Sustainable Handpump Projects in Africa

A literature review

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S. Parry-Jones, R. Reed and B. H. Skinner

Water, Engineering and Development Centre
Loughborough University
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Water, Engineering and Development Centre
Loughborough University
Leicestershire
LE11 3TU UK

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Parry-Jones, S., Reed, R. A., and Skinner, B. H.
WEDC, Loughborough University. UK.

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List of Acronyms

CBO	Community-Based Organization
DFID	Department for International Development (formerly ODA), UK
DRA	Demand Responsive Approach
FGN	Federal Government of Nigeria
HTN	Network for Cost-Effective Technologies in Water Supply and Sanitaion (formerly Handpump Technology Network)
HCA	Household Centred Approach
IEC	Information, Education and Communication
IWSSD	International Water Supply and Sanitation Decade
KAR	Knowledge and Applied Research
M&E	Monitoring and Evaluation
NGO	Non-Government Organization
O&M	Operation and Maintenance
ODA	Overseas Development Administration, UK (now DFID)
PHAST	Participatory Hygiene And Sanitation Transformation
PLA	Participatory Learning and Action
SKAT	Swiss Centre for Development Cooperation in Technology and Management
SMEs	Small and Medium Enterprises
SPWS	Small Piped Water System
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Emergency Fund
WEDC	Water, Engineering and Development Centre
WELL	Water and Environmental Health at London and Loughborough
WHO	World Health Organization
WS&S	Water Supply and Sanitation
WSP	Water and Sanitation Programme of UNDP/World Bank
WTP	Willingness to pay
VLOM	Village Level Operation and Maintenance

Executive Summary

The handpump has been the most popular and widely-used technology for rural water supply in Africa since the early 1980s. However, very often pumps fall into disuse shortly after installation, and handpump sustainability continues to be an elusive goal for many projects in Africa. The Department for International Development (DFID) is currently funding WEDC to carry out research into the features that promote handpump sustainability in Africa. The main output of the project will be guidelines designed to aid planners, implementers and decision-makers to prepare handpump projects that have a long-term chance of being sustained.

This report, which has been prepared as part of the first phase of research, is a review of current published knowledge and practice relating to handpump projects in Africa. Whilst the work focuses on Africa, experience has also been drawn from other continents where it is directly relevant.

The review found a wide range of definitions for sustainability relating to water supply projects, but concluded that the most frequently recurring core issues in these definitions were:

- Minimal external assistance in the long term
- Financing of regular operation and maintenance costs by users
- Continued flow of benefits over a long period

In order to break down the concept of sustainability relating to handpumps, it has been examined under eight key factors which were identified as being critical to achieving sustainability. These are:

- Policy context
- Institutional and organizational arrangements
- Technology
- Natural environment
- Community and social aspects
- Financing and cost recovery
- Key linkages (training, IEC - Information, Education and Communication, and supply chains)
- The project process

The review found that each factor has important implications for handpump sustainability but that, due to complex inter-linkages and interactions, it was not possible to define any one factor as being more crucial than another. However, there were some common themes and recurring problems or weaknesses that were highlighted by the comparison of 10 case studies on handpump proj-

ect evaluations from eight African countries. The seven critical issues that can undermine handpump sustainability were identified as:

- On-going use of alternative (non-potable) sources
- Lack of user involvement in choice of technology
- Failure of community to undertake preventive maintenance
- Poor systems of cost recovery for maintenance
- Inadequate training and ongoing support for community
- Excessive numbers of users of handpumps
- Inadequate attention to water quality leading to taste and corrosion problems

A number of new emerging models for service delivery and maintenance, which move away from the currently favoured model of community maintenance, were reviewed. One of these is the *Handpump Leasing* concept in which a local company owns a number of handpumps and provides operation and maintenance services under a contract signed with the communities. Another interesting approach is the *Total Warranty* concept, which is essentially a partnership between a foreign pump manufacturer, local after-sales private companies, local governments and users. Both of these models merit further investigation and may become more widespread in Africa the coming years.

The final part of this review focused on how to measure or assess the sustainability of a handpump project. Many studies have attempted to develop indicators or analytical frameworks for measuring sustainability, but these are often too complex or extensive to be used as simple field tools for practitioners in rural water supply projects. The non-government organisation WaterAid has been developing a simple tool for helping project staff to assess the sustainability of their projects. The new tool, called the *Sustainability Snapshot*, requires project staff and partners to ask themselves some basic questions relating to areas of project sustainability, for example on maintenance funds, or skills in the community. They have to decide where they are on a scale of 1 (least sustainable) to 3 (most sustainable) and this helps to identify key weaknesses or areas for action. This is one of the tools that will be tested and developed during the next phase of this project to develop guidelines for sustainable handpump projects.

A printable version of this literature review and the latest details of the progress of this research project can be found on the web site http://www.lboro.ac.uk/departments/cv/wedc/projects/shp/index.htm

Comments on the contents of this review are welcomed, and should be sent by e-mail to b.h.skinner@lboro.ac.uk or by mail to WEDC. It is hoped that the review will also be the subject of discussion on the HTN e-mail discussion list. This can be joined at http://www.jiscmail.ac.uk/lists/htn.html where you can also find an archive of past discussions on a number of handpump topics.

1. Introduction

1.1 Background to this review

Over the past 30 years, handpumps have been an increasingly high profile in the constant challenge to provide potable water to rural populations in developing countries. The main players in the sector, such as the World Bank and UNICEF, along with numerous international NGOs have promoted the handpump as the best community option based on the following set of assumptions (Wood, 1994):

That handpumps are:

- Low cost
- Affordable
- Easy to maintain
- An appropriate technology
- Readily available
- Easy to install
- User friendly
- Efficient

Whilst many of these assumptions may be valid, the harsh reality is that in Africa many handpump projects have failed to live up to expectations. In most countries of sub-Saharan Africa, examples can easily be found of projects where handpumps have fallen into disrepair soon after installation. There are, of course, also examples of successful handpumps projects around the world but often knowledge and experience are not being passed on to improve the sustainability of other projects.

WEDC is currently working on a Knowledge and Research (KAR) project, with funding from the UK's Department for International Development (DFID) to investigate the factors that contribute to sustainability of handpumps, with a particular focus on Africa. The project will collect and analyse experiences from handpump projects in Africa to establish which features are most crucial in relation to sustainability. The main output of the project will be guidelines designed to aid planners, implementers and decision-makers to prepare handpump projects that have an improved chance of long-term sustainability. This literature review is the first phase of the KAR. Further details about this research can be found on the web site:
http://www.lboro.ac.uk/departments/cv/wedc/projects/shp/index.htm

1.2 Purpose of this literature review

The purpose of this preliminary piece of work is to identify and review current published knowledge and practice relating to handpump projects, particularly sustainable ones, in Africa and elsewhere. The review has included an assessment of information from published literature, internet web sites, unpublished reports, personal communications with WEDC staff and also from the author's own experience.

The key sustainability factors identified in this review will form the basis for the methodology and approach to the handpump evaluation fieldwork to be carried out between August 2001 and March 2003 as part of this KAR.

1.3 Structure of review

The literature review comprises nine sections, including this introduction.

Section 2 explains why the work has focused on African experience as much as possible, rather than trying to draw lessons or parallels from experience in Asia and the rest of the world.

Section 3 investigates what is meant by "sustainability" in the general sense, in relation to water supply services and more specifically in relation to handpump projects. The key sustainability factors are identified in this section.

Section 4 deals with each sustainability factor in turn, and examines the range of issues that emerge from documented experiences of handpump projects in Africa.

Section 5 contains a table that provides an overview of 10 handpump evaluations or case studies from eight African countries. It allows the reader to see more clearly some of the positive and negative lessons that have been learnt over the past 10 years or so.

Section 6 looks at some of the new alternative models that are emerging for provision of sustainable delivery of water with handpump technology. These new approaches are still at the conceptual or piloting stage and are not yet well documented so literature is scarce. However, there are some exciting new ideas to challenge the current model of community management.

The issue of how to measure sustainability is dealt with in Section 7. Since sustainability results from the interaction of a number of factors, finding ways to measuring it is not straightforward. This section looks at some of the studies that have attempted to define indicators or analytical frameworks. It then focuses on a new approach to assessing sustainability, which is currently being

developed by the NGO, WaterAid. Section 7 is the starting point for developing tools that will be used in the guidelines for field evaluation of handpump projects.

Section 8 draws some general conclusions that emerge from the review, and highlights seven areas that appear to be critical to ongoing handpump sustainability.

The recommendations in Section 9 are for the WEDC team, on how to move forward into the next phase of this important applied research project.

2. Comparing experience from Africa and the rest of the world

It is easy to forget that, as late as the 1950s, many people living in rural areas of the UK and other developed countries relied on handpumps for their potable water supply. However, the literature research did not yield much information on the history of handpumps in Britain. It seems that, in rural areas wealthier families installed and maintained their own pumps and sometimes allowed poorer families access to use them (Naylor, 1983). Philanthropists often provided public pumps and drinking fountains in urban areas (Hassan 1998, Vince 1978) but these were poorly maintained, as was discovered in Exeter in 1831 when the threat of a cholera epidemic reached the city (Minchinton, 1987). A rapid water survey in response to the threat found that most of the public handpumps in the poorest quarters were out of order, and people were dependent on water carriers or vendors who drew their water from the polluted River Exe. So it seems that there are few documented lessons to be learnt from our own history, even though we have gone through the process of moving from handpumps to piped supplies.

The literature search was initially carried out on a non-geographical basis, so current information on handpumps and sustainability was collected from all around the world. It was found that there is a wealth of literature from Asia, and India in particular. The handpump has a long history there, and many lessons have been learned along the way. However, whilst parallels can certainly be drawn between handpump projects in Africa and the rest of the developing world there are a number of important differences that, in the author's opinion, detract from the value of sharing experience between continents. These differences, which have not generally been documented in literature, are:

- Institutional arrangements

  The institutional set-up for handpump installation and maintenance is more developed in South Asia and Central America, where private sector small and medium enterprises (SMEs) are very active (Oyo, 2001). India has a significant grass-root presence of village level mechanics, which is missing in sub-Saharan Africa. Local governments in Asia have more capacity and experience in delivering services than in Africa where decentralisation of services is still a relatively new concept.

- Market forces

  Population densities in many parts of Asia and Central America are much higher than those in rural sub-Saharan Africa. This means that markets are more concentrated and the per capita cost of delivering a service is lower. It is also easier for user groups to access information and express a demand.

This can strengthen the role of the private sector by making the demand (e.g. for spare parts) more visible. The dispersed and remote communities commonly found in rural Africa do not have easy access to markets and are difficult to serve. They are also often subsisting outside of the cash economy and have little or no access to rural credit, whilst in Asia micro-finance credit schemes are much more common.

- Traditional practices

  Most communities in sub-Saharan Africa do not have a tradition of using mechanised lifting devices for irrigating crops or drawing drinking water. This means that the handpump, although popular, takes time to become a culturally-accepted norm. Conversely, in many parts of Asian and Central America there is a long tradition of using pumps or lifting devices, so families or communities are more aware of the importance of maintaining a handpump.

There have been some global studies on water supply which draw on experience from all continents – most notably the UNDP-World studies on demand responsiveness, gender and poverty (Katz and Sara, 1997, Dayal et al. 2000, WSP, 2000b). These global syntheses aim to provide an overview of key sector issues and do not highlight regional differences. This project is focusing on the sustainability of handpumps in Africa and, for the reasons outlined above, will therefore seek to draw lessons mainly from literature on Africa. Where there are clearly applicable lessons, comparisons or opportunities to be drawn from other regions these will be referred to. One example of this is the potential for technology transfer on the Nicaraguan rope pump, which has recently been introduced in Ghana (WSP, 2001).

