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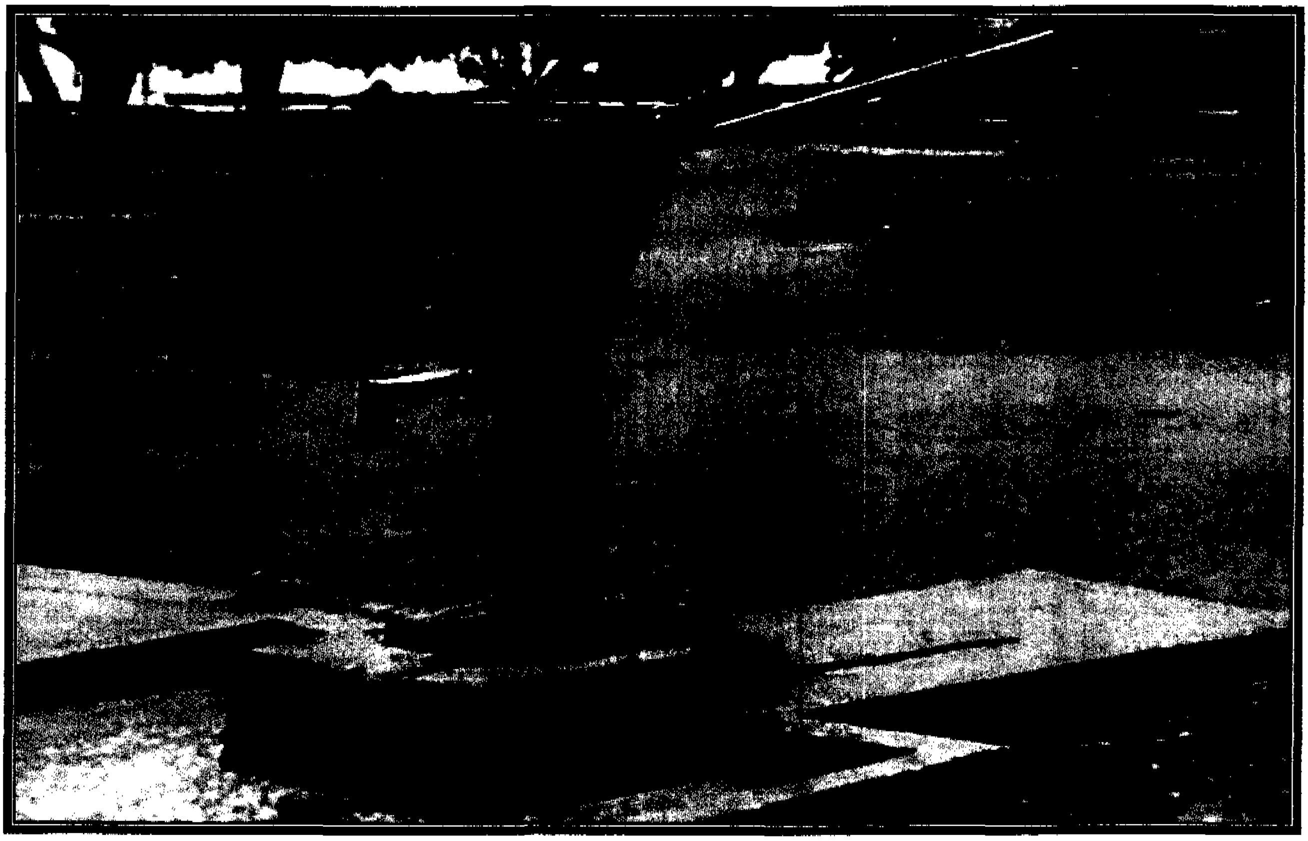

Evaluation of Handpump Water Supplies in Selected Rural and Semi-Urban Areas in Zambia.

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Master of Science Thesis
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Abstract

For many years handpumps have been a dependable technology for rural and semi-urban water supply in Zambia. However most of the handpumps (India Mark II anf Afridev) and spares are imported mainly from India. Provision of handpump water supply systems is mainly done by External Support Agencies, while the O&M of these handpumps is the responsibility of the users, who are predominantly poor communities. Often users are not able to mobilise resources required for O&M of the handpumps and as a result some are abandoned after a few years of operation. The sustainability of handpump water supplies is in jeopardy. Therefore an investigation into factors affecting smooth operation (sustainability) of handpump water supply systems is of utmost priority.

The sustainability of handpumps water supply systems requires strong link among the five factors of sustainability namely financial, technical, institutional, social and environmental, the failure of any one of them endangers the entire service delivery. The aim of this study is to evaluate policies, planning, implementation and operation management aspects of handpump water supply systems in selected rural and semi-urban areas in Zambia with the ultimate objective of improving awareness of factors affecting sustainability of handpump water supplies.

The evaluation is based on review of relevant literature and field assessment. The desk study included reviewing of international experience on sustainability of handpumps water supply and preparation of field data collection questionnaires. During the field study questionnaire-guided interviews and discussions were held with 6 National Policy Agencies, 8 External Support Agencies, 9 District Implementing Agencies, 36 community handpump sites, 3 private handpump dealers and 1 technology research institution. Furthermore, the condition of all the handpump systems at all the sites was examined.

It was observed that handpumps owned by community with good income base (e.g. markets, farmers groups) demonstrated fairly high levels of sustainability. Community handpumps in districts with better access to transportation, often resulted in decreased downtime and comparatively higher levels of sustainability. On the other hand handpumps owned by the public institutions like district councils and schools showed low levels of sustainability due to lack of operations control and careless handling from the users who normally do not pay for the service. Access to spare parts is a problem especially for those communities in rural areas. Borehole drilling cost of borehole is substantially higher than the cost of handpump. Above all, the government involvement in hand pump water supply project is not very effective for its long-term sustainability.

Handpump water supplies have, to some extent, proved affordable and sustainable to the communities in the study areas. However, there are various missing links in the sustainability chain mainly attributed to lack of guidelines and proper service coordination by Government. The application of short term approaches in the provision of handpump systems by most implementing agencies could be a serious constraint to sustainability of handpump water supplies in Zambia hence the need to change. The continued support to the user community during the O&M phase is equally important.

Key words: *evaluation, handpump water supply, rural areas, semi-urban areas, sustainability, financial sustainability, technical sustainability, institutional sustainability, social sustainability, environmental sustainability, national policy, implementing agencies, users, private sector, operation and maintenance.*

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Abbreviations

ACO	Area Community Organiser
ADP	Area Development Project
APM	Area Pump Mender
CBO	Community Based Organisation
DAPP	Development Aid from People to People
DDCC	District Development Co-ordination Committee
DISS	Department of Infrastructure Support Services
DFID	Department for International Development (UK Government)
DWA	Department for Water Affairs
D-WASHE	District Water, Sanitation and Hygiene Education
ECZ	Environmental Council of Zambia
EHT	Environmental Health Technician
EIA	Environmental Impact Assessment
ESA	External Support Agency
G.I.	Galvanised Iron
GTZ	German Technical Co-operation
I.D.	Internal Diameter
JICA	Japanese International Co-operation Agency
MCDSS	Ministry of Community Development and Social Services
MEWD	Ministry of Energy and Water Development
MLGH	Ministry of Local Government and Housing
MOA	Ministry of Agriculture
MOE	Ministry of Education
MOH	Ministry of Health
N.B.	Nominal Bore
NGO	Non-Governmental Organisation
NWASCO	National Water Supply and Sanitation Council
N-WASHE	National Water, Sanitation and Hygiene Education
O.D	Outside Diameter
PVC	Polyvinyl Chloride
PSRP	Poverty Reduction Strategy Paper
RWSS	Rural Water Supply and Sanitation
UNICEF	United Nations Children's Fund
uPVC	Unplastisised Polyvinyl Chloride
VLOM	Village Level Operation and Maintenance
WASHE	Water, Sanitation and Hygiene Education
WEDC	Water, Engineering and Development Centre (Loughborough University)
WRAP	Water Resources Action Programme
WSS	Water Supply and Sanitation

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1 Introduction

There is no doubt that a closer and cleaner source of water can produce far-reaching health, social and economic benefits to mankind. Handpumps world over have been promoted as the means of bringing groundwater closer to the poor especially in rural and semi-urban areas. They have been considered an appropriate low cost solution that uses technology that can be operated and maintained by the users (Arlosoroff, 1987). Regrettably in scores of cases, predominantly in the sub-Saharan Africa, they have failed to fulfil their expectations. Researchers in this field have identified various reasons contributing the failures (Parry-Jones et. al, 2001a). The most common reason has been the lack of awareness of the factors affecting sustainable implementation and management of handpump water supplies projects. This chapter presents an introduction to a study set to evaluate handpump water supply systems in Zambia and to investigate factors affecting their sustainability.

1.1 Country Profile

The Republic of Zambia is a land-locked country occupying a total area of 752,614 sq km of an elevated plateau in South-Central Africa. Eight other countries border Zambia: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Democratic Republic of Congo and Zimbabwe.

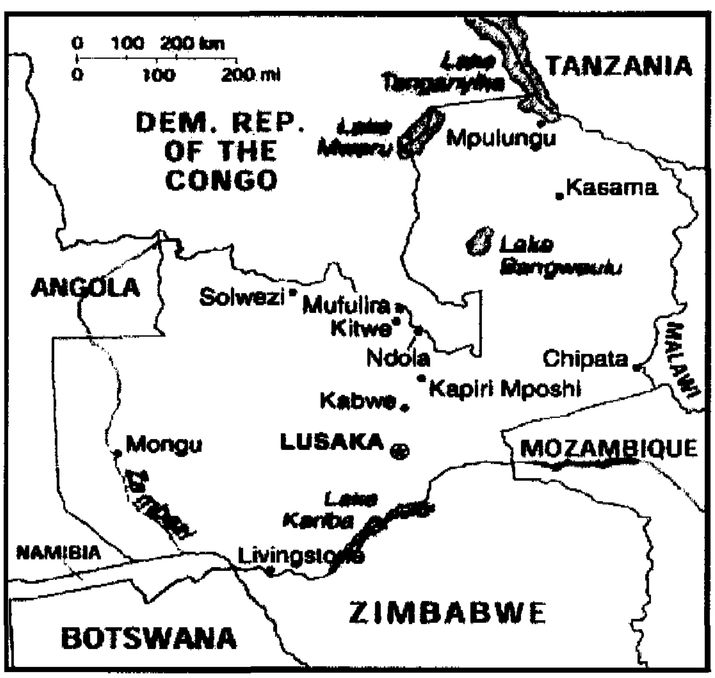

Figure 1.1: Map of Zambia.

Zambia's shortest route to the sea is via Zimbabwe to Beira in Mozambique. It has a total population of 10 million (Zambia Census of Population and Housing, 2000). Zambia is divided into nine provinces namely: Lusaka, Copperbelt, Southern, Northern, Western, North-Western, Central, Eastern and Luapula Provinces. The capital city of Zambia is Lusaka with total population of approximately 2 million. The major economic activities include mining, agriculture and tourism.

1.2 Water Supply Coverage in Zambia

Based on the water supply facilities, access to safe water in Zambia is estimated at 89% of population in urban areas and 37% of the population in rural and semi-urban areas. Real coverage is much lower and varies considerably from one place to another due to non-functioning of water facilities, which are either broken down, abandoned or seasonal. In peri-urban areas, where 50 – 70 % of the urban population live, water supply services are poor, inadequate, and unreliable and at least 56% of the population do not have access to safe water supply. The Living Conditions Monitoring Survey Zambia Report (1998) reveals that most districts in the country do not have access to safe water supply.

However, the data provided with regards to coverage does not indicate or differentiate percentages of populations that are served from centralised supply systems or those from decentralised supplies, though handpumps are the most common means of safe water supplies in rural and semi-urban districts.

1.3 Existing Rural Water Supply Programmes and Projects in Zambia

Major ongoing rural and semi-urban water supply projects in Zambia include the Eastern Province Water Supply Project; Water Development to Drought Prone Areas in Southern, Western and Central Provinces; Northern Province Water Supply and Sanitation Programme and the Central Province Water Supply and Sanitation Project. There are also several urban water supply projects mainly involving rehabilitation and improvement of water supply systems in a number of townships throughout the country (PSRP, 2002).

1.4 Research Background

Handpumps have been given a high profile in the pursuit to provide potable water to the world's growing rural population by leading players in development like the World Bank, UNICEF and various international non-government organizations based on the following set of assumptions: That handpumps are: low cost; affordable; easy to maintain, an appropriate technology; readily available; easy to install; user friendly and efficient (Wood, 1994).

Today handpumps continue to be one of the principal technologies used to supply water to rural people. In Zambia, many rural and semi-urban areas have had an opportunity to receive a handpump water point as a source of safe drinking water. Handpumps systems and spares in Zambia are mainly imported from India. The India Mark II and Afridev are the sole handpump systems standardised in Zambia.

However, the proper maintenance of community handpumps is still a major problem in many parts of the country. Many questions remain unanswered.

- For how long have these handpumps remained in operation after commissioning?
- Have the beneficiaries accepted them?
- And if they have been accepted, are the operations and maintenance requirements affordable?

Experience has shown that many handpumps have been abandoned shortly after installation and users return to their original contaminated source of water (Wood, 1994). Even though many handpumps are in disuse, several more are being sunk throughout the country without due consideration of the factors affecting sustainability of these facilities.

Some international development agencies such as World Bank, and DFID have realised the significance of lack of sustainability of handpump technology in developing countries. DFID is currently investigating factors that contribute to sustainability of handpumps with a focus on Africa (Parry-Jones et. al 2001a&b).

1.5 Problem Identification

Nearly 40% of rural population in Zambia have boreholes equipped with handpumps (Living Conditions Monitoring Survey Zambia Report, 1998). Many of these boreholes were sunk either by government departments or by international development agencies through different implementing partnerships. Whoever the implementing agency has been, handpump delivery to the communities has included borehole drilling and supply and installation of the facility. Operation and maintenance has then remained the responsibility of the user communities. Very often the donors are ready to finance the implementation but not the operation and maintenance. A typical problem has been that of maintenance of the handpump water supply systems. Many handpumps have been abandoned shortly after installation due to lack of repair after breakdowns and users return to their original contaminated source of water.

As pointed out earlier, handpumps are in every rural district in Zambia but often, the establishments of spare parts distribution networks and repair services needed to maintain the equipment have not accompanied the introduction of this imported technology. In a number of cases when the equipment fails, repairs are delayed or it is not repaired completely.

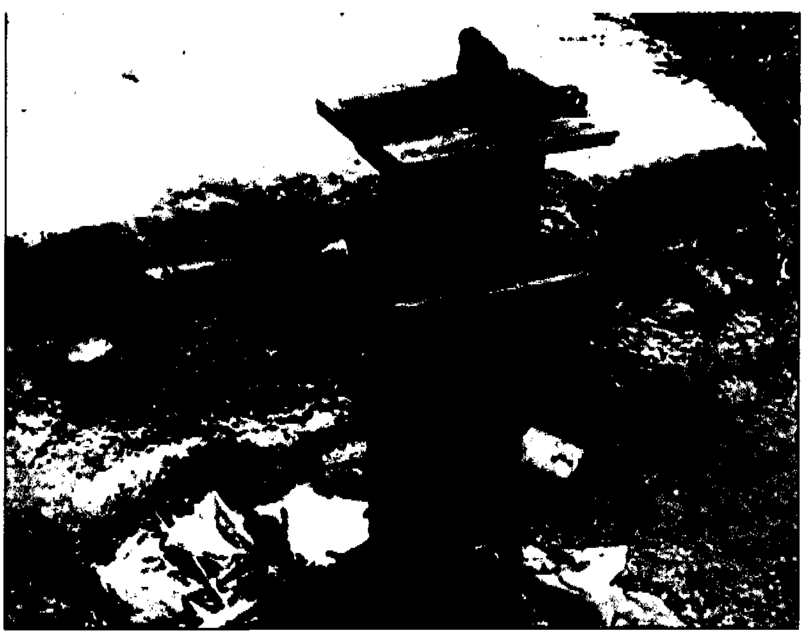

Figure 1.2: An abandoned broken India Mark II pump in Chongwe District.

Therefore, the urgent need to investigate the inherent factors that affect sustainability of handpump water supplies systems in Zambia and come-up with recommendations that can aid planners and decision makers to prepare community water supply projects that can be sustainable can not be over emphasised.

1.6 Goal and Objectives

The goal of this research is improved awareness of factors affecting sustainability of handpump water supplies in Zambia.

The main objective of research is to evaluate handpump water supply systems in Zambia and to investigate the factors affecting their sustainability.

The specific objectives are as follows:

i. To study the factors affecting sustainability of handpump water supply systems in selected rural and semi-urban areas in Zambia.

ii. To review relevant literature on handpumps water supply and international experience with the sustainability of handpump water supply projects.

iii. To evaluate the policies, planning, implementation and operation management aspects of handpump water supply systems in selected rural and semi-urban areas in Zambia by conducting field study.

iv. To recommend improvements towards planning, implementation and operations management for sustainable handpump water supply projects in Zambia.

1.7 Hypothesis

The main hypotheses of this study are:

- Handpumps water supply is very appropriate technology for rural and semi-urban areas in Zambia, however its sustainability is affected by lack of proper policy measures, financial and institutional arrangements.
- Sustainable community-based management of handpump water supply systems in Zambia is undermined by poor approaches in project implementation and insufficient support from government.
- Although the private sector have been involved to some extent in handpump projects, their participation has not been exploited fully for sustainable operation.

1.8 Research Questions

The main research questions to verify the above-mentioned hypotheses are:

- To what extent are the main stakeholders contributing the sustainability of handpumps water supplies in Zambia?
- What are the most critical factors undermining sustainability of handpump water supplies in Zambia?
- What are the possibilities of increasing sustainability of handpumps water supply in Zambia?

2 Literature Review

This chapter presents a review of available literature on international experiences relating to sustainability of handpump water supplies. A review of literature on rural and semi-urban water supply policy with regards to the handpump technology in Zambia is also presented. The key sustainability factors identified in this review formed the basis for the development of methodology and approach for the evaluation of handpump water supply systems in this research.

2.1 Zambia Water Sector

2.1.1 Water Resources in Zambia

Zambia is endowed with relatively abundant fresh water resources. The annual rainfall averages 700 mm in the south and 1400 mm in the north. There is an extensive river network consisting of Zambezi, Kafue, Luangwa, Chambeshi and Luapula Rivers. In addition, there are several small and large lakes and a number of relatively productive aquifers in various parts of the country. Taken as a sum total for the whole country, the available fresh water resources far exceed the consumptive use (including domestic, and industrial water supplies, irrigation and livestock) even in a drought year. However, there are significant variations across the country and there is strong seasonal distribution leading to deficits in certain localities (PRSP, 2002).

2.1.2 Water Sector Policy Framework in Zambia

During the 1993 – 1994 period, the government established a comprehensive framework for the water sector. Seven policy principles were adopted as a basis for restructuring the sector (Zambia Water Sector, 1994). These principles were:

- Separation of water resources management from water supply and sanitation provision;
- Separation of the functions of regulation and service provision;
- Devolution of authority to local authorities and private enterprises;
- Full cost recovery in the long run;
- Human resources development resulting in more effective institutions;
- Technology appropriate to local conditions;
- Increased government budget to the sector.

This was followed in 1994 by the adoption of the National Water Policy, which covers water resources management, water use, and water quality aspects. The policy framework includes the following key policy strategies:

- Recognising the important role of the water sector in the overall socio-economic development of the country.
- Vesting control of water resources in the country under the state control.
- Promoting water resources development through an integrated management approach.

- Providing adequate, safe, and cost-effective water supply and sanitation services with due regard to environmental protection.
- Defining clear institutional responsibilities of all stakeholders in the water sector for effective management and coordination.
- Recognising water as an economic good.

For the rural and semi-urban areas, in 1996 the government adopted the Water, Sanitation, Health and Education (WASHE) concept as a national strategy for the improvement of WSS services. The strategy facilitates the involvement of the rural population in assessing priorities; determining affordable and sustainable technology; management of operation and maintenance; and improving the health and hygiene practices in communities. The strategy is being implemented through district level committees (D-WASHEs), which are part of the government district level planning process. The D-WASHE committees promote the formation of Village water, sanitation and health education (V-WASHE) committees to oversee the coordination and implementation of WASHE programmes at community level. WASHE also promotes gender equity in participation at all levels.

2.1.3 Legal and Institutional Framework

The primary legislation prescribing the development and management of water resources in Zambia is the Water Act, Cap. 198, which was originally enacted in 1948. The Water Act though, does not adequately address the development and control groundwater and international rivers. It does not make sufficient provision for water quality control, or for institutional framework for regulating development of water resources. The Act also does not have provision for water resources management and stakeholder participation (PSRP, 2002).

With regards to water supply, the Water Supply and Sanitation Act number 28 of 1997 anchors the legal framework. According to the Act, local authorities (under the Ministry of Local Government and Housing (MLGH)), acting by themselves or through commercial utilities, or the private sector, are responsible for provision of water and sanitation services to all areas in the jurisdiction of the local authority. The Department of Infrastructure Support Services (DISS) in the Ministry of Local Government and Housing provides technical support to local authorities and assists in the mobilisation and coordination of financial resources for all infrastructure development in local authorities. The Act also establishes the National Water Supply and Sanitation Council (NWASCO) as the regulator for provision of WSS services throughout the country (PSRP, 2002).

2.1.4 National Water Supply Policy and Strategy

The National Water Policy has adopted the following strategies as cornerstone to water sector development activities (PSRP, 2002):

- Development and sustaining of human resource capacity within the sector in parallel with infrastructure development, to facilitate or directly plan, design, implement, monitor, operate, maintain, and evaluate water projects.
- Strengthen the institutional capacity for addressing the water development needs of the poor in the two water sector ministries (MLGH and MEWD).

- Promote effective community participation and stakeholder involvement, particularly women and children, in design, execution and management of water programmes and projects.
- Establish inter-ministerial, inter-sectoral, broad-based collaboration and consultative mechanisms for implementation of water sector activities.
- Develop water sector resources projects in coordination with other sectors, particularly agriculture, energy and tourism.
- Extend provision of WSS services to approximately 2.5 million peri-urban residents and 2.5 million rural population who are currently not supplied with the minimum standards as defined in the Peri-Urban Water and Sanitation Strategy and Community Water Supply and Sanitation Draft Strategy.
- Promote low cost, appropriate, and sustainable WSS technologies as alternatives to higher technologies with proven operation and maintenance shortcomings.
- Provide ongoing maintenance and management support systems, auditing, monitoring, and evaluation services in order to reinforce existing WSS services.

Despite all the above brilliant strategies, sustainability of water supply infrastructure such as handpump water points still remains an elusive concept in Zambia (Harvey and Skinner, 2002b).

2.2 Handpump Technology in Water Supply

2.2.1 History of Handpumps Water Supplies

The first generation of handpumps included such stalwarts as the British made Godwin, which were installed in the 1930s, 40s and 50s. They were made of super heavy duty materials like cast iron and hardened steel in the belief that one had, in the colonial era, to make pumps virtually indestructible so as to withstand constant use and abuse by people in the Third World who could not be expected to maintain, let alone repair them. To their credit, many such pumps continued to pump water for many years beyond their original life expectancy, but many also broke down and stayed that way for months or years because government mechanics did not come to repair them for a variety of well-documented reasons (Wood, 1994).

Today the standard types handpumps available on the market are designs that can be repaired by a trained person in the village (Village Level Operation and Maintenance - VLOM), providing he or she has access to the specific spare parts that come with these designs (e.g. India Mark II, India Mark III, Afridev, Nira, Volanta, Bush, etc). These handpumps, except India Mark II, are commonly known as Public Domain handpumps and can be fabricated by any metal fabrication company in any country. A shortcoming in these handpumps is that several spare parts, unfortunately the most important and recurrent ones like some nylon and rubber parts, are difficult to fabricate locally. In most cases they still have to be imported from countries like India and Pakistan that can produce handpumps in high quantities at low prices. As a result, local production of public domain handpumps cannot be developed sufficiently in most developing countries (Wood, 1994).

2.2.2 Types of Handpumps

When rain falls, it seeps into the ground and collects in an underground reservoir commonly known as groundwater. The upper limit of this reservoir, the "water-table", may vary in depth, from just below the surface (like in a spring or oasis) to well over 100 meters. The only way to get at this water is to dig down.

The choice of groundwater lifters available is large and varied, making the selection of an appropriate device difficult. There is now a large number of adequate, rather than optimum, pump designs conceived by local manufacturers, and it is hard to know which pump is the best for each application (Fraenkel. 1986). This brief presents an overview of the types of manually operated water pumps available, the applications appropriate to them and their comparative advantages.

a. Open-well

The simplest and cheapest method of lifting groundwater remains the rope and bucket in a wide, shallow well. These can operate to a depth of 100 meters, although they rarely exceed 45 meters, and can last for a very long time without maintenance. It is worth considering this design before proceeding with more complicated methods. It may not be possible to construct an open-well if the water table is too deep or if the foundations are very hard (such as rock) or very soft (such as fine running sands). These restrictions also depend on the method of construction. If the groundwater can only be accessed through a bore, then a groundwater pump must be used. Groundwater manually operated pumps or commonly known as handpumps can be split into two categories, shallow-well and deepwell (Fraenkel, 1986).

b. Shallow-well pumps

Most types of groundwater pumps have a piston that moves back and forth inside a two-valve cylinder. A valve allows water to pass in only one direction - in this case, upwards (see Figure 2.1). Suction pumps have the cylinder situated above ground or near the surface. This means that they can only be used for shallow wells. It is called a suction pump because pulling up on the piston creates a low pressure ("suction") in the cylinder, causing the atmospheric pressure outside to push the water up to the surface. Because atmospheric pressure is fairly low, the pressure difference between inside and outside the cylinder is only large enough to raise water from a maximum depth of about 7 meters. It should also be noted that if a shallow-well is used too much, the water table might fall as the underground reservoir of water is reduced. If this level falls below 7 meters, the pump will not work. Four types of shallow-well pumps are shown below: rower, piston, diaphragm and treadle pumps (Fraenkel, 1986).

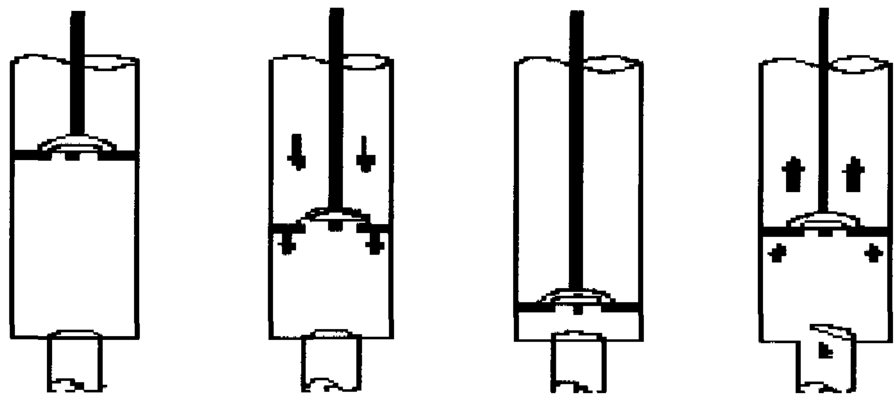

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Figure 2.1: Stages of how most types of pump cylinders work (Source: Fraenkel, 1986).

i. Rower pump

The rower pump is a simpler and cheaper version of the traditional piston pump (see Figure 2.2). Its simple design means it can be easily manufactured and maintained using locally available skills and materials. This type of pump may require "priming", which means pouring water into the cylinder so that the seal around the piston is airtight. It is very important that clean water is used, to avoid contamination of the pump and the spread of water-borne diseases (Fraenkel, 1986).

