most impact on water costs.

Testing

The first phase of testing and evaluation includes data collection for five photovoltaic pumps, four wind pumps, and six diesel pumps. These pumps are already used in drinking water supply and agricultural and forestry applications. Wind and solar pump performance is dependent on the availability of the renewable energy resource. The water that can be pumped by windmills or solar pumps is a function of the wind speed or solar radiation. The testing of these pumps utilizes a programmable data- logger to collect all the input and output energy terms to be used for evaluation. The data-loggers are capable of sampling voltage of frequency inputs on 16 input channels at rates of up to once per minute, calculating the input values in engineering terms and recording the results on EPROM (Erasable Programmable Read Only Memory) chips. Data can be collected and stored at the test sites for up to several months before the data is retrieved and down-loaded to computers for analysis. Two of these data- loggers have already been installed, one at the Grundfos solar pump at the University of Gezira.

The data collected at solar pump sites include solar radiation level, air temperature, array output current and voltage, total pumping head, and water pumped. This data permits the calculation of pump efficiencies and the validation of the solar pump performance model.

Figure 1
28 MODULE GRUNDFOS SOLAR PUMP
University of Gezira (H=19m)

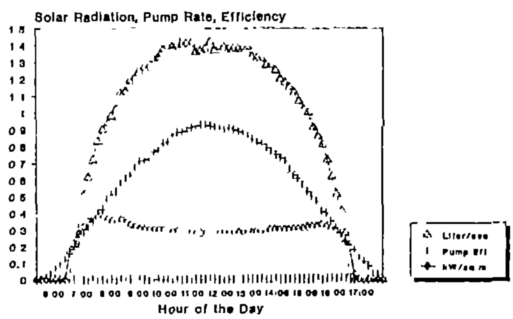
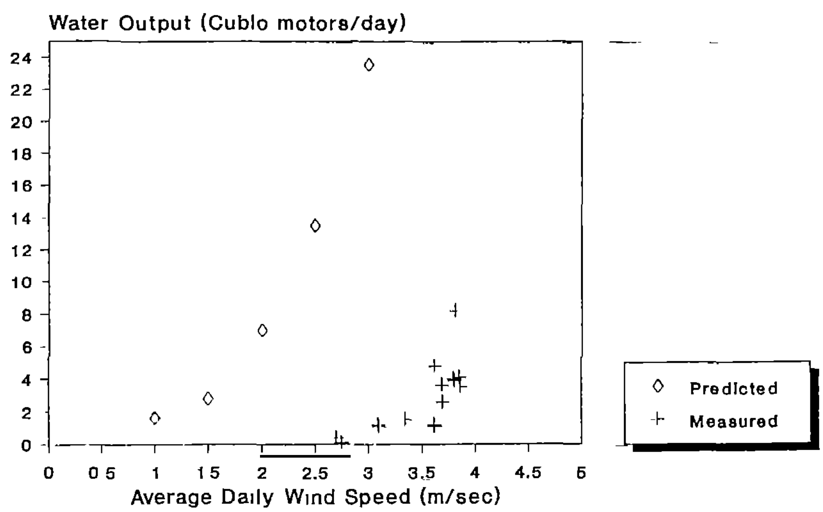


Figure 1 shows the performance of the 28 module (1120 Wp) solar pump installed at the University of Gezira over the course of a day. The data shown include the solar radiation level, the pumping rate, and the solar pump efficiency calculated from the data collected. Over the course of this day, nearly 40 cubic meters were pumped through a head of 20 meters. This information, along with knowledge of solar radiation levels throughout the year, will allow an accurate prediction of the performance of this pump. Daily summaries of performance are also being recorded to verify these predictions.

For windmills, the data collected include the wind speed, water pumped, and the total pumping head. In accordance with internationally accepted practice, data recorded at ten minute intervals were the basis for developing a plot of water delivery as a function of wind speed as shown in Figure 2. As with solar pumps, this pump curve serves to validate a wind pump output prediction model. Along with site wind speeds and distributions, average daily, monthly, or annual water output predictions can be made for this wind pump. Daily summaries of average wind speed and water pumped are also being recorded to help validate the performance model.