At the end of this report there is a bibliography containing references from Asia and other parts of the world that were reviewed but not used in this report. These may interest readers who are working with handpumps outside of Africa.

3. What is a "sustainable" handpump project?

3.1 Sustainabiliity defined

The word "sustainability" is now almost a prerequisite for inclusion in a project proposal document and in the objectives of any water supply and sanitation programme. But what exactly does it mean and, more importantly, what are the implications of aiming for "sustainable" interventions?

To sustain literally means "to keep or maintain at the proper standard" (Shorter Oxford English Dictionary, 1973). However, in recent years the concept of sustainability has been closely linked to environmental issues and, in ecology, is defined as "the amount or degree to which the earth's resources may be exploited without damage to the environment" (Chambers, 1998). The 1987 Bruntland Commission defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." The WHO/UNICEF Global Water and Sanitation Assessment (WHO 2000) differentiates between functional and environmental sustainability. In the specific context of handpump projects the issue of natural resource depletion is not normally a key factor and so functional sustainability is more relevant.

In a brainstorming session at WEDC three groups of water and sanitation professionals were asked to define a sustainable handpump project. It was interesting to find that each group responded differently: one defined it as the continuing delivery of anticipated benefits, another as ongoing operation with a minimum of external support and the third as the continued use of the handpump over a specified timeframe. These differing responses from a group of homogenous UK professionals point to the complexity of the challenges that all practitioners face when trying to plan, design and implement sustainable projects.

Many reports and studies have developed definitions of sustainability in the context of water supply (and sanitation) projects in developing countries. The key issues emerging again and again from these definitions are:

- Minimal external assistance in the long term
- Financing of regular operation and maintenance costs by users
- Continued flow of benefits over a long period

Some of the most comprehensive definitions, which could be applied to handpump projects, are shown in Box 1 below.

Box 1: Definitions of "sustainability" for water supply projects

"*Sustainability may be defined as an intervention which is capable of being supported and maintained by a community or individual over an extended period of time with an absolute minimum of outside assistance*."

(Wood, 1994)

"*…sustainability is the ability of a WS&S development project to maintain or expand a flow of benefits at a specified level for a long period after project inputs have ceased*."

(Hodgkin, 1994)

"*A water supply system is sustainable when it:*
Provides an efficient and reliable service at a level which is desirable
Can be financed or co-financed by the users with limited but feasible external support and technical assistance
Is being used in an efficient and effective way, without negatively affecting the environment."

(IRC/CINARA 1997)

A sustained water supply is "*a service that regularly and reliably provides enough water of an acceptable standard for at least domestic use. Breakdowns are rare and repairs rapid (within 48 hours), and local financing covers at least the regular costs of operation, maintenance (O&M) and repairs*."

(Dayal et al., 2000)

A sustained service means *"the ability of the community to maintain the water or sanitation system at an acceptable level throughout its design life without direct external support."*

(WSP, 2000b)

3.2 Success criteria

In the DFID guidance manual on water and sanitation projects, sustainability is defined as "ensuring that WS&S services and interventions continue to operate satisfactorily and generate benefits over their planned life." (WELL, 1998). It suggests that, for programmes targeted at the poor, sustainability must be linked at sector policy level and in programme design to four success criteria:

- Effectiveness
- Equity
- Efficiency
- Replicability

Box 2: Success criteria linked to sustainability

Effectiveness
The extent to which a project, intervention or service delivers its intended benefits.
Equity
Ensuring that the programme benefits reach the poor and disadvantaged groups
Efficiency
Value for money needs to be considered in terms of per capita capital expenditure, increased coverage and operation and maintenance costs.
Replicability
Programme models should be developed that can be replicated elsewhere to continue expansion of water services

(WELL, 1998)

3.3 Key sustainability factors

Sustainability of WS&S projects is often broken down into the following five dimensions (WELL 1998, Abrams 1998, Mukherjee 1999):

- Institutional (organizational)
- Social
- Technical
- Environmental
- Financial/economic

These dimensions all interact with each other and will vary considerably depending on the context. This explains why understanding, and measuring, sustainability is such a complex challenge (Mukherjee 1999). Some conceptual models or frameworks have been developed to illustrate the factors involved in sustainability of WS&S projects (IRC/CINARA 1997, Coad 2000). These models help people to see the bigger picture and can be useful for planning purposes and clarifying roles and responsibilities. They cannot adequately show all the dynamic interlinkages and interaction between different factors. The DFID sustainable livelihoods framework (Ashley and Carney 1999), although not designed specifically for WS&S projects, can provide a useful model for thinking more holistically about the effectiveness of development interventions.

3.4 Sustainability factors for handpump projects

In the specific context of handpump projects, Arlosoff et al. (1987) stated that the success of a community handpump project depends on six key factors, namely:

- The community
- The aquifer
- The well
- The maintenance system
- The pump
- Finance

These six key factors tie in closely with the five sustainability dimensions mentioned previously. More recently Schoolkate (1992), in a report on planning for sustainable handpump projects, classified and discussed four key areas related to handpump-based rural water supply as follows:

- Group I, related to the policy environment: Enabling Environment
- Group II, related to perceptions and attitudes: Health Awareness, Felt Need and Supportive Attitudes
- Group III, related to skills and institutions: Strong Institutions, Expertise and Skills and Support Services
- Group IV, related to the selection of appropriate options: Appropriate Service Level, Appropriate Technology and Materials and Equipment.

There is clearly no definitive way to subdivide the concept of sustainability; for the purposes of this report sustainability will be looked at under the five key areas of social, technical, environmental, institutional and financial issues. In addition to these five areas, it also important to consider the policy environment (which may be beyond the control of a project) and the project cycle or process itself. The key inputs or linkages which cross-cut all the above factors also need to be considered.

Section 4 deals with each of these factors in some detail, but summarised in the table below are the main issues or activities, which will be discussed under each sub-section.

Table 1: Sustainability factors for handpump projects

Sustainability Factor	Key Issues or activities
Policy context	□ Enabling environment (National Policies) □ Coordination (donors, government bodies, NGOs) □ Standardization
Institutional arrangements	□ Key partners □ Defined roles and responsibility □ Maintenance models (centralised, decentralised, VLOM) □ Village formal/informal power structures
Technology	□ Choice of handpump □ Design criteria □ Local manufacture □ Spares availability □ Preventative maintenance
Natural environment	□ Groundwater availability □ Exploration, siting and development □ Water quality □ Contamination
Community and social aspects	□ Expressed priority need, demand, acceptability of technology □ Culture and tradition □ Women's role □ Ownership
Financing and cost recovery	□ Financing capital costs □ O&M cost recovery (preventative, periodic, major overhaul) □ Tariffs for handpumps □ Hire-purchase
The project process	□ Maintenance/cost recovery included in project preparation □ Participatory planning □ Demand assessment/DRA □ Timescale/timing/phasing of key activities □ Roles and responsibilities defined □ Clear objectives/intended benefits □ Linkage to hygiene promotion/education □ Monitoring and evaluation □ Replicability
Key inputs or linkages	□ Training/capacity building □ IEC (Information, Education and Communication) □ Supply chains for pumps and spares

4. Sustainability factors examined

4.1 Policy context

The policy context within which handpump projects are developed and implemented is central to providing a supportive environment that ensures long-term sustainability. Tanzania was one of the first developing countries to formulate clear policies and targets for the water sector in the 1970s (Lium and Msuya 1989). This led to substantial donor investments in the Tanzanian rural sector. With over 20 years of handpump experience behind them, donor projects in Tanzania are now developing policies which will lead to legal community ownership, local private sector strengthening and facilitation and regulation from district authorities (Woodhouse, 1999).

Many African countries now have in place a national water (and sometimes sanitation) policy. In Uganda the draft National Water Policy (Ministry of Natural Resources, 1997) includes detailed strategies for domestic water supply in the areas of:

- Technology and service provision
- Financing, subsidies and tariffs
- Management and sustainability aspects
- Private sector participation
- Co-ordination and collaboration

Whilst the existence of a well-formulated policy cannot guarantee that projects are more sustainable, it can at least provide the basis for a common understanding and focus amongst government departments, NGOs, CBOs and external support agencies. This is particularly important given the increasingly high profile that the voluntary sector plays in service delivery in Africa (IIED, 2000). In the absence of a coherent policy, different actors often employ different implementation approaches and different handpump technologies, which can lead to a fragmented and unsustainable rural water supply sector. This was the case in Liberia during the war years, but there are now efforts to develop or reintroduce policies to guide the post-war sector forward from reconstruction into development (Thompson and Crawshaw, 1998).

Political will is an important factor in achieving sustainability; if a government does not have a commitment to promoting and supporting handpump projects then they are likely to be unsuccessful, as was the case in Sudan in the 1980s (Razig and AlAzharai 1989). Even where policy makers are committed to low cost technologies they must be prepared to accept that policy formulation is a dynamic process that may need to adapt to changing circumstances at the policy implementation stage (Kennedy, 1997).

4.2 Institutional and organizational arrangements

The institutional set-up or organizational arrangements are considered to be a central factor in sustaining a handpump project. These arrangements relate mainly to the maintenance system that is established to provide ongoing financing and repair mechanisms over the intended life of the system. Morgan (1993) stated that "no pump should be installed unless a proven handpump maintenance system is also established to support it." Mudege (1993), also drawing from experience in Zimbabwe, strengthens this perspective by stating that "it is the system which keeps the technology functioning which is important, not the actual technology."

Maintenance models

There have been three phases of evolution to the broad handpump maintenance model: the first model was a centrally managed system, the second a more structured three-tier system and the third a community managed system. The **first** generation of heavy-duty pumps had to be maintained by specialised, central government teams. **Second** generation handpumps, such as the India Mark II, were introduced in the 1970s and **third** generation pumps such as the Afridev and India Mark III, designed to be managed by the community, started to come onto the market in the 1980s.

The three-tier maintenance system for second-generation pumps was piloted in India in 1976 (Gray, 1984). It comprised:

Tier One: Community carry out preventative maintenance
Tier Two: Local area mechanics carry out routine repairs
Tier Three: Government-paid mobile teams carry out major repairs

(Colin, 1999)

This tiered maintenance system for India Mark IIs largely failed in Africa due to an absence of village level mechanics that are common in rural India (Wood, 1994). In Zimbabwe, the system was found to be less cost-effective than expected and the long reporting lines led to slow responses to breakdowns (Mudege, 1993).

In the 1980s there was a growing realisation that central governments did not have physical or financial resources to adequately fulfil their role in rural handpump maintenance. This led to development of a third maintenance system (together with third-generation pumps), which placed greater emphasis on the role of the community in maintaining their handpumps (Arlosoroff et al., 1987). This system was termed VLOM: village level operation and maintenance. The VLOM concept initially focused more on the hardware aspect of introducing a handpump (such as the India Mark III or Afridev) that could be more easily maintained by a community than most previous designs of pump.

A fourth maintenance based on self-reliance at village level exists where villagers make and sustain their own pumps, normally for irrigation in Asia. However, there is potential for this model to be expanded, as has been seen with the increasing popularity of the rope pump in Nicaragua (Alberts et al., 1993). This technology is discussed further in Section 4.3.