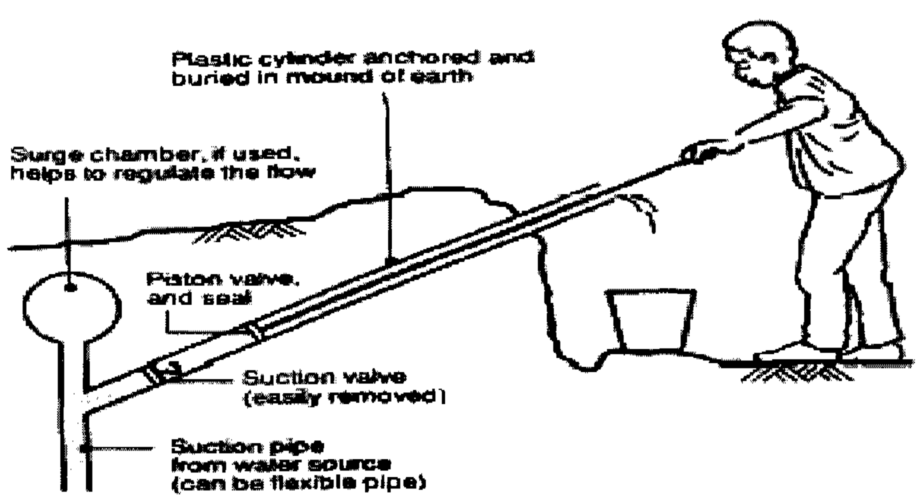


Figure 2.2: Rower pump (Source: Fraenkel, 1986).

ii. Piston pump

Piston pumps, based on the same design as shown in Figure 2.1, are more widely used. There is a similar risk of contamination from dirty priming water. In cases where the water is to be delivered under pressure (such as to a village water mains) or to a point higher than the cylinder (such as a water storage tank), a "force" pump is required. The operation is the same, but the design is slightly altered so that the top is airtight. This is done by putting a valve on the spout and adding a "trap tube" and air chamber which maintains the pressure (and therefore the flow) during the up-stroke (Fraenkel, 1986).

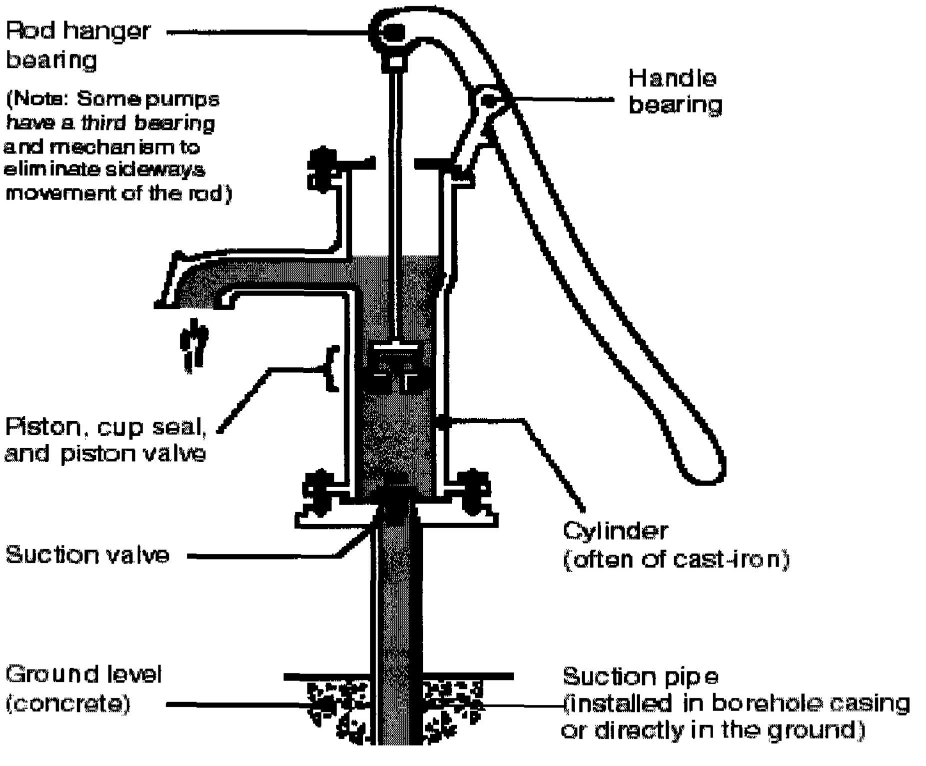


Figure 2.3: Shallow-well piston pump (Source: Fraenkel, 1986).

iii. Diaphragm pump

This design is often used for fuel pumps in cars. The Vergnet pump is an adaptation of this principle for deep-well use, which can be used in curved wells, where a rod operated pump would have problems, and which is fairly easy to maintain (Fraenkel, 1986).

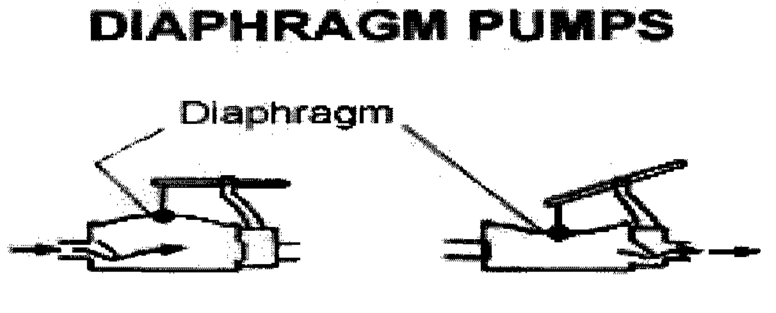


Figure 2.4: Diaphragm pump (Source: Fraenkel, 1986).

f. Treadle pump

The treadle pump (foot pedal pump) is a low-lift, human-powered pump. Because leg muscles are stronger than arm muscles, this design is less tiring to use. Most of the parts can be manufactured locally, the exceptions being the cylinders and pulley (Fraenkel, 1986). This pump has mostly been used in irrigation.

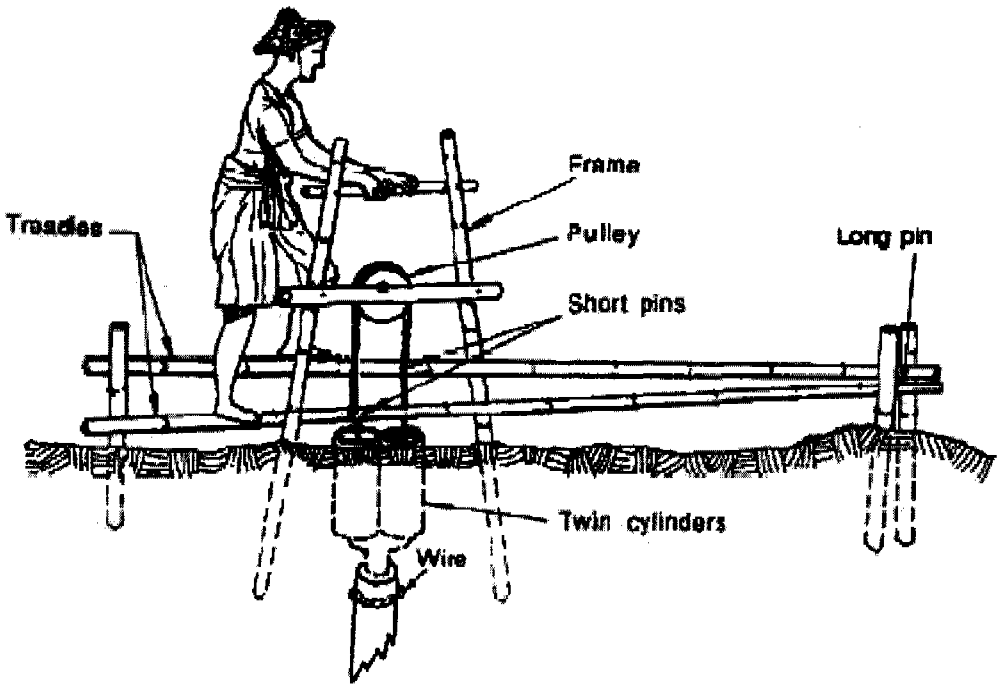


Figure 2.5: Treadle pump (Source: Fraenkel, 1986)

c. Deep-well pumps

Deep-well pumps can be used for depths over 7 metres because the cylinder or lifting device is below ground, as shown in Figure 2.6, often below the groundwater line. They are often known as "lift" pumps because they do not rely on suction to raise the water. As a result of their depth, they are harder to maintain than surface pumps, since the pump-rod must be removed to get at the cylinder. Like suction pumps, lift pumps can be made into force pumps by the addition of a spout valve, air chamber and trap tube. Three types of deep-well pump are described below: piston, helical rotor and direct action (Fraenkel, 1986).

i. Piston pump

The design is very similar to the shallow-well pump and is capable of lifting water from depths of up to 50 meters. However, the cylinder is situated deep underground, below the groundwater-line, connected to the pump handle via a long rod called a "pump rod" (see Figure 2.6). Sometimes the outside pipe, called the "rising main", is of a larger diameter so that it is possible to pull the whole cylinder up to the surface for repair without taking the pump apart. However, this is more expensive.

ii. Helical rotor (or progressive cavity) pump

Helical rotors are capable of lifting water from depths of up to 100 meters. Instead of a piston, there is a metal "rotor" which has a corkscrew shape and which turns inside a rubber "stator" or sleeve (see Figure 2.6). The lever is replaced with one or two turning handles.

iii. Direct action (or direct drive) pump

This design is capable of lifting from a depth of 12 meters. The narrow pump rod is replaced by a hollow plastic pipe, which displaces water as the pump handle is pushed down. During the upstroke, the pipe acts as a pump rod, the valve on the piston closes and water is lifted up. The pump is therefore capable of pushing water up the rising main during both strokes. Because the pipe is hollow, it floats, so the handle does not have to be pulled up so hard.

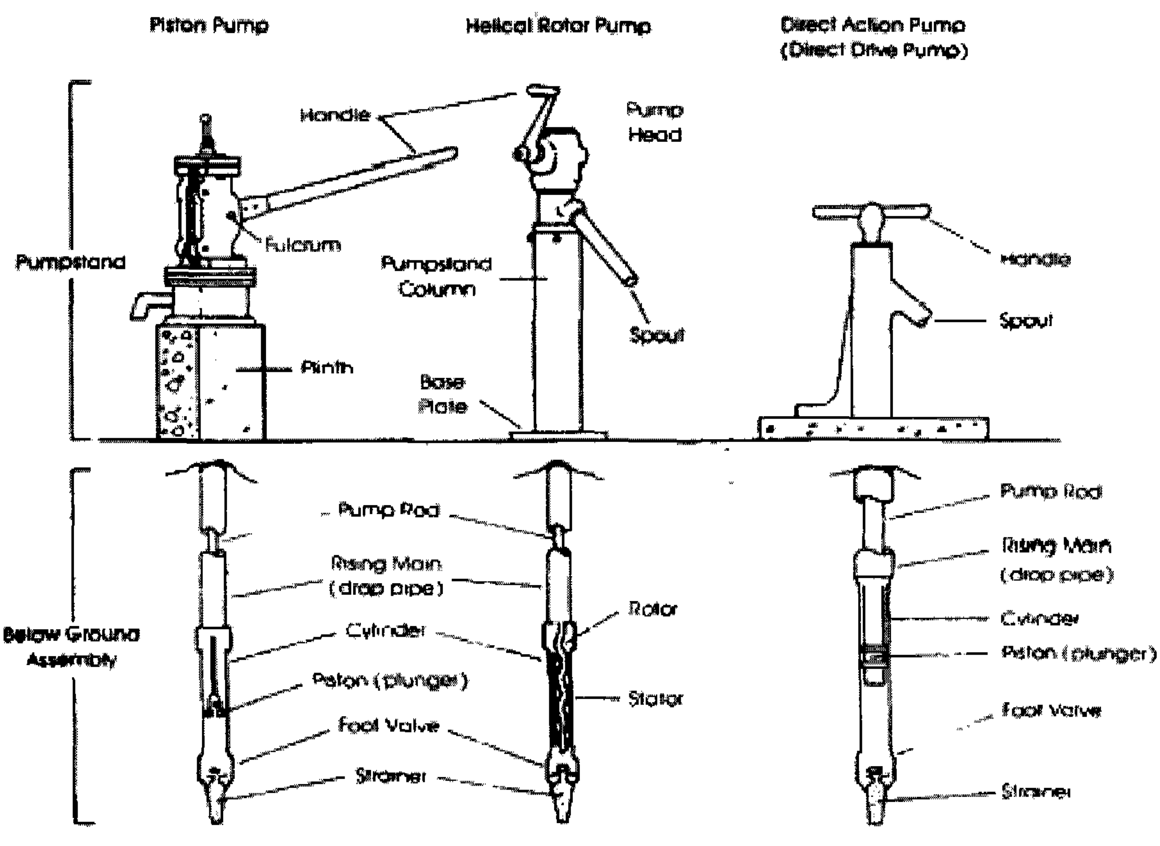


Figure 2.6: Types of deep-well lift pumps - piston, helical rotor and direct action (Source: Fraenkel, 1986)

Handpumps are often classified as shallow, intermediate or deep depending on the depth from which it can lift the water. Table 2.1 summarizes the different types of pump under each category and their operation depth range.

Table 2.1: Depth Range of Different Types of Pumps (Adapted from MTU, 2004)

Classification	Pump Type	Depth Range
Shallow Well Pump	Rower	6 m
	Suction	7 m
	Treadle / Foot pedal	7 – 8 m
Intermediate Depth Pump	Direct action plunger pump	12 m
	Bucket pump	15 m
	Direct action pump	15 m
Deep Well Pump	Diaphragm pump	45 m
	Rope and Disk pump	60 m
	Progressive cavity pump	60 m
	Deep well piston pump	90 m

2.2.3 Selecting a Handpump Technology

The proper selection of a pump will reduce undesirable downtime and will empower the users to manage their water source. The choice of the pump involves investigating the groundwater depth, water characteristics (quality/quantity) and water demand.

Apart from the above mentioned, there are many other criteria, which should be considered before making a selection. Where possible, the pump should be suitable for Village Level Operation and Maintenance (VLOM) or Management of Maintenance (VLOMM). This reduces the reliance of the users upon large institutions to sustain the development of the water supply. A checklist of things to consider when choosing a pump is shown below (Fraenkel, 1986).

a. **Capital cost**

- How much does the handpump cost initially?
- Will a loan be needed, or do the potential users have sufficient funds?

b. **Running cost**

- What is the cost of operating the pump?
- Do the users have sufficient manpower available to operate the pump for all the design period?

c. **Maintenance cost**

- What is the cost of and skill required for the maintenance of the pump?
- Can the pump be repaired by users or somewhere nearby?
- Are spare parts available?
- Can the users afford spares? How often is it likely to need repair?

- How long would it take to repair the pump and what will the users do in the meantime?

Maintenance is an integral part of pump management. For more complicated designs, such as the deep-well pumps, it is important that this maintenance is preventative. Problems should be avoided by regular inspection and servicing of the mechanical parts. Wear and tear will be less severe this way, and any problems will be solved before they cause more damage.

d. Manufacture and materials

- Can the pump be manufactured locally using local skills and materials?

e. Life expectancy

- How long is the pump expected to last before it has to be replaced?
- How resistant is the pump to abuse?

f. Lift height and flow rate

- How much water does the community need?
- The maximum flow capacity of the pump should be matched to the demand from the community.
- How high does the pump have to raise the water?
- How deep is the groundwater and is it likely to fall in future (such as from over-use)?

g. Operators

- Is the pump suitable and acceptable to the people who will actually operate it?
- Are there health and safety considerations, such as dangerous machinery or risk of contamination?
- Is the pump easy to operate by the users (women and children)?

h. Community

- Is there a capable community organisation, which can oversee maintenance and management of the device and the water?
- Will the users be instructed how to use and look after the device?

2.2.4 Handpumps used in Zambia

Harvey and Skinner (2002b) reported that handpumps have been standardised in Zambia and that only India Mark II and Afridev have been selected as the sole handpumps to be used in the country. Some details of these handpumps are presented in the following section.

2.2.4.1 India Mark II Handpump

India Mark II is a deepwell handpump, commonly used in different parts of the world. A sketch of this pump and its cylinder assembly is presented in Figure 2.7 (Source: Shree S K Industries, India).

a. Construction

- Pump Head Assembly (above ground mechanism) consists of three sub assemblies: Conversion head, Water tank and Base.
- Fully fabricated steel construction duly hot dip galvanized. Also available with different mounting arrangements.
- Cylinder assembly Consisting of Cast iron body lined from inside with seamless brass liner of 63.5 mm ID.
- Gun metal valve components and nitrile rubber cup seals capable of giving discharge of 0.4 litres per stroke of 125 mm. Brass / Stainless Steel Cylinder available in 3 different inner diameters of 50 mm, 63.5 mm and 76 mm to suit discharge requirements of 0.2, 0.4 and 0.4 liters per stroke.
- Connecting rod 12 mm dia x 3 meters long mild steel electro-galvanized with hexagonal coupling.
- Riser Pipe (Drop Pipe) 32 mm NB x 3 meters long G.I. medium with socket at one end.

b. Cylinder Assembly

The cylinder assembly consists of a cast iron cylinder body with two caps, and the operating mechanism like plunger yoke body with follower, spacer, upper valve assembly along with the check valve assembly. The upper valve assembly or plunger assembly moves up inside the cylinder. At this point, the lower valve, which is the check valve, will start opening and the upper valve will close, thus allowing the water from the well to flow inside the cylinder. On the return stroke when the handle is moved up, the plunger assembly starts coming down inside the cylinder. The check valve of the bottom will close thereby forcing the water through the follower upwards, opening the upper valve. Thus when the plunger moves up and down in the cylinder, the water is displaced and finds its way to the water tank. The Riser Pipe used is of 32 mm Nominal Bore.

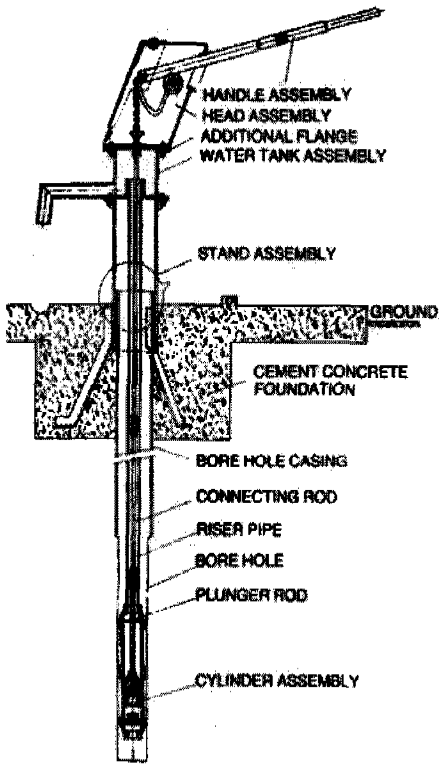
c. Performance Data

- Minimum Bore Size 100 mm.
- Stroke Length 125 mm Cylinder setting depth range 9-45 m.
- Discharge per stroke 0.40 litres.
- Discharge per hour 0.8 m^3.
- Different Cylinder sizes available to suit different discharge requirements

d. Corrosive Water

- Underground sub assemblies are offered in non-corrosive material to handle corrosive water situation.
- Connecting rod of 12 mm diameter x 3 m long with coupling made of stainless steel (AISI 304 grade).

- Brass or stainless steel cylinder assembly
- uPVC riser pipe 48 mm O.D. x 6 mm wall thick x 3 metres long with threaded coupling welded on ends.



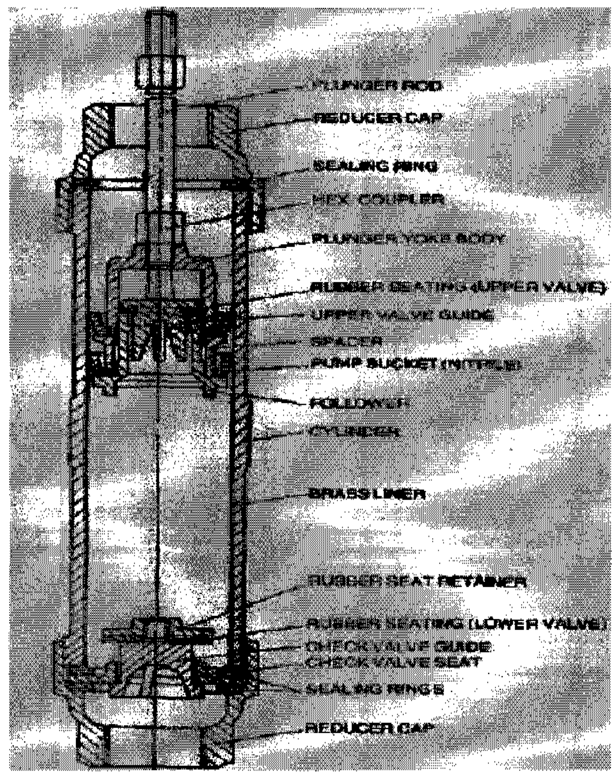


Figure 2.7: Sectional details of India Mark II deep well Handpump (left) and its Cylinder Assembly (right) (Source: Shree S K Industries, India).

2.2.4.2 Afridev Handpump

The Afridev Deep Well Hand Pump has emerged from field trials in Malawi and Kenya and currently its specification is controlled by SKAT, Switzerland. A sketch of this pump and its cylinder assembly is presented in Figure 2.8. The salient features of this pump as given by Shree S K Industries, India are:

a. Construction Features

- Bearing bushes for the pivot assemblies are made from injection moulded special grade plastic.
- Variable handle settings suit changes in static water levels.
- 225 mm stroke length of the handle provides a water discharge of 17 litres per minute per 40 strokes with an installation depth range between 15 m to 45 m below ground level.
- Easy to install, can be accomplished by village women mechanics.

- Cone Plate and rubber Cone for improved attachment of uPVC Riser pipe to pump body.
- Extra long spigot ends in riser pipe to ensure high joint strength, leak proof pipe joints, and verticality of the pipe string. Rubber centralisers on riser pipes prevent external wear.
- Standard cylinder components are comprised of injection moulded interchangeable plunger and foot valve assemblies, made from modern engineering plastics.
- The Afridev Pump's cylinder is also suited to use cast gunmetal monolithic plunger and foot valve assemblies of the Universal Cylinder.
- Quick release eye & hook 'tool-less' ends on connecting rods with rubber centralisers, are standard supply. These facilitate maintenance and protect the riser pipe against internal wear.
- Non-corrosive underground components are capable of handling corrosive water and therefore will last longer.
- Lightweight µPVC riser pipes; easy installation & inexpensive.
- Adjustable handle to suit varying installation depths.
- Two options for pedestal designs are available:
    a. Pedestal for concrete stand.
    b. Pedestal of India Mark II design with either 3 legs mounting or flange mounting arrangement.
- U-Seal, bobbins and 'O' Rings are of Nitrile Rubber and Plunger Rod of Stainless Steel.
- 10 mm diameter x 3 m long mild steel hot-dip galvanized rod / SS with Forged Eye and Hook Connectors welded at both ends. This provides easy Rod Connections without use of any tool.
- Each rod is provided with a Rubber Centraliser to avoid contact with µPVC Riser Pipe.
- Fulcrum & Rod Hanger Pins are supported on special grade Plastic Bush Bearings that are very easy to replace at village level.
- µPVC Cylinder 50 mm ID with Gun Metal Plunger Assembly / Inter changeable Plunger and Foot Valve made with special grade Plastic material.
- uPVC Pipe 63mm OD x 47 mm wall x 3 Meters long with socket-spigot cemented joint.
- Each pipe is provided with a Rubber Centraliser to avoid contact with Casing Pipe.

b. **Application Data**

- Minimum bore size - 100 mm.
- Internal diameter of Cylinder - 50 mm
- Stroke length - 225±3 mm.
- Average discharge per stroke - 17 liters per minute of 40 strokes.
- Operating depth up to 45 m.

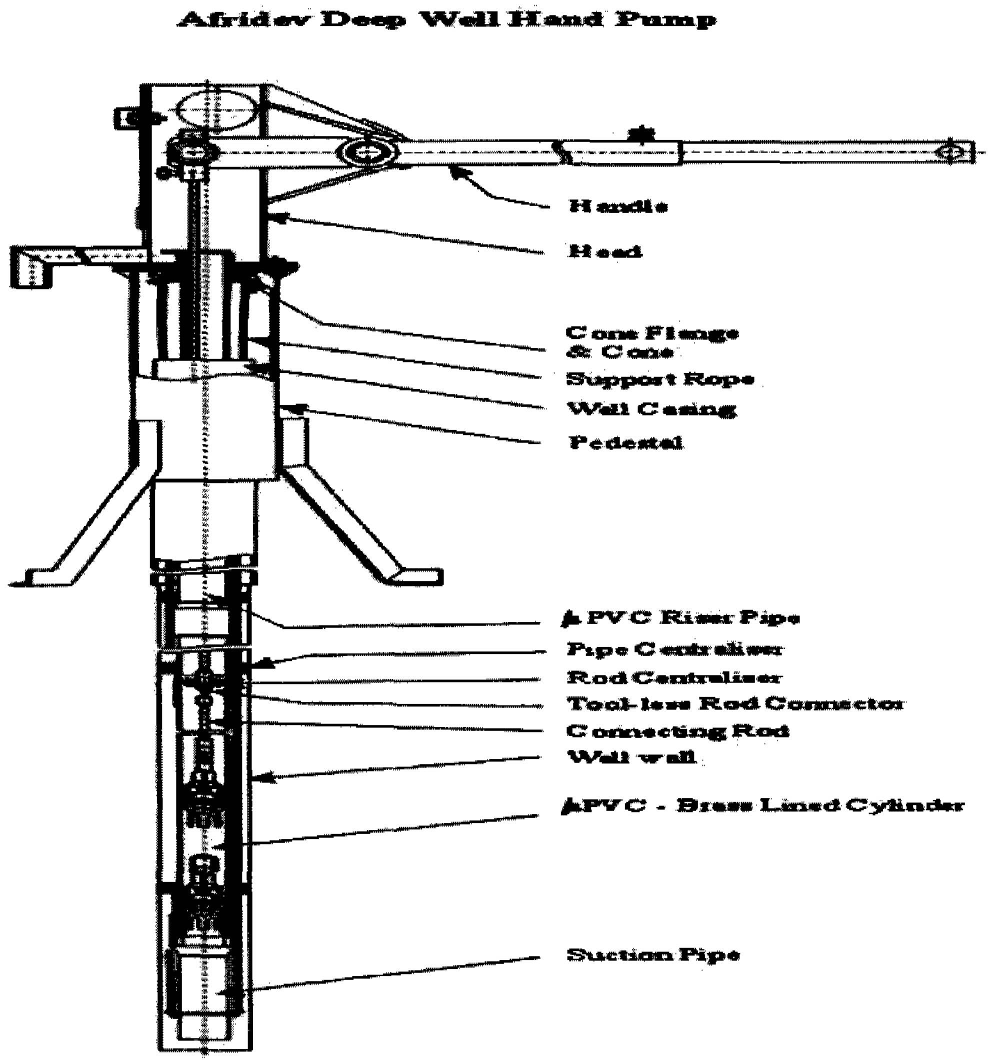


Figure 2.8: Sectional details of Afridev Deepwell pump. (Source: Shree S K Industries, India)

2.2.5 Borehole Drilling and Handpump Installation -Technical Briefs

There are internationally recognised standard technical practices that must be followed in order to successfully implement a sustainable handpump water supply point. These are outlined as follows:

a. Well Siting

When deciding where to drill the well often multiple sites are identified, each having advantages and disadvantages. The Implementing Agency, the User Water Committee, the Drillers, Government Representatives and Hydrogeological Consultants must together decide which site is best for the community.

b. Drilling Wells

Drilling methods using machine-mounted rigs are essentially of two types, the cable tool method (percussion) and one of several rotary methods. Both methods have particular advantages.