Figure 2
CWD 5000 WINDPUMP
Saba Research Station (H=19m)



Since the performance of diesel engines is not a function of a fluctuating energy source, short-term tests to measure water delivery rate, fuel consumption, engine RPM, and pumping head are sufficient to characterize short-term performance. This procedure allows the calculation of the energy efficiency of the pumping system, the fuel consumption per unit of water delivered, and the fuel consumption per hour of operation to be calculated. This, along with the technical specifications of the engine and pump, also allows the calculation of the engine loading. Engine loading is a measure of how well matched the pumping system is to the application at hand. In practice, engines are often oversized for the pumping application and this results in higher capital costs than necessary and less efficient operation.

Modeling and Analysis.

Although these data are interesting as pure technical research, they are being used to verify a series of technical models of pump performance. For example, the wind pump model predicts the output of a wind, starting with inputs which include rotor size, pumping head, cylinder size, wind speed, and all other relevant parameters. The model generates a pump curve and integrates it through a wind regime to calculate the water delivery, windmill start-up speed, and its overall efficiency. The solar pump model requires a system description including array size, type of pump, subsystem efficiency, and the site variables including pumping head, solar radiation, and ambient temperature. With this information, the daily performance of the solar pump can be calculated.

These computer models have several applications:

- The design of wind, solar, and diesel pumping systems and prediction with some degree of certainty the performance of the specific pump under a range of conditions other than the test conditions;

- Predicted performance can be compared with the actual performance;

- The identification of the existence of problems and possible solutions for pumping systems which are not performing as predicted (as shown in Figure 2); and

- When used in conjunction with broader technical, geographic, and water use patterns for a particular area, areas where different pumping technologies may have future application can be identified.

Operation and Maintenance Practices and Costs.

Any analysis or comparison of water pumping technology choices (be it comparison of solar or wind to diesel or different configurations of diesel-driven pumps) must consider the mechanisms whereby maintenance and repair are performed. For these reasons, information is being assembled about operation and maintenance practices and the financial and economic costs associated with these practices.

The project is now beginning to draw together available information from written sources and individual experience. The project will also perform limited surveys of current pumping practices and costs among several user groups including rural village water systems and private farmers. This information will help in more clearly defining how pumps are actually operated.

The surveys of village water supplies will focus on installed capital costs, typical pump configuration, pumping heads and water requirements. In addition, such aspects as the frequency of repairs, the duration of breakdowns, the cost of repairs (divided into materials, labour, and transportation components), and mechanisms used for obtaining fuel, spare parts, and skilled mechanics will be examined. An effort is also being made to identify those geographical areas where limited pumping head and water requirements are most likely to make renewable pumping technologies feasible. The first stage of this work, a broad survey of village water supply systems, is being completed with the assistance of the NRWC. A second phase, which will include more detailed surveys of pump operators and villagers in selected rural villages, is scheduled to be completed by the end of the year.

Small farmers are also major purchasers and users of small diesel pumps. A survey of the small-scale irrigated sub-sector is being conducted. The Agricultural Extension Service has been assisting with this broad survey to identify areas where small private irrigated plots are concentrated. Again, common pumping practices and costs will be examined in a series of more detailed surveys in these areas.

Concurrent with these surveys, information will be collected from the equipment suppliers and dealers to identify sources of supply for pumping equipment and to gather information on performance, cost, and availability of this equipment and the spare parts required for maintenance and repair.

Taken together, this information will help define current operation and maintenance practices, and an explanation of why these practices are used, the costs associated with these approaches to operation and maintenance, and constraints to changing these practices if any potentially more effective approaches can be identified. The cost-data collected will be crucial in performing the financial and economic analysis of water pumping systems.

Financial and Economic Analysis

A complete evaluation of water pumping technologies includes a financial and economic analysis. A present-value approach will be used for evaluation and comparison of water pumping systems. Using this method, a financial and economic unit cost of water can be calculated. When evaluating different pump types and configurations, it is important to compare systems designed to operate under similar head and water delivery conditions. It is misleading to compare pumping systems designed to provide small amounts of water from shallow wells with larger systems designed to pump large quantities from deep wells. Technical capability, economies of scale, differing pump rates, and energy requirements invalidate such comparisons. However, an evaluation of systems based on comparable pumping head, pumping rate, and total water delivery can provide meaningful insight into the technical and economic issues surrounding technology choice, equipment specification, and factors effecting pumping costs.