Management at the lowest appropriate level

Whilst current thinking still places responsibility for routine handpump maintenance squarely with village committees or authorities, there is a much greater awareness of the need to consider roles and responsibilities and build institutional capacity at all levels. The term VLOM has been largely superseded by "community management" and "demand responsive approaches" (Colin, 1999), but the underlying principle is still management at the lowest appropriate level. It is widely acknowledged that decentralization of maintenance is desirable for improved effectiveness and efficiency (Wishart, 1997). Experience has shown that highly centralized decision-making does not produce efficient or sustainable service (Boydell, 1999). However, experience has also shown that communities do not generally have the capacity to manage their own services without any outside support (Rall, 2000). Many African governments are moving towards decentralization of handpump maintenance services, for example in Ghana (Fonseka and Baumann, 1994) and Guniea-Bissau (van der Werff and Visscher, 1995). This shift requires a change in institutional role of the government from service provider to facilitator.

Role of local government

Under a decentralized approach, responsibility for service delivery and maintenance support is devolved to local government authorities. However, in most African countries these bodies are under-resourced and lack capacity to fulfil this role. There may also be a lack of co-operation or trust between different layers of government, as is the case in the newly emerging democracy in Nigeria (WELL, 2001). In Zambia, the lack of co-ordination between provincial and local government institutions and NGOs has led to overlaps, conflicts and omissions in service delivery (Kimena et al., 2000). There may also be a lack of political will at local level to devolve responsibilities for maintenance to communities. To achieve sustainable handpump projects it is essential to build adequate capacity at all levels, but in particular at local government level, to ensure that support systems are in place for service delivery and maintenance. (Note: this is one area that was not found to be well documented in literature).

Private sector development

The difficulty that many governments have in fulfilling their role as service provider has led to increased expectations and hope in the involvement of the private sector (Frölich, 1999). In the context of handpump projects the private sector is typified by small and medium enterprises (SMEs) and appropriate roles may be in manufacture and supply of handpumps and spare parts, installation, training or undertaking maintenance work. Many projects now empha-

size the need to involve the private sector, but often still fail to identify appropriate strategies or mechanisms for partnership. If the private sector is to have a meaningful role in a handpump project then it is essential that a strategy is developed at the initial planning stage (Barrett and Shahidullah, 1992). There is further discussion on the private sector role in Section 5.

4.3 Technology

Although handpump technology itself may no longer be the key determining factor in sustainability, this is more as a positive result of years of hardware research and development. During the IWSS Decade, the United Nations Development Programme (UNDP) and the World Bank initiated a global/interregional project for the laboratory testing and technological development of handpumps for community water supply. Two of the key documents to emerge from this comprehensive study are "Community water supply, the handpump option" (Arlosoroff et al., 1987) and the subsequent work "Handpumps: towards a sustainable technology" (Reynolds, 1992). These provide definitive information on the performance of a wide range of second-generation and VLOM pumps in Africa and Asia at that time, and it is not appropriate to try and summarise the findings in this review.

Since the Decade, there has been no similar comprehensive study on handpump performance, but there is plenty of project-related data on performance of handpumps in Africa. The best-documented handpump technology in Africa is the Afridev, which was developed by the World Bank/UNDP in the late 1970s as an appropriate, low-cost handpump that could be maintained by women or men in the community. Papers on the field performance of the Afridev have been reviewed from Mozambique (Obiols, 1998), Ghana (Osafo-Yeboah, 1994) and Malawi (Hankin, 1997). Experience from Kenya is documented on the Afridev, Nira AF 85, Nira AF 76 and India MkII (Sarkkinen, 1994) and from Tanzania on the Afridev, SWN-80 and Nira AF 85 (Woodhouse, 1999).

Hardware problems

In all of these countries, the Afridev has experienced similar technical problems, particularly with regard to pump rod breakages. In Ghana this was overcome by replacing welded hook-and-eye rods with forged ones. In other countries, manufacturers have found other solutions, such as use of plastic clips. Problems with cracked uPVC riser mains have also been experienced in a number of countries. The important point is that there is no such thing as an ideal handpump since there are many that will do the job (van Beers, 1999a), but if there is a critical mass of a certain type of a locally-manufactured pump then market forces will drive continued adaptations and improvements.

Local manufacture

Many African countries, including Mozambique, Uganda, Tanzania and Nigeria, are now manufacturing public domain handpumps such as the Afridev and the India mark IIIs. However, the quality of these locally manufactured pumps is often poor. Standards can be assured by enforcing strict quality control procedures and carrying out independent third party inspections (for example, in Mozambique this has been done since 1995 by a university engineering department checking compliance with the Afridev specification). However, there is still a difficult conundrum to overcome since locally manufactured pumps are nearly always more expensive than imported ones from countries such as India and Pakistan where the industry is much more highly developed. In these two countries, manufacturers benefit from economies of scale and competition keeps prices low. In some of these exporting countries, the governments have sometimes provided hidden subsidies to make the pump competitive in the international market so that foreign exchange can be earned from their sale. In Tanzania, local pump manufacturers charge high prices to a limited market. There is an argument that better sustainability and similar local profits could be achieved if pumps were procured offshore and sold through local franchises.

Availability of spares

The quality, availability and distribution of spare parts are issues that challenge the sustainability of all handpump projects but are generally not adequately addressed within project frameworks. Many donor-funded projects still buy stocks of spare parts for future use, for example Oxfam purchased up-front a 10 year supply of spare parts for the Afridevs they installed in Ethiopia (Garvey et al., 1991). This approach will only stifle private sector involvement at the detriment of long-term sustainability (WSP, 2000a). If the private sector is to be involved in spare parts distribution, experience from Ghana suggests that it needs to be tied in with the supply of new equipment to be economically viable (Baumann, 1994). In Tanzania, efforts are being focused on local spare part manufacture linked to village commerce so that there is good contact with the users (Woodhouse, 1999). In Niassa Province in Mozambique, the problem appears to be not the availability of spares, but willingness to purchase them (Breslin, 2001). This issue is explored further in Section 4.5.

Preventive maintenance

Handpump life is usually based on the assumption that routine, preventive maintenance will be carried out. Under the concept of VLOM or community management this maintenance is the responsibility of community members themselves. Unfortunately, many project reports and evaluations have noted that this preventive maintenance role is being neglected.

In Ghana a comparison was made between pumps regularly maintained under a centralized system and those being maintained by community management. The cost-effectiveness of preventive maintenance was demonstrated beyond doubt since much higher repair costs were being incurred on the pumps that

had not been routinely maintained by communities (Fonseka and Baumann, 1994). In Mali, a World Bank evaluation found that only one of the 15 villages visited had been carrying out preventive maintenance on their pump (OED, 1997). This evaluation recommended that, for future sustainability, work must be done to ensure that preventive maintenance becomes part of village culture.

Pump usage and durability

The standard design criterion for handpump usage is often taken at 250 people per pump per day. In practice, the number of people accessing a pump is often much higher due to lack of potable sources in rural and peri-urban areas. Different types of pump are also designed to operate at different cylinder depths (pump settings). Operating outside of the design parameters will inevitably lead to faster wear and tear on the pump. A CARE project in Inhambane, Mozambique (Obiols, 1998) monitored a total of 51 Afridevs from 9 to 55 months after installation. Over half these pumps were operating beyond CARE's design parameters of use by a maximum of 100 families and a cylinder depth of up to 45m. The study indicated that the effects of large user groups are much more significant than those of high pumping lifts. This finding is supported by a study of 480 handpumps in Zimbabwe (Cleaver, 1991), which found that pumps serving multiple users such as at schools and clinics broke down most often.

A study from Kenya projected the working and economic lifespan of some common handpumps in Africa. The results are presented in Table 2 below.

Table 2: Economic and working lifespan of handpumps

Pump Type	Economic Lifespan (years)	Working Lifespan (years)
NIRA AF 85 (shallow well)	12-15	25-30
AFRIDEV (deep well)	9-12	18-25
India Mark II (deep well)	8-10	15-20

Source: Sarkinnen, 1994

The relatively short *economic* life of the common Afridev and India MkII pumps has serious implications for the long-term sustainability of rural communities depending on handpumped water supplies since they are normally expected to bear the maintenance costs. This issue is discussed further in Section 4.6.

Technology transfer – the rope pump

The rope pump has been promoted in Nicaragua since the 1980s (Sandiford et al., 1993) and has been gaining popularity to the extent that in 2000 an estimated 7,500 pumps were manufactured and sold by the private sector. It has frequently been suggested that the pump has a great future in other countries

with similar economic conditions to Nicaragua (Alberts et al., 1993). Its appeal is that it is relatively cheap at around US$110 and all parts can be manufactured and repaired locally (WSP, 2001). In a case study on 31 rope pumps in Nicaragua it was found that all users, even those with donated pumps, carry out their own maintenance (Blackman, 1999). In 1999 Ghanaian authorities started to investigate the possibility of technology transfer to establish a private sector base for production, installation and repair of rope pumps in Ghana (WSP, 2001). There has also been limited technology transfer to Madagascar, Angola and Zambia (Alberts, 2000). The process is still in its early stages, but it will be interesting to see how the popularity of this pump expands in Ghana and beyond.

4.4 Exploitation of the natural environment

There is very little documentation on the sustainability of groundwater resources in relation to handpump projects. This is probably because handpumps draw such small quantities of water from the aquifer; a typical an India Mark II pump typically yields 12 litres/minute (Arlosoroff, 1987), which equates to less than $6m^3$/day for eight hours of continuous pumping. In general this level of abstraction will not contribute to long-term depletion of the groundwater aquifer since a low yielding crystalline aquifer can support an abstraction of up to $250m^3$/day (Clark, 1996). However, there are some aquifers that cannot support even low levels of abstraction. The author has seen many non-functioning handpumps that have reportedly "dried up" in parts of Uganda, Nigeria and Mozambique. This may be due to very poor aquifer properties but there are other possible technical reasons for these wells drying up, such as: poor well siting techniques, inadequate well development and testing or screen blockage due to badly designed or missing gravel packs. Borehole siting, development and testing are clearly essential components of a successful handpump project. Hazelton (2000) estimates that, when the cost of drilling unsuccessful holes is included, borehole siting, development and testing can represent 65 to 70% of the total project cost.

The chemical composition of the water will have an impact on sustainability, since aggressive water will speed up corrosion of metallic parts that are not corrosion-resistant. There is little documentation on this aspect of handpump sustainability. In general there is a move towards using plastic rising mains and other down-hole components to prolong the life of the handpump in aggressive water. Stainless steel may have to be used for rods although cheaper glass-fibre rods are being developed. A WaterAid project in Busoga, Uganda, where the groundwater is very aggressive, failed to carry out a technical survey to identify the risk of using easily corrodible galvanised iron riser pipes (ODA, 1995). As a result the cost-effectiveness and sustainability of the project were greatly reduced. New handpump programmes in Uganda are being encouraged to use locally manufactured uPVC components (Wishart, 2000).

Chemical composition can also affect sustainability in terms of acceptability by users: people may dislike the taste, colour or smell of groundwater when compared to their traditional surface water sources. According to Carter et al. (1996), user rejection due to aesthetic factors is often underestimated by engineers, with serious consequences (see Section 4.5).

The bacteriological quality of water from handpumps is often assumed to be high, with zero faecal coliforms. However, this may not always be the case if the headworks are poorly constructed leading to bad drainage and ingress of surface water or if pit latrines are constructed too close to wells in soils with high transmissivity. None of the project reports or studies reviewed mentioned any problems with water quality, or contamination and none of them appeared to have a water quality testing component in the project. The only mention found in relation to bacteriological quality is with respect to the rope pump. Gorter et al (1993) found in a study in Nicargua that rope pumps lower coliform concentration by 60% when compared to traditional bucket wells.