The cable tool or percussion method is one of the oldest and still one of the most popular drilling techniques. Drilling is accomplished by the regular lifting and dropping of a string of tools made up of a swivel socket, a set of jars, a drill stem, and a drill bit, total weight being up to several tons. The drill bit, which does the actual drilling, is essentially a chisel. It can weigh a ton or two and is in various shapes for drilling in different rock formations. The drill bit is worked up and down in the hole pulverising the rock until 1-2 metres of loose material fills the hole. The cuttings are removed from the well by a bailer or a sand bucket. To monitor drilling progress the experienced driller holds the drilling cable to 'feel' progress. The feel of the cable, as experienced drillers refer to it, can give information as to the hardness of the rock, whether water has been struck or whether the bit is blunt. Casing is required during drilling in order to prevent caving of the hole (Wurzel, 2001).

In recent past, rotary rigs have become increasingly popular in the drilling sector due to the speed of drilling and the fact that casing is rarely needed during drilling. Drilling is achieved by rotating bits of various types. The power is delivered to the rotating bit by a rotating hollow steel tube or drill pipe. Pre-mixed mud is forced down the drill pipe and out of the bit. The function of the mud is to carry the rock fragments upwards and then deposit them in a settling tank. Drilling mud consists of a suspension of water, bentonite, clay, and various organic additives. The maintenance of the correct mud in terms of weight, viscosity and jellying strength is important to ensure trouble free drilling and requires considerable skill. Generally no casing is required because the hole is filled with the mud slurry and, once drilling stops and the water level goes down, the mud cake keeps the walls intact. Where industry-grade bentonite or polymer is not available, suitable locally available clays can be used (Wurzel, 2001).

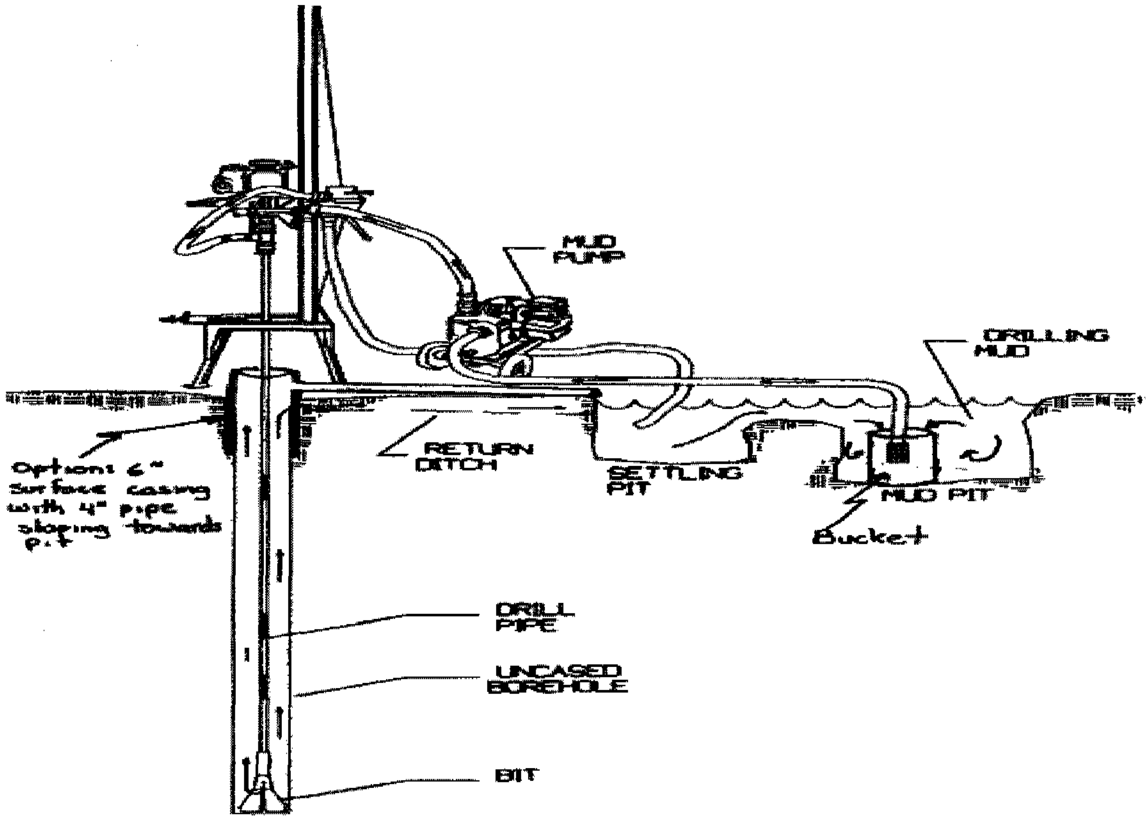


Figure 2.9 : Drill Set-up (Source: Lifewater Canada, 2002)

c. Well Casing and Screen

To keep loose sand and gravel from collapsing into the well, it is necessary to use well casing and screen. The screen supports the borehole walls while allowing water to enter the well; unslotted casing is placed above the screen to keep the rest of the well open and serve as a housing for pumping equipment. The well screen is the most important single factor affecting the efficiency of a well, it is sometimes called the "heart of the well" (Lifewater Canada, 2002). Well screens should have as large a percentage of non-clogging slots as possible, be resistant to corrosion, have sufficient strength to resist collapse, be easily developed and prevent sand pumping.

d. Gravel Filter Pack

A filter pack is coarse sand or fine gravel (2-6 mm diameter) that is placed between the borehole wall and screen. Filter packs are used to settle-out fine-grained particles that may otherwise enter the well and to increase the effective hydraulic diameter of the well. A filter pack is like a wells "lungs" passing water to the "heart of the well". A filter pack should be installed in all wells except those completed in rock, coarse sand or gravel. Ideally, the filter media should consist of silica-based material since it does not dissolve over time; this ensures that the integrity of the filter pack is maintained and that harmful or unpleasant substances are not leached into the water. Filter material should be clean because the filter pack should remove dirt from the water rather than add it. Clean material minimizes filter pack collapse and reduces well development time. All filter material must be treated with 50 mg/L chlorine solution prior to placement to ensure it doesn't contaminate the well. The sand or gravel should be of a uniform size, which is just slightly larger than the size of the slots in the well screen. This is the main factor controlling the possibility of sand pumping. Well-rounded and sorted grains from river or ocean deposits should be used since they will reduce drawdown, increase yield and allow for more effective development. Flake-like grains are unacceptable because they settle to form a filter media with a low permeability (Driscoll, 1986).

The volume of filter material should fill the well annulus to 2 metres above the top of the well screen - this allows for areas of borehole washout to be filled without exposing the upper screen to formation stabilizer or borehole fines. Whenever possible, however, gravel should not be placed within 3-6 m of ground surface. After the filter pack is installed, a cap should be over the casing so that nothing can fall in the well during grouting and cement pad construction (Wurzel, 2001).

e. Sanitary Grout Seal

After the filter pack is placed, there is still an irregularly shaped annular space around the casing. A formation seal (cement grout) is placed into the annular space to prevent the seepage of contaminated surface water down along the outside of the casing into the well. The sealant grout may be cement grout, bentonite or concrete. The formation seal must be effectively placed to prevent contaminated surface run-off from infiltrating into the well. Keeping the concrete mix as dry as possible is important since increasing the amount of water will increase the amount of subsequent shrinkage and increase the chance of contaminants entering the well. Once casing is grouted in-place, bank soil around the well and grade it away from the well (Lifewater Canada, 2002).

f. Well Development

The well screen is the "heart of a well" and the filter pack acts as the "lungs" passing water to the screen. However, after drilling a borehole and installing a casing and filter pack, it is necessary to get the "heart pumping" and the "lungs breathing" since the drilling fluid forms a thin layer of mud on the sand grains of the borehole wall and is forced into the pore spaces and cracks in the aquifer. This plugging effect decreases the flow of water into the well.

The act of cleaning out the clay and silt introduced during the drilling process as well as the finer part of the aquifer directly around the well screen prior to putting the well into service is called "well development". Effective well development:

- Increases the rate of water movement from the aquifer into the well;
- Stabilizes the aquifer to prevent sand pumping, thereby producing better quality water and increasing the service life of the pump cylinder and well
- Removes organic and inorganic material, which may inhibit effective well disinfection.

By ensuring that wells are developed to the best possible technical standards, the high borehole capacity will be maintained through its life period (Lifewater Canada, 2002).

g. Testing Well Yield

Well yield is the volume of water that can be pumped during a specific period of time (it is expressed as litres per minute). Sometimes the yield of existing wells will be tested to determine if it is worthwhile to drill in the same area. Water level in the well should be measured before and after pumping. Pumping should be at a steady rate for as long as possible (1-4 hours if new wells will be heavily used). This pumping rate is sustainable if the water level returns to pre-pumping levels within 6-12 hours. The shorter the time, the better the aquifer. If the yield of a newly drilled well is questionable, it is often suggested to test it to determine whether or not it is worthwhile to pour a concrete pad and install a handpump. In general, a well which is capable of reliably supporting a heavily used pump should be able to yield at least 0.2 litres per second (Driscoll, 1986).

If the yield of a well is inadequate to support a handpump, the well should be abandoned by removing as much casing as possible and filling the well with clay or silty sand and filling the top 2 meters with concrete. If this is not done, future well supplies may be jeopardized since the well may allow contaminants to pass into the groundwater (Driscoll, 1986).

h. Handpump Pad Construction

The purpose of a handpump cement pad is to prevent contaminated surface water from entering the well and to prevent the area around the well from becoming muddy and unsanitary over time. The size and shape of the pad may be decided with freedom, although it should be at least 2 meters radius and 10 cm thick all around the well. If the pad is to be this small, a concrete rectangle must be added on the side of the pump handle so that the person pumping will have firm footing. The pad should be linked to a drainage channel that may lead to a garden where appropriate (Driscoll, 1986).

j. Well Disinfection

After constructing or repairing a well or pump, the entire well and pumping system must be disinfected in order to kill harmful microorganisms that may be on the well casing, gravel, soil, rising main, pumping rod or in the water from the digging operation.

k. Water Quality Testing

After a new water well is completed or when the quality of a water supply is suspect (because of turbid water, unusual colour, taste or smell), water samples should be collected and analysed chemically and bacterially. Water quality is defined by analysing it in terms of its:

- **Chemical Content**: Hardness (calcium + magnesium), Metals (iron etc), nutrients (nitrogen and phosphorus), chloride, sodium, organic compounds, etc.
- **Physical Content**: Turbidity, colour, odour, etc.
- **Biological Content**: Faecal coliform, total coliform, viruses, etc .

Good quality drinking water is free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, is aesthetically appealing and is free from objectionable colour or odour. It should be emphasized that there is a difference between pure water and safe drinking water. Pure water, often defined as water containing no minerals or chemicals, does not exist naturally in the environment. Safe drinking water, on the other hand, may retain naturally occurring minerals and chemicals such as calcium, potassium, sodium or fluoride which are actually beneficial to human health. These will impart a taste to the water that may take some time getting used to. It is only when the proper authority has pronounced the water safe to drink that it may be used by people (Lifewater Canada, 2002).

l. Well Construction Report

A Water Well Record should be prepared for each well that is drilled. The record is used to guide future drilling, to ensure that the well screen extends across the appropriate thickness of the aquifer and that the well casing/screen has been lowered to the bottom of the hole. It is also useful if there is ever a need to conduct repairs on the well in the future. Well records document details of drilling a borehole and completing a well. Well records should include the driller's description of:

- The geologic character of each formation;
- The depth at which changes were observed;
- The thickness of the various formations;
- The drilling speed;
- The depth to water or where water appears to have been reached;
- The depth at which drilling was stopped.

Observations made by the driller should be included in the well records because the drilling action and penetration rate indicate the character of the formation and especially the depth at which a formation change is encountered (Driscoll, 1986).

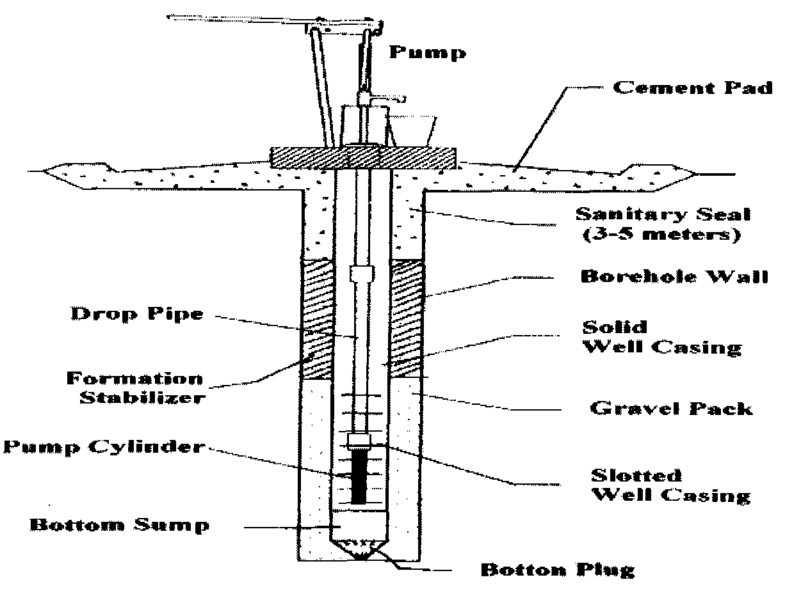


Figure 2.10: Completed Well with Handpump Sketch Details (Source: Lifewater Canada, 2002).

m. Handpump Maintenance

Once the handpump well has been put in operation, it must be kept in good working condition. The well and surroundings should be regularly inspected to ensure that (Lifewater Canada, 2002):

- The well is fully accessible to all users and is fenced off to prevent animal access.
- The sanitary well cap is securely in place and watertight.
- No openings have developed in the well casing due to subsidence or damage that could allow surface water to enter the well.
- The annular space around the well casing and the cement pad are not cracked allowing surface water to seep into the well.
- The ground surface is sloped so that surface-water drainage in the vicinity of the well is directed away from the well and does not collect or pond in the vicinity of the well.
- Debris is not floating on the surface of the well water.
- The area around the well is being kept free of potential sources of pollution such as animal and human waste, garbage, fuel or chemical storage facilities, road runoff etc., and that no activities are taking place near the well that could contaminate the well and the aquifer. The benefits of clean water must not be reduced by poor hygienic practices!
- The well yield is still adequate and has not declined significantly over time.
- The pump is still drawing effectively (depending on use and specification from the manufacturer some parts may need to be changed every after a period of 6 months to a year). The pump cylinder may need to be replaced every 5-10 years).
- Ensure that the well is chlorinated each time the well is opened and the rising main pipe is removed.
- That all screws and connecting bolts on the pump are tight.
- That the wooden bearings and steel on steel contact points are lubricated and, if worn, replaced.
- That any broken or worn parts or supports are promptly re-fastened or replaced.
- Ensure that people are not mixing or using pesticides, fertilizers, herbicides, degreasers, fuels, or other pollutants near the well.
- Make sure that nearby unused wells are properly abandoned are not filled with garbage or organic matter.
- Test the well once a year for coliform, bacteria, nitrates and any other constituents of concern.
- Disinfect drinking water wells at least once per year with bleach or hypochlorite granules.

- Keep accurate records of all maintenance work & chlorination.

For a sustainable handpump water supply, these ongoing monitoring activities must be performed by users and appropriate actions initiated to correct any detected potential problems the pump breaks down or water becomes contaminated.

2.2.6 Sustainability Issues with Handpumps Water Supplies

Handpump water supply is sustainable if the system is functioning continuously, satisfactorily, and is being used effectively by the community. The ability of a community to keep a handpump water point operational over a long period of time is a complex mix of national policy, institutional/managerial, technical/environmental, financial, and social issues. Each of these elements is often dynamic, inter-linked and inter-dependent (Sugden, 2003, Carter et al., 1996). Furthermore, the sustainability of community water supply and sanitation involves a chain of four essential links, the failure of any one of which endangers the entire enterprise (see Figure 2.11).

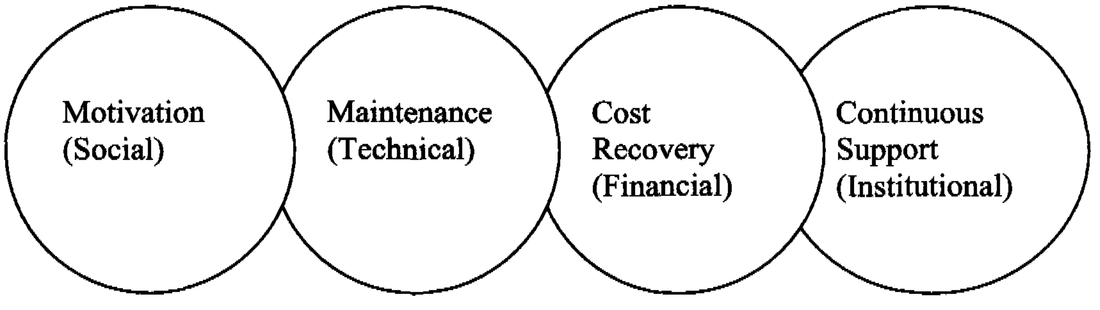


Figure 2.11: Sustainability chain for community water supply and sanitation. (Adapted from Carter et al., 1999)

The following issues are common to handpumps projects sustainability particularly in Africa:

2.2.6.1 National Policy Issues

National policies and strategies need to be developed in a way which recognises the service-based nature of water supply and the need for government to play a crucial role, especially in providing support, co-ordination and regulation. Institutional frameworks and models for service delivery must be developed and government should be free from external pressure to select the most appropriate options for service delivery (Harvey and Reed, 2004).

2.2.6.2 Institutional Issues

Harvey and Reed (2004) state that there are many different institutional issues that influence rural water supply sustainability. In order to determine the most appropriate management options and partnership approaches the relative strengths and weaknesses of potential stakeholders need to be assessed, especially with respect to long-term sustainability of the institutions themselves. The traditional approach to rural water supply in Africa has been that of a project with a finite life span. This is convenient for external donors and implementing NGOs but conflicts with the very principle of sustainability. A water supply is a service, and any service requires ongoing management. The focus on the facility or static infrastructure (which it is hoped that the users will keep going somehow) detracts from the importance of managing and maintaining a water service, which is a dynamic process. Some donors however, have now recognized the limitations of the project model and are moving towards a programmatic approach, such as that promoted by the Sector-Wide Approach to planning (SWAp) where central government is the administrator. There remains a need to develop long-term strategies which recognize the importance of ongoing support, whether this be fulfilled by government, the private sector or NGOs. No longer is it acceptable for an implementing agency to install water supply facilities which are simply 'handed over' to the users, and then to leave, washing its hands of them. Unfortunately, however, this still happens far too often. Whether through central budget support or regional programmes it is important that donors, governments and implementers subscribe to the concept of rural water supply services. This does not mean that these services cannot be financed by the end-users but does recognize the importance of institutional management, monitoring and regulation.

2.2.6.3 Financial Issues

Sustainable financing mechanisms need to consider O&M and longer-term rehabilitation needs. This is essential if systems are to remain operational indefinitely. Implementers should strive to instill in users a sense of the need to pay for a water service. The emphasis must be shifted from paying for maintenance of a facility to paying for the provision of safe, adequate and accessible water. This concept of paying for water may be difficult to instill in water users in poor rural communities, but has the potential to remove many barriers to sustainable community financing (Harvey and Reed, 2004).

2.2.6.4 Technical and Environmental Issues

a. Technology choice

It is more important that handpumps be easy to maintain than durable but hard to maintain. Designs should be adaptable to suit local conditions and local solutions to maintenance problems. Handpumps should not be viewed as the only option for rural water supply. Alternative technology choices must be investigated and the possible upgrading of traditional water supplies considered. Donor agencies should be more receptive to the adaptation of existing technologies, and to the development of both new deep-well handpumps and alternative pumping technologies for shallow sources of groundwater.

b. Standardisation

Standardisation has many positive and negative effects. Handpump standards should become more flexible to encourage local manufacturing and adaptation. Standardisation coupled with a rigid procurement system can cause problems, especially if there is a great deal of mistrust of the private sector; standardisation to improve pump quality is fine but this should not stifle innovation. The design of public domain pumps needs to be seriously reviewed with much more focus on local capacity and designs which can be improvised locally

c. Maintenance

Sustainable handpumps should be of a type whereby local mechanics can use locally available (or improvisable) tools and parts to repair them. Alternatively, providing low quality equipment will increase the turnover of spare parts and may contribute to sustainability by enhancing local spare parts markets and improving the skills and status of pump caretakers. In the past the focus of handpump development has been on producing durable pumps, rather than 'reliable' pumps which may break down frequently but which can be fixed easily by users. Durable pumps, which do not breakdown for many years, are likely to lead to rehabilitation projects for years to come (Wood, 1994).

d. Spare Parts

Spare parts distribution has also been a problem, especially in areas of low population (and hence few pumps) density. Unless there is a critical mass of pumps in a district, the market for spares is so small that no commercial operator is likely to have an incentive to import and stock them. This again leads to dependency on government or, more commonly, on donors (Colin, 1999).

e. Local Manufacture

The advantage of locally manufactured pumps is that there is a direct relationship between the buyer/installer and the manufacturer. This should lead to greater accountability on the behalf of the manufacturer, proper guarantees, good after-sales service and direct feedback from implementers. However, cost may be restrictive since locally manufactured pumps may prove more expensive than those imported

f. Installation Costs

The cost of well construction has remained several times more expensive than the handpump. This casts doubt on handpumps is an affordable technology. Published data indicate that whereas drilling costs in India are typically in the region of $1,000 per well, in many African countries the figure is over $10,000 (Colin, 1999).

g. Installation Quality

The installation of good pumps on bad wells or boreholes has been a problem in many places, resulting in early failure of the pump due to problems such as sand caving and silting. Quality control of both community construction and private contractors is essential but often logistically problematic, and is not always achieved (Colin, 1999). Handpump installations, which allow easy monitoring of groundwater levels, should be encouraged.

2.2.6.5 Social Issues

Harvey et al. (2002a) at the E-Conference Synthesis on Sustainable Handpumps in Africa reports the conference findings, outlining some of the reasons for an unwillingness to support handpumps among the user community as follows:

- The users were never involved in the choice of the pump.
- The user does not feel that the pump is theirs or that they should contribute towards maintenance.
- The level of service is not considered to be desirable.
- The quality of water from existing sources is preferred.
- Access to the pump is restricted.
- The location of the pump excludes some users.
- It's too time-consuming to collect water.
- There is a taboo relating to using groundwater.
- It is considered hard or dangerous to operate the pump.

- The pumping action is embarrassing for some women.
- The community may have weak leadership.
- Participation of women in managing handpumps is not welcome.
- People have too little free time to take on management roles.
- People do not trust those who collect the money.

2.2.7 International Experience with Sustainability of Handpumps

The introduction of VLOM should have brought a new epoch of sustainability in handpump water supply schemes. According to Colin (1999) this did not happen and by the early 1990s pumps had fallen into disrepair throughout the developing world. Handpumps, including some VLOM designs, despite their many advantages were not living up to earlier expectations. The problem was lack of ability of both governments and user communities to maintain them; this was especially true in Africa. Affordability of both capital and repair costs was also cited as a problem (Wood, 1994). Even where communities did attempt to take care of their pumps, this largely involved carrying out repairs after a breakdown; preventive maintenance was hardly ever undertaken.

The VLOM approach relies on simple technology, the maintenance of which can be managed by the end-users. Water committees are usually set-up and include handpump caretakers; and training on handpump maintenance and management of water systems and finances is undertaken. Whilst accepting that the VLOM concept is not viable in all situations, it has initiated social change and has an empowering effect on rural communities and especially women. Harvey et al. (2002a) at the E-Conference Synthesis on Sustainable Handpumps in Africa reports that VLOM approach has been successful in Uganda where it has been used since 1984 and functionality had risen from 25% to 76% after a survey. Other successful VLOM case studies include the SIDA project in the Coastal district of Kenya; FINNIDA project in Western Kenya; the Dutch project in the Lake region of Kenya (Harvey et al., 2003a); and UNICEF projects in India (Kolsky et al., 2000).

The following handpump types have been developed and standardised in many developing countries:

Suction Pumps - for Shallow Wells (Erpf, 2002),
- No.6 Handpump, India

Direct Action Pumps - for Shallow and Medium Wells (Erpf, 2002)
- Malda Pump, Malawi
- Maya-Yaku Pump, Bolivia
- Tara Pump, India

Rotary Pumps - for Shallow, Medium and Deep Wells (Erpf, 2002)
- Rope Pump, Madagascar
- Rope Pump, Nicaragua

Lever operated Pumps - for Medium and Deep Wells (Erpf, 2002)
- Jibon Pump, Bangladesh
- Walimi Pump, Tanzania
- India Mark II Pump
- India Mark III Pump

- U3M Pump, Uganda
- Afridev Handpump
- Bush Pump, Zimbabwe

Lever operated Pumps - for Extra Deep Wells (Erpf, 2002)

- India Mark II Extra Deep Well
- Afridev Deep Well Pump with Bottom Support

Based on the experiences gained in the development of different types of handpumps in different countries (as listed above) and O&M of these pumps, the following has been identified as the key issues to a sustainable handpump water supply programme are:

- Good facilitation and support services from government and donor agencies.
- Community involvement in decision making at all stages.
- Cost sharing (full cost recovery for operation and maintenance and a contribution to capital cost in cash or in kind).
- Adoption of VLOM designs (robust pump design with minimum number of spare parts which needs to be replaced).
- Local manufacture.
- National standardisation.
- Easy availability of spares (locally).
- Water quality measurement (to avoid future water quality problems and abandonment of wells).

2.3 Sustainability of Handpumps in Zambia

2.3.1 Account of Handpumps Water Supplies in Zambia

The Zambia handpump history in drinking water supply can be divided in three periods, namely before 1992, the drought years of 1992-95, and post 1995. By 1998, 24,020 water points had been sunk in the rural areas. The annual rate of drilling was 200 – 300 boreholes with an average of around 10 per district. Prior to 1996, there was no borehole standard design. There was no borehole inventory and thus no groundwater data, no guidelines, no central policy, nor basic sector principles. All boreholes were sunk to 60 meters depth irrespective of water first struck and the yield. In hard rock areas boreholes were sunk without casing except for upper few metres and most of these collapsed due to caving. The situation was compounded by the drought period when an expanded borehole drilling programme was initiated with minimum guidelines. Supervision was weak and with some of the work reported complete, had in fact not been done.

In the early 1990's the Zambian Government adopted a handpump standardisation policy. The India Mark II pump was selected as the sole standardised handpump to be used in the country.

Some External Support Agencies (ESAs) have promoted and lobbied for the use of the Afridev pump. Recently, the Department of Water Affairs (DWA) has agreed to installation of Afridev pumps in some areas of the country.

2.3.2 Institutional Arrangement

a. National Government

As part of the water sector reforms, water supply responsibilities have been transferred between Government ministries. The institutional framework adopted by the Government in 1994 stated that the operational functions of the water supply and sanitation, which were previously carried out by the Department of Water Affairs (DWA) should be transferred to the Local Authorities under the supervision of the Department of Infrastructure Support Services (DISS) of the Ministry of Local Government and Housing (MLGH).

DWA remains responsible for water resource development and drilling of boreholes and installation of handpumps, but no longer responsible for operation and maintenance of handpumps. As a result of these shifts in responsibility some uncertainty and confusion has arisen, particularly among collaborating non-governmental partners some of whom still liaise with DWA only.