Financial and economic analysis programmes have been developed to calculate unit water cost. The economic models utilize engineering performance data, site characteristics, and capital and recurrent costs to calculate the financial and economic unit water cost. Private sector pump users and government agencies will be interested in the financial costs of establishing and operating a water system. Of greater concern to government planners and economists is the economic analysis which takes into consideration premiums on the use of foreign exchange, opportunity cost of labour, and any subsidies, taxes, and other transfers.

Table 1 gives an example of the approach used in the financial and economic analysis of a hypothetical diesel pumping system. The capital and recurrent cost categories are indicated along the left-hand side of the table. The year-by-year projection of recurrent costs are provided in both financial and economic terms. The economic figures are adjusted by the appropriate economic factors as shown in the upper right corner of the table. Note that the water output, head, and pumping rate are indicated. Also, the unit cost figures may change due to changes in prices or economic adjustments. One of the advantages of the approach used is that the effect of changing financial and economic conditions can be easily and quickly explored. Analogous spreadsheets have also been developed for analysis of wind and solar pumping technologies.

The value of any such financial and economic analysis is dependent on the accuracy of the values used for capital costs, recurrent costs, and economic adjustments. Capital costs are relatively easy to determine. However, recurrent costs are much more difficult to characterize. Future costs will quite clearly vary by technology, pumping type, geographical location, operation and maintenance strategies, and practices of the different users and different applications.

Table 1

SAMPLE SPREADSHEET FOR DIESEL PUMPS

Output: cubic m/day	50		
Head: Meters	30		
Pumping Rate cubic meters/hr	3.6		
	Financial	Economic	
Total Installed Costs	11600	147500	
PV of Recurrent Costs	169551	203633	
Present value per cubic meter	0.78	0 96	

(assumptions)	
Real Discount Rate	0.20
Shadow Price unskilled labor	0.50
Shadow Foreign Exchange	1.50
Taxes on Equipment	0.00
Life of Engine/Pump in years	10

Financial Analysis

Recurrent Costs		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
fuel	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600	3600
parts/materials	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
engine/pump replacement											
skilled labor	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
unskilled labor	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
on site staff	9360	9360	9360	9360	9360	9360	9360	9360	9360	9360	9360
transportation	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
TOTAL		33160	33160	33160	33160	33160	33160	33160	33160	33160	83160
Capital Costs		**year 11**	**year 12**	**year 13**	**year 14**	**year 15**	**year 16**	**year 17**	**year 18**	**year 19**	**year 20**
pump	45000										
engine	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
other	3000	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
site prepartaion	2000	0	0	0	0	0	0	0	0	0	0
pumphouse & works	4000	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
storage tank	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
other	0	9360	9360	9360	9360	9360	9360	9360	9360	9360	9360
installation		6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
skilled labor	7000	33160	33160	33160	33160	33160	33160	33160	33160	33160	33160
unskilled labor	10000										
transport	20000										
Total Installed Cost	116000										

Economic analysis

Recurrent Costs		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
fuel	9600	9600	9600	9600	9600	9600	9600	9600	9600	9600	9600
parts/material	10800	10800	10800	10800	10800	10800	10800	10800	10800	10800	10800
engine/pump replacement											75000
skilled labor	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
unskilled labor	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
on site staff	4680	4680	4680	4680	4680	4680	4680	4680	4680	4680	4680
transportation	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
TOTAL	39330	39330	39330	39330	39330	39330	39330	39330	39330	39330	114330
Capital Costs		**year 11**	**year 12**	**ear 13**	**year 14**	**year 15**	**year 16**	**year 17**	**year 18**	**year 19**	**year 20**
engine	67500										
pump	7500	9600	9600	9600	9600	9600	9600	9600	9600	9600	9600
other	4500	10800	10800	10800	10800	10800	10800	10800	10800	10800	10800
site preparation	2000	0	0	0	0	0	0	0	0	0	0
pumphouse & works	4000	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
storage tank	20000	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
other	0	4680	4680	4680	4680	4680	4680	4680	4680	4680	4680
installation		9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
skilled labor	7000	39330	39330	39330	39330	39330	39330	39330	39330	39330	39330
unskilled labor	5000										
transport	30000										
Total Installed Costs	147500										

When technology choice or pump configuration is at issue, factors beyond purely technical and economic indicators must be considered. Such factors include technical skills, availability of spare parts, cash flow constraints, and acceptability of the intermittent nature of water delivery of wind and solar pumps. However, an awareness of these factors, along with an understanding of the technical capability and economic factors associated with pumping systems, is invaluable in making the best pump choice for a specific site and application in the formulation of policy regarding the use of pumping equipment.