4.5 Community and social aspects

What is a community?
The term "community" is used almost indiscriminately in the context of handpump projects, and many engineers probably imagine it represents a homogenous, cohesive group of like-minded people. However, this is not always the case (Waterkeyn, 1993). It can be extremely difficult to engender a sense of collective, community responsibility to maintain handpumps, as was found to be the case in the peri-urban environment of Mankhokwe, Mozambique where Malawian refugees integrated with the indigenous population (Wood, 1989).

A group of individuals will come together and act as a "community" when they have a common felt need – for example for a potable water source. This expression of need is central to the sustainability of a handpump project since people will only support and participate in a project if they can clearly see the benefits (WSP 2000b, Cleaver 1991). However, even a community with a common water supply need is not an island and social mechanisms such as migrant labour, communications and urban drift create a social flux that is central to the development process (Abrams, 1998). The complex and dynamic nature of a community must not be underestimated when implementing a project.

Needs and priorities
One of the commonest reasons for a handpump project to fail, or not deliver the intended benefits, is that people continue to use their traditional sources, or quickly revert to them when the pump breaks down. This problem has been well documented from many projects and African countries (van Wijk and Visscher 1987, Partners in Development and Geomeasure 2000). It is a problem

which relates to need, or demand; if a community is satisfied with its existing water source then, although they may be willing to contribute to and participate in a handpump project, they will not place a high priority on subsequently operating and maintaining it. A study of 480 handumps in Zimbabwe clearly highlighted this point: it found that only communities in the driest parts of the country, where dependence on the handpump was greatest, were taking on a substantial role in maintenance, including fabrication of spare parts (Cleaver, 1991). In Chimbonila, Mozambique, people are choosing not to maintain handpumps, even though they have access to spares, because water supply is not their number one priority for their scarce resources (Breslin, 2001).

Social acceptance of technology

The social acceptance of handpump technology is an important sustainability factor. In an Irish development assistance programme in Zambia, people strongly resisted the proposed handpump technology because they had seen so many broken down pumps in the area. Instead, they requested assistance with hand-dug wells equipped with windlass and bucket, which they knew how to maintain. A project in South Africa reports a little-documented fact that women do not like to use the Monolift pumps installed under the programme, because their breasts get in the way when they are leaning over to rotate the handles of the pump! (Metcalf, undated)

The role of women

Gender issues have been high on the water supply agenda for sometime, and projects generally acknowledge the need to listen to the voice of women, as well as men, and to fully involve them in decision-making and management of the system. However, even where women have been trained as pump mechanics or caretakers, they are often expected to undertake this work voluntarily whilst men get paid for the same job (Hoffman, 1992). Many African countries now have positive policies towards women's participation: for example the Uganda National Water Policy states that a minimum of half the members of a Water Source Committee must be women (Ministry of Natural Resources, 1997). However, Cleaver's 1991 study in Zimbabwe found that often, whilst women would be official committee members, it was still their husbands that undertook all the duties. This finding was backed up by the recent global World Bank study on linking sustainability and gender-sensitivity (WSP, 2000b). The key factor is that communities are allowed to build on their own perceptions of roles and responsibilities of various groups, and that women are given the opportunity to gain technical and facilitation skills.

Village level power structures

Most community managed handpump projects require the community to establish some form of committee or authority to manage the ongoing operation and maintenance of the pump. There are often rules or regulations about the composition and roles of these committees. However evidence from the Zimbabwe study (Cleaver, 1991) suggests that the form of the committee is not as impor-

tant as the presence of a dynamic local leader. Traditional leaders in many rural areas of Africa still play a key role in decision-making at village level and this existing power structure needs to be allowed for in the project. Communities should be given support and encouragement to build their own management structures in a way that suits their needs (Breslin, 2001). In a recent evaluation of the UNICEF rural water programme in Nigeria (WELL, 2001) it was found that the groups most active in handpump maintenance were the Village Development Committees which villagers had formed themselves, without external duress. The water and sanitation committees, which villages were required to form as a prerequisite to project participation, were generally found to become inactive or defunct after the pump had been installed.

Ownership
One of the objectives of community participation is to engender a sense of ownership, which will lead to improved maintenance of the pump (Cleaver, 1991). However, this is not always the case: in Zimbabwe people felt that their contributions to implementation meant they had paid off their debt to the provider! In Tanzania there are now strong moves to replace the concept of "ownership" with a formal process leading to government recognition that a community legally owns a handpump (Woodhouse, 1999).

4.6 Financing and cost recovery

Capital costs and community contributions
The capital costs of handpump projects are generally financed by donors, governments or NGOs, since communities or individuals cannot afford the full cost of a handpump (Sarkinnen, 1994, Woodhouse, 1999). Many projects require communities to make some form of contribution towards the capital cost: this contribution is often "in-kind" in the form of labour or materials, rather than financial. The rational behind this is that the poorest communities may not deal in a cash economy or cannot afford to pay towards the facility. Unfortunately this is in direct contradiction to the principle that communities should pay for the ongoing maintenance of their handpumps. Since 1998, WaterAid has been working in Mozambique with some of the poorest rural communities. Through their work, they have come to the conclusion that these communities should not be provided with handpumps unless they are willing and able to make a significant financial contribution up-front (Breslin, 2000a). This financial contribution is considered to be the only true indicator that the community is committed to the project and have the financial and organisational capacity to sustain it. At present WaterAid requests an arbitrary minimum 2% of the capital costs. Breslin proposes that in future a more rigorous approach should be taken to try and work with the community to establish how much it will really cost to maintain the handpump.

Many projects fail to look at the real cost of maintaining a handpump; village water committees are often instructed to collect monthly water fees, but are given little idea of what the real costs will be. Communities will normally not collect money until the pump actually breaks down, and this leads to unacceptably long down-times. Communities are rarely trained on simple accounting procedures and do not normally have access to banks or safe places to save money.

The lack of attention to financing O&M during the project cycle is certainly one of the key factors leading to handpump failures. An evaluation of a UNCDF project in Guinea Bissau (1996) concluded that the failure of the project to develop any mechanism for O&M cost recovery at community level was likely to seriously undermine the sustainability of the project benefits.

Real costs of maintenance
There is surprisingly little data or information on the real cost of maintaining handpumps. In many countries it is simply subsidised by the government. The best documentation is for the rope pump – possibly because it impressively cheap to maintain. It is estimated that a rope pump in Nicaragua only costs a maximum of US$10 per year, and in most cases is less than US$5. This compares with an estimated US$59-107 per year for an India Mark II (WSP, 2001).

Water tariffs
One of the few documented attempts to recover recurrent costs through handpumps tariffs was in Ghana in the 1980s (Wood, 1988). The Ghana Water and Sewerage Corporation (GWSC) introduced a rural handpump tariff as a result of financial constraints arising from World Bank/IMF conditions. Communities were expected to pay an equivalent of US$120 per pump per year. By the end of the first year, about 40% of communities had paid, but a policy of disconnection led to 81% payment. The long-term defaulters were found to be those who had access to alternative sources. Unsurprisingly, the levying of a tariff led to the expectation that the government would start to maintain the pumps, and the concept of VLOM fell by the wayside. There is no follow-up to this story, so it is difficult to say whether this tariff approach was found to be sustainable or not.

4.7 Key linkages

There are three core areas to achieving sustainability that link all the previously-mentioned factors and merit being discussed separately. These are:

- Training and capacity building
- Information, education and communication
- Supply chains

Training and capacity building
In order to achieve sustainable projects, all stakeholders need a degree of training or capacity building in order to fulfil their roles effectively (Wishart, 1997). National governments need to be re-oriented to develop appropriate policies and an enabling environment. Local government partners need to build skills in participatory approaches. Perhaps most importantly of all, communities need to be given the opportunity to learn how to effectively initiate, manage and maintain handpumps with limited outside support. Donors also need to review their approach to project preparation, implementation and ongoing support to projects to allow the increasing emphasis on participatory approaches and demand responsiveness.

Information, education and communication
Flow of information is key to achieving sustainability; if all partners are well informed about options, costs, potential problems and solutions then decision-making becomes more effective. Good lines of communication need to be in place between all levels so that information can flow from communities upwards and from implementing and supporting agencies downwards (Katz and Sara, 1997).

Supply chains
In the same way that information needs to flow freely, so too do physical resources. This is particularly important for supply of handpumps and spare parts to rural areas. One component is that small and medium private sector enterprises need to be encouraged to get involved in supply, and external support agencies that have established supply chains need to develop exit strategies (WSP, 2000a). Supply chains in Africa are still poorly developed and much work needs to be done to strengthen this aspect of handpump sustainability. See Section 6.4 for information from recent research work into supply chains.

4.8 The project process – planning for sustainability

There are a few comprehensive, well-written (although perhaps somewhat outdated) texts on planning for sustainability of handpump programmes (IRC 1988, Schoolkate 1992, Hodgkin 1994). This section aims only to highlight some of the key sustainability issues arising from the literature review, which often seem to be neglected or badly done when managing the project cycle.

Defining objectives and project benefits
Stated objectives for handpump projects often refer to health improvements and timesavings in water collection. These objectives need to be clearly defined and measurable in order to ensure effective planning and monitoring and evaluation (IRC, 1988). Carter et al. (1996) propose an ideal set of objectives

which relate to the expected impacts on health and time/energy saving. They argue that the clear setting of objectives then leads to better definition of the project objectives that will bring about a sustainable development. The logical framework (WELL, 1998) is one of the tools that can be used to formalise this process.

Cost recovery strategy in project preparation
As previously mentioned, the need to plan ahead for cost recovery for handpump maintenance is frequently overlooked during project preparation. Cost sharing mechanisms need to be developed at the start of the project and agreed with all stakeholders ahead of implementation (UNCDF, 1996). The cost recovery system is the most critical, and potentially weakest, link to project sustainability (Carter et al., 1996).

Participatory approaches to planning
To work effectively with communities in handpump projects, implementers need to adopt a participatory approach to planning and implementation. This requires changes in attitude as well as new skills such as the use of PHAST tools (Breslin, 2000b).

Timing/phasing of key activities
Sufficient time needs to be allowed for proposed building capacity, reorienting service providers and empowering communities. Physical implementation and software aspects such as social mobilisation must be synchronised as far as possible (ODA, 1992). There is a suggestion that projects should be considered in two phases for sustainability: the initiation phase in which the service is established, and the ongoing or continuation phase is the rest of the service's life (Abrams, 1998). Sustainability will only be possible if the second phase is given adequate attention. This approach is also supported by Nicol (1999) who suggests that communities should be trained in phase one on preventive maintenance and in phase two on more major repairs.

Linking hygiene promotion and education
Providing a sustainable handpump is only one component of a project objective, it is equally important to ensure that it continues to be used in a hygienic way. One of the major reasons that handpumps do not get maintained seems to be that people often revert to using their traditional sources in the case of a breakdown. This could be an indicator of poor levels of understanding of the linkage between dirty water and disease. It is therefore important that health education is closely linked to training about use and maintenance of the handpump. However, although health education may increase use of handpumps, local needs and preferences must not be ignored. It may therefore be necessary to consider upgrading traditional sources or promoting rainwater harvesting in conjunction with a handpump project (van Wijk, 1987).