In addition, other Government ministries are involved in different aspects of rural and semi-urban water supply. Other relevant ministries and their respective responsibilities are: Ministry of Health (MOH) -*Promoting good sanitation and health hygiene practices;* Ministry of Community Development and Social Services (MCDSS) - *Facilitation of better community management;* Ministry of Education (MOE) - *Introduction of WASHE into schools;* Ministry of Agriculture (MOA) – *Irrigation.*

b. District Councils

District Councils are the centres of decentralised government activities for the provision of services within districts. Each council has a District WASHE (D-WASHE) Committee, which is responsible for overseeing the implementation and monitoring of WASHE projects and activities. The D-WASHE is an intersectoral committee, which normally consists of representatives of the District Council, DWA, MOH, MOE, MOA, MCDSS and Non-Governmental Organisations (NGOs) involved in water, sanitation and hygiene education in the district. Some districts have also established sub-district WASHE committees but these are not commonplace at present.

c. The World Bank

The World Bank has provided substantial funding for the Zambia water sector restructuring process and the government view World Bank as part of the water sector reforms.

d. Other external support agencies (ESAs)

There are several multi-lateral and bi-lateral ESAs involved in the water sector in Zambia. These include the United Nations Children's Fund (UNICEF), German Technical Co-operation (GTZ) and the Japanese International Co-operation Agency (JICA). UNICEF has been instrumental in increasing handpump provision and in developing and supporting the WASHE programme nationwide. It is also still actively involved in the supply of spare parts. JICA and GTZ have supported and are currently supporting large-scale drilling and handpump installation programmes in several provinces of Zambia.

e. Non-governmental organisations

There are several International NGOs involved in rural and semi-urban water supply activities in Zambia, including WaterAid, Care International, Irish Aid, Africare, World Vision International and Development Aid from People to People (DAPP). These NGOs work in close collaboration with D-WASHE and have representatives on relevant WASHE committees. The objective is that implementation and operation and maintenance procedures should be as uniform as possible for all partners involved in a District.

f. Community based organisations

Many communities form V-WASHE committees, which are responsible for managing operation and maintenance of community-owned handpumps. Such committees, which can have up to ten members, are normally elected by community members and are responsible for collection and storage of maintenance funds, monitoring of pump performance, routine preventive maintenance and organisation of repairs and replacements. These community-based organisations (CBOs) are often given training in management and maintenance procedures by the implementing agency, and sometimes by the District. Communities are encouraged to ensure that women are sufficiently well represented on V-WASHE committees (Harvey and Skinner, 2002b).

g. The private sector

It is the Zambian government policy that the private sector has a key role to play in water supply projects. There are several private companies in Zambia, which are involved in borehole drilling and handpump installation, and as a result there is significant competition to win contracts. In addition, there are also several companies involved in importing handpumps and spare parts into the country. These include AFE Ltd., Aquagro Ltd. and SARO Ltd., all of which are based in Lusaka (the Capital City) and import pumps and spares from India. These companies are also involved in drilling and installation. Aquagro manufacturers some spare parts, such as rods and pipes, in country and offers free training to pump menders. Private individuals work as Area Pump Menders (APMs) in some areas. Each APM is selected by the community and trained by D-WASHE in pump maintenance and repair. He or she is provided with a standard India Mark II toolkit, and is responsible for a zone in which they live and in which several pumps are located. Fishing tools for fishing out dropped pipes are kept at District Council stores and are available for use by APMs. Training of APMs usually consists of a seven day training course at the district centre and sometimes in villages. There is a need for refresher training in some districts. Pump menders charge communities for each pump repair carried out. APMs are also used for installation of handpumps and an increasing number of APMs have been trained (over a further seven days) to carry out the role of Area Community Organisers (ACOs) also. ACOs are responsible for mobilising communities, mainly on a voluntary basis, and promote the use of appropriate WASHE facilities and activities (Harvey and Skinner, 2002b).

2.3.3 Groundwater Resource Management

The National Water Policy recognises that water is an important input for all development activities and so it is necessary to develop, utilise and economically manage it on an integrated basis so as to meet its ever-growing demand. In this regard the government has embarked on Water Resources Action Programme (WRAP) which aims to establish a comprehensive framework for effective development and management of the nation's water resources. It is therefore clear that Zambia does not have, at present, a hydrogeological database nor does she have any monitoring policy of her groundwater resource.

2.3.4 Handpump Technology Development in Zambia

Although handpump technology is no longer considered to be the key determining factor in sustainability in other parts of sub-Saharan Africa, in Zambia local manufacture of handpumps is still an elusive concept. All handpumps and the spare parts inclusive are still imported. The few handpump spares that are manufactured by local companies are often more expensive than the imported ones.

2.3.5 Projects Planning and Implementation Process

Previously, handpump water supply projects were very much donor-driven and supply-led. Beneficiaries had little or no involvement in prioritising their own needs, selecting appropriate solutions or planning and managing their own facilities. Various NGOs and government institutions have often installed handpumps with minimal consultation with the beneficiary or with other donors and institutions. Consequently, implementation approaches have varied greatly and a wide variety of different handpumps have been installed nationwide. Harvey and Skinner (2002b) report that UNICEF has in the recent past worked with the Government to create an inventory of water points in Zambia, although there seems to be some gaps in the data. The WASHE strategy is at the centre of the current national handpump water supply. The WASHE model is based on devolving responsibility and authority to district level government. However, the model is still in its transitional stage and many district councils lack technical staff.

In the context of handpump project planning and implementation Arlosoroff et al. (1987) states six factors contributing to the sustainability of any handpump project namely: the community, the aquifer, the well, the maintenance system, the pump and the finance. From Harvey and Skinner's (2002b) fieldwork report, it appears that sustainability factors relating to the environment (aquifer), technology (handpump and maintenance system) have not been appropriately addressed by handpump projects in Zambia. Needless to say in the absence of environmental information regarding to groundwater occurrence disposition drilling for handpumps becomes an extremely expensive venture making the project unaffordable. Handpump technology adaptation on the other hand requires a strong investment in engineering research and development. In the past thirty years or so that handpumps have been in the Zambia, not a single handpump has been manufactured locally although, there has been some insignificant attempts to make some spares.

2.3.6 Community Participation

The WASHE model is reported to place much emphasis on the role of the beneficiaries in sustainability of handpump water supply projects. The model is characterized by the following key elements: Demand responsive approach in which a project is initiated at the request of the community; Technology choice made by community; Community contribution to capital cost of installation; Community collection and management of maintenance funds; Community level maintenance and local technical backup.

2.3.7 Project Financing

a. Costs

The average cost of drilling a borehole to be equipped with a handpump in Zambia is about US$ 3,000, making this by far the most costly part of a handpump project and way beyond the means of most users. Additional 'hidden' costs that should be added to the cost of boreholes include the cost of feasibility studies, community mobilisation and training. The cost of the pump itself ranges between US$ 300 and US$ 1000 depending on specifications, whilst the prices of spare parts range between a few cents and about $100. Pump menders charge for their services and these fees often vary despite attempts by N-WASHE to standardise (Harvey and Skinner, 2002b).

b. Donor support

One important sustainability issue is that the Zambia water supply sector is heavily dependent on donor support from the international community. Harvey and Skinner (2002b) report that between 95% and 100% of implementation costs for handpump projects are met by donors.

c. Government Support

Harvey and Skinner (2002b) report that the PRSP allocates US$ 10 million to MEWD and MLGH to implement a new RWSS programme targeting half a million people, and a further US$ 3.5 million to MEWD and NWASCO to implement a complementary D-WASHE support programme.

d. Community financing

The current government policy requires a community contribution to the capital cost of implementation (drilling and installation) which is known as a 'commitment fee', and is usually of the order of 150,000 Kwacha (about US$ 30). In addition, communities are expected to contribute local materials (sand and gravel) and labour for pad and drainage construction. Communities are also expected to meet all on-going maintenance and repair costs. In some cases communities charge a monthly household contribution, typically of 500 Kwacha (10 US$ cents). More commonly the V-WASHE committee raises money only when repair is necessary (Harvey and Skinner, 2002b).

2.3.8 Handpump Maintenance and Linkages

a. Maintenance System

There are two maintenance systems adopted in different regions of Zambia namely: Decentralised and Centralised. In the decentralised maintenance system, each V-WASHE committee includes a pump caretaker who is trained in preventive maintenance only and any major faults are reported to the local Area Pump Mender (APM) who diagnoses the fault and carries out repairs. A cash or in-kind charge is made for this service. Spare parts are, in general, purchased by community members from the local D-WASHE outlet. Major repairs such as borehole rehabilitation are carried out by private sector maintenance units supported by D-WASHE or ESAs. APMs are also sometimes responsible for handpump installation, although evidence of poor installation of some pumps suggests that refresher training may be required in some areas. In the centralised maintenance system, communities are expected to call on district pump repairers in the event of breakdown. A call-out fee is charged for this service and communities are expected to meet the cost of spare parts and some staff upkeep allowances. In both systems there is an Environmental Health Technician who is responsible for pump performance (Harvey and Skinner, 2002b).

b. Spare parts chain

The current spare parts supply network is heavily dependent on UNICEF and relies on the existence of active D-WASHE committees. Most spare parts are stored at district warehouses or stores managed by D-WASHE where communities can purchase spares at subsidised prices. The management of spares at district-level varies greatly and some spares may deteriorate due to inappropriate storage. Certain spare parts, in particular pipes and rods, are not available at some district centres. Some spare parts are also available at private hardware stores and commercial enterprises in some districts, but these are sold at market prices except where UNICEF is providing and subsidising private sector sales through D-WASHE committees.

c. Cost of spares

The cost of spares to the handpump users is between 15% and 30% of the market price, when purchased from D-WASHE outlets. This is due to subsidisation by UNICEF. In order to buy spares at subsidised prices authorisation is required from the District Council Executive. Subsidisation only applies to spares for community-managed handpumps. Private individuals and organisations can buy spares from D-WASHE but have to pay the full market price. Storekeepers at the district headquarters are responsible for keeping records.

2.4 Evaluation Methods

There is no general agreement about the instruments, methodologies or definitions that should be used for data collection at global, national or local level and no unified and harmonised system has been established. Various data collection methods are available for field data surveys. Data collection methods can be used as one or in combination. Some of the common methods applied are:

2.4.1 Structured Interview Method

A Structured Interview is an interview that uses a Data Collection Instrument (DCI) (or simply a questionnaire) to gather data, either by telephone or face to face. It is one in which evaluators ask the same questions to numerous individuals or individuals representing numerous organizations in a precise manner, offering each interviewee the same set of possible responses. A DCI is a document containing questions presented in a systematic, highly precise fashion. Its purpose is to enable the evaluator to obtain uniform data that can be compared, summed, and, if it is quantitative, subjected to additional statistical analysis. DCI are used on assignments that require the same or uniform information on numerous cases. In contrast, an unstructured interview contains many open-ended questions, which are not asked in a structured, precise manner. Different evaluators interpret questions and often offer different explanations when respondents ask for clarification.

2.4.2 Field Checklists

This is a semi-structured kind of data collection instrument. They are a set of itemised notes, statements or questions that are used when holding interviews, meetings or discussions with different stakeholders. It is important that notes are taken on the issues discussed, and that all of the key areas on the checklists are covered (Parry-Jones et al., 2001b)

2.4.3 Participatory Methods

The fieldwork should be supplemented with some basis participatory tools to ensure that valid and useful data are obtained from community members. The following tools are used in conjunction with the sustainability snapshot, checklists and the community handpump data (Parry-Jones et al., 2001b):

- **Transect walk**: This is simply an informal walk through the village to identify key features, and to visit and inspect all the handpumps and other sources that the villagers are using. The evaluation team should be accompanied by local residents so that questions can be asked and issues clarified as they arise. Much of the data for the handpump summary sheet will be obtained during the transect walk.
- **Village Map:** A group of residents is asked to map out their village on a large scale, using pen and paper or local material as available (it is often done on the ground with stones, sticks, leaves etc). It can act as a good ice-breaker when starting to work with the village, but it also provides important information on the relative location of different sources, zonal uses of village, location of chief's house, institutions etc.
- **Venn diagram**: This is a visual tool for mapping the inter-relations of different formal and informal institutions and power structures in the community. It helps to clarify where the responsibility lies for management of handpump and other sources. Using pen and paper, different circles are drawn to represent institutions and individuals with decision-making powers. Where the circles are separate there is no contact between them and where they touch, information passes between them. If the circles are drawn overlapping this indicates that there is some cooperation in decision-making. The degree of overlap represents the amount of interaction of cooperation between groups. For example, if a community water committee could not take any decision without first getting approval or agreement from a community development committee, then the water committee circle would be drawn inside the community development committee circle.
- **Focus discussion group:** A small group (maximum 15) of representatives from the community is asked to attend a closed meeting to discuss certain issues. In the fieldwork associated with handpump evaluation it would be useful to get a representative cross-section of handpump users and managers to attend a focus group discussion to carry out the sustainability snapshot exercise. The facilitation of this type of group is important since it needs to be well-managed and controlled without directing or manipulating the responses from the group.

3 Research Methodology

The evaluation of handpump water supply in selected rural and semi-urban areas of Zambia is based on desk study of relevant literature and field assessment of performance of handpump water supply systems in the country and factors affecting sustainability. This chapter presents the details of the research methodology used in this evaluation study which included desk study, field data collection (interviews and site visits) and data analysis.

3.1 Desk Study

Desk study included review of documentation on the Zambia water supply sector policy and strategy, international experiences with handpump technology in water supply including factors affecting sustainability, review of available literature on Zambian experience with handpump technology in water supply and finally a review of literature on evaluation methods as well as preparation of study instruments.

3.1.1 Preparation of Data Collection Instruments

Based on the literature review, handpump water supply systems performance and sustainability evaluation factors and criteria were developed. The evaluation of performance and sustainability were based on five main factors namely:

i. Financial Sustainability

ii. Technical Sustainability

iii. Institutional Sustainability

iv. Social Sustainability

v. Environmental Sustainability

The factors affecting sustainability and their evaluation criteria are presented in Table 3.1. During the evaluation each criteria was assessed with a set of questions.

Table 3.1: Evaluation factors and criteria (Adapted from Parry-Jones, 2001a).

Factor	**Evaluation Criteria**
Financial	Capital Contribution
	Maintenance Funds
	Community Training
	R&D financing
Technical	Technical Skills
	Availability of Equipment and Spares
	Preventive Maintenance
	Major Repairs
	Reliability of Spares Supply
	Community Training
	R&D support
	Standardisation
Institutional	Ownership
	Pump Management System/ Communication
	Project Monitoring
	Private Sector Participation
Social	Hygiene Awareness
	Community Participation
	Access/Exclusion
	User Satisfaction
	Impact
Environmental	Source Reliability
	Water Quality
	Competition from alternative sources
	Water Use

During the desk study stakeholders/informants were also identified according to their categories and information required as presented in Table 3.2.

Table 3.2 : Stakeholders in handpump water supply.

Category	Stakeholder/Informant	Information Required
National Policy Level Agencies	Government Stakeholder Ministries and Departments	-Policy Development and Strategy -Financing Policy -Technical Policy -Institutional Arrangements -Community Development Policy -Environmental Policy
Implementing Agencies	External Support Agencies /NGOs	-Financial support -Technical Support -Institutional support -Community development support -Environmental support
	District Councils / Department of Water Affairs	-Financial support -Technical support -Institutional support -Community development support -Environmental support
Community	Users/CBO/Caretaker/ Area Pump Menders	-Participation -Financial Contribution -Technical skills -O&M management -Responsibilities -Perceptions
Private Sector	Handpump/Spares Manufacturers, Suppliers, Traders, and Artisans	-Participation in handpump projects

Based on the evaluation factors and criteria, separate set of questionnaires were developed for each category of stakeholders in order to aid the field data collection as presented in Appendix A. Each questionnaire contained questions developed to source information around a particular evaluation factor and criteria. The purpose of such a format was to enable the evaluator to obtain uniform data that can be compared.

Additionally, handpump data collection form was prepared (see Appendix A.5). The form was to assist the evaluator in obtaining the information on the general condition of the handpump unit and its surrounding.

3.2 Field Study

The field study consisted of visits and holding one on one interviews and discussions with the stakeholders by category beginning with National Policy level agencies in the relevant government ministries and departments, implementing agencies, the district councils, the communities and ending with the private sector (see Appendix D). In each category the respective questionnaires were used to guide the interviews.

The field study visits coverage was as follows:

i. Six (6) relevant government ministries and departments at which interviews were conducted with assigned responsible senior technical government officials (see details in Appendix D.1).

ii. Eight (8) external support agencies active in handpump water supply system provision, at which interviews were held with designated water supply and sanitation officers (see detailed list in Appendix D.2).

iii. Nine (9) district councils in the selected study districts in which interviews were held with respective water supply and sanitation officers (see detailed list in Appendix D.3).

iv. Four (3) community handpump sites in each of the nine (9) districts making a total of 36 sites of which twelve (12) are in peri-urban while twenty-four (24) are in semi-urban and rural areas (see detailed list in Appendix D.4). At each handpump site interviews were held with handpump caretakers, area pump menders and the general users. The handpump condition and its surrounding was also assessed.

v. Four (3) private handpump and spare parts suppliers, all based in Lusaka (see Appendix D.5). At each company interviews were held with senior technical staffs.

vi. One (1) technology research institution based in the School of Engineering at the University of Zambia in Lusaka at which the interview was held with the water and sanitation officer (see Appendix).

3.2.1 Selection of Study Area

The primary purpose of this study was to evaluate handpump water supply systems with regard to sustainability. It was therefore necessary to conduct the study in areas where handpump technology is given a priority compared to other methods of rural water supply. Such areas are those chronically affected by drought where water tables are reportedly in the range 60 to 90 metres below ground level. Although the latter selection criterion was followed to some extent, the major limiting factor was the research cost. Three provinces namely Lusaka, Central and Southern were selected. In each province, three districts were selected and four handpump water points were visited in each district. Also while selecting the sites for field visits, care was taken to select the sites of different implementing agencies and sites of different operating conditions. Figure 3.1 show the sectional map of Zambia with the three selected provinces and the spots painted illustrating the nine (9) study districts.

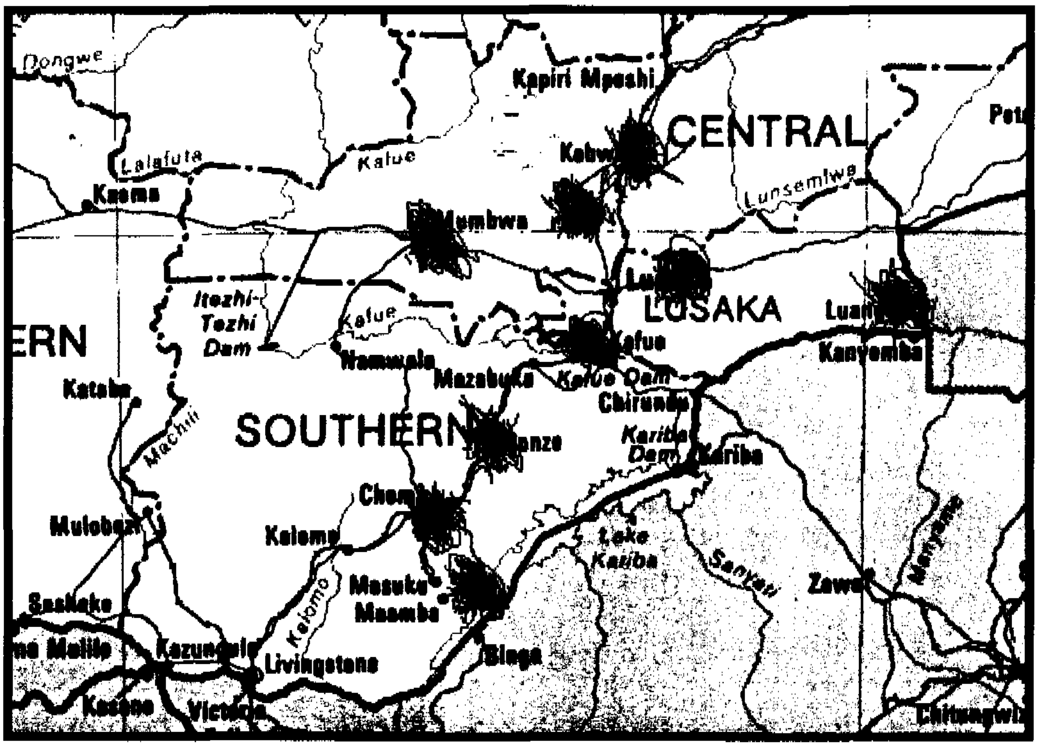


Figure 3.1: Sectional map of Zambia with painted spots showing the study areas (location of handpump sites).

3.3 Data Analysis

For the purpose of quantifying the qualitative field data, three situational statements were developed around each question except for the private sector where general interviews were held. The statements were assigned numerical values to represent a relative scale of performance and sustainable situation, ranging from a score of one (1) as the least favourable case to a score of three (3) as the most favourable scenario as shown in Table 3.3. The scoring system in presented along the questions in the questionnaires in Appendix B.

Table 3.3: Stakeholder score criteria.

Score	Condition	Explanation
3	Favourable	The situation is such that it meets all the requirements of a handpump water supply system sustainability.
2	Moderately favourable	The situation is such that it meets some/most requirements of a handpump water supply system sustainability but needs some improvements for smooth operation.
1	Least favourable	The situation is such that it meets very few or no requirements for sustainability of a handpump water supply system.

As well, a scoring system was developed to gauge handpump condition and general pump site order. The scoring system was based on a developed numerical judgement scale ranging from 3 as a very good condition down to 0 as the worst situation as shown in Table 3.4.

Table 3.4: Handpump score criteria.

Score	Condition	Details
3	Very good	Handpump working well, all parts intact, clean surrounding and the capacity is okay.
2	Good	Handpump working well, all parts okay, surrounding clean, a few small improvements possible.
1	Fair	Handpump working but need minor repair, surrounding not clean/platform not in good condition.
0	Poor	Handpump not working at all, for more than a month (parts may be in good condition).

4 Results and Discussion

4.1 Introduction

This chapter presents the results of the field study conducted for the evaluation of the handpump water supply systems in Zambia based on the information collected with different sets of questionnaire developed (see Appendix A) and field observation by the researcher. The chapter further analyses the weaknesses and strengths from the handpump water supply projects as identified in this study and suggests measures/future strategies for sustainability of handpump water supply in Zambia.

The study was conducted by the researcher through direct interviews with each category of stakeholders involved in handpump water supply projects namely the national policy agencies, implementing agencies, external donors, handpump users and the private sector. The information collected from each stakeholder was scored according to the respective scoring system (see Appendix B) and recorded in the evaluation score grid (see Appendix C). The scoring system was developed in order to get a value judgement about the level of sustainability of the handpump water supply systems in the study areas.

In order to highlight which areas are the weakest in relation to handpump sustainability, **average scores and modes** were calculated for each sustainability factor for each category of stakeholder and the results are tabulated in the Appendix C. **However, it is to be noted that the comparisons based on averages and modes do not have any real physical significance of the situation affecting a particular district or province, but give the general impression of the situation.**

4.2 National Policy

In order to get an overview of national policy on WSS and particularly handpump water supply, interviews were conducted with the government stakeholder ministries and departments namely, the Ministry of Local Government and Housing, Ministry of Energy and Water Development, Ministry of Environment and Natural Resources, Ministry of Health, Ministry of Commerce and Industry and the Ministry of Community Development. These interviews were conducted using the questionnaire developed in Appendix A.1. This included the questions on all the aspects of sustainability namely financial, technical, institutional, social and environmental. It was found that different government ministries and departments are responsible for different policy aspects of water supply in the country as listed below:

- Ministry of Local Government and Housing (MLGH) through the Department of Infrastructure and Support Services is responsible for operation of water supply sanitation facilities through the District Water, Sanitation and Hygiene Education (D-WASHE) committees. D-WASHE committees are in all the 72 districts of Zambia. The D-WASHE committees coordinate the implementation of all handpump projects in their respective districts regardless of the implementing or funding agency.
- National Water Supply and Sanitation Council is a statutory institution under the MLGH responsible for regulation of urban and peri-urban water supply and sanitation facilities.

- Ministry of Energy and Water through the Department of Water Affairs – responsible for water resource development, provision of technical guidelines for drilling of boreholes and installation of handpumps.
- Ministry of Health is responsible for community sanitation and hygiene education.
- Ministry of Community Development and Social Welfare is responsible for facilitation of community-managed projects.
- Ministry of Environment is responsible for environmental protection policy.

Therefore, interviews were held on appointed dates with responsible senior technical/management staff (see Appendix D.1), covering only relevant questions to each of the above ministries and departments. Based on the information collected from the responses on each question, a sustainability score grid was created as presented in Appendix C.1. An average score was calculated for questions under each sustainability factor and the results are presented in Table 4.1:

Table 4.1: Evaluation score grid for National Policy contribution to handpump sustainability.

Sustainability Factor	Average Score
Financial sustainability (FS)	1.8
Technical sustainability (TS)	2
Institutional sustainability (IS)	1.5
Social sustainability (SS)	2
Environmental sustainability (ES)	1

In order to visualise the differences of the scores of the sustainability factors the information in Table 4.1 was further presented in a histogram form in Figure 4.1.

From Figure 4.1 shows that the environmental sustainability factor has emerged the lowest with an average score of 1. The reason is due to inadequate enforcement of environmental laws that affect handpump water systems (see Appendix B.1). Technical and social sustainability factors however appear to favour handpump sustainability with an average score of 2 each due to proper policies in place handpump standardisation and the adoption of WASHE concept in the implementation of handpump projects. The scores are explained in detail under the successive sections analysing the sustainability policy factors.

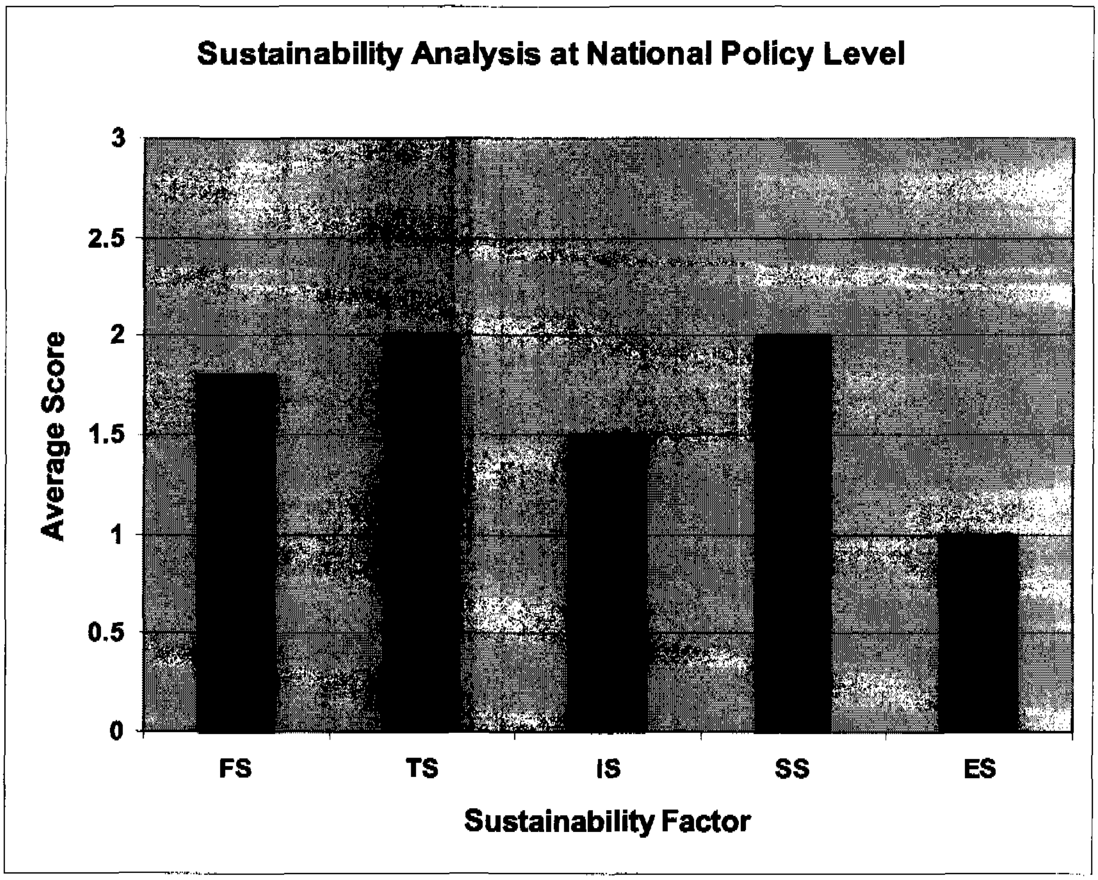


Figure 4.1: Histogram of Sustainability Analysis at National Policy Level

4.2.1 Financial Sustainability

Under WASHE concept, rural water supply and sanitation financing requires a community contribution (commitment fee) to the capital cost towards implementation on handpump projects. However, most projects are either funded 100% by donor agencies or on sharing basis between the community and the donor, in which case the community contribute a standardised amount of K 300,000.00 (US$ 60) translating into 1% if the total capital cost is US$ 6000.00. The Government's role is to solicit financial support from ESAs. WASHE concept also requires that communities must be responsible for management of operation and maintenance through cost recovery from users. District Councils are required to assist communities when major repairs costs are needed.