Project Outputs

The SREP project is scheduled for completion in mid-1990. It is anticipated that at this point at least 4 windmills, 5 solar pumps, and 6 diesel systems will have been tested. A report will be completed which will include the technical details of these tests and a financial and economic analysis of the results. This work will contribute to further understanding of the potential role of renewable energy pumping systems in the Sudan and provide recommendations concerning suitable uses.

In addition to this report, there will be a series of reports detailing the survey work completed on operation and maintenance practices and costs for diesel pumps used in both village water supplies and small-scale irrigation settings.

Conclusion

The current applied research and analytic capability of the ERC provides a resource for those struggling with the problems of sustainable operation and maintenance of rural water delivery systems. This may include community involvement in decisions concerning level of service and technology choice. If the issue of cost recovery is to be satisfactorily addressed, some understanding of how much must be recovered must be included. These are issues that the ERC is willing and able to assist with in partnership with other agencies within and outside the government

One of the results of the research efforts of the ERC is a growing understanding of water pumping issues including design, technical capacity and limitations, operation and maintenance, and costs. These capabilities will be brought to bear upon some of the problems of sustainable rural water systems in the Sudan over the next year.

The ERC has agreed to assist the Save the Children Foundation in testing diesel pumps in the Um Ruwaba area with the goal of providing information on fuel consumption and pumping rates. This information will help in the development of realistic estimates for the recurrent cost for pump operation. In addition, the ERC has agreed to examine the potential for wind energy utilization in the Karima area for the Adventist Development Relief Agency.

A third initiative will be the testing of diesel-driven Mono pumps being introduced by the World University Services of Canada project in Darfur. This information may help define future pump choices for deep well application. Through efforts such as these the ERC has a role to play in helping to understand some of the issues important to the establishment of sustainable rural water supplies in the Sudan.

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OPERATION AND MAINTENANCE ASPECTS OF KIBWEZI WATER PROJECT, KENYA

Melvin Woodhouse
African Medical Research Foundation
Nairobi, Kenya

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

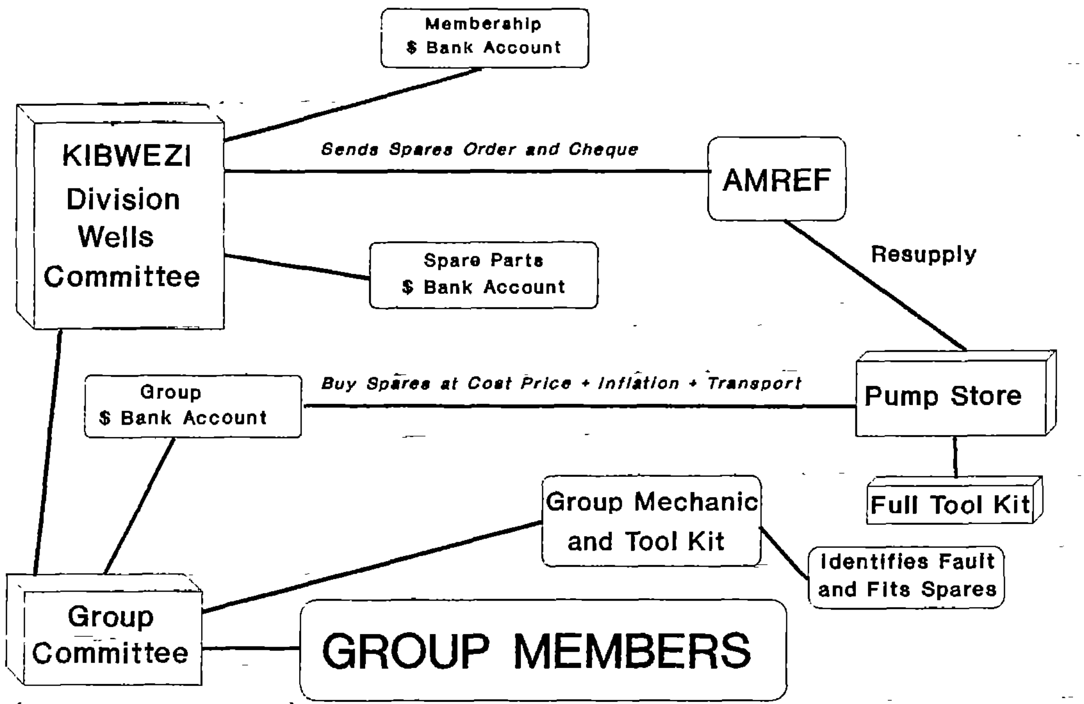
There are many factors in the background of the Akamba people of Kibwezi which contribute to the success of a community based water project. Firstly, water is a scarce commodity which has a high value (in remote areas, water vendors using tractors charge up to USD 12 per m^3) and consequently there is 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. The maintenance for the Kibwezi project is shown in Figure 1.