Monitoring and evaluation framework

Monitoring and evaluation is central to providing both users and support agencies with the right kind of information to ensure that the handpump continues to operate effectively. All information collected within the M&E framework should be collected for a purpose (IRC, 1988). Participatory M&E at village level allows users to collect relevant and timely data relating to their handpump and requires them to send monthly reports to local government: for example this system has been set up in the Shinyanga region of Tanzania (Mtunzi, 1993). It is much more cost-effective than top-down collection of data, but can be difficult to put in place. Section 7 deals further with appropriate indicators and frameworks for monitoring and evaluating sustainability.

5. Key lessons from selected case studies

The preceding section on sustainability issues may have left readers with the feeling that all the answers have already been found, and that now it is just a question of getting on with the job. However, a closer look at some of the project evaluations that have been reviewed shows that this is clearly not the case. Whilst there are some positive examples of successful approaches, many projects are still failing to address basic issues such as training communities, establishing cost recovery mechanisms and supply of spares.

One of the difficulties with this kind of study is that sustainability, by definition, implies taking a long-term view. However, most of the available literature on handpump evaluations has been carried out either during or at the end of the donor project cycle (normally five years or less after installation). This does not allow for a critical assessment of long-term sustainability prospects. Much of the literature reviewed also focuses on positive rather than negative aspects; whilst this is understandable it does not provide an objective perspective for lesson learning. After reading all these papers, it would perhaps be a shock to go out into the field and see hundreds of non-functioning village handpumps. Unfortunately this is still the reality in many parts of rural Africa.

The following table has distilled some key positive and negative lessons from 10 handpump project evaluations or case studies from eight African countries. It does not intend to give a detailed profile of each project, but rather to provide an overview of what has and hasn't worked. It is certainly not trying to rank projects or label them as successes or failures. The reader should obtain the full referenced documents for detailed information on each project.

Table 3: Key lessons from selected case studies

Country	Project Title/Area	Funding/Scope	Project description and overall performance	Key lessons or issues	Reference
Mozambique	Chimbonila	International NGO working with local government and contractors. Implementation 1998.	5 new handpumps, 3 rehabilitated handpumps and 8 washing slabs. 75% functioning one year after construction. Drainage problems at all points. One out of eight communities collected maintenance funds.	• People not prepared to pay for repairs because have other sources • Spares are available but this does not automatically lead to repair • People must be given choice of technology and how they manage their system	Breslin (2000a) Breslin (2000b) Breslin (2001)
Uganda	Busoga Borehole Rehabilitation Programme	International NGO working with local government, funded by ODA. Implementation 1989-1992	215 boreholes rehabilitated and equipped with handpumps, community-based management system set up. 61% of pumps in use three years post project (but nearly half of these had been subsequently repaired or replaced by Danida-funded programme).	• Many boreholes failed due to corrosion of GI parts (initial survey lacking) • Willingness to pay low where boreholes/handpumps are not the communities' preferred source • Communities not carrying out preventive maintenance, long-term sustainability of pumps is questionable • Little sense of ownership, partly due to lack of formal handover to community • Physical work must not outstrip social mobilisation	ODA 1995
Zimbabwe	Rural Water Supply Programme	Government programme with three tier maintenance system	480 handpumps visited in study to assess factors that promote or inhibit community maintenance. 83% of pumps were deemed to be operational but 53% had broken down at least once in preceding 12 months.	• Multiple user pumps (schools, clinics) break down most often • Community maintenance role improves over time as people adjust • Communities most active in maintenance in driest areas where no alternative sources exist • The form or composition of the water committee is less important than role of dynamic local leader	Cleaver 1991
Mali	Mali Rural Water Supply Project	World Bank funded project to provide 628 boreholes to drought-prone villages. Project completed 1992.	1996 evaluation visited 15 villages, found 20 out of 22 (91%) handpumps operating. Only one out of 15 villages had an active committee; this was the only village carrying out preventive maintenance.	• Health impact not achieved because people continued to use traditional sources in wet season • Support to repair staff lost when project closed. Suggests that Bank should take additional post-implementation responsibility for ensuring sustainable systems are in place. • Working through local NGOs would help to provide ongoing support to communities.	OED, World Bank (1997)

(Continued)

Country	Project Title/Area	Funding/Scope	Project description and overall performance	Key lessons or issues	Reference
Mozambique	CARE Community Water and Sanitation Project, Inhambane	International NGO with participation of private sector. Transfer of maintenance to communities started in 1996. Monitoring of 135 Afridevs from Feb 1996 to Dec 1997.	After two years, 97% pumps functioning and average downtime <10 days. 77% of breakdowns repaired by community, 19% need some assistance, 4% of breakdowns repaired by external agency. 66% of communities carry out routine maintenance and collect water fees periodically.	• Four main factors relating to Afridev performance are: quality control of pump manufacturing, quality control of pump installation and maintenance, depth of installation and number of users. • Negative effects of large user groups more significant than depth of cylinder • Cost of maintenance estimated at US$0.05/household/month • Extensive and good quality "on-the-job" training is key to VLOM.	Obiols (1998)
Ghana	Centralized and decentralized handpump projects in rural Ghana	Six donor funded or NGO projects visited.	85% of pumps under centralized system of maintenance found to be operational 15 years after installation. O&M is subsidized in all projects.	• If repair costs become too high, communities refuse to participate. • Technical support systems and financial aid will be needed to assure community maintenance. • Handpump suppliers should be compelled to establish after-sales service network	Fonseka and Baumann (1994)
Ghana	Water project under Northern Region Rural Integrated Programme (NORRIP)	Funded by Governments of Ghana and Canada. Project started in 1989, by 1994 200 VLOM handpumps in operation. This study monitored 53 pumps for first two years of operation.	Total number of faults recorded 135: 109 due to broken rods. Over 90% of pumps are functioning. Mean time before handpump experiences its first breakdown was 10 months and average repair time was five days.	• Majority of village handpump mechanics not carrying out routine maintenance two years after installation – regular refresher courses needed to ensure this • 60% of communities have established maintenance funds but people normally only pay into it when there is a breakdown • Rod breakages have been reduced significantly by introducing forged instead of welded hook-and-eyes and problems can be dealt with by village pump mechanics	Osafo-Yeboah (1994)

(Continued)

Country	Project Title/Area	Funding/Scope	Project description and overall performance	Key lessons or issues	Reference
Guinea-Bissau	Rural water supply in Gabu and Oio (Eastern Province)	UNCDF funding to government programme to provide 336 boreholes. Implementation 1992 to 1996.	Evaluation carried out in 1996 found that 68% of the 276 productive boreholes had been equipped with handpumps. Water from 40 boreholes had an iron content 10 times higher than WHO standard.	• The establishment of a well-defined strategy to reinforce decentralized structure is major asset. • Insufficient attention was given to the issue of pump maintenance in the initial project document. • The absence of water fees will undermine sustainability of project benefits • The impact of the project was lessened by the ferrous iron problem	UNCDF (1996)
Burkina Faso	Handpump maintenance project in Seno and Oudalan	International NGO programme to establish maintenance systems for 540 handpumps. Implemented from 1988 to 1993.	In 1987 only 66% of the handpumps in the area were functioning. The project trained 23 rural pump mechanic teams, established one mobile team and trained 350 pump caretakers. The 1993 evaluation found that 79% of the 87 handpumps visited were functioning. The main reasons for non-repair were given as lack of money (63%) and organizational problems (25%).	• Collaboration and cooperation in the water sector, and also within the NGO, was poor and this needed strengthening • The future sustainability of the project is largely dependent on role of rural pump mechanics; they need to be accepted by communities and government as private individuals operating on a commercial basis • The mobile team was still being financially supported by the NGO and there was a lack of commitment from the government to allocate budget in the long-term • Broken pumps may remain unusable in the driest months since money is most scarce; it is therefore important to encourage communities to establish funds. Training of managing funds should be linked with other rural development programmes	Curtis et al. (1993)
Nigeria	UNICEF-FGN Rural water and environmental sanitation project	National programme to support state and local governments in delivering water and sanitation services under new decentralized arrangements.	Current project cycle (1997 – 2001) aims to provide 11,000 safe water sources. The majority of new sources are boreholes equipped with handpumps. Independent evaluation carried out in 2001 could not ascertain functionality rates due to poor monitoring data but identified some key sustainability factors.	• Community management model has failed, due to lack of tool kits or access to spare parts at village level and inadequate training • There is a lack of political will to devolve responsibility for maintenance to communities • The most effective/active community institutions are those which have been formed on the initiative of the villagers independent of project interventions • Local manufacture of India Mark II and III handpumps has been successfully pursued. The market for pumps and spares is strong where the project has not supplied these free of charge	WELL (2001)

6. New models for service delivery and maintenance

Much of the literature reviewed covers the same ground and focuses on community management and maintenance, with a degree of external support from government or non-government partners, as the best model for sustainability. However, there is a growing realization that handpumps continue to be poorly maintained, and some people are looking for other, potentially more sustainable, models for handpump projects. A number of interesting new alternative approaches or models have emerged from this literature review. These are outlined below.

6.1 Social sector funds in Tanzania

There is a significant pool of experience on handpump projects in Tanzania, since there has been over 25 years of government and donor investment in the sector. Woodhouse (1999) has summarised this field experience, and also puts forward a new model for financing and implementing handpump projects in response to ongoing sector reform in the country.

Using the handpump as a vehicle, donor programmes have established mechanisms that will lead to legal community ownership, local private sector expertise for implementation and regulation/facilitation by district authorities. Although these components are already working separately, they are presently isolated from each other. The "vision" for the future is that a community or water user group would have access to a decentralised social sector fund and could implement their own handpump project using local contractors with technical support and regulation from the district authorities. In this context all funds, whether from government, donor or NGO, represent a subsidy towards a social good as opposed to financing a "project". The community would have legal ownership of the supply and would be responsible for its upkeep.

6.2 Handpump leasing concept

The concept of leasing a handpump has been put forward by a number of stakeholders in the field (van Beers, 1999b). It provides an alternative model for O&M of a handpump in which a local private company owns, say, 50 to 100 handpumps that are placed in the community with a clear maintenance contract. The lease company then guarantees operation and provides preventive, routine and emergency maintenance at a cost of around US$1 or 2 per family per month. The pump remains the property of the company whilst the community owns the source. There is also scope for a lease to buy model or

hire-purchase, which has been put forward as an idea in Kenya (Sarkinnen, 1994).

Van Beers (2001) develops the concept further by proposing that the O&M of handpumps is integrated with O&M of small piped water systems (SPWS) in small towns. This is of particular relevance to new donor projects in small towns where donors can supply handpumps to new or existing boreholes with a SPWS lease contract. The handpumps are the property of SPWS under a public-private partnership and communities contribute a pre-determined amount to cover costs of maintenance plus a profit element. This concept has apparently been operating successfully in Lubango, South Angola for the past five years. There are 20 communities around the town with two or more boreholes per community. Each family pays US$3 per year and this covers preventive maintenance and repairs. In the future the SPWS should also aim to recover depreciation costs (which van Beers estimates at US$5 per family per year).

6.3 Household centred approach

In 1993 Waterkeyn suggested that the way to achieve sustainable water supplies may be to focus on the smallest unit or lowest level: the family. This concept has recently been taken forward at the Aguasan 2000 workshop (Coad, 2000) where the "household-centred approach" (HCA) was explored as a new way to plan development projects. It was looked at in the specific context of urban and peri-urban environmental sanitation, but the workshop aimed to assess how the approach could also be applied to provision of drinking water in rural areas.