The study noted that there is no financial support policy from government to research and development in handpump technology.

4.2.2 Technical Sustainability

It was noted that the National Water Policy agencies recognise that technology selection and standardisation are the two most important aspects for community based water supply systems. In this regard, the Zambian Government has standardised India Mark II and

Afridev as the sole handpumps to be used in the country. However, none of the two handpumps is manufactured in the country. Furthermore, there are no measures in place to check the manufacturing quality of handpumps imported into the country. Neither potential local handpump manufacturers, nor technology researchers are supported.

In order to minimise pump use overload the government has adopted 250 – 300 people (50-60 households) per handpump water point as a design criteria. However, there is no guideline or policy related to handpump spacing.

4.2.3 Institutional Sustainability

Realising that the National Water Supply and Sanitation Act does not address community water supply the Government adopted the Water, Sanitation and Hygiene Education (WASHE) concept as a foundation of its water service delivery for rural communities. The WASHE is supposed to promote capacity building through intersectoral planning, prioritisation and implementation through coordinated and participatory approaches. District Councils are the centres of District WASHE (D-WASHE) activities for the provision of water and sanitation services within districts. Each council has a District WASHE (D-WASHE) Committee responsible for overseeing the implementation and monitoring of WASHE projects and activities. The D-WASHE is an intersectoral committee which consists of representatives of the District Council, DWA, MOH, MOE, MOA, MCDSS and Non-Governmental Organisations (NGOs)/Donor agencies involved in water, sanitation and hygiene education in the district. Communities are to be involved at all stages of the projects cycle from identification to management. However, WASHE is not a government policy but a model, which was adopted from UNICEF. Different stakeholders have interpreted the WASHE concept in different ways resulting in reduced sustainability in many RWSS interventions. Therefore there is need to from the government to come-up with national community water supply policy that will remove this developmental constraint.

4.2.4 Social Sustainability

Through the Ministry of Health and the Ministry of Community Development and Social Welfare representation on WASHE committees, the government has a mandate to sensitise the communities in matters of water sanitation and hygiene in all handpump projects. The implementation of this sensitisation exercise has been coordinated by the Rural Health and Community Development centres in the districts. However, the study noted that the pursuit is highly dependent on donor support.

4.2.5 Environmental Sustainability

From the histogram in Figure 4.1, it is clear that the government strategy with regards to environmental sustainability of handpump technology is the weakest. The major legislation relating to the development and management of the water resources are the:

- Water Act, Cap 198 and
- Environmental Protection and Pollution Control Act, Cap.204, which is the primary legislative basis for managing, water pollution.

The main objective of the Water Act is to provide for the ownership, control, and use of water. The law is inadequate and weakly enforced. The Act mainly regulates surface water. The use of groundwater, on the other hand, is not monitored or regulated. Groundwater is the source of wells and the springs that feed streams, rivers and lakes. Its use should, therefore, be brought under the control of Government so that both groundwater and surface water are properly regulated.

The Environmental Protection and Pollution Control Act forms the umbrella legislation for issues related to environmental aspects in water management. The executive authority under this Act is given to the Environmental Council of Zambia (ECZ). The Act gives the Council the mandate to take action and initiative on a number of environmental issues, including among other things to co-ordinate the activities of all ministries and other bodies concerned with the protection of the environment.

There is an Inspectorate established under the Act, for the purpose of enforcing the regulations. This includes the provision of issuing waste discharge permits or licences in watercourses. The Inspectorate is also in charge of monitoring the compliance of the conditions given in the permits.

Environmental Impact Assessment (EIA) regulations give instructions of the process of carrying out an EIA for a development project. It also includes a list of projects where an Environmental Project Brief has to be issued and a list of categories of projects where a full EIA would be required. According to the regulation a Project Brief would be required for the exploration for and use of groundwater resources.

At the moment the capacity to enforce the duties and tasks described in the environmental legislation is far from satisfactory. The Inspectorate does not have the manpower, infrastructure and technical means to control the compliance of water regulations. ECZ does not have laboratory facilities to carry out water quality analyses on a routine or regular basis. The efforts to assess water quality situations have mostly been based on ad.hoc studies and research programmes.

4.3 Implementing Agencies

In terms of implementation, there are two types of handpump projects implementation arrangements:

a. Projects funded and implemented by External Agency and supported by District Government Agency

b. Projects funded by External Agency and implemented by District Government Agency

In order to get an indication of how the project implementation process affect the sustainability of handpump water systems, interviews were conducted with External Agencies and Districts Government Agencies. A total of eight External Agencies active in handpump projects were interviewed. Also, a total of nine District Government agencies were interviewed. The District Government agencies interviewed are only those operating in the selected study areas. The interviews were conducted using the questionnaire developed in Appendix A.2. This included the questions on all the aspects of sustainability namely financial, technical, institutional, social and environmental.

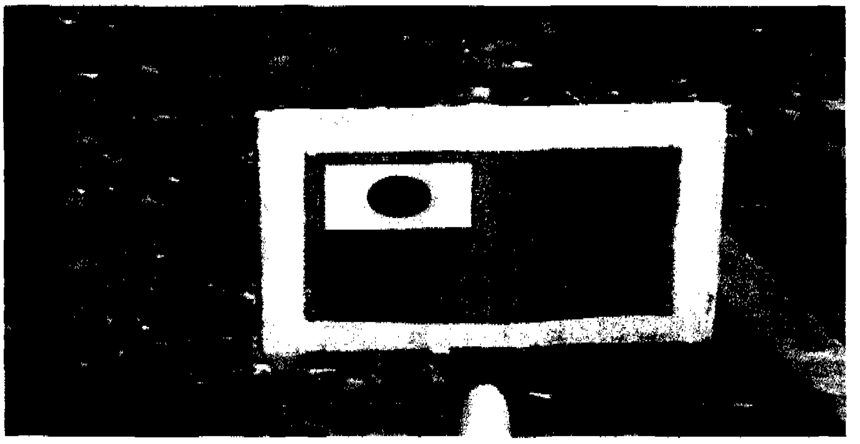


Figure 4.2: A foundation stone showing the flag of Japan and that of Zambia left by JICA at a handpump site in Mumbwa District.

For the External Agencies interviews were held at the Lusaka-based offices on appointed dates with responsible senior technical/management staff (see Appendix D.2). For the District Government Agencies interviews were held at the District Council offices with the designated officials on an impromptu basis when the district was visited. Based on the information collected from the responses on each question, a sustainability score grid was created as presented in Appendix C.1. An average score was calculated for questions under each sustainability factor and the results are presented in Table 4.1 for External agencies:

Table 4.2: Evaluation score grid for External agencies contribution to handpump sustainability

Sustainability Factor	External Agencies								
	Z	W	U	K	O	J	Af	CI	Factor Average
Financial Sustainability	1.8	1.8	2.5	1.7	1.7	2	1.3	1.7	1.81
Technical Sustainability	2.4	2.4	2.9	2.4	2.1	2.4	1.9	2.6	2.39
Institutional Sustainability	2	2.6	2.8	1.8	2.4	2.4	1.8	2.6	2.3
Social Sustainability	3	3	3	3	3	3	3	3	3
Environmental Sustainability	2.9	3	2.9	3	2.9	3	3	2.9	2.9
Overall Average	2.3	2.5	2.8	2.3	2.3	2.5	2.1	2.5	2.4

Z - Zamsif
O - Oxfam
J - JICA
W - WaterAID
U - UNICEF
K - KWF
Af - Africare
CI - Care International

In order to envision differences of scores of sustainability factors the overall average scores for each agency are presented in the histogram form in Figure 4.2. UNICEF has scored the highest with an average score of 2.8, signifying that their handpump projects are implemented in a manner that favour sustainability the most. This is because UNICEF has more experience in community-based projects in Zambia (see Appendix B.2). Africare on the other hand is the lowest with an average score of 2.1. This is because Africare projects were mostly implemented under emergency circumstances such as drought or disease outbreaks, making planning to involve the communities difficult. The scores are explained in detail under the successive analysis of sustainability factors.

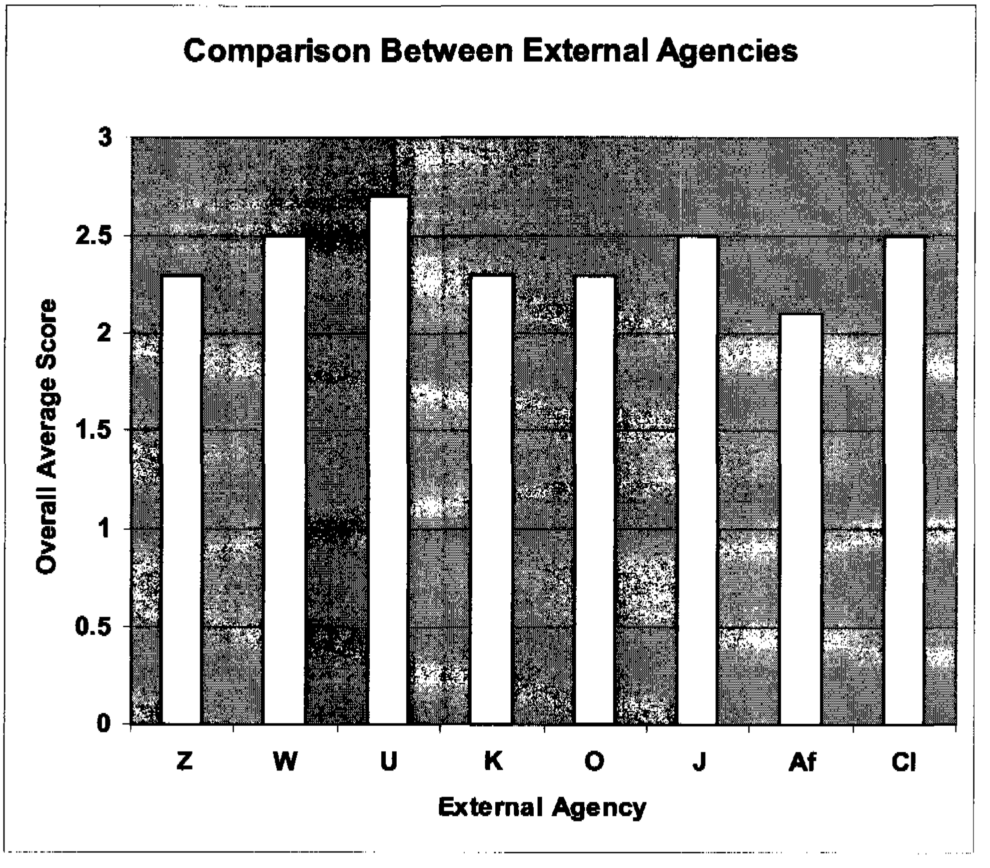


Figure 4.3: Histogram of comparing performance from External Agencies.

Like for the External Agencies, an average score was calculated for questions under each sustainability factor for District Government agencies and the results are presented in Table 4.3

Table 4.3: Evaluation score grid for District Government agencies contribution to handpump sustainability

Sustainability Factor	District Government Agencies									
	CD	LD	KD	KW	ChD	MD	SD	CW	MoD	Factor Average
Financial Sustainability	1.8	1.8	1.8	1.3	1.83	1.8	1.8	1.3	1.83	1.69
Technical Sustainability	2.3	2.3	2.3	2.3	2	2.3	2.3	2	2.25	2.23
Institutional Sustainability	2.8	2.8	2.8	2.8	1.6	2.8	2.8	1.6	2.8	2.53
Social Sustainability	3	3	3	3	1	3	3	1	3	2.56
Environmental Sustainability	2	2	2	2	2	2	2	2	2	2
Overall Average	2.3	2.3	2.3	1.7	2.27	2.3	2.3	1.7	2.27	2.16

CD - Chongwe District Council
LD - Luangwa District Council
KD - Kafue District Council
KW - Kabwe Department of Water Affairs
ChD - Chibombo District Council
MD - Mumbwa District Council
SD - Sinazongwe District Council
CW - Choma Department of Water Affairs
MoD - Monze District Council

Figure 4.4 shows a comparison of overall average scores for District Government agencies. At least all the districts except for Kabwe and Choma have high levels of sustainability with an overall average score of 2.3. In these districts, community participation in decision-making process in projects implemented by the District Councils is substantial, hence the relatively high score. Where possible, District Councils in these areas do assist communities in carrying out major repairs on handpumps. In Kabwe and Choma the situation is different. The Government agency in these districts is the Department of Water Affairs, whose main role in handpump projects is exploration, drilling, handpump installation and training of pump mechanics. Municipalities in these areas do not deal with community water supply systems. However, neither the District Councils nor the Department of Water Affairs carry out water quality test of their handpumps.

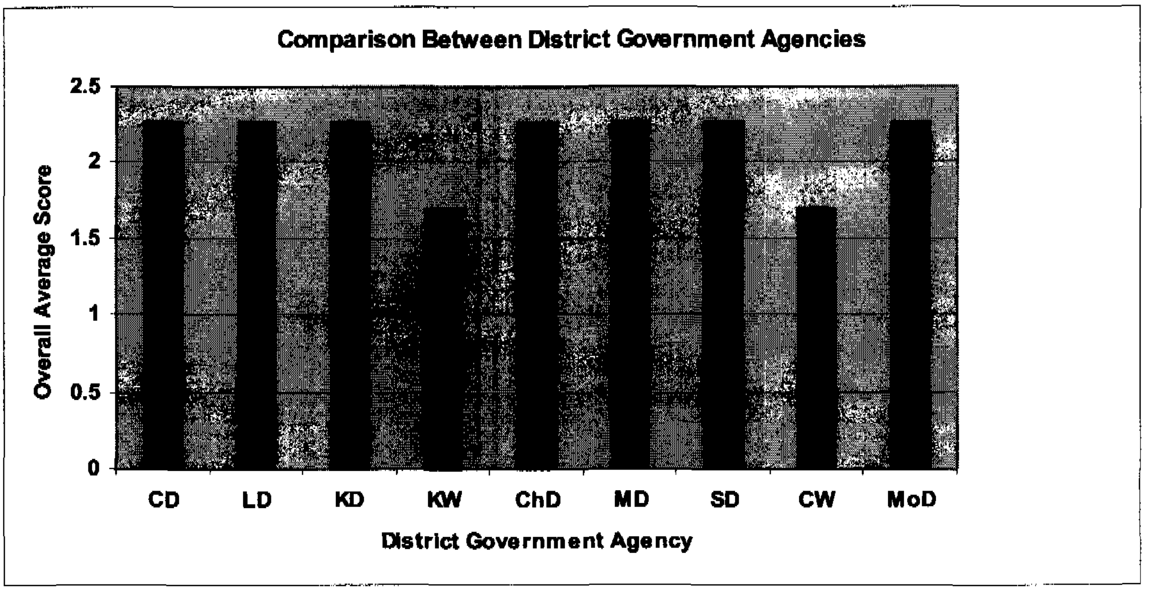


Figure 4.4: Histogram comparing performance from District Government Agencies

Figure 4.5 shows a comparison between External Agencies and District Government agencies in all aspects of sustainability. Though External Agencies have higher scores than District Government agencies in all aspects except institutionally, the difference is more noticeable in environmental sustainability. This is because External Agencies reported that they carry out water quality testing in all projects whereas district government agencies often do not carry out water quality testing in their projects. Government agencies are institutionally better because they operate with the communities even after the project. The general superiority in other sustainability factors by the External Agencies is a matter of availability of resources, which are perennially insufficient from the Government.

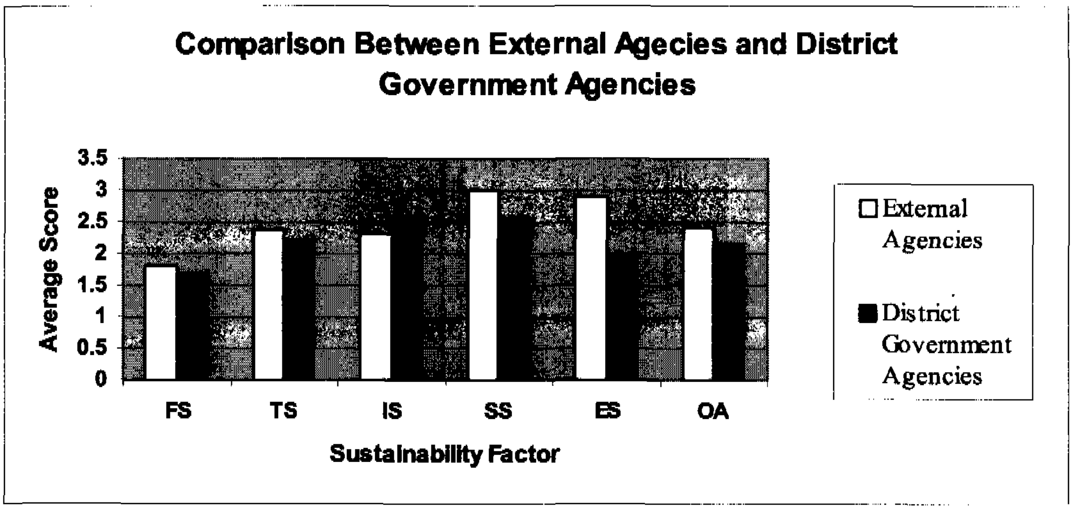


Figure 4.5: Histogram comparing performance between External Agencies and District Government Agencies

4.3.1 Financial Sustainability

The study observed that the handpump water supply in Zambia is heavily dependent on donor agencies, who meet almost 100% of the capital cost. The major donors include World Bank/Zambia Social Investment Fund (Zamsif), African Development Bank (ADB), UNICEF, KFW-Germany Technical Cooperation, Japanese International Cooperation Agency (JICA). External agencies operating as international NGOs involved in handpump water supply activities include Water Aid, Oxfam and Care International, Africare. Other External agencies though not included in this study are Irish Aid, World Vision International and Danish International Development Agency. The study noted that all External agencies operate separately from each other though with common support from the government. Government agencies' financial sustainability of handpump systems is the lowest due to a constant inadequate resources situation. External agencies performance with regard to financial sustainability is also low due to unfavourable approaches of involving of the communities in handpump financing decision-making systems.

4.3.2 Technical Sustainability

The selection of a range of water supply technology varies according to environmental conditions, affordability and social acceptance. The survey observed that most implementing agencies recognize that sustainability of water services is enhanced when communities are allowed to select a technology, which they believe they can support financially, managerially and technically. However, environmental conditions in some areas where water tables are as low as 40 m have left implementing agencies with no option but to apply expensive technologies like deepwell India Mark II or Afridev handpumps. Design criteria in terms of number of people to be served per handpump point was found to be 300 or below for almost all implementing agencies.

Implementing agencies recognize availability of technical skills within the community as an important pre-requisite for a sustainable handpump water supply service. For this reason, all implementing agencies do undertake training of Area Pump Menders in:

- Pump installation;
- All minor and major pump repairs (including the fishing of rods and pipes; replacement of cylinders; and repairs on the pump head);
- Small business management;

Area Pump Menders are sometimes hired as private contractors to train community pump caretakers in:

- Familiarization with pump components;
- Explanation and demonstration of all component functions
- Daily, weekly and monthly maintenance checks;
- Replacement of common problems causing parts, like U-seals, bearings and O-rings;
- Fault diagnosis;
- How to locate and liaise with Area Pump Menders for further technical support in major repairs; and

- How to locate and deal with other service providers, including retailers of spare parts and commercial repair shops.

Some implementing agencies like UNICEF and Zamsif offer pump repair work resulting from faulty manufacture or installation for a period of up to one year from the date of pump installation.

The handpumps, once installed, became the full responsibility of the community, under the care of community caretakers. Following this period, communities contact an Area Pump Menders, contracting directly for services on an as needed basis to provide support to the community caretakers in the above listed tasks, or to provide further training in operation and maintenance of their handpumps.

Table 4.3 shows how each implementing agency is fairing with regards to technical sustainability of handpump projects with UNICEF topping the list with a score of 2.9 and Africare the last with a score of 1.9 for the reason mentioned before. UNICEF has a programme to continuously support their projects through monitoring and evaluation.

4.3.3 Institutional Sustainability

Handpump water supply schemes in Zambia are determined and implemented by donor agencies who leave after the end of the project. During the project period the communities are sensitised and mobilised by the implementing agency of the need to form Community Based Organisations (CBO) who would be responsible for future management and financing of O&M. After the project the District Councils through the D-WASHE Committees are supposed to play an enabling role, while being responsible for motivating, monitoring and evaluation of the CBO operations. However, it was observed that some Councils do not even have a system of communication with the communities. Figure 4.4 show Government agencies are have a higher contribution to handpump sustainability with regards to institutional sustainability of handpump projects because of their continuous support to the service.

4.3.4 Social Sustainability

Figure 4.4 shows all implementing agencies (government or external) are doing very well with regards to social sustainability of handpump projects. This is because all implementing agencies do conduct community sensitisation in hygiene and sanitation in their handpump project period and gender balance is observed at all stages. However, External agencies demonstrate higher level of social sustainability due sufficient resources available to them for such community activities. The DWA in Kabwe and Choma districts do not carryout any social work in their projects since they are purely technical service establishments.

4.3.5 Environmental Sustainability

With regards to environmental sustainability of handpumps Government agencies have lower levels due lack of resources to support rehabilitation of boreholes, water quality testing and disinfections of boreholes. Most implementing agencies interviewed reported that most drilled boreholes struck water tables within 10 to 15 metres of drilling although drilling has continued up to depth of 60 metres, which is the standard. However, there are some boreholes in areas like Sinazongwe district in the Southern Province where groundwater is only encountered at depth of between 70 to 90 metres below ground level. This is because the district is in a drought prone area where water resources are scarce. Handpumps operating with cylinder assemblies located at depth more than 45 metres have been reported to have problems of frequent pump rod breakages due to high pumping heads resulting in frequent repairs. The later comprises sustainability of handpump water supply systems due to unaffordable costs.

4.4 Users

Users are the primary stakeholders in the sustainability of community handpump water supply given that they are the beneficiaries and that they have responsibility to keep the water service running for the designed period. It is for this reason that this study included visiting the community handpump water points in the study areas. The aim of the visits to the community handpumps was to assess the state of the handpump water supply systems and their use by the communities as well as to determine how well the community-based maintenance system was operating.

The researcher visited three provinces and in each province three districts were visited. In each district four handpump water points were visited bringing the total number of handpumps assessed to thirty-six. Spontaneous visits were conducted to randomly selected handpump water points. At each handpump the visit began with looking for the caretaker or any member of the handpump committee who would become the focal person in the interviews and discussions. Therefore, interviews started with the focal person at his/her house before moving to the handpump site. Thereafter, the focal person would lead the researcher to handpump site for an interview with the handpump users. The interviews with the focal person were held on one to one basis while those with the handpump users were held in form of discussions.

The study noted that Area Pump Menders were very busy people and difficult to get for a impromptu interview. Therefore, only in possible circumstances someone would be sent to call the Area Pump Mender so that he/she could be interviewed. Interviews were conducted with handpump users and caretakers and/Area Pump Menders using the questionnaire developed in Appendix A.3.

The information collected from the field was given the corresponding 1, 2 or 3 scores (see Appendix B.3) and inserted in the sustainability evaluation grid (see Appendix C.3). An average sustainability score was calculated at factor and pump levels and the results are presented in table 4.4.

Table 4.4: Average sustainability score at pump level

Province	District	E A	Pump Location	FS	TS	IS	SS	ES	Overall Average at Pump level
Lusaka	**Chongwe**	**Af**	**1**	1.5	2	1.6	1.9	2.3	**1.9**
		Af	**2**	2.2	1.2	2.1	2.2	2.4	**1.9**
		Z	**3**	1.9	2.5	3	2.6	2.9	**2.5**
		Af	**4**	2.2	2.1	2.7	2.3	2.1	**2.3**
	Luangwa	**Z**	**5**	2.6	2.3	3	2.4	1.7	**2.4**
		Z	**6**	1.8	1.7	2.9	2.4	1.9	**2.1**
		J	**7**	2.4	2.3	2.7	2.5	2.1	**2.4**
		J	**8**	1.6	1.7	1.6	1.9	2.3	**1.8**
	Kafue	**J**	**9**	2.8	2.6	3	2.9	2.7	**2.8**
		J	**10**	2.3	2.3	2.7	2.5	2.7	**2.5**
		J	**11**	2.3	2.4	2.7	2.7	2.6	**2.5**
		J	**12**	2.1	2.4	2.7	2.1	2.7	**2.4**
Central	**Kabwe**	**Z**	**13**	2.7	2.7	2.4	2.8	1.9	**2.6**
		AD	**14**	2.3	2.3	2.4	2.7	2.3	**2.4**
		Z	**15**	2.3	2.4	2.4	2.6	2	**2.4**
		AD	**16**	2	2	2.4	2.4	2	**2.2**
	Chibombo	**AD**	**17**	1.8	2.8	2.7	2.5	2.6	**2.4**
		AD	**18**	2.2	2.6	2.6	2.5	2.4	**2.4**
		K	**19**	2.2	2.8	2.6	2.2	2.4	**2.4**
		K	**20**	2.2	2.8	3	2.6	2.4	**2.6**
	Mumbwa	**Z**	**21**	2.6	2.5	2.7	2.4	2.7	**2.5**
		J	**22**	2.5	2.3	2.7	2.1	2.4	**2.4**
		J	**23**	2.6	2.4	2.7	2.5	2.7	**2.5**
		J	**24**	2.6	2.2	2.7	2.1	2.7	**2.4**
Southern	**Sinazongwe**	**GD**	**25**	2.4	2.3	2.9	2.5	1.6	**2.4**
		GD	**26**	2	2.1	2.9	2.5	2.1	**2.3**
		GD	**27**	2.1	2.1	2.9	2.5	2.1	**2.3**
		GD	**28**	1.7	1.9	2.4	2	1.9	**2**
	Choma	**O**	**29**	3	2.6	2.7	2.7	2.3	**2.7**
		O	**30**	2.4	2.8	2.7	2.7	2.3	**2.6**
		O	**31**	3	2.8	2.7	2.8	2.4	**2.8**
		O	**32**	3	2.9	2.4	2.7	2.6	**2.8**
	Monze	**U**	**33**	2.7	2.3	2.7	2.6	2.3	**2.5**
		U	**34**	2.7	2.3	2.7	2.6	2.6	**2.6**
		U	**35**	2.6	2.3	2.7	2.6	2.6	**2.5**
		U	**36**	2.5	2	2.7	2.5	2.6	**2.4**

Note: EA*- Implementing Agency; IS* - Institutional Sustainability
FS* - Financial Sustainability; SS* - Social Sustainability
TS* - Technical Sustainability; ES* - Environmental Sustainability

Figure 4.6 shows the average sustainability score for handpump water points visited in Lusaka Province. Pump point 9 (Mwanachilenga Community) located in Kafue District has emerged the most sustainable with a score of 2.8. The pump was first installed in the 1980s and has recently (05/2004) been rehabilitated by JICA after being out of function for one year. The pump has not broken down since rehabilitation and is in very good working condition. The community has a pump management committee in place. Users contribute K 1200 (US$ 0.25) per month from each of the 52 families using the pump. A weakness however was that no preventive maintenance had been done on the pump even though seven months had past after rehabilitation.