Figure 1

Kibweze Water Project: Maintenance System*



*(only one well shown)

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. So far an unknown number of wells, possibly four, have been built without the AMREF field team.

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" water 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.

YEI WATER PROJECT, ITS OPERATION AND MAINTENANCE.

Tom Ateka
African Medical Research Foundation
Nairobi, Kenya

Introduction

The Republic of Sudan is said to have the largest number of refugees in Africa - some one million. As a result of unrest in neighbouring countries, this sizeable number of refugees have found a home in the Sudan and by the end of 1981 there was an estimated 100,000 in the Equatoria Region of South Sudan, coming mainly from Uganda. Some of these people settled in the Yei River District (Western Area Council) where the project to be discussed is located. Owing to their ethnic roots, many settled alongside indigenous Sudanese who welcomed and accepted them as their kin. Others, however, were assisted by the United Nations High Commission for Refugees to settle in refugee camps where basic facilities like water, health and schools were provided by UNHCR. Those who settled alongside Sudanese nationals had to compete with them for these basic facilities which were generally inadequate in the first place. This situation prompted the Federal Republic of Germany to provide a special allocation of funds for refugee-related programmes. Out of these funds, about DM 3.5 million was earmarked for a water project in the South; thus was born the Yei Water Project.

Initially, implementation of the project was carried out by GTZ but in 1984, however, all German nationals were withdrawn from the South Sudan due to the civil war. Notwithstanding this set-back, drilling commenced in March, 1985 and the first 27 boreholes were drilled but without motivation and community participation being in place. The drilling consultant, did however, put in a community motivator before the resumption of further drilling in November, 1985. In the meantime, negotiations were continuing between the German government and AMREF with the hope that AMREF would take over the maintenance consultancy, motivation and hygiene education components of the project. It was logical to request AMREF to do undertake these activities as they had already taken over GTZ's Primary Health Care Programme in the project area. An agreement was signed on April 14, 1986.

When AMREF took over, a series of problems were already emerging. These problems were created by the motivational approach in the initial stages of the project. This approach was not deemed appropriate by both the Government of Sudan and the consumers. In addition, the motivation team insisted on charging the consumers LS 250 before opening the pump even though the system was tested and completed. This action proved unpopular in Government circles and was the cause of tension and ill-feeling towards the motivation team. Consultations were held with Government officials and communities to streamline the community motivation process.

Goals and Objectives

The goal of the project is to improve the health situation of some 80,000 people in the refugee affected areas by providing safe drinking water. The project has the following specific objectives:

- To motivate communities to establish water committees for mobilization and community participation;

- To select drilling sites from a socio-cultural stand-point in cooperation with members of the water committee and the hydrogeologist attached to the motivation team;

- To assist the communities to develop a sound financial system appropriate to their capacity and organizational structure. The community would thus assume full financial responsibility for the operation and maintenance of their pump;

- To initiate and control a local, private maintenance service that would be responsible for ordering and stocking spare parts;

- To mount a health education campaign on water utilization, the need to keep the area around the pump clean and the linkages between water supply, hygiene and water related diseases; and

- To assist the communities to establish cottage industries, i.e. brick-making, vegetable gardens, tree nurseries, etc. using the new water supply.