The HCA model is based on the ideas that:

- The *thinking* starts at household level
- The *solution* to the problem might be found at any level.

The conclusion of the workshop was that HCA is more of an analytical tool than an approach and that more work needs to be done to integrate HCA into existing water sector tools, approaches and philosophies. On the basis of the workshop proceedings, it is difficult to see how it could be applied to handpump projects. However, it is interesting to note that in Bangladesh UNICEF is adopting a household level approach to provision of potable water by subsidising handpumps for individual families. These families are solely responsible for maintaining the pump and sell water to the rest of the community to cover their costs (Reed, 2001).

6.4 Supply chains initiative

The importance of supply chains as a key linkage to sustainability has already been mentioned in Section 4.7. The Water and Sanitation Programme is currently supporting a global initiative to identify the principles underlying successful private sector supply chains and to develop tools for practitioners to create enabling environments for successful supply chains (WSP, 2000a). The initiative is still in its early stages, but has identified some key factors for supply chains. These are summarised by Oyo (2001) as:

- Adequate demand
- Effective information flow
- Effective stakeholder incentives
- Effective supply chain management
- An enabling business environment

Some of the interesting issues arising from the supply chain studies to date are that governments and donors should avoid distorting the market by distributing items free of charge, and that subsidy packages need a clear timeframe and exit strategy with parallel market development.

6.5 Local private sector involvement in Mauritania

In some West African States the responsibility for handpump maintenance has been successfully transferred to the private sector, according to a paper produced by Vergnet pump manufacturer (Bernage, 2000). The case study from Mauritania explains that the community maintenance model was failing mainly due to problems with access to spare parts and lack of qualified mechanics. Vergnet therefore decided to pilot the *Total Warranty* concept on 75 water points. The model is essentially a partnership between the (foreign) manufacturer, local enterprises managing after-sales networks, local government administrations and users. The manufacturer's commitment is to support and train the local enterprises. The users pay an annual contract fee (equivalent to US$1.5 per person per year) to the local enterprises, which then are responsible for all aspects of pump maintenance. The government administration role is one of regulation.

The pilot project has been running for two years now, and an evaluation found that 60% of the villages had paid the enterprise, 20% had paid half. Where the cost recovery rate was low, systems were not operating. Vergnet believes that, based on the pilot results, the *Total Warranty* concept should be further developed in Mauritania.

7. Measuring handpump sustainability

The concept of sustainability encompasses a wide range of issues and factors as already discussed in Sections 3 and 4. The influence and interaction between these factors makes measuring sustainability a complex challenge (Mukherjee, 1999). In order measure sustainability, it is necessary first to define the key issues, select appropriate indicators and set up a framework for measuring and acting on these indicators. Indicators provide an objective way of measuring that progress is being achieved, and must relate to the aims and objectives of the project (Save the Children, 1995).

Some studies have attempted to define frameworks or indicators for sustainability. The WSP's recently completed global Participatory Learning and Action (PLA) initiative has defined a set of indicators, and an analytical framework, for measuring sustainability linked to demand, gender and poverty (Dayal et al., 2000). Another useful piece of work that provides some guidance on measuring sustainability is the WASH report on sustainability of donor-assisted rural water projects (Hodgkin, 1994). This report suggests eight key questions which, when asked several years after a donor-assisted project has been completed, can attest to sustained benefits. These are shown in Box 3.

Box 3: Key questions relating to sustained project benefits

1. Are most of the people covered by the project using the facilities?
2. Are the facilities in operational order?
3. Are management committees functioning?
4. Are extension agents meeting with committees regularly?
5. Are trained repair persons and supplies of spare parts easily available?
6. Is a specific government agency effectively managing the WS&S sector?
7. Is there an importer or manufacturer of spare parts?
8. Does each institution have adequate financial resources?

(Hodgkin, 1994)

However, it is probably true to say that a one-size-fits-all solution to measuring sustainability does not exist, since every project will have different local conditions and constraints within which it must operate. The 1998 Aguasan workshop (Niederer, 1998) proposed a two-step approach for projects that are concerned about sustainability:

- First debate on the issues ("What are the issues that support or hinder sustainability?")
- Second identify indicators for these issues ("How can we observe and study these indicators in the field?")

The NGO WaterAid has followed a similar approach in trying to develop a framework for assessing sustainability (Sugden, 2001). During a regional meeting in Ghana, assessment of project sustainability was the subject of a series of community visits and discussions. The conclusion was that there is a lack of a framework or methodology for assessing barriers to maintenance and sustainability. The WaterAid team therefore decided to develop a framework that would help people to think more clearly about the sustainability of handpumps.

The first step that the team took was to brainstorm a list of all the key issues that affect handpump sustainability in their projects. The list was:

- Prohibitive maintenance costs
- Poor money collection system for handpump maintenance
- Poor water point usage
- Poor water quality, quantity and accessibility
- Water point reliability and attitude towards other sources
- Spare parts cost and availability
- Water extraction technology available
- Lack of sense of feeling of responsibility towards the water point
- Lack of role for communities once project implementation completed
- Lack of women's involvement at community level
- Divisions within the community regarding ownership and use of water point

Having identified the key issues, the team developed a simple system or framework for asking questions related to project sustainability. This system, the *Sustainability Snapshot*, is shown in Box 4. At present it is still in draft form, and WaterAid are in the process of developing it to cover all other aspects of sustainability. Their initial tests with the draft tool with project and partner staff in Africa were very successful. It drew participants into thinking more deeply about key sustainability issues and generated useful discussions. WaterAid consider that the snapshot will provide a useful evaluation tool and will lead to a clear organisational position on sustainability of their projects and programmes. It provides an excellent and timely opportunity for collaboration on the production of the guidelines, which will be the key output from this research project.

Box 4: The WaterAid Sustainability Snapshot framework

STAGE ONE
The aim of stage one is to undertake a quick evaluation of a community's ability to maintain the various types of water point your programme/project is installing.

Complete this 'sustainability' grid for each type **of water point** with reference to the description below:

Project name:			
Technology	Hand Dug Well with Pump	Hand Dug Well with no pump	Borehole with hand-pump
Financial			
Technical skills			
Spares and equipment			

Financial
Which of the following is applicable to the type of water point in question
1. No funds available for maintenance when needed
2. Fund available but not sufficient for most expensive maintenance process
3. Fund available and sufficient for most expensive maintenance process

Technical skills
Which of the following is applicable to the type of water point in question
1. Technical skills not available for maintenance when needed
2. Some technical skills for maintenance, but not for all.
3. Technical skills for all maintenance processes available

NB : Available in this context means available to an average community member within a reasonable time

Equipment and spare parts
Which of the following is applicable to the type of water point in question
1. Not available when needed
2. Available but not for all repairs
3. Available for all repairs

STAGE TWO – COMMENTS
Given your above ranking, can you give a brief explanation of the reasons why you allocated such a score.

STAGE THREE - THE WAY FORWARD
Answer these questions -
- Is it reasonable to aim for 3's in all your examples above?
- What do you think you need to do differently to achieve '3's?
- Is this possible?

If you have a series of '3s' or if you have moved recently from a 2 to a 3, have you documented this process?

(Sugden, 2001)

8. Conclusions

This literature review has identified a wealth of information relating to sustainability of handpump projects, both in Africa and the rest of the world. The review has focused on Africa-based literature since there are some fundamentally important differences between conditions for handpump projects in Africa and other continents.

The concept of sustainability in the context of water services has been defined and explored by many people and numerous definitions exist. The core issues, which frequently recur in these definitions, are:

- Minimal external assistance in the long term
- Financing of regular operation and maintenance costs by users
- Continued flow of benefits over a long period

There are five key areas under which sustainability issues relating to handpump projects can be considered. These are:

- Institutional (organizational)
- Social
- Technical
- Environmental
- Financial/economic

It is also important to consider the policy context within which the project operates, and the project process or cycle that shapes the objectives, inputs and outputs.

After reading Section 4, which examined sustainability factors in detail, you could be forgiven for thinking that we already have all the answers on how to "do" a sustainable handpump project. Much has been written on the various aspects that contribute to a sustainable project and there is generally a pervading optimism in the literature that makes one think that perhaps, finally, we are getting it right. However, let's not be too complacent. There are still many, many projects getting it wrong and broken handpumps continue to be abandoned every day in sub-Saharan Africa. In the light of this reality, perhaps the most useful part of the literature review is the summary of case studies in Section 5. This provides a broad overview of some of the lessons that have been documented in project or programme evaluations and case studies. Seven of the most critical issues that have emerged from the lesson-learning exercise are presented in Box 5 below.

Box 5: Some key conclusions from the review

Alternative sources
Where people have access to traditional sources of water, they are likely to continue to use them, and this will limit their motivation to take responsibility or to pay for maintenance of a handpump. Where a community is highly dependent on a handpump, it is most likely to be well-maintained. This strongly relates to the concept of *demand* for a service.

Choice of technology
A handpump is not always a community's preferred choice of water source. Where a handpump is provided without offering people alternative options (e.g. bucket and windlass, spring protection) the community may not be willing to take on responsibility for maintenance. It's a question of *demand* again.

Preventive maintenance
There is very little positive experience of communities ensuring that routine preventive pump maintenance is carried out. This may be because is considered unnecessary or arduous or because inadequate training and advice is given, or because maintenance culture is lacking. However, what is clear is that the working life of the pump can be negatively affected when preventive maintenance is neglected.

Cost recovery for maintenance
Most projects assume that communities will bear the cost of maintaining their handpump. However, people are rarely told how much this will really cost, and are given little or no advice on how to organise the financial side of maintenance. Most projects find that, at best, money is only collected when a breakdown actually occurs. Rural communities with little access to cash should be asked to make an upfront contribution to a handpump to demonstrate that they have the financial capacity to operate and maintain the pump.

Ongoing training and support
Many definitions of sustainability emphasize the importance of limiting external support. However, a number of project evaluations conclude that a degree of continued external support is needed to ensure sustainability. Training, and re-training, are also important components which need to be allocated adequate resources both during and after the project.

Heavy usage
The design standard for handpump usage is often taken as 250 people/day. However, where water sources are scarce the number of users may exceed 1000. Project evaluations found that the number of users is a critical factor in determining pump life and reliability. Handpumps at institutions (e.g. schools or clinics) break down most frequently, but the institutional arrangements in these settings may allow pumps to be more easily maintained.

Chemical composition of groundwater
Chemical composition of groundwater an is important factor in sustainability. Corrosive groundwater may significantly reduce the life of down-hole parts. Bad tasting water, for example with high ferrous iron content (possibly from corrosion), may lead users to abandon the handpump in favour of other sources.

Much of the literature still focuses on community management and maintenance of handpumps and there do not appear to have been many innovations in handpump projects since the water decade. However, some new models are emerging for service delivery and it will be interesting to see how they develop in the coming years. There is no doubt that the role of the private sector, in particular local artisans and traders, is becoming more and more important in service delivery and maintenance. There are as yet few useful models on how this will work in Africa., However, much is being done by the Water and Sanitation Programme and others, to learn lessons from Asia and to replicate relevant approaches in Africa. This will take time, but provides a clear lead for new handpump projects.

Finally, all this talk of sustainability is of little use unless it can be measured and monitored. There are some recent studies that have attempted to define analytical frameworks and indicators for sustainability. These are often quite complex and the potential for application to handpumps projects may not be great. The most exciting new piece of work is from WaterAid, which is in the process of developing a simple, user-friendly approach to assessing sustainability of handpump projects. The literature review did not find any other similar tools in existence so there is potential for WaterAid's *Sustainability Snapshot* to become widely used in the field.