Pump point 8 (Indeco Milling Compound) located in Luangwa Township area is the lowest with a score of 1.8. The pump is located in an area, which is served from a central piped water supply system. The pump was donated by JICA for the purpose of beefing up the intermittent centralised water supply system in the area. Maintenance of the pump is the responsibility of the Luangwa District Council and users do not contribute anything towards maintenance. There was report that the pump has had down times of up to one month after breaking down, although, it was working well at the time of the visit.

Sustainability levels for pumps 1 and 2 are also low with average scores of 1.9. The two pumps are located near centralised piped water system within Chongwe Township. Pump 1 is owned by Chongwe District Council although, it is used by the surrounding public. Maintenance of the pump is the responsibility of the Council and users do not contribute anything towards maintenance. There was report that the pump is poorly maintained and has had down times of up to one month after breaking down. The pump was working well at the time of the visit.

Pump 2 is not working and is owned by a school within Chongwe Township. The School Authorities reported that the pump had been out of function for one year at the time the visit. They told the researcher that the pump problem had been reported to the Chongwe District Council but no action had been taken. This shows that handpump owned by the public institutions like District Councils and Schools have low level of sustainability due lack of operation maintenance and control.

Chongwe Township has difficulties in obtaining chemicals to treat their centralised water system though supply service in the town is 24 hours of untreated water. Township Authorities have sensitised the community not to drink water from the central supply but from the handpump. The scores are explained in detail under the successive analysis of sustainability factors.

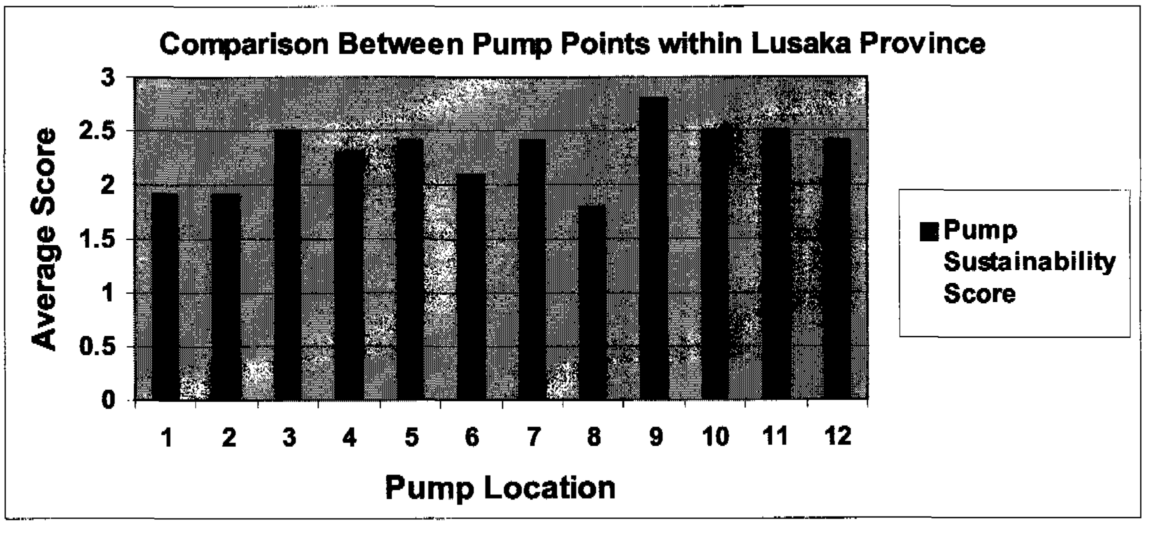


Figure 4.6: Histogram of sustainability performance at pump point level in Lusaka Province.

Figure 4.7 shows the average sustainability score for handpump water points visited in Central Province. Generally the pumps visited in the Central Province show high levels of sustainability with minimum score of 2.2 at pump 16 (Nakoli Compound) in Kabwe Peri-Urban and a maximum score of 2.6 at pump 13 (Kaputula Compound) in Kabwe Peri-Urban and at pump 2 (Chitanda Palace) in Chibombo District. The relative high levels of sustainability are attributed to effective management systems of the Pump Committees in the area. All the 12 pumps have management committees who ensure timely collection of maintenance fund from the users. Preventive maintenance is done routinely at all the pumps. Moreover, the pumps visited are reported to be relatively new and are located in areas with easy access to developed business centres with good transportation network.

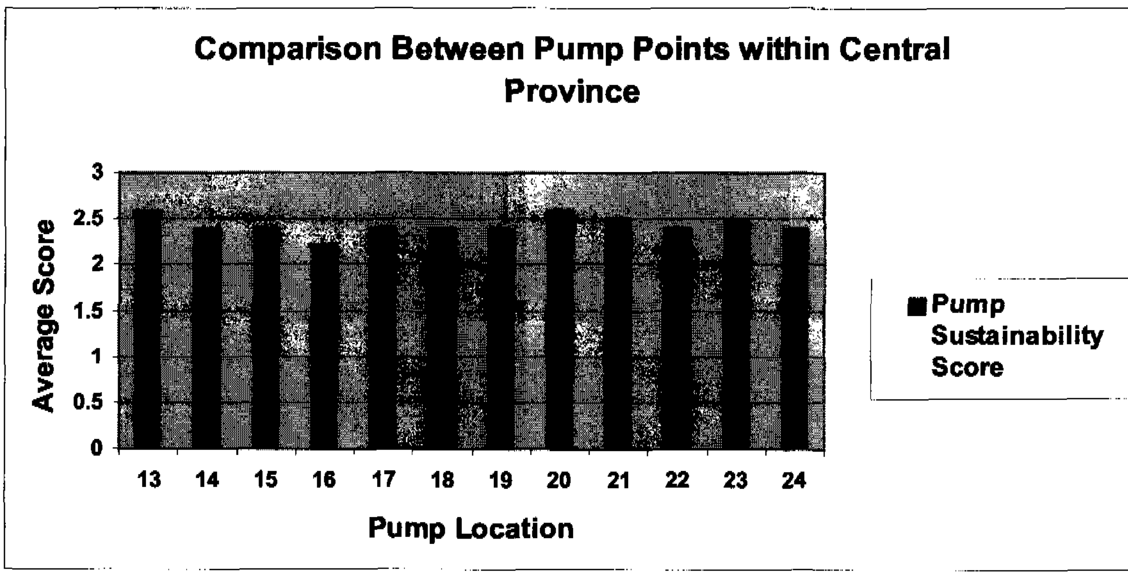


Figure 4.7: Histogram of sustainability performance at pump point level in Central Province.

Figure 4.8 shows the average sustainability score for handpump water points visited in Southern Province. Community pumps visited in the province show high levels of sustainability with the lowest score of 2.0 at pump 28 located at Sinazongwe Basic School in Sinazongwe District. The pump is not working and was locked at the time of the visit. Its general appearance though was good. The school authorities interviewed reported that the pump had been out of operation for six months. There were complaints that the water from the pump is salty and reddish in colour and is only used for gardening. Though located about three kilometres away, the school is connected to the Sinazongwe Town centralised system, which supplies them with drinking water. Reports of salty and reddish coloured water were received from three of the visited four pumps in the district. All the 12 pumps have management committees who ensure timely collection of maintenance fund from the users. Preventive maintenance is done routinely at eight of the visited 12 pumps. Pumps in Choma and Monze are located in areas with easy access to developed business centres with good transportation network.

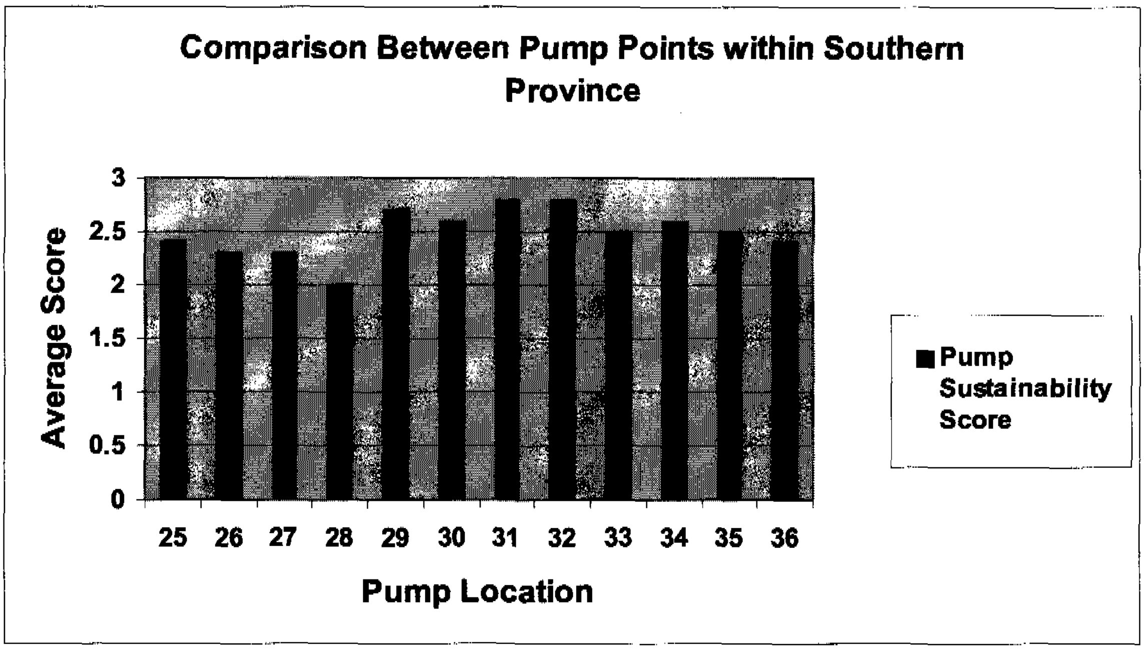


Figure 4.8: Histogram of sustainability performance at pump point level in Southern Province.

Table 4.5 shows the average sustainability score for each factor calculated at district level. The scores are further presented in Figure 4.9 in order to compare sustainability levels among districts.

Table 4.5: Average sustainability score at district level

Sustainability Factor	Chongwe	Luangwa	Kafue	Kabwe	Chibombo	Mumbwa	Sinazongwe	Choma	Monze
FS	1.9	2.1	2.4	2.3	2	2.5	2	2.9	2.6
TS	1.9	2	2.4	2.3	2.7	2.4	2.1	2.8	2.2
IS	2.4	2.5	2.8	2.4	2.7	2.7	2.8	2.6	2.7
SS	2.3	2.3	2.6	2.6	2.4	2.3	2.7	2.7	2.6
ES	2.4	2	2.7	2	2.5	2.6	1.9	2.4	2.5

Figure 4.9 illustrate that on average financial sustainability levels for handpumps visited Choma District is the highest with an average score of 2.9 followed by technical sustainability in Choma at 2.8, institutional sustainability in Kafue and Sinazongwe both with at average score of 2.8. The reason behind Choma's better performance is that the handpumps visited demonstrated higher levels of organization in terms of cost recovery. The handpumps are located in areas with relatively good income users. These handpumps were pump 29 which owned by Batoka Market (business center), pump 30 owned by Pemba Resettlement Center (who are a group of resettled farmers), pump 31 owned by Kasiya Rural Health Center (water supply to a rural clinic) and pump 32 owned by Muyuni Farmers Group. As mentioned before, Chongwe on the hand had pump 1 owned by the Council but used buy the community who do not contributed anything towards O&M and pump 2 is not had not been working for one year although it is owned by a government school. Therefore, the average scores for Chongwe have been weakened by the two handpumps.

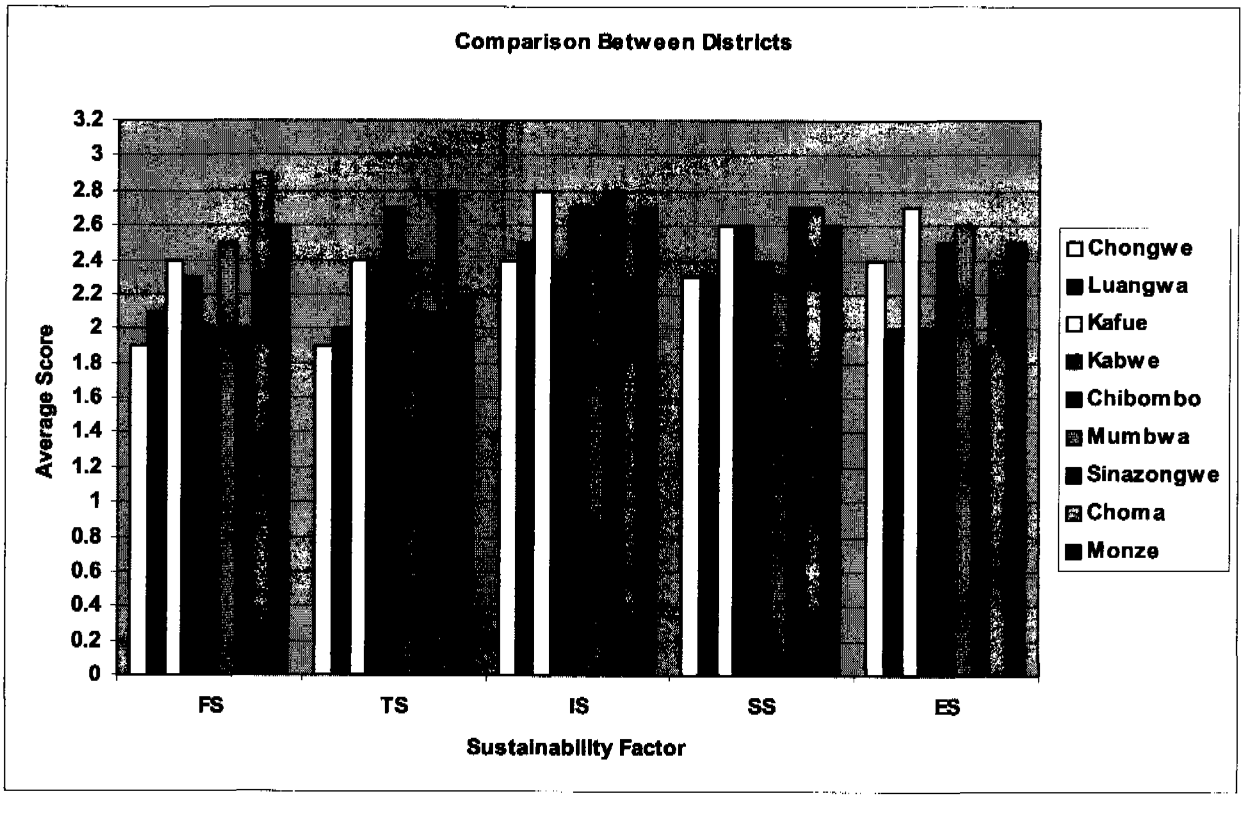


Figure 4.9 Histogram of sustainability performance at district level

Table 4.6 shows the average sustainability score for each factor calculated at provincial level. The scores are further presented in Figure 4.10 in order to highlight sustainability levels in among provinces.

Table 4.6: Average sustainability score at provincial level

Sustainability Factor	Province		
	Lusaka	Central	Southern
FS	2.1	2.3	2.5
TS	2.1	2.5	2.4
IS	2.6	2.6	2.7
SS	2.4	2.4	2.6
ES	2.4	2.4	2.3

Figure 4.10 illustrates that on average institutional sustainability levels of the handpumps is the highest in all provinces, a sign that at least functioning management structures have been created at community level. Sustainability levels for other factors are also relatively high with a minimum score of 2.1 for financial and technical issues in Lusaka Province. The latter signifies that handpump water supply technology is sustainable at community level.

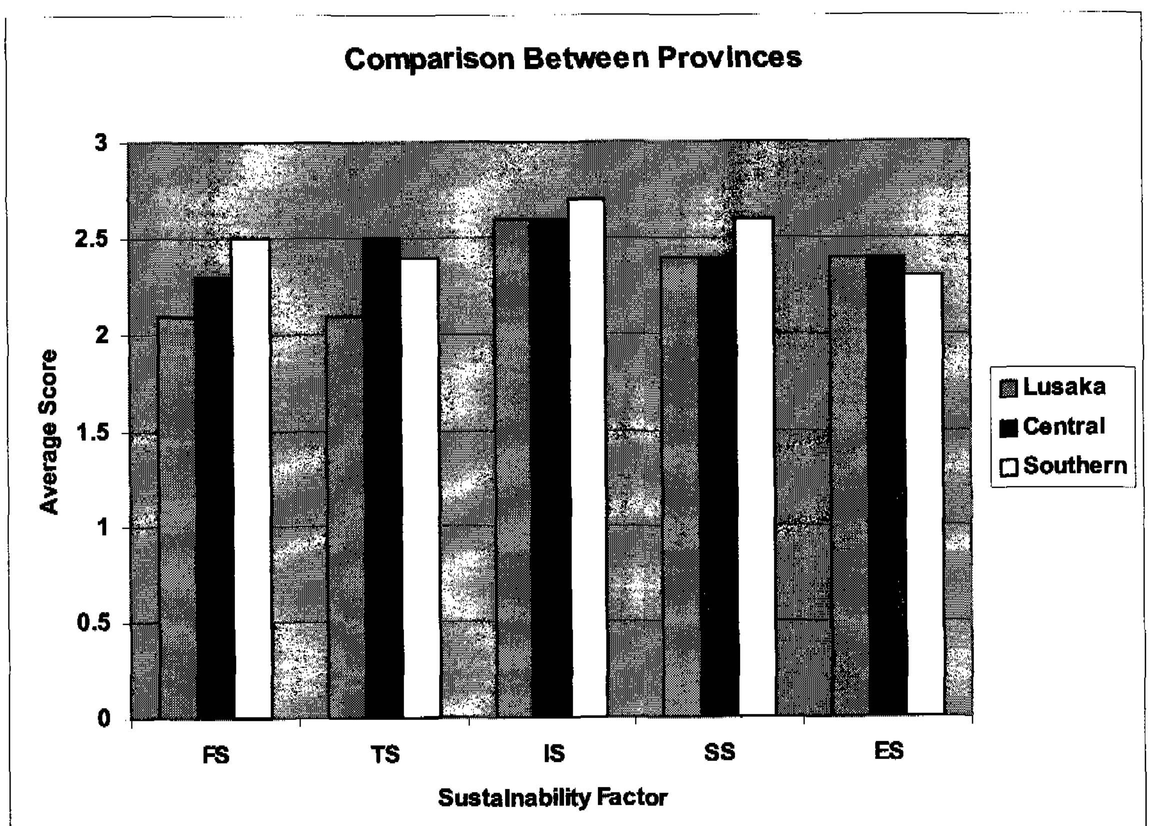


Figure 4.10: Histogram of sustainability performance at provincial level.

4.4.1 Financial Sustainability

It was noted that communities varied in their ability to find cash. Some rural communities in Luangwa (Kabila Fishing Camp and Hotela Village), Sinazongwe (Tusombane Village) did not have money but do have goods (fish, goats, chickens, etc), which they contributed to the pump committee. The committee then sell these goods to raise money for buying spare parts. Sometimes, money is raised by working for someone in the community who needed labour and was rich enough to pay.

Another important issue for the communities was the timing of collections. Of the total communities interviewed 31 reported that they collect the money monthly, in advance of breakdowns and stored in some form (bank/caretaker's house or any community trustee), in order to give a rapid response to the breakdown. Three reported that they collected the money when the repairs are required. Two communities collected the money in advance and stored the collect finances in the form of spares (inflation proofed), which are then readily available to attend the breakdown.

The difficulty experienced by the communities buy spares in advance is that some spares stored for too long may get spoiled (e.g. rubber seals). Sometimes the stored spares may be the wrong spares for the breakdown because for example: the problem might be a broken handle when the spares stored are the O-rings.

4.4.2 Technical Sustainability

Of the thirty-six handpumps visited thirty-three were India Mark II and the other three were Afridev. Both pumps are deepwell handpumps capable of pumping from as deep as 90 m. The Afridev handpumps are all located in Mumbwa District. In all the study areas only two handpumps were not working the rest thirty-four handpumps were found good working condition.

The handpump maintenance arrangement in all districts visited is centered on Area Pump Menders (APMs) and Caretakers who are normally selected by the community and trained by the projects. Men and women have proved to be equally competent in conducting repairs. Preventive maintenance, such as greasing of the chain, is conducted by the pump Caretakers, but for fault diagnosis and repairs are done APM. If the APM is able to, he/she repairs the pump immediately or informs the pump committee which components they need to buy. In rural districts, if the fault is beyond the capabilities of the APM, the problem is reported to the District Council who would find a solution generally within ten days. In the peri-urban areas the approach is different. If the problem is beyond the area pump mender the community has to look for experienced contractors to repair the pump at their own cost. Municipal Councils do not assist peri-urban communities in carrying out repairs.

Figure 4.11: A woman pump mechanic repairing an Afridev handpump in Mumbwa District.

All the Caretakers and APMs are provided with an India Mark II or Afridev standard toolkit by the project, which they keep in their houses.

Spare parts are available from District Council stores, which are located at the District Council offices. These spares were left by the projects as initial required spares. There are also a number of private hardware stores, which have stocks of some spares within the Townships. Rural villages buy their spares from the Townships of may be required to travel to big towns to if the spares are not available in the nearby towns.

Other than the Caretakers and APMs, people in most communities had limited knowledge about common technical problems with their handpump. However a general observation was that rubber seals and pump rods remain a common problem. The rods easily break and drop in the hole especially where pump cylinder assembly was located below 40 metres. Once dropped a pump mender is normally called to fish them out. The stress on the rods seems very much related to the depth of borehole. The deeper the borehole the higher the risks of breaking. The down time did not exceed ten days at most handpump points.

In Sinazongwe District users complained of frequent requirement to replace RISING MAIN GI pipes due to corrosion (pipes developing pin holes) at nearly all handpump sites in the district. Frequent pump rod breaking was also reported. The District Council Office has expressed concern over the water table depth, which are as low 90 m in some cases. GI Riser pipes and rods are available from District Council Offices at reduced cost. This is a significant problem since groundwater levels are falling throughout the Province and additional pipes are often needed to increase the cylinder depth.

4.4.3 Institutional Sustainability

The WASHE strategy is multi-layered, multi-disciplinary model, which recognizes the need for institutional support for community management. Village level (V-WASHE) committees exist at user level and provide a framework for strategy development, training, capacity building, O&M and monitoring. This model works most effectively in some communities where there is dynamic management; where leadership is weak, handpump sustainability levels are usually low. Handpumps owned by the District Councils showed low levels of sustainability due to lack of operations control and careless handling from the users who normal do not pay for water service. On the other hand handpumps shared by institutions good income base (e.g. markets, farmers groups) and communities demonstrated fairly high levels of sustainability. However, where the institution dominated the maintenance committee the sense of community ownership became lost. Some handpumps in districts like Kabwe, Chibombo, Monze and Choma where there is better access to transportation, often, resulted in decreased downtime and consequently fairly higher levels of sustainability.

4.4.4 Social Sustainability

The study noted that communities appreciated that handpump water point was a safer source of drinking water than that from surface ponds or unprotected wells. They acknowledged that implementing agencies do sensitise them matters of hygiene and sanitation and their relation to safe water. Most handpumps installed in the past were brought as donations with very little no contribution from the users. They expressed happiness with the location of the pumps, access to the pumps and that pumps were easy to operate. However, raising funds for O&M is major problem, due to limited income generating opportunities.

Figure 4.12: Women drawing water from an India Mark II handpump at Tusombane Village in Sinazongwe District of Southern Province.

4.4.5 Environmental Sustainability

In Sinazongwe and Luangwa Districts there were reports of complaints of salty water in at nearly all handpump sites in the district. The District Council Office has expressed concern over the water table depth, which are as low 90m in some cases.

4.5 Private Sector

During the study, a general interview with private companies dealing with drilling boreholes, supply of and installation of handpumps and spares parts were conducted in order to analyse the different aspects of handpumps water supply systems sustainability from their side. Three private companies were visited namely, AFE Ltd, Aquagro Ltd. and SARO Ltd.

4.5.1 Financial Sustainability

Private companies visited reported that the cost of a handpump water system including drilling and handpump installation is about US$ 6,000 for an average 60 m deep fully cased and screened hole. The cost of the pump itself ranges between US$ 300 and US$ 1000 depending on specifications, whilst the prices of spare parts range from a few cents for nuts and rubbers seals up to about US$ 100 for handpump cylinder.

Visited dealers reported that negligible profit is made from handpump spare parts because of combination of low turnover and small profit margins, but felt that since the necessary infrastructure and systems are already in place for the provision and distribution of other pumps and related spares, it is a relatively easy option to add handpump spares to their product list.

Pump menders charge for their services and these fees often vary despite attempts by WASHE to standardise. A typical belowground repair labour cost is about 20,000 Kwacha (US$ 4.00). Spare parts are normally specified by the APM. The APM may supply the spare part if he/she has them in stock. If he/she does not have the required spare he would then request the pump community to buy it. Either the APM or the Caretaker or any member of the pump committee can do purchasing of spares. The travel costs if any are borne by the committee.

4.5.2 Technical/Environmental Sustainability

AFE Ltd, Aquagro Ltd. and SARO Ltd are private companies in Zambia, which specialize in water pumps, borehole services, swimming pools and water treatment equipment. The companies import handpumps and spare parts into the country. In addition they are involved in exploration, drilling and installation of handpumps. There are various handpump spare part outlets in provincial capital cities and other small towns nationwide, and any spare part for the Afridev or India Mark II handpumps can be purchased from these outlets. The Technology Development and Advisory Unit (TDAU) of the University of Zambia is a research and development institution in appropriate technology have in the past designed some handpumps which have even been field-tested. None of the designs is produced at commercial level due lack of local capacity to fabricate these pumps. The study noted that there is lack of product marketing capacity on the part of TDAU.

4.5.3 Institutional/Social Sustainability

The companies interviewed recognize the importance of promoting a supply chain network, both as a service and to promote future sales of handpumps. However given the scattered nature of rural settlements, communities have to travel more than 100 km to the nearest outlet. Access therefore still remains a constraining factor, especially for the more remote communities.

4.6 Handpump Data Evaluation.

Additionally a scoring system was developed to gauge pump condition and general pump site order. The scoring system was based on a developed numerical judgement scale ranging from 3 as a very good condition down to 0 as the worst situation as described in Chapter 3, Section 3.3 (see Table 4.7 foot note). The study was done through physical observation and interview with the caretaker by the researcher. The observation parameters were: whether the pump was working or not, platform, drainage, handle and spout condition, condition of the down hole parts like rising main, plunger, bearings and the general pump appearance including caretaker experience. All the 36 handpump water points covered in the study were included in this section of the research. Of the 36 sites visited, twelve (12) were in peri-urban and semi-urban areas, while twenty-four (24) were in rural areas (see detailed list in Appendix D.4). All the scores were recorded and average score calculated for each pump point. The results are presented in Table 4.7. Pump discharge capacity was also measured at every pump point.

It was found that all the pumps were India Mark II except for pumps 22, 23, and 24 which were Afridev. All the pumps had an average discharge of 1 m^3/hour regardless of the make of the pump. It was reported that in all the Afridev pumps were quite new and that they were installed in 2003.