Present Status

The project, being rural and community-based, ran into serious problems when, due to the worsening security in the project area, it became impossible to leave Yei Town. Furthermore, the rural people began to move into Yei Town to seek protection from the armed forces. In the resultant confusion, several pumps were damaged and will need to be overhauled when peace finally comes.

Before the security worsened, the following activities had been accomplished:

- 143 boreholes drilled;

- 98 boreholes in productive operation;

- 49 communities installed with bank accounts;

- 39 communities with contributions but which cannot open bank accounts for one reason or another;

- 10 communities where motivation seems to have failed;

- 144 committee members trained in hygiene education; and

- A total amount of community contributions toward O&M of LS 30,105.00 collected.

Ten more boreholes have been drilled in Yei Town and even with the existing difficulties, water committees have been formed and the consumers are making contributions.

The maintenance company continues to look after the pumps in Yei Town and from time to time, whenever they can join a convoy, they go farther afield.

There is a skeleton motivation team consisting of a technician, a community development officer, and a driver together with a vehicle and a bicycle. This team continues to motivate consumers in Yei Town, assist with the collection and banking contributions and do hygiene education at the pump sites when consumers come to collect their water.

Issues in Operation and Maintenance

The technology used in this project mitigates against full community participation in operation and maintenance. This is because:

- Drilling was done using a highly sophisticated rig weighing 22 tons. Accessibility was therefore a major consideration in choosing where to drill and not always the community's choice;

- The operation of the rig needed highly qualified technicians and mechanics working under an able master driller;

- The very large distances to be covered over extremely poor roads often meant that the maintenance company could not act immediately. Prolonged delays would drive the community to resort to their original, often polluted, source;

- To report a pump breakdown to the drilling company in Yei often meant the consumers walking for many days except where there is radio communication; and

- Local artisans were not recruited because the maintenance company had its own crew.

The communities were nonetheless quite enthusiastic and proud of their pump. They contributed money regularly and engaged in such tasks as erecting a fence to protect the pump and generally keeping the surrounding area clean.

Recommendations

Mistakes were made at the beginning, some of which were unavoidable. For example, drilling was done before motivation was in place and therefore without the participation of the communities. A proper approach to motivation calls for a lot of patience, time and tolerance. Impatience and intolerance sometimes prompted members of the motivation team to take high-handed actions such as unilaterally closing pumps if consumers were not prompt in making their payment. This approach which I term "motivation by intimidation" created ill-feeling and drove a wedge between the motivators and the communities.

Our experiences suggests the following recommendations should be followed if a successful project is to be assured:

- Motivation of communities must move well ahead of drilling;

- Explain in very simple language the duties and responsibilities of the consumers including their contributions for operation and maintenance;

- After the formation of a water committee, the motivators should "hand over" all responsibilities to this water committee and remain in the background;

- Motivators need to visit and live with the community they are helping and not just make infrequent visits for a few hours;

- Political and other influences should not be entertained - this nearly wrecked the Yei Water Project. In this respect, a national is more subject to these pressures and could easily give in more easily than perhaps an expatriate would;

- The project should link with related development projects in the area and not develop in isolation;

- Having a national counterpart with a lot of experience in working with communities is a great asset as this would ensure continuity;

- It is necessary to protect the traditional water source because this is what the community will fall back to whenever the pump fails; and

- Finally, the project should be seen to be supportive of government efforts to improve the water situation. For this reason, there is a need to involve local government officials (Chiefs, public health officers, community health workers, etc) and other agencies. In Yei, collaboration with the government led to the formation of the district water committee and efforts were made to establish a common water policy and to adopt a standard make of pump.

CONFERENCE SUMMARY

The fourteen papers presented during the conference provided the operations and maintenance experiences of a wide variety of multilateral, bilateral, non-government and Government of Sudan organizations.

This sharing of knowledge on operations and maintenance was valuable, and stimulated considerable discussion among conference participants. A number of issues were repeatedly raised in the papers and in the conference discussions. These appear to be the key concerns of the participants and are worth emphasizing.

Key Issues

It was repeatedly stated that the Government of Sudan does not have a comprehensive or integrated policy for the water sector. It was made apparent that inadequate attention is given to rural water supply operations and maintenance in Government policy and practice. The frequent administrative changes in the water sector organization and mandates have also adversely affected rural water supply development and sustainability. There is an urgent need for the Government of Sudan to more effectively coordinate its water sector activities with those of the various external support agencies. The Minister responsible for the water sector, in his opening address to the conference, stated his Ministry's commitment to sustainable operations and maintenance. However, practical steps are needed to translate this commitment into action.