9. Recommendations for this project

The recommendations put forward in this section are internal for the project staff working on this KAR. They are based on the findings of the review, and in particular relate to the areas that have been found to be lacking in information or in need of further research or investigation.

1. The project team should discuss Section 3 to agree on what exactly "sustainability" means in the context of a handpump project. This project needs a clear definition and boundaries before moving into the fieldwork phase. The issue of timeframe is an important one, since many definitions require the project benefits to flow for a "long time" after project inputs have ceased. If this project is going to evaluate long term sustainability of projects then it is important to decide on this timeframe: are you looking beyond the working life of the pump, or the rising main?

2. The literature search was based around keywords such as handpump, sustainability, maintenance, spares and it identified very little published information relating to exploration, siting, drilling and development. This indicates that few people have linked handpump sustainability to hydrogeological factors. However, this gap does not necessarily imply that there is no causal link. Further work should be done focusing on the groundwater resource aspect of handpump projects and it would be useful to consult with some experienced practitioners in this field (e.g. Alan MacDonald and others at BGS)

3. The review has highlighted poor cost recovery for ongoing pump maintenance as one of the key factors undermining sustainability. Communities are rarely told what the real cost of maintaining a handpump will be. It would be very useful to look more closely at this aspect of handpumps. However, the review did not identify any up to date information on cost data relating to pump maintenance in Africa. This issue should be put to practitioners who may have access to current data (via the HTN electronic discussion group or other appropriate forums) so that a better insight into real costs of routine and periodic handpump maintenance for different models of pump can be obtained.

4. Another important factor contributing to sustainability is preventive maintenance. Most of the literature reviewed found that communities were not carrying out routine preventive maintenance. It would be interesting to try and identify some projects where, after a period of time, communities are still carrying out preventive maintenance to VLOM pumps. This could also be an issue to raise with HTN and other practitioners to find examples of positive experiences and identify the reasons

why communities are prepared to undertake preventive maintenance in these projects.

5. Some of the new models for service delivery and maintenance outlined in Section 6 are of great interest and should be followed up to see how experiences are developing. Of particular interest are the leasing concept in Angola (Volanta pumps, Paul van Beers) and the Total Warranty approach in Mauritania (Vergnet). It would be interesting to see how the pumps installed under these programmes are performing now.

6. Collaborators for the fieldwork should be identified as soon as possible so that the tools can be further developed and key issues identified. There may be other important issues or viewpoints that this review has not yet identified. The project must decide how to approach the fieldwork; since some sustainability issues are context-specific (e.g. involvement of private sector, role of NGOs, logistical constraints, hydrogeological conditions). There may be an argument for examining different sustainability factors in different locations, rather than trying to do a comprehensive evaluation at every project selected. This needs to be given serious thought in relation to the tools that will be used and the team composition for the fieldwork.

7. A close working relationship with WaterAid with some of the projects that have already started testing the sustainability snapshot tool (Malawi, Zambia and Mozambique) will strengthen this project considerably. WaterAid are very prepared to be self-critical and learn lessons from past experience and have a great deal to offer the sustainability debate. It may even be worth considering some exchange visits between WaterAid staff and staff/government partners from other projects to see how focusing on sustainability issues can improve long term project performance and benefits.

8. The outputs to be produced from this project need to be given careful thought: what do people *want* and *need* to know (not necessarily the same thing!) and what is the user-friendliest way to present this information. It is clear that different sets of stakeholders have different roles to play in achieving sustainability. Consideration should therefore be given to preparing different guidelines for different stakeholders e.g. one for those involved in policy making (national governments), one for project preparation and design (donors, consultants, NGOs) and one for implementation and on-going support (local government, NGOs, private sector). It may also be interesting to develop some information/education materials for communities on the importance of preventive maintenance and other community-based issues relating to sustainability.

References

Abrams, L (1998) *Understanding sustainability of local water services*, March 1998, http://www.africanwater.org/sustainability.htm

Alberts, H., Meza, R., Solis, D. and Rodriguez, M. (1993) How the rope pump won in Nicaragua. *Waterlines*, Vol.12 No.2 October 1993, pp.3-5

Alberts, H (2000) 'Community rope pumps in Nicaragua; a private sector approach'. Paper presented at *Clean water delivery, Village Power 2000*, December 2000.

Arlosoroff, S., Tschannerl, G., Grey, D., Journey, W., Karp, A., Langenegger, O. and Roche, R. (1987) *Community water supply: the handpump option*, The World Bank, Washington DC 1987

Ashley, C. and Carney, D. (1999) *Sustainable livelihoods: lessons from early experience* UK Department for International Development (DFID) 1999

Barrett, D.E. and Shahidullah (1992) 'Public sector stimulus for private sector repair systems'. Paper presented at 18th WEDC conference, Kathmandu, Nepal 1992, pp.86-87

Baumann, E. (1994) *Private sector involvement in production, distribution and maintenance of handpumps. Policy to build the private sector in Ghana*. SKAT Handpump Technology News, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland, June 1994

Bernage, F (2000) 'Local private sector involvement: the Mauritania experience'. Paper presented at SKAT HTN workshop on Civil Society and Government Partnerships in RWS, Hyderabad, India, March 2000, published by SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland

Blackman, R. (1999) *Financing of rural water supply systems from a rights perspective: a case study of the rope pump in Nicaragua*. Report based on a dissertation for MSc 1998-1999 submitted to International Development Department, University of Birmingham (unpublished)

Boydell, R.A. (1999) Making rural water supply and sanitation projects sustainable, *Waterlines,* Vol.18 No.1 July 1999 pp.2-4

Breslin, E.D. (2000a) *Lessons from the field update series: Maúa and Nipepe*. Number 8 October 2000, WaterAid, Prince Consort House, 27-29 Albert Embankment, London, UK (unpublished)

Breslin, E.D. (2000b) *Lessons from the field update series: Maúa and Nipepe*. Number 9 October 2000, WaterAid, Prince Consort House, 27-29 Albert Embankment, London, UK (unpublished)

Breslin, E.D. (2001) *Lessons from the field: Chimbonila mais uma vez (one more time)*. May 2001, WaterAid, Prince Consort House, 27-29 Albert Embankment, London, UK (unpublished)

Carter, R.C., Tyrrel, S.F. and Howsam, P. (1996) Strategies for handpump water supply programmes in less-developed countries, *Journal of the Chartered Institution of Water and Environmental Management*, Vol.10 April 1996, pp.130-136

Chambers (1998) *The Chambers Dictionary*, Chambers Harrap Publishers Ltd 1998

Clark, L. (1996) *The field guide to water wells and boreholes.* Geological Society of London Professional Handbook, John Wiley and Sons, reprinted January 1996

Cleaver, F. (1991) Maintenance of rural water supplies in Zimbabwe. *Waterlines*, Vol.9 No.2 April 1991 pp.23-26

Coad, A. (2000) *HCA – the household centred approach – a new way to increase the sustainability of water and sanitation projects?* A report on the 16th AGUASAN workshop, June 2000, SKAT SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland, June 1994, www.skat.ch

Colin, J. (1999) *Lessons learned from village level operation and maintenance.* WELL study Task 162, WELL, WEDC, Loughborough University, UK, 1999. http://www.lboro.ac.uk/well/studies/contents.htm

Curtis, V., Diallo, I., Konate, J. and Skitt, T. (1993) *The hand-pump maintenance project in Seno and Oudalan, Burkina Faso.* Draft evaluation report April 1993. Save the Children Fund, UK (unpublished)

Dayal, R., van Wijk, C. and Mukherjee, N. (2000) *Methodology for participatory assessments with communities, institutions and policy makers. Linking sustainability with demand, gender and poverty*, IRC-WSP METGUIDE, March 2000

Fonseka,, J. and Baumann, E. (1994) *Evaluation of maintenance systems in Ghana*, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland, October 1994, www.skat.ch

Frölich, U. (1999) *Private sector - just a (new) hope?*. Proceedings of 15th Aguasan 1999, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland , July 1999, www.skat.ch

Garvey, G., Gebrehiwot, K. and Yegletu, A. (1991) 'Hand dug wells – field experience from Ethiopia'. Paper presented at 17th WEDC conference, Nairobi, Kenya, 1991. pp.181-184

Gorter A.C., Alberts J.H., Gago J.F. and Sandiford P, A randomised trial of the impact of rope-pumps on water quality, *Journal of Tropical Medicine and Hygiene,* 1993; 98:247 – 255

Gray, K.D. (1984) Working towards village-based handpump maintenance – UNICEF's approach in India. *Waterlines*, Vol.3 No.1 July 1984, pp.26-28

Hankin, P. (1997) Zomba Water and Sanitation meeting: AFRIDEV handpump problems (unpublished), GITEC Consult GMBH, Kalembo Groundwater Project, Malawi

Hassan, J. (1998) *A history of water in modern England and Wales*, Manchester University Press, 1998

Hazelton, D. (2000) *The development of community water supply systems using deep and shallow well handpumps*. WRC Report No, TT132/00, Water Research Centre, South Africa.

Hodgkin, J. (1994) *The sustainability of donor-assisted rural water supply projects* WASH Technical Report No.94, April 1994, USAID Washington DC

Hoffman, L. (1992) Women handpump mechanics in Kenya. *Waterlines,* Vol.11 No.2, October 1992, pp.19-21

IIED (2000) *Drawers of Water II – Institutional and Policy Lessons* Sustainable Agriculture and Rural Livelihoods website
http://www.iied.org/agri/dowrv-institutional.html

IRC (1988) *Handpumps: issues and concepts in rural water supply programmes*, Technical Paper No.25, The Hague, The Netherlands, 1988

IRC/CINARA (1997) *Technology transfer in the water supply and sanitation sector: a learning experience from Colombia* Technical Paper Series 32-E, IRC The Hague, December 1997

Katz, T. and Sara,. (1997) *Making rural water supply sustainable: Recommendations from a global study.* UNDP- World Bank Water and Sanitation Programme, The World Bank, 1997

Kennedy, W.H. (1997) 'Malawi water developments: a systems approach'. Paper presented at 23rd WEDC conference, Durban, South Africa, 1997. pp.286-288. http://www.lboro.ac.uk/departments/cv/wedc/conferences/23contents.htm

Kimena, P.P.L.M., Chola, P. and Phiri, S. (2000) 'Water supply and sanitation reforms in Zambia'. Paper presented at HTN SKAT workshop, Hyderabad, India, March 2000

Lium T. and Msuya, M. (1989) Dialogue for improved sector performance, Tanzania, Water Supply, 17th International Water Supply Congress and Exhibition, IWSA, Vol.7 No.2/3 1989 pp. SS14-9 to SS14-12

Metcalf, G. (undated) *Umgeni water groundwater development programme* (unpublished) http://www.iwra.siu.edu/pdf/Metcalf.pdf

Minchinton, W. (1987) *Life to the city: a social history of Exeter's water supply from the Romans to the present day*, Published by Devon Books, UK

Ministry of Natural Resources and Directorate of Water Development (1997) *Draft National Water Policy*, Uganda, July 1997

Morgan, P. (1993) Maintenance, the key to handpump survival. *Waterlines*, Vol.1 No.4 April 1993. pp.2-4

Mtunzi, M.B.E. and Lombardi, N. (1993) Maintaining handpumped wells in Tanzania, *Waterlines,* Vol.11 No.4 April 1993 pp.5-7