From the handpump point evaluation results presented in table 4.7, on average the water points are kept fairly well, giving chance to higher levels of sustainability with a general an average score ranging from 2.5 to 3 except for pump 2 and 28 which are not working

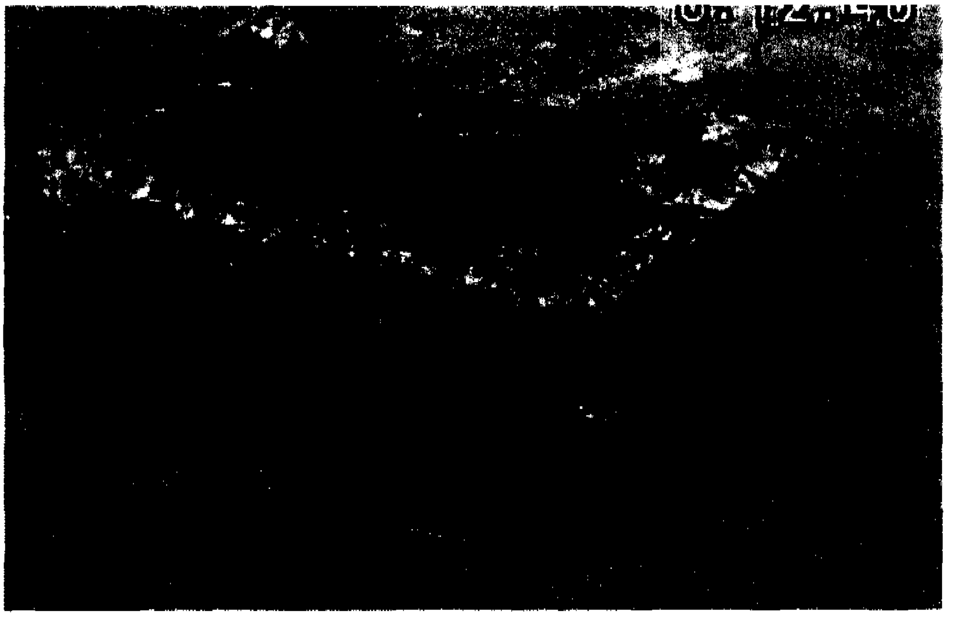


Figure 4.13: A sealed and abandoned borehole at Ngoma Community in Monze District

Table 4.7: Handpump water point evaluation results.

Pump Location	Condition											
	Working Condition	Platform	Drainage	Handle	Spout	Rising Main	Rod joints	Plunger	Bearings	General Pump appearance	Care taker	Avg
1	3	3	3	3	3	3	3	2	2	3	2	2.7
2	0	3	3	3	3	0	0	0	0	3	3	1.6
3	3	3	3	3	3	3	3	2	2	3	3	2.8
4	3	3	3	3	3	2	2	2	2	3	3	2.6
5	3	3	3	3	3	2	2	2	2	3	3	2.6
6	3	3	3	3	3	2	2	2	2	3	3	2.6
7	3	3	3	3	3	2	2	2	2	3	3	2.6
8	3	2	3	3	3	2	2	2	2	3	3	2.5
9	3	3	3	3	3	3	3	3	3	3	3	3
10	3	3	3	3	3	2	2	2	2	3	3	2.6
11	3	3	3	3	3	2	2	2	2	3	3	2.6
12	3	3	3	3	3	2	2	2	2	3	3	2.6
13	3	3	3	3	3	2	2	2	2	3	3	2.6
14	3	3	3	3	3	2	2	2	2	3	3	2.6
15	3	3	2	3	3	2	2	2	2	3	3	2.5
16	3	3	3	3	3	2	3	3	3	3	3	2.9
17	3	3	3	3	3	2	3	3	3	3	3	2.9
18	3	3	3	3	3	3	3	3	3	3	3	3
19	3	3	3	3	3	2	3	3	3	3	3	2.9
20	3	3	3	3	3	2	3	3	3	3	3	2.9
21	3	3	3	3	3	3	3	3	3	3	3	3
22	3	3	3	3	3	3	3	3	3	3	3	3
23	3	3	3	3	3	3	3	3	3	3	3	3
24	3	3	3	3	3	2	3	3	3	3	3	3
25	3	3	3	3	3	3	3	3	3	3	3	3
26	3	3	3	3	3	2	3	2	3	3	3	2.8
27	3	3	3	3	3	2	3	3	3	3	3	2.9
28	0	3	3	3	3	0	0	0	0	3	3	1.6
29	3	3	3	3	3	3	3	3	3	3	3	3
30	3	3	3	3	3	2	3	3	3	3	3	2.9
31	3	3	3	3	3	3	3	3	3	3	3	3
32	3	3	3	3	3	2	3	3	2	3	3	2.8
33	3	3	3	3	3	3	3	3	3	3	3	3
34	3	3	3	3	3	2	3	3	2	3	3	2.8
35	3	3	3	3	3	3	3	3	3	3	3	3
36	3	3	3	3	3	2	3	3	2	3	3	2.8

Condition Scale: 3-very good; 2-good; 1-fair; 0-bad

Figure 4.14: Handpump 2 at Chongwe Basic School looking intact but not working for the past one year.

4.7 Alternative Water Supply Sources Available.

This field study also made an observation with regards to other alternative sources of drinking water used in the study areas, and how far away these sources are located. Common alternative sources in the communities visited in the Luangwa and Kafue districts were the rivers and streams. In Chongwe alternative water sources were protected wells with rope and bucket and from untreated piped water from the Councils central supply system. In Mumbwa, Chibombo, Sinazongwe and Choma and Monze they got water from unprotected and protected well. Distances to these water sources ranged from 0 up to more than 5 kilometres.

Rainwater harvesting could be an alternative source although such a source will be seasonal (November to March). The trap is that, rainwater harvesting would require an extra investment to improve people's traditional grass thatched roofs to iron or asbestos roofing sheets in order to facilitate rainwater collection. Centralized piped water supply schemes with house connections, which require electrical installations would demand huge investments, which may be difficult to recover the operational costs from the rural communities who are predominantly poor. After all, the main reason for applying handpump water supply technology is because electricity is inaccessible and unaffordable for most rural communities in Zambia.

4.8 Water Carrying Vessels

Groundwater from protected and deepwells are generally of very good quality. However, as the users in the rural and semi-urban areas use different sizes and types of containers to fetch water from community handpumps to their households, the water is likely to be contaminated during this step. The use of clean vessels with proper cover is important to avoid contamination, so that water is kept safe until consumption. Hygiene education on handling of water vessels and how to keep the water safe at home are equally impotant to realize the total benefit of improved and safe water supply provisions. In this respect the study also made an observation of the vessels used by the communities to transport the water to their homes in order to establish the possible ways through which water can get contaminated during transportation. It was noted that households have some form of open vessels. The vessels used to carry water are mainly, open buckets, clay pots and calabashes. It was also noted that a good number of households have adopted the use of 20 liters plastic containers with lids that reduce chances of the water getting contaminated on the way.

4.9 Discussion

From the table 4.2 it is clear that government financial support to handpump water supplies project in Zambia is weak with an average financial sustainability score of 1.8. The sustainability of handpump water supply from the government financing policy point of view is in jeopardy. The handpump water supply projects are too dependent on external financial support with negligible contribution from the government. Communities on the other hand do not have the necessary organisational capacity to finance the O&M. Communities need continuous government support in order to effectively finance the handpump water supplies. To some extent though, the government through the District Councils do assist the communities in financing out major replacements costs from time to time when funds are available. Local development and promotion of appropriate water supply technologies require government investment in establishment of a research and development (R&D) fund in order to implement pilot studies to field test existing local pumping technologies. The field study reveals that there is no government financial support to R&D in handpump technology. Government commitment to financing community water supply is generally low. However, it is government policy to sensitise the communities in financial management in all community projects.

Technical sustainability of handpump water supply is also under threat in Zambia. Unlike in the neighbouring countries where indigenous handpumps have been developed and standardised, no such efforts are encouraged from the Zambian government. All handpumps and spares in the country are imported mainly from India. However, the Ministry of Local Government and Housing through the newly formed Rural Water Supply and Sanitation Unit are doing some deskwork to try and promote local manufacture of handpumps. The Government of Zambia has adopted handpump standardisation policy.

Though the Zambia Bureau of Standards is mandated to monitor the quality of goods and machinery imported, the field study revealed that handpump dealers refuse to give guarantee over handpumps or spares sold because they cannot claim compensation over defects identified in quality of manufacture. Evidently, there is no government policy to develop incentives that would encourage the private sector to participate in handpump design and fabrication O&M, including spares supply.

The study noted that several innovative handpumps have been developed in the past by the Technology Development and Adivisory Unit of the University of Zambia and private companies like Saro Ltd to secure a safe supply for rural communities in Zambia. However, the diffusion of this technology and its utilization has been constrained by the lack of local producers and the inability of communities to purchase the pumps. Imported handpumps from neighbouring countries are reported to be more expensive and less robust than those imported from India.

Sustainability of handpumps in Zambia is weakened by insufficient participation by government in monitoring and evaluation of community water supply projects. Monitoring, evaluation and review are very important to ensure the integration of the different sustainability factors. Monitoring is an ongoing process that should cover all levels of operation (from national governments to communities) and all aspects of rural water supply programmes (e.g. policy, institutions, finances, technology and O&M). At its most basic, monitoring should determine whether or not communities have access to water. It should also aim to assess management, operational, maintenance and environmental performance, for which measurable indicators must be set. Monitoring is necessary to determine overall success rates for a given programme, area or technology, and identify problems early in order to find timely solutions and pre-empt failures. Effective monitoring involves much more than data collection. It is important that data are evaluated and reviewed to inform decision-makers and to improve performance.

There exists though, an institutional framework established by government to coordinate community water supplies. District level coordination of community water supply is performed by the District Councils through D-WASHE committees.

Social sustainability of handpumps in Zambia is lack of clear policy to promote community participation in the implementation process of community based water supply projects. Communities are not given informed water supply technology options from which they can choose, participate in implementation, become owners and be responsible for managing the operation and maintenance of their chosen technology. What is observed from the field study is that communities are only pressured to follow the preferences of the Donors.

The field study noted that there is very little information with regards to groundwater resources in Zambia. Only in the recent past has the Government been making efforts to come up with a policy on groundwater resource mapping and monitoring. The sustainability is fundamentally linked to the water source used. A handpump water point will be sustained if the extraction does not exceed replenishment rate of the resource over the lifetime of the system. It is therefore essential that groundwater sources are assessed and the yield of potential wells and boreholes. Groundwater quality is equally important for sustainability of a handpump water point. If the consumption of water from a handpump water point has adverse health effects it can hardly be said to meet the definition of sustainability. Additionally if water quality is known correct handpump materials of construction can easily be selected. Groundwater quality monitoring should therefore be a continuous process.

From the score grid in Appendix C.2, it can be observed that the financing arrangement of the handpump projects weakens sustainability. The field study observed that some donor agencies still financed 100% of the total capital cost of handpump installation and thereafter leave the community to manage the O&M. This financing mechanism undermines community participation in contributing to the capital costs of their future water supply. Implementing agencies should endeavour to introduce in communities the sense of the need to pay for water service from the beginning. Community participation from early on stage enhances the future sense of ownership. The field study further observed that financial sustainability is further weakened by lack of planning for future O&M financing arrangement from as early as planning stage. At least all implementing agencies visited declined having any responsibility to support financing of O&M of the handpumps they have installed. The capital cost of installing an India Mark II or Afridev handpumps in Zambia is estimated at

US$ 6000. This amount is far beyond the affordable limits of the communities. The communities can never wholly fund handpump projects. Local government institutions also lack sufficient financial resources rely heavily on external support. Communities are also trained by the project in small business financial management, to assist them in their future role of providing community service.

The field study is concerned with the groundwater quality especially in Luangwa District in Lusaka Province and Sinazongwe in Southern Province where salt taste in water was reported. This might be resulting from natural inorganic parameters present in the geological formations, which are not tested by some implementing agencies. Analysis of water quality parameters of principal public health concern should be conducted for boreholes, prior to commissioning handpump water supplies. This is important in areas where water quality problems suspected with regards to high concentrations of health-related parameters such as arsenic, fluoride or lead, and particularly where mining activities are commonplace. If borehole water samples are found with concentrations outside those recommended by WHO guidelines for drinking water quality or local standards, the borehole may have to be abandoned or appropriate treatment systems installed, which may be expensive. Aesthetic parameters such as iron and manganese, which affect colour and taste, do not have any adverse health effects but, where present, may make it difficult to persuade users to accept a new water supply. Where there is community dissatisfaction this is likely to have a direct impact on their willingness to pay for and maintain their original water supply. It is only when the proper authority has pronounced the water safe to drink that it may be used by people.

5 Conclusions & Recommendations

5.1 Conclusions

Based on the literature study, field data collection and analysis the following conclusions can be drawn:

a. National Policy Agencies

- The perpetual dependence on donor financing by Government is generally putting all sustainability factors of handpump water supply systems at risk.
- The environmental sustainability of handpump water supply systems is the most affected due lack of environmental policy and strategies to guide groundwater exploitation and consequence of people consuming water of unknown and unpleasant quality in Luangwa and Sinazongwe districts.
- Institutional sustainability is also weak due to insufficient government participation in monitoring and evaluation of handpump water supply systems.
- The standardisation of handpump technology has however shown to be a positive step towards technical sustainability of handpump water supply systems in Zambia, although technical guidelines with respect to quality of handpumps supplies need to be put in place.
- The dependence on WASHE concept by government is not sufficient to guide development in this respect. Stakeholders, including the private sector, will find it difficult to participate in the absence of clear role definition.

b. Implementing Agencies

- There is lack of comprehensive approach to handpump water supply projects on the part of implementing agencies – one that focus on strengthening institutions to continue identifying the much needed technical and financial support to the community based organisations.
- The "project" approach in which implementing agencies (excluding UNICEF) install handpump systems, train the communities in financial management, technical skills and community mobilisation and leave is undermining of sustainability. Communities need uninterrupted motivation from all the supporting agencies including External Agencies and District Councils.

c. Users

- Cost recovery systems in some communities, especially those with steady income like markets and farmers groups, have shown to be very successful. This has been demonstrated by the high levels of household contributions and low down times of less than two days at such communities. Most community though are managing to maintain the operations of the handpumps with maximum down times of ten days.
- Because preventive maintenance is still not part of the community culture and the handpumps are used on a daily basis, more expensive spare parts may ware out and break prematurely thereby putting technical sustainability of handpump systems

under threat. However, Area Pump Menders and Caretakers who include men and women possess skills for most maintenance and repair works.

- Although spares parts for either India Mark II or Afridev are available in many outlets in urban areas, transport cost to access to spare parts still remains considerable disadvantage for the rural communities.
- Communities have demonstrated high levels of commitment to sustain handpump water supply, which has manifested in the high levels institutional and social sustainability, nearly in all districts visited. Other than handpumps which are owned by institutions such as schools, clinics and the councils where caretakers are salaried employees of such institutions, community caretakers are purely undertaking a voluntary responsibility.

d. Private Sector

- Drilling cost of borehole is substantially higher than the cost of handpump. It is to be noted that this is one of the major constraints in expanding water supply coverage in rural and semi-urban areas.
- Other than drilling and installation of handpumps, the private sector in rural and semi-urban areas traders are generally traders with little or no capacity to engage in local fabrication of handpumps and spares. Initiatives for local manufacturing of handpumps should be taken by big industries with support from the government.
- Distribution of spare parts by the small private retailers still remains a problem because of low profits.

5.2 Recommendations

Based on the results and conclusions obtained from this study the following recommendations can be made:

- Government must develop strategies to mobilise resources from it own budget or from donors and the private sector either in cash or in kind to support the rural handpump water supply schemes.
- The government should take the lead in the sector for policy and strategy development, coordination and facilitating for NGOs, ESAs, District Councils and the private sector to deliver water and saniation services.
- Strategies for continuous monitoring and evaluation of handpump water supply systems in order to assess management, operational, maintenance and environmental performance must be put in place by the government.
- WASHE concept is not a Zambian Government policy but an interim measure adopted from UNICEF to coordinate the rural water supply activities. The WASHE concept does not have legal mandate to guide government in planning development planning the rural areas. Therefore there is an urgent need for the government to come up with a policy and strategies for rural water supply and sanitation.
- District Councils, NGOs, External agencies and the private sector should carry out the implementation work and provide training and retraining to the beneficiary

communities. The handover process to the users should not be immediately after the project but properly planned for it to succeed.

- Implementing agencies must focus on continuously strengthening the community based handpump committees and waging campaigns to promote preventive maintenance.
- Sustainable spare parts supply chain to the rural community should be worked out in the project planning process.
- Water quality from handpumps in Luangwa and Sinazongwe districts requires serious consideration. The water quality must be tested in order to determine the risks emerging from the reported salty taste. In this respect the study recommends that water quality testing should be a must in all handpump projects.
- In the case of O&M, full costs should be borne by the users with continuous support from Government, Implementing Agencies and the District Councils.
- Preventive maintenance must become part of community culture, so that routine maintenance can be carried out as a more integral and ongoing part of handpump water supply activities.
- As the main stakeholders, the users should be involved fully in decision-making process, planning physical implementation, cost sharing and management of O&M.
- Drilling cost should be reduced through optimisation of well design (e.g drilled wells yielding 1 m^3/h should be acceptable), adoption of appropriate low cost drilling or digging options, uPVC casing and screen pipes and selection of minimum well diameter.
- The private sector should be encouraged to provide a complete package including drilling, handpump supply and installation and after sale service.
- All parties involved in handpump water supply must support the efforts by TDAU of the University of Zambia in order to locally manufacture handpumps in Zambia.

5.2.1 Suggestion for Further Study

- Study the actual cost of operation and maintenance for both rural and semi-urban handpump water supply system.
- Investigate the possibility of Private Sector Participation in operation and maintenance of handpumps located in semi-urban areas in combination with the piped water systems.

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APPENDIX

7 Appendices

Appendix A: Questionnaires for Field Study

Appendix A.1: Questionnaire for National Policy Agencies

Office Name:
Place:
Province:
Date:
Person Contacted:

General Introduction

- Is there any national water supply policy in the sector strategy?
- Does the policy consider handpump water supply as an option to increase the service coverage?
- What are the current rules, regulations and by-laws that can affect handpump water supply programmes?
- What is the current water supply coverage by handpumps?

Financial Sustainability

- What is the national policy towards handpumps capital costs?
- What is the policy towards regular (day to day) handpumps O&M costs (labour, electricity general)?
- What is the policy towards major replacements costs (e.g. cylinder assembly, rising main, pump rod or handpumps)?
- Is there a policy regulations with regards to community training in financial management?
- Is there a policy to financially support for research and development of handpumps of technology?

Technical Sustainability

- Is there a policy to promotion of handpump technology in country?
- Is standardisation of handpumps promoted in the country?
- Is there a system of handpump quality inspection?
- Is there a design criteria with regards to population per handpump and spacing?
- Is local design and manufacture of handpumps and spare parts supported?
- Is Private Sector participation in handpumps water supplies encouraged?
- What other groundwater water lifting options are being promoted?

Institutional Sustainability

- What are the institutional roles of different agencies (National Government/ Local Authorities/ Water Supply/ NGOs) in development and implementation of handpump projects?
- Is there a regulatory mechanism for external support for handpump projects?
- Is there a policy to stimulate private sector participation in handpump water supply?

Social Sustainability

- Is there any health awareness policy with regards to water and sanitation?
- Policy on participatory approach in handpumps project execution
- What policy is there to promote social equity?

Environmental Sustainability

- Is there a policy on groundwater monitoring?
- Is there a policy on groundwater exploitation?
- Are there technical National Guidelines with regards to borehole drilling and installation of handpumps?

Appendix A.2: Questionnaire for Implementing Agencies

Name of Institution:
Place:
District & Province:
Date:
Person Contacted:

Financial Sustainability

- What is the total capital cost a handpump water supply point (India Mark II/ Afridev)?
- How are they actually financing the handpump water supply?
- Is there any capital cost sharing with the users (e.g. labour, construction materials)/ are users already involved at the construction phase?
- Is any fund set-up for O&M (at the start or after completion of construction)?
- Is there O&M costs sharing (100% by users, 20% by users etc. or 100% by IA)?
- Is there any training offered to the community in financial management?

Technical Sustainability

- Who selects the water supply technology (are alternative technologies considered)?
- What is the design criteria for the handpump i.e. population served per pump/ distance between the pumps (e.g. 10 families per pump/1 pump every 1 kilometre)?
- Are users given any training with regards to handpump maintenance?
- What support is provided towards O&M and for how long?
- Is handpump guarantee required from the supplier and so how long is it valid?
- Is any caretaker selected by the implementation agency and maintenance tools provided?

Institutional Sustainability

- How are handpump projects initiated (by users or by Donor/Government)?
- At what stage are users involved in the project?
- How are the users involved?
- What is their after completion of the project and handover to the users/ Governments?
- Does the implementing agency conduct any project monitoring and evaluation once the pump is installed?

Social Sustainability

- Did the communities receive training in hygiene?
- How were the participants selected?

Environmental Sustainability

- What is the criterion for determining the number of users per pump?
- Are there standard guidelines for handpump installation?
- Water is the yield of the aquifer in the pump area?
- What is the depth of the borehole?
- Who did the exploration and borehole siting and what instruments were used?
- What is the success rate of drilling?
- Is there a problem with borehole drying?
- Have any boreholes been rehabilitated?
- Is chemical composition of the water tested during drilling?
- Is bacteriological quality of water tested?
- Is borehole dissinfection done?
- Is the borehole construction report prepared?

Appendix A.3: Questionnaire for Handpump Users

Community Name:
Town/Village Name:
District:
Province:

Financial Sustainability

- Did users participate in planning of financing arrangements?
- Did users pay towards capital cost?
- How much do handpump users pay currently towards handpump use?
- Are users willing to pay i.e. happy with the service level?
- Can users afford to pay the user fee i.e. what is average income level for users?
- How is money collected (e.g. is it collected every month from everyone or when one can afford to pay/ is it paid in cash, in kind or both/who collects it/ who keeps the account)?
- Where is the money kept (in the bank / with the caretaker / headman / CBO)?
- Is there sufficient revolving fund for O&M?
- Who pay for major replacements? What is the cost limit to distinguish between major and minor replacements?
- Are finances accounted for and if so to whom and how often i.e. is there an auditing system in place?
- Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in financial management? How many?

Technical Sustainability

- Were users involved in choice of: level of service/handpump?
- Did users participate in planning, monitoring and control of construction and handpump installation process?
- Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in O&M of the handpump? How many?
- Does anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) carryout preventive maintenance and how often?
- What are the common O&M problems with the pump and how often?
- What do users do when the pump breaks down?
- What level of skill do the users possess in repair of handpump (e.g. repair of cylinder assembly)?
- How long does the pump typically remain broken before it is repaired?
- Do they have the tools to do maintenance and repairs?
- Are spare parts available and affordable when needed?
- Who does the major repairs?
- Does the handpump produce sufficient water?c. Institutional Sustainability
- Who owns the handpump?
- Is there a formal organisation responsible for managing the handpump. (Yes there is handpump committee/ just a caretaker or pump technician / no formal handpump maintenance)?
- If there a committee do are the rules with regards to equity in participation and leadership?
- How are the rest of the community's views incorporated in decisions?
- What system is in place for O&M (centralised/decentralised)?
- What is the procedure when the handpump breaks down?
- Did the pump technician receive training and if so how were they selected?
- Who selected the pump technician?
- Does the community have any system of communication with the local authority or the implementing agency?
- Does the community have any pump performance monitoring and evaluation mechanism?

Social Sustainability

- What was the source of water before the handpump was installed?
- Were they happy with the water source?
- Did anyone explain why they should abandon their water source for the handpump?
- Who and how was the pump brought to the community?
- What role did they play in bringing the handpump water supply to the community?
- Are they happy with the location of pump?
- Are there any restrictions to access the pump?
- Is the pump easy to operate?
- Does the pump give them enough water for users' needs?
- Who gets the water from the pump to the household (women/children/men)?
- What benefit(s) has the handpump water supply brought to them?
- Do they feel the handpump water supply should be paid for?
- Are users happy with the way their money is used?
- Do men and women participate equally in the affairs the pump?
- What do they think is the problem with the pump?
- Where do they get water when the pump breaks?

Environmental Sustainability

- How many households are using the handpump?
- How much water per day does a typical household use?
- How far is the furthest household from the pump?
- How often do they use the pump (How many times do they come to fetch water)?
- How long do they have to wait at the pump before they can fetch water?
- Do the users like the taste of water?
- Does the taste/colour of the water change with the season?
- Does the water quantity from the pump vary with the season?
- Who cleans the area around the pump?

Appendix A.4: Questionnaire for Private Sector

Company/Enterprise/Individual Name:
Business Type:
Place:
District & Province:
Date
Person Contacted:

Financial Sustainability

- What is the cost of drilling a borehole?
- Are handpumps available and what is their cost (e.g. India Mark II, Afridev etc.)?
- Are spare parts available and what are their costs (e.g. U-seal, O-rings, plunger, foot valve, bearings etc.)?
- Who are their customers for pumps/spare parts?
- What is the realistic O&M cost of a handpump?
- Is the handpump/spare parts business making profit?

Technical Sustainability

- Which model of handpumps/spare parts do they stock?
- How long have they been in business?
- Did they receive any support from ESAs/Govt towards the business?
- Do they the full range of spare parts?
- Where do they purchase their supplies from?

Institutional Sustainability

- What jobs are contracted to the private sector?
- How are the private sector contracted?
- How are private pump menders contracted?
- How many pump technicians are available in the area?
- Can handpump menders conduct major repairs?
- What does they do when they fail to repair?
- How many pumps do they work on in a month?
- How are the paid (cash or in kind)?
- Do they earn enough from pump repair for their living if not why?
- Do they have other employment?

Social Sustainability

- Are there local blacksmith in the area?
- What implements do they make?
- Do they sale their produce?
- What contribution do they make towards handpump maintenance?
- Is water vending a common practice?
- Do they get water from the handpump?
- Do they pay for the water?

Environmental Sustainability

- Are borehole construction reports mandatory?