The participants agreed that rural water supply development has to be considered in the context of an overall development approach, where water sector planning and implementation are linked with other natural resource management activities.

Many of the papers and the discussants stated that planning for operations and maintenance and long term project sustainability must be incorporated into project planning right from the outset, and not be added as an afterthought.

In the Sudan, the true economic cost of water is not usually paid by the beneficiaries. Further, the Government of Sudan's annual budget allocations only cover about ten per cent of the actual cost of operating and maintaining rural water supply systems. The principle of cost recovery is a priority issue for rural water supply sustainability and is one that the participants felt must be more fully addressed in the future.

Community participation, especially the delegation of rural water supply operations and maintenance functions to local water committees was stressed by many conference participants as being the most appropriate way to ensure the long term sustainability of water supplies. Several people and agencies support some form of a community operated operations and maintenance revolving fund into which are paid some portion of the tariffs collected at the water points.

The relationship between the National Rural Water Corporation and the recipient communities was mentioned on a number of occasions. It was suggested that the Government of Sudan give a formal status to local water committees and that the activities of local water committees should be institutionalized and coordinated with the NRWC. Also there was a suggestion that an office be created to assist with the formation of local water committees and to provide them with technical and administrative training.

In the past, the Government of Sudan and the NRWC has in general favoured higher levels of technology such as wateryards with pumping systems at the expense of improving and developing existing traditional and local technologies. This was particularly prevalent during the National Anti-Thirst Campaign. A number of the papers presented and many of the participants stressed the advisability of adopting low cost appropriate water supply technologies. Appropriate technology may be in some cases, a simple improvement of traditional technology, or may be something quite different, depending upon site-specific conditions. Traditional bucket and windlass systems and local suction pumps have been improved and successfully used in the Western and Northern Sudan in several projects. Operations and maintenance have been generally successful in well planned and implemented handpump projects in the middle and western Sudan, particularly by UNICEF and WADS. Wind and solar power may be appropriate in certain situations as viable sources of alternative energy to power pumping systems. These energy supplies would reduce the dependence on oil and diesel fuel which are generally in short supply in the Sudan. However, the conference participants also recognized that technologically more complex water supply systems may be the only appropriate solution in certain specific situations; for example, the need for deep boreholes in parts of Darfur and Kordofan.

A further point which was repeatedly referred to was the need to standardize the type of water supply equipment in use. A diverse variety of pumping units are in operation throughout the Sudan. Dr. Sammani's paper on the Northern Sudan identified 8 different types of engines and 9 varieties of pumps. Clearly, this myriad of equipment types poses a major problem for operations and maintenance. Also these pumps are all imported and this makes the task of obtaining spare parts difficult especially in light of the foreign currency shortages and restrictions in the Sudan. There is a need in the Sudan to greatly reduce the variety of equipment makes and to standardize on a manageable few. In addition efforts should be directed to developing and enhancing the local capability to manufacture equipment and spare parts.

Plan of Action

The conference, in its closing session adopted a plan of action to improve operations and maintenance in the water sector. This proposal is to be presented to the government ministry responsible for rural water supplies.

It was proposed that an operations and maintenance working group be established to make recommendations on financial, administrative and technical issues relating to operations and maintenance.. This working group would consist of representatives from:

- Ministry of Finance and Economic Planning (MFEP);
- National Rural Water Corporation (NRWC);
- Institute of Environmental Studies (IES);
- United Nations agencies;
- Bilateral development agencies; and
- Non-government organizations.

Initially the working group would be organized by the conference steering committee, with inputs from the World Bank to ensure coordination with the UNDP/World Bank water sector support project. An initial plan of action for the working group would be to address the following issues:

- Conduct brief case studies into current operations and maintenance initiatives in the Sudan;
- Organize a workshop (May 1990) to discuss these initiatives; and
- Formulate an operations and maintenance programme/s for implementation in various parts of the Sudan.

For further information, write to:

The Manager
Community Water Supply and
Sanitation, EHE/CWS
World Health Organization
1211 Geneva 27, Switzerland

WHO 891200