Mudege, N.R. (1993) Handpump maintenance in Zimbabwe. *Waterlines,* Vol.11 No.4 April 1993, pp.9-12

Mukherjee, N. (1999) Measuring sustainability – recent lessons from Indonesia. *Waterlines* Vol.18 No.1 July 1999 pp.13-16

Naylor, P. (1983) *Ancient wells and springs of Derbyshire*, Scarthin books, Derbyshire, UK, 1983

Niederer, S. (1998) *Technology and balanced development*. Report on the 14th Aguasan workshop, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland, June 1998, www.skat.ch

Nicol, A. (1999) 'Mchinji water project, Malawi'. Paper presented at *Lessons learned from NGO experience in the water and sanitation,* WELL, WEDC, Loughborough University, UK 1999 http://www.lboro.ac.uk/well/pubs.htm

Obiols, A.L. (1998) Performance of Afridev pumps in the CARE community water and sanitation project, Inhambane, Mozambique. Main article SKAT News, http://www.skat.Ch/news/Skatnews/news_33_main.htm

ODA (1995) Uganda (Busoga) Project Evaluation, available from Overseas Evaluation Manager, WaterAid, Prince Consort House, 27-29 Albert Embankment, London, UK (unpublished) 1995

OED (1997) Sustaining rural water supplies, Precis Number 154. World Bank, Operations Evaluation Department, January 1997. http://www.worldbank.org/oed

Osafo-Yeboah, A. (1994) 'Using the Afridev handpump Norrip's experience'. Paper presented at 20th WEDC conference, Colombo, Sri Lanka, 1994, pp.118-119 http://www.lboro.ac.uk/departments/cv/wedc/conferences/20contents.htm

Oyo (2001) 'Developing RWSS supply chains. Creating an enabling environment for small and medium enterprises to deliver goods and services in the rural water supply and sanitation sector'. Paper to be presented at 27th WEDC conference, Lusaka, Zambia, 2001.
http://www.lboro.ac.uk/departments/cv/wedc/conferences/index.htm

Partners in Development and Geomeasure Services (2000) *Community handpump water supplies in Kwazulu-Natal. An Overview*. Report prepared on behalf of the Department of Water Affairs and Forestry (unpublished)

Rall, M. (2000) 'Partnerships for sustainability: The Mvula Trust experience'. Paper presented at *Government and Civil Society Partnerships*, SKAT HTN International Workshop, India, March 2000, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland

Razig, M.A. and AlAzharai, A-S. I. (1989) 'Efficiency and cost-containment of water and sanitation in Sudan'. Paper presented at 15th WEDC conference, Kano, Nigeria, 1989. pp.11-13

Reed, R.A. (2001) (Senior Lecturer, WEDC, Loughborough University, UK) Personal communication.

Reynolds, J. (1992) *Handpumps: Toward a sustainable technology. Research and development during the water supply and sanitation decade*, UNDP-World Bank Water and Sanitation Programme, Water and Sanitation Report 5 October 1992

Sandiford, P., Alberts, H., Guillermo, J.O. and Gorter, A. (1993). The Nicaraguan rope pump. *Waterlines,* Vol.11 No.3 January 1993 pp.27-30

Sara, J. (1999) *Giving communities choice is not enough!* Water and Sanitation Programme. http://www.wsp.org/English/focus/Conference/Communities.html

Sarkinnen, P. (1994) *Lessons learned from Kenya-Finland Western water supply programme (1981-1993)* UNDP-World Bank regional Water and Sanitation Group, December 1994

Save the Children (1995) *Toolkits. A practical guide to assessment, monitoring, review and evaluation.* Development Manual 5. Save the Children, 17 Grove Lane, London, UK, 1995, reprinted 1998

Schoolkate, H. (1992) *Planning for sustainable handpump-based rural water supplies. A partnership approach to resources coverage* IRC, The Hague, January 1992

Shorter Oxford English Dictionary (1973) Volume II pp.2205, Oxford University Press

Sugden (2001) 'Assessing sustainability – the sustainability snapshot'. Paper to be presented at forthcoming 27th WEDC conference, Lusaka, Zambia, 2001. http://www.lboro.ac.uk/departments/cv/wedc/conferences/index.htm

Thompson, K. and Crawshaw, J. (1998) Water in Liberia – how war affects policy formulation and implementation. *Waterlines*, Vol.16 No.3 January 1998 pp.27-29

UNCDF (1996) Guinea Bissau Project Evaluation Summary, Policy, Planning and Evaluation Unit, UNCDF, http://www.uncdf.org/projects/eval/bs90c01.html

van Beers, P. (1999a) "…Re: Ideal handpump?" Contribution to electronic discussion group, posted on 4 May 1999. http://www.mailbase.ac.uk/lists/htn

van Beers, P. (1999b) "Volanta lease concept" Discussion document sent to electronic discussion group, posted on 18 October 1999. http://www.mailbase.ac.uk/lists/htn

van Beers, P. (2001) 'Leasing, a new handpump O&M concept'. Paper presented at 27th WEDC conference in Lusaka, Zambia 2001. http://www.lboro.ac.uk/departments/cv/wedc/conferences/index.htm

van der Werff, K. and Visscher, J.T. (1995) *Towards sustainable water supply. Eight years of experience from Guinea-Bissau.* IRC PPP01, IRC, The Hague, 1995

van Wijk, C. and Visscher, J.T. (1987) Handpump projects: avoiding neglect. *World Water,* May 1987 pp.44-46

Vince, J (1978) *Wells and water supply*, Shire Album 36, Shire Publications, Aylesbury 1978

Waterkeyn, A. (1993) Pipe dream or pump dream? *Waterlines,* Vol.11 No.4 April 1993, pp.19-21

WELL (1998) *DFID Guidance manual on water supply and sanitation programmes.* WELL, WEDC, Loughborough University, UK, 1998, www.lboro.ac.uk/well

WELL (2001) *Evaluation of the FGN-UNICEF water and environmental sanitation programme in Nigeria*. WELL Task 404, WEDC, Loughborough University, UK, June 2001 (unpublished)

WHO (2000) *Gobal water supply and sanitation assessment 2000 report,* WHO/UNICEF, New York.

Wishart, G. (1997) *Partnerships, roles and responsibilities*. Proceedings of HTN workshop, Malawi 17-21 March 1997, HTN, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland. http://www.skat.ch/htn/Publications/download/malawi.pdf

Wishart, G. (2000) *Government and civil society partnerships*. Proceedings of HTN international workshop, India 6-10 March 2000, HTN, SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland.
http://www.skat.ch/htn/Publications/download/proceedings1.pdf

Wood, M. (1988) Ghana's tariffs have mixed effects. *World Water*, August 1988 pp.32-35

Wood, M. (1989) Meeting a water need in Malawi. *World Water*, November 1989 pp.26-28

Wood, M. (1994) 'Are handpumps really affordable?' Paper presented at 20th WEDC conference, Colombo, Sri Lanka, 1994. pp.132-134.
http://www.lboro.ac.uk/departments/cv/wedc/conferences/20contents.htm

Woodhouse, M. (1999) *Field experiences from shallow well programmes in Tanzania – focusing on the handpump* Minutes of meeting at UNICEF Dar es Salaam, attended by Ministry of Water, HESAWA (Sida), Maji/Danida, DWSP, WaterAid, UNICEF, May 1999 (unpublished)

WSP (2000a) *Supply chains – a global initiative*, update spring 2000, Water and Sanitation Programme. http://www.wsp.org/pdfs/global_supplyupdate.pdf

WSP (2000b) *Linking sustainability with community participation and gender-sensitivity*. Water and Sanitation East and Southern Africa Region, Field Note Number 6, March 2000

WSP (2001) *The rope pump: private sector technology transfer from Nicaragua to Ghana.* Water and Sanitation Programme, Supply Chain Links to Sustainability No.5, February 2001 http://www.wsp.org/

Bibliography

Gunyon, W *India: making government funding work harder*. A WaterAid report (undated), WaterAid, Prince Consort House, 27-29 Albert Embankment, London, UK (unpublished)

Hoque, B.A., Juncker, T., Sack, R.B., Ali, M. and Aziz, K.M.A. Sustainability of a water, sanitation and hygiene education project in rural Bangladesh: a five year follow-up. *Bulletin of the World Health Organization* 1996 Vol.74 (4) pp.431-437

Isley, R. and Rosensweig, F. Training non-technical workers for rural water and sanitation projects. *Waterlines,* Vol.3 No.2 October 1984 pp.9-11

Iyer, P. Mechanisms for sustainability in a supply-driven environment, *Waterlines*, Vol.18 No.1 July 1999 pp.25-27

Kjellerup, B. and Asimah, S.E. 'Handpump performance monitoring (HPPM)'. Paper presented at 26th WEDC Conference, Dhaka, Bangladesh, 2000.
http://www.lboro.ac.uk/departments/cv/wedc/conferences/26contents.htm

Morgan, P. The handpump phenomenon, *Waterlines*, Vol.8 No.2 October 1989 pp.2-5

Ockelford, J., Rosenboom, J-W. and Kjellerup, B. 'A VLOM framework for Cambodia'. Paper presented at 22nd WEDC conference, New Delhi, India, 1996, pp.99-102.
http://www.lboro.ac.uk/departments/cv/wedc/conferences/22contents.htm

Pacey, A. *Hand-pump maintenance*. Intermediate Technology/Oxfam, UK, Revised edition April 1980

Ramachandran, S. and Chaudhuri, B.B. 'Rejuvenation of drinking water tubewells'. Paper presented at 18th WEDC conference, Nepal, 1992, pp.170-173

Roark, P. 'Design and management of rural water supply projects: Lessons learned from comparative study of USAID projects in Burkina Faso and Togo'. The State-of-the-Art of Hydrology and Hydrogeology in the Arid and Semi-arid areas of Africa. Proceedings of Sahel Forum 1989, IWRA Illinois 1990 pp.902-910

Roy, S. A one-tier system: the Tilonia approach to handpump maintenance, *Waterlines*, Vol.2 No.3 January 1984, pp.13-16

Srivastava, J.C. Women as handpump caretakers in rural water systems. *Water and Wastewater International*, August 1991

Sundaresen, B.B. Evaluation of rural water supply systems in India – focus on sustainability. *Water Supply*, Vol.15 No.4 Harrogate Yorkshire 1997 pp.117-128

Talbot, R. 'Goals, roles and innovations in India' Paper presented at 23rd WEDC conference, Durban, South Africa, 1997, pp. 11-15.
http://www.lboro.ac.uk/departments/cv/wedc/conferences/23contents.htm

Trevett, A. and Nunez, O. AHJASA – ongoing management and maintenance support for Honduras' community water systems, *Waterlines*, Vol. 16 No.3 January 1998, pp.24-26

WSP *The treadle pump. An NGO introduces a low-cost irrigation pump to Bangladesh*. Supply chain links to sustainability case study 1, Water and Sanitation Programme, August 2000, www.wsp.org

WSP *Afridev handpumps in Africa. Private demand emerges for affordable and reliable pump*. Supply chain links to sustainability case study 2, Water and Sanitation Programme, December 2000, www.wsp.org

WSP *The growth of private sector participation in rural water supply and sanitation in Bangladesh*. Supply chain links to sustainability case study 4, Water and Sanitation Programme, December 2000, www.wsp.org

Yacoob, M. Community self-financing of water supply and sanitation: what are the promises and pitfalls. *Health Policy and Planning* 5(4) pp.358-366, 1990