Appendix A.5: Handpump Data Collection Form

Handpump Location:
Name of Village/Community:
District & Province:
Type of Pump (model, make, country of origin and supplier' name):
Date of Installation: By:
Name of Contractor:
Date:

Observation	**Condition**	**Problem**
Pump working?		
Platform		
Drainage		
Handle		
Spout		
Rising main (material: uPVC, Steel, GI)		
Rod joints		
Plunger Seal and O-rings		
Valves		
Bearings		
General Pump Appearance		
Caretaker/ Mechanic		

Appendix B: Scoring System

Appendix B.1: Scoring System for National Policy Agencies

Financial Sustainability	a. What is the national policy towards handpumps capital costs?	1. Dependence on ESA for financing handpumps capital costs 2. Finance handpumps capital costs in partnership with the private sector 3. Allocation of a percentage of the national budget towards financing of handpumps capital costs
	b. *What is the policy towards regular* (day to day) handpumps O&M costs (labour, electricity general)?	1. *Users to finance 100% of handpumps O&M* 2. Dependence on donor/NGO cooperation to support community efforts 3. Government support user efforts to finance handpump O&M
	c. What is the policy towards major replacements costs (e.g. cylinder assembly, rising main, pump rod or handpumps)?	1. Leave it up to the community to finance major replacements 2. Local government or NGO/ Implementing agency do major replacements 3. The Government undertakes all parts replacements of rehabilitative nature
	d. Is there a policy regulation with regards to community training in financial management?	1. No 2. Policy in place but not practiced 3. The policy is there and is being practiced
	e. Is there a policy to financially support research and development of handpumps of technology?	1. The policy is there but is not coordinated 2. The policy is there but there no money to support R&D 3. The policy is there and R&D is funded
Technical Sustainability	a. Is there a policy to promotion of handpump technology in country?	4. The policy is being formulated 5. The policy is there but is not little is done to promote it 6. The policy is there and promotion is going on
	b. Is standardisation of handpumps promoted in the country?	1. Several pumps are being standardised 2. Two to three pumps are being standardised 3. Only one type of pump is being standardised
	c. Is there a system of handpump quality inspection?	1. The system exists but is not enforced 2. It is up to the handpump/or spare parts importer to carry out inspection 3. All handpumps/spare parts are inspected and inspection certificate issued prior to shipment in the country.
	d. Is there a design criteria with regards to population per handpump and spacing of handpumps?	1. No criteria in place, donors determine who to give a pump 2. *More than three hundred (300) people per pump* 3. Less than three hundred people (300) people per pump

	e. Is local design and manufacture of handpumps and spare parts supported?	1. It is up to the private sector to take up the business 2. The government has a private sector support programme but poorly coordinated 3. The government is fully in support of local design and manufacturing of handpumps and spares
	f. Is Private Sector participation in handpumps water supplies encouraged?	1. No 2. In some areas government gives loans to those wishing to participate 3. The government gives loans to those wishing to participate
	g. What other groundwater water lifting options are being promoted?	1. None 2. Electrical pumps 3. Improved traditional methods
Institutional Sustainability	a. What are the institutional roles of different agencies (National Government/ Local Authorities/ Water Supply/ NGOs) in development and implementation of handpump projects?	4. None 5. Installation and rehabilitation of handpumps 6. Installation and rehabilitation of handpumps and supporting handpump O&M in communities
	b. Is there a regulato mechanism for externally supportedandpump projects?	1. None 2. Donors are suppose to cooperate with government in their development projects but not always 3. Every donor project is regulated by the government
Social Sustainability	a. Is there any health awareness policy with regards to water and sanitation?	1. None 2. Donors do that in their WSS projects 3. The government is fully involved in this campaign in all districts
	b. Is there a policy on participatory approach in handpumps project execution?	1. None 2. Donors do that in their WSS projects 3. All community projects must be adopted through participatory approaches as a government policy
Environmental Sustainability	a. Is there a policy on groundwater quality and/or level monitoring (i.e well field protection or zoning regulation)?	1. None 2. The government is drafting a policy to this effect 3. Yes there is a policy being enforced
	b. Is there a policy on groundwater exploitation?	1. None 2. The government is drafting a policy to this effect 3. Yes there is a policy being enforced

Appendix B.2: Scoring System for Implementing Agencies

Financial Sustainability	a. How are they actually financing the handpump water supply projects?	1. Implementing Agency finances 100% of the project and demand nothing from the users 2. Implementing Agency demand cash or in kind contribution towards capital cost from users 3. Users initiate capital contributions and are supplemented by Implementing Agency
	b. What is the total capital cost of a handpump water supply point (India Mark II/ Afridev)?	1. More than US$ 6000 2. Between US$ 3000 and US$ 6000 3. Below US$ 3000
	c. Are the users required to contribute towards capital costs (e.g. labour, construction materials)/ are users already involved at the construction phase?	1. Implementing Agency does everything and users wait for handover 2. Users participate in construction and contribution of materials 3. Users initiate the construction and are helped by the Implementing Agency
	d. Is any fund set-up for O&M (at the start or after completion of construction)?	1. No fund set-up for O&M after completion of construction 2. The Implementing agency set-up a fund for O&M after completion of construction 3. Users set-up fund for O&M after completion of construction
	e. Is there O&M costs sharing (100% by users, 20% by users etc. or 100% by IA)?	1. 100% by Implementing Agency 2. 100% by Users 3. Shared between users and Implementing agency
	f. Is there any training offered to the community in financial management?	1. No training is offered to users in financial management 2. Only the Caretaker/Headman/Treasurer is trained 3. The whole community is sensitised in financial mobilisation and management
Technical Sustainability	a. Who selects the water supply technology to be used?	1. The Implementing Agency 2. The Implementing Agency in consultation with the users 3. The users make informed choices
	b. Are alternative water supply technologies considered)?	1. Only handpump water supply technology is considered 2. Only handpump is considered with an explanation of what is expected of O&M 3. Improvement of traditional technologies is considered as an options

	c. What is the design criteria for the handpump i.e. population served per pump; distance between pumps locations (e.g. 10 families per pump/1 pump every 1 kilometre)?	1. Pumps are installed without any consideration of number of people to be served 2. 300 – 400 People per pump 3. Less than 300 people per pump
	d. Are there standard guidelines provided for handpump installation?	1. There no standards to guide handpump installation in the country 2. Standards are there but not enforced 3. Standards are there are they are enforced
	e. Are users given any training with regards to handpump maintenance?	1. The Implementing Agency does not give training in handpump O&M to users 2. Training is given when funds are enough but not always 3. Training in handpump maintenance is always part of the handpump project
	f. What support is provided towards O&M and for how long?	1. The Implementing Agency only supports the installation of the handpump 2. The Implementing Agency provides a maintenance tool kit and nothing else 3. The Implementing Agency supports O&M for until the community can manage it for themselves
	g. Is handpump guarantee required from the supplier and for how long is it valid?	1. No guarantee is given 2. A guarantee is given for one month 3. A guarantee is given for 1 year
	h. Is any caretaker selected by the implementation agency and maintenance tools provided?	1. No caretaker selected 2. Caretaker selected by the Implementation Agency and tool kit provided 3. Caretaker selected by the community and tool kit provided.
Institutional Sustainability	a. How is the project area selected (initiated and requested by users/ initiated by Donor/Government in consultation with users/ just brought to users byDonor/Government)?	1. Just brought to users by Donor/Government 2. Initiated by Donor/Government in consultation with users 3. Initiated and requested by users
	b. At what stage are users involved in the project?	1. At handpump project handing over 2. At handpump project implementation 3. At handpump project identification
	c. How are the users involved?	1. Not involved in anything 2. Provision of labour for construction of system and facilities 3. Decision making

	d. What is their role after completion of the project and handover to the users/ Governments?	1. Drawing water from the pump only 2. 100% responsible for management of operation and maintenance and their costs 3. Management of operation and maintenance while being assisted by the Implementing agency
	e. Does the implementing agency conduct any project monitoring and evaluation once the pump is installed?	1. Never 2. When funds are available 3. Always
Social Sustainability	a. Did the communities receive training in hygiene and sanitation?	1. Not part of the project 2. If the funds allow 3. All water projects carry this component
	b. If the community received training, how were the participants selected and how many (***social mix***: *men/women; rich/poor; same tribe/ different tribes*)?	1. Only the influential in the community 2. The community choose who should attend training in consultation with the implementing agency 3. All members of the community are sensitised equally
Environmental Sustainability	a. Who does the exploration and borehole setting and what instruments were used?	1. No need for exploration 2. Traditional water finders 3. Professional Hydrogeologists
	b. What is the success rate of drilling?	1. Less than 50% 2. Between 50% and 90% 3. Above 90%
	c. Is there a problem with borehole drying?	1. More than 50% 2. Less than 50% 3. Never
	d. Have any boreholes been rehabilitated?	1. Never 2. Sometimes 3. All broken down boreholes are rehabilitated
	e. Is any chemical test done to the water?	1. Never 2. Sometimes 3. All the time
	f. Is bacteriological quality of water tested?	1. Never 2. Sometimes 3. All the time
	g. Is borehole disinfection done?	1. Never 2. Sometimes 3. All the time

	h. Is the borehole construction report prepared?	1. Never 2. Sometimes 3. All the time

Appendix B.3: Scoring System for Handpump Users

Financial Sustainability	Did users participate in planning of financing arrangements?	1. Users not asked to participate in financial planning towards the pump 2. Users asked to participate in financial planning towards the pump 3. Users initiated financial planning towards the pump
	Did users pay towards capital cost?	1. Users did not make any financial or in kind contribution towards the pump 2. Users made significant contribution in kind 3. Users made significant financial contribution
	How much do handpump users pay currently towards handpump use?	1. Users pay nothing towards pump use 2. Some Users pay towards pump use 3. All users pay towards pump use
	Are users willing to pay i.e. happy with the service level?	1. Users are not willing to pay towards the pump maintenance 2. Some Users are willing to pay towards the pump maintenance 3. All users are willing to pay towards the pump maintenance
	Can users afford to pay the user fee i.e. what is average income level for users?	1. Users can not afford to pay towards the pump maintenance 2. Some users can afford to pay while some cannot. 3. All users can afford to pay
	How is money collected (e.g. is it collected every month from everyone or when one can afford to pay/ is it paid in cash, in kind or both/who collects it/ who keeps the account)?	1. Collected in kind when one can afford 2. Collected every month in cash and in kind 3. Collected every months from everyone in cash
	Where is the money kept (in the bank / with the caretaker / headman / CBO)?	1. Buried in a tin 2. Kept by the Caretaker/Headman/CBO Treasurer 3. In the Bank
	Is there sufficient revolving fund for O&M?	1. No money for O&M 2. There is money but not enough for O&M 3. There is enough money for O&M
	Who pay for major replacements?	1. Nobody pays for major replacements 2. The Council/Donor/NGO pays for major replacements 3. The User fund can pay for major replacements
	Are finances accounted for and if so to whom and how often i.e. is there an auditing system in place?	1. Users are never informed of how the money is used 2. Users are informed when they request 3. There is a financial accounting system in place

	Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in financial management? How many?	1. Nobody is trained in financial management 2. The Caretaker/Treasurer/Headman/CBO Member(s) has financial management experience. 3. The project trained CBO members in financial management and are practicing what they learnt
Technical Sustainability	Were users involved in choice of: level of service/handpump?	1. The pump was just given, users not given a choice level of service/handpump 2. Users asked to make a choice on the level of service they required 3. Users initiated the project and are given the level of service they require
	Did users participate in planning, monitoring and control of construction and handpump installation process?	1. Users not asked to participate in planning, monitoring and control of construction and handpump installation. 2. Users asked participate in planning, monitoring and control of construction and handpump installation. 3. Users initiated in planning, monitoring and control of construction and handpump installation.
	Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in O&M of the handpump? How many?	1. Nobody is trained in O&M of the handpump 2. The Treasurer/Headman/CBO Member(s)/Area Pump Mender has experience in O&M of the handpump. 3. The project trained CBO members/ Area Pump Menders in O&M of the handpump and are practicing what they learnt
	Does anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) carryout preventive maintenance and how often?	1. No preventive maintenance is carried out on the pump 2. Some preventive maintenance being carried out but not regularly 3. Regular programme of preventive maintenance done
	What are the common O&M problems with the pump and how often?	1. Failure of the main parts like rising main, plunger, foot valve more than twice a year 2. Failure of minor parts like rubber seals more than twice a year 3. Failure of minor parts not more than twice a year
	What do users do when the pump breaks down?	1. Abandon the pump 2. Wait until the Area Pump Mender comes to repair 3. The Caretaker does the repair
	What level of skill do the users possess in repair of handpump (e.g. repair of cylinder assembly)?	1. Know nothing 2. Some technical skills available for maintenance but not all 3. Technical skills for all maintenance processes available
	How long does the pump typically remain broken before it is repaired?	1. A week or more 2. Less than one week 3. One day

	Do they have the tools to do maintenance and repairs?	1. No tools 2. Some tools but not all 3. All the tools are there
	Are spare parts available and affordable when needed?	1. Spares are not available 2. Some spare are available but not for all repairs 3. All spares are available for all repairs
	Who does the major repairs?	1. Nobody is there to do major repairs 2. Major repairs are done by external agency 3. Major repairs are done by users
	Does the handpump produce sufficient water?	1. The pump does not give sufficient water all the seasons 2. The pump only gives sufficient water in the season 3. The pump gives sufficient water all the time
Institutional Sustainability	Who owns the handpump?	1. The pump belongs to an external agency 2. The pump belongs to the local authority 3. The pump belongs to the users
	Is there a formal organisation responsible for managing the handpump.	1. No formal handpump committee 2. Just a caretaker /pump technician 3. There is a handpump committee
	How are the rest of the community's views incorporated in decisions?	1. No need for community views 2. Only community representatives are invited for pump meetings 3. Open meetings are held from time to time to get user views on the pump affairs
	What system is in place for O&M (centralised/decentralised)?	1. The is no O&M system in place 2. Centralised 3. Decentralised
	Who selected the pump technician?	1. By the external donor 2. By the local authority 3. By the users
	Does the community have any system of communication with the local authority or the implementing agency?	1. There is no communication with the local authority 2. Only political representatives communicate with the users 3. The users have regular communication with the local authority
	Does the community have any pump performance monitoring and evaluation mechanism?	1. There is no such a thing as pump performance monitoring and evaluation mechanism 2. The local authorities come to do pump performance monitoring and evaluation once in a while 3. The caretaker does pump performance monitoring and evaluation periodically

Community/ Social Sustainability	What was the source of water before the handpump was installed?	1. A near protected well/handpump with clean with clean water 2. A near by unprotected/perennial stream 3. A distant unprotected well/perennial stream
	Were they happy with the water source?	1. Yes 2. It did not matter 3. No
	Did anyone explain why they should abandon their water source for the handpump?	1. No one 2. Someone explained but not everyone understood 3. Some explained and everyone believes handpump water is better for drinking
	Who and how was the pump brought to the community?	1. The pump was brought by an external agency without consultation with the users 2. The pump was brought by the external agency in consultation with the users 3. The pump was project was initiated and requested by the users
	What role did they play in bringing the handpump water supply to the community?	1. Nothing 2. Construction cheap labour 3. Planning, material contribution and labour
	Are they happy with the location of pump?	1. No 2. They had no choice 3. Yes they are happy
	Are there any restrictions to access the pump?	1. Not everyone is allowed to use the pump 2. Everyone is allowed to use the pump but it is sometimes locked 3. Everyone uses the pump whenever they need water
	Is the pump easy to operate?	1. The pump is too complicated to operate 2. It is easy to operate but requires too much effort 3. It is very easy to operate
	Who gets the water from the pump to the household (women/children/men)?	1. Only men 2. Only women and children 3. Children/Women/Men
	What benefit(s) has the handpump water supply brought to them?	1. Nothing 2. Clean water for good but with a burden of paying maintenance costs 3. No more water borne diseases and walking long distances
	Do they feel the handpump water supply should be paid for?	1. Handpump water must be free 2. The government must half of the maintenance cost 3. Water must be paid for in order to meet maintenance costs

	Are users happy with the way their money is used?	1. People do not trust those who collect the money 2. Those collecting the money are trusted but do not produce financial reports 3. People are happy with the way the money is used
	Do men and women participate equally in the affairs the pump?	1. Women are not allowed in management of pump affairs 2. Women are only take part in meetings of lower level 3. Men and women both participate in meetings of lower and higher level management
	What do they think is the problem with the pump?	1. The pump fails too often 2. The pump maintenance cost is too high but manageable 3. The pump maintenance costs is manageable
	Where do they get water when the pump breaks?	1. A near protected well/handpump with clean with clean water 2. A near by unprotected/perennial stream 3. A distant unprotected well/perennial stream
Environmental Sustainability	How many households are using the handpump?	1. More than 50 2. Between 40 and 50 3. Less than 40
	How far is the furthest household from the pump?	1. Beyond 1 km 2. Between 500m and 1 km 3. Less than 500m
	How often do they use the pump (How many times do they come to fetch water)?	1. Three times or more 2. Twice 3. Once
	How long do they have to wait at the pump before they can fetch water?	1. More than 1 hour 2. Between 30 minutes to 1 hour 3. Less than 30 minutes
	Do the users like the taste of water?	1. Bad taste 2. Just okay 3. Tastes very nice
	Does the taste/colour of the water change with the season?	1. Changes to the waste in some season 2. It does but not easily noticeable 3. Never changes
	Does the water quantity from the pump vary with the season?	1. The borehole dries up in the dry season 2. Reduces in dry season but not drying up 3. Never changes

Appendix C: Evaluation Score Grids

Appendix C.1: Evaluation Score Grid for National Policy Agencies

Financial Sustainability	a. What is the national policy towards handpumps capital costs?	1	
	b. What is the policy towards regular (day to day) handpumps O&M costs (labour, electricity general)?	1	
	c. What is the policy towards major replacements costs (e.g. cylinder assembly, rising main, pump rod or handpumps)?	2	
	d. Is there a policy regulation with regards to community training in financial management?	3	
	e. Is there a policy to financially support research and development of handpumps of technology?	2	1.8
Technical Sustainability	a. Is there a policy to promotion of handpump technology in country?	2	
	b. Is standardisation of handpumps promoted in the country?	2	
	c. Is there a system of handpump quality inspection?	2	
	d. Is there a design criteria with regards to population per handpump and spacing of handpumps?	3	
	e. Is local design and manufacture of handpumps and spare parts supported?	1	
	f. Is Private Sector participation in handpumps water supplies encouraged?	1	
	g. What other groundwater water lifting options are being promoted?	3	2
Institutional Sustainability	a. What are the institutional roles of different agencies (National Government/ Local Authorities/ Water Supply/ NGOs) in development and implementation of handpump projects?	2	

	b. Is there a regulatory mechanism for externally supported handpump projects?	1	1.5
Social Sustainability	a. Is there any health awareness policy with regards to water and sanitation?	2	
	b. Is there a policy on participatory approach in handpumps project execution?	2	2
Environmental Sustainability	a. Is there a policy on groundwater quality and/or level monitoring (i.e well field protection or zoning regulation)?	1	
	b. Is there a policy on groundwater exploitation?	1	1
		1.78	

Appendix C.2: Evaluation Score Grid for Implementing Agencies

		EXTERNAL AGENCIES								DISTRICT GOVERNMENT AGENCIES									
	IMPLEMENTING AGENCY	Z	W	U	K	O	J	Af	CI	CD	LD	KD	KW	ChD	MD	SD	CW	MoD	Mode
Financial Sustainability	a. How are they actually financing the handpump water supply projects?	1	1	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	**1**
	b. What is the total capital cost of a handpump water supply point (India Mark II/ Afridev)?	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	**2**
	c. Are the users required to contribute towards capital costs (e.g. labour, construction materials)/ are users already involved at the construction phase?	2	2	2	1	1	2	1	1	2	2	2	2	2	2	2	2	2	**2**
	d. Is any fund set-up for O&M (at the start or after completion of construction)?	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	**1**
	e. Is there O&M costs sharing (100% by users, 20% by users etc. or 100% by IA)?	2	2	3	2	2	2	2	2	3	3	3	1	3	3	3	1	3	**3**
	f. Is there any training offered to the community in financial management?	3	3	3	3	3	3	1	3	2	2	2	1	2	2	2	1	2	**3**
	Average Score	**1.8**	**1.8**	**2.5**	**1.7**	**1.7**	**2**	**1.3**	**1.7**	**1.8**	**1.8**	**1.8**	**1.3**	**1.83**	**1.8**	**1.8**	**1.3**	**1.83**	**1.8333**
Technical Sustainability	a. Who selects the water supply technology to be used?	1	3	3	3	1	2	1	1	1	1	1	1	1	1	1	1	1	**1**
	b. Are alternative water supply technologies considered)?	1	3	3	3	1	1	1	3	1	1	1	1	1	1	1	1	1	**1**
	c. What is the design criteria for the handpump i.e. population served per pump; distance between pumps locations (e.g. 10 families per pump/1 pump every 1 kilometre)?	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	**3**
	d. Are there standard guidelines provided for handpump installation?	3	3	3	1	1	3	1	3	3	3	3	3	3	3	3	3	3	**3**
	e. Are users given any training with regards to handpump maintenance?	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	**3**

	f. What support is provided towards O&M and for how long?	2	1	3	2	2	1	2	2	3	3	3	1	3	3	3	1	3	3
	g. Is handpump guarantee required from the supplier and for how long is it valid?	3	1	2	1	3	3	1	3	1	1	1	1	1	1	1	1	1	1
	h. Is any caretaker selected by the implementation agency and maintenance tools provided?	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Average Score	**2.4**	**2.4**	**2.9**	**2.4**	**2.1**	**2.4**	**1.9**	**2.6**	**2.3**	**2.3**	**2.3**	**2**	**2.25**	**2.3**	**2.3**	**2**	**2.25**	**2.25**
Institutional Sustainability	a. How is the project area selected (initiated and requested by users/ initiated by Donor/Government in consultation with users/ just brought to users byDonor/Government)?	2	3	3	2	3	2	2	3	2	2	2	2	2	2	2	2	2	2
	b. At what stage are users involved in the project?	3	3	3	2	3	2	2	3	3	3	3	2	3	3	3	2	3	3
	c. How are the users involved?	2	3	3	2	2	3	2	2	3	3	3	2	3	3	3	2	3	3
	d. What is their role after completion of the project and handover to the users/ Governments?	2	2	3	2	1	2	2	2	3	3	3	1	3	3	3	1	3	3
	e. Does the implementing agency conduct any project monitoring and evaluation once the pump is installed?	1	2	2	1	3	3	1	3	3	3	3	1	3	3	3	1	3	3
	Average Score	**2**	**2.6**	**2.8**	**1.8**	**2.4**	**2.4**	**1.8**	**2.6**	**2.8**	**2.8**	**2.8**	**1.6**	**2.8**	**2.8**	**2.8**	**1.6**	**2.8**	**2.8**
Social Sustainability	a. Did the communities receive training in hygiene and sanitation?	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	1	3	3
	b. If the community received training, how were the participants selected and how many (***social mix***: *men/women; rich/poor; same tribe/ different tribes*)?	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	1	3	3
	Average Score	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**1**	**3**	**3**
Environmental Sustainability	a. Who does the exploration and borehole setting and what instruments were used?	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	b. What is the success rate of drilling?	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3

	c. Is there a problem with borehole drying?	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
	d. Have any boreholes been rehabilitated?	2	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1
	e. Is any chemical test done to the water?	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1
	f. Is bacteriological quality of water tested?	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1
	g. Is borehole disinfection done?	3	3	3	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1
	h. Is the borehole construction report prepared?	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Average Score	**2.9**	**3**	**2.9**	**3**	**2.9**	**3**	**3**	**2.9**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
	Overall Average Score	**2.4**	**2.5**	**2.8**	**2.3**	**2.3**	**2.5**	**2.1**	**2.5**	**2.3**	**2.3**	**2.3**	**1.7**	**2.27**	**2.3**	**2.3**	**1.7**	**2.27**	**2.2692**

Z - Zamsif
U - UNICEF
O - Oxfam
K - KWF
J - JICA
Af - Africare
W - WaterAID
CI - Care International

CD - Chongwe District Council
LD - Luangwa District Council
KD - Kafue District Council
KW - Kabwe Department of Water Affairs
ChD - Chibombo District Council
MD - Mumbwa District Council
SD - Sinazongwe District Council
CW - Choma Department of Water Affairs
MoD - Monze District Council

Appendix C.3: Evaluation Score Grid for Handpump Users (Lusaka Province)

	PROVINCE	**LUSAKA PROVINCE**												
	DISTRICT	**CHONGWE**				**LUANGWA**				**KAFUE**				
	IMPLEMENTING AGENCY	**Af**	**Af**	**Z**	**Af**	**Z**	**Z**	**J**	**J**	**J**	**J**	**J**	**J**	
	PUMP LOCATION	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
	PUMP TYPE	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**IM**	**Mode**
I. Financial Sustainability	a. Did users participate in planning of financing arrangements?	1	2	3	1	1	1	3	1	3	1	1	1	1
	b. Did users pay towards capital cost?	1	1	1	1	1	1	3	1	1	1	1	1	1
	c. How much do handpump users pay currently towards handpump use?	1	3	1	3	3	2	2	1	3	2	2	3	3
	d. Are users willing to pay i.e. happy with the service level?	2	3	3	2	3	3	3	1	3	2	3	3	3
	e. Can users afford to pay the user fee i.e. what is average income level for users?	2	1	1	2	3	2	1	3	3	2	2	2	2
	f. How is money collected (e.g. is it collected every month from everyone or when one can afford to pay/ is it paid in cash, in kind or both/who collects it/ who keeps the account)?	1	1	1	2	3	3	3	1	3	3	3	3	3
	g. Where is the money kept (in the bank / with the caretaker / headman / CBO)?	1	3	3	3	3	1	1	1	3	3	3	1	3
	h. Is there sufficient revolving fund for O&M?	3	1	1	3	3	1	2	2	3	2	2	2	2
	i. Who pay for major replacements?	2	3	2	2	3	2	2	2	3	3	2	2	2
	j. Are finances accounted for and if so to whom and how often i.e. is there an auditing system in place?	1	3	3	3	3	2	3	2	3	3	3	2	3

	k. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in financial management? How many?	1	3	2	2	2	2	3	2	3	3	3	3	3	2.12
Average Score		1.5	2.2	1.9	2.2	2.5	1.8	2.4	1.5	2.8	2.3	2.3	2.1	2.1818	
II. Technical Sustainability	a. Were users involved in choice of: level of service/handpump?	1	1	1	1	1	1	1	1	1	1	1	1	1	
	b. Did users participate in planning, monitoring and control of construction and handpump installation process?	1	1	1	1	1	1	3	1	3	1	3	3	1	
	c. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in O&M of the handpump? How many?	1	1	3	3	3	3	3	1	3	3	3	3	3	
	d. Does anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) carryout preventive maintenance and how often?	2	1	3	3	3	1	3	2	2	1	3	1	3	
	e. What are the common O&M problems with the pump and how often?	2	1	3	2	1	1	2	1	2	2	2	3	2	
	f. What do users do when the pump breaks down?	2	1	3	2	3	2	3	1	3	3	3	3	3	
	g. What level of skill do the users possess in repair of handpump (e.g. repair of cylinder assembly)?	1	1	2	2	2	1	1	1	2	3	3	3	1	
	h. How long does the pump typically remain broken before it is repaired?	3	1	3	2	2	1	2	3	3	2	1	2	2	
	i. Do they have the tools to do maintenance and repairs?	3	1	2	2	3	2	3	3	3	3	3	3	3	
	j. Are spare parts available and affordable when needed?	3	1	3	2	3	2	2	3	3	3	2	2	3	

	k. Who does the major repairs?	2	1	3	2	3	2	2	2	3	3	2	2	2	
	l. Does the handpump produce sufficient water?	3	3	3	3	3	3	3	1	3	3	3	3	3	2.13
Average Score		2	1.2	2.5	2.1	2.3	1.7	2.3	1.7	2.6	2.3	2.4	2.4	2.3333	
III. Institutional Sustainability	a. Who owns the handpump?	2	3	3	3	3	3	3	1	3	3	3	3	3	
	b. Is there a formal organisation responsible for managing the handpump.	2	3	3	3	3	3	3	1	3	3	3	3	3	
	c. How are the rest of the community's views incorporated in decisions?	1	3	3	3	3	2	3	1	3	3	3	3	3	
	d. What system is in place for O&M (centralised/decentralised)?	2	3	3	3	3	3	3	2	3	3	3	3	3	
	e. Who selected the pump technician?	2	1	3	3	3	3	3	2	3	3	3	3	3	
	f. Does the community have any system of communication with the local authority or the implementing agency?	1	1	3	3	3	3	3	3	3	3	3	3	3	
	g. Does the community have any pump performance monitoring and evaluation mechanism?	1	1	3	1	3	3	1	1	3	1	1	1	1	2.56
	Average Score	1.6	2.1	3	2.7	3	2.9	2.7	1.6	3	2.7	2.7	2.7	2.7143	
IV. Social Sustainability	a. What was the source of water before the handpump was installed?	2	2	2	2	3	1	2	2	3	1	2	1	2	
	b. Were they happy with the water source?	3	1	1	3	1	3	3	1	3	2	3	1	3	
	c. Did anyone explain why they should abandon their water source for the handpump?	3	3	3	3	1	3	1	1	3	3	3	3	3	
	d. Who and how was the pump brought to the community?	1	2	2	1	1	2	3	1	3	3	2	1	1	
	e. What role did they play in bringing the handpump water supply to the community?	1	1	1	1	2	1	2	2	2	1	2	1	1	
	f. Are they happy with the location of pump?	2	3	3	1	3	3	3	3	3	3	3	3	3	

	g. Are there any restrictions to access the pump?	3	2	3	3	3	3	3	3	3	3	3	3	3	
	h. Is the pump easy to operate?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	i. Who gets the water from the pump to the household (women/children/men)?	2	3	3	3	3	3	3	3	3	3	3	3	3	
	j. What benefit(s) has the handpump water supply brought to them?	1	1	3	3	3	3	3	3	3	3	3	2	3	
	k. Do they feel the handpump water supply should be paid for?	1	3	3	3	3	3	3	1	3	3	3	2	3	
	l. Are users happy with the way their money is used?	1	3	3	3	3	3	3	1	3	3	3	3	3	
	m. Do men and women participate equally in the affairs the pump?	1	3	3	3	3	3	1	1	3	3	3	3	3	
	n. What do they think is the problem with the pump?	3	1	3	2	3	1	1	1	3	1	2	2	1	
	o. Where do they get water when the pump breaks?	2	2	3	1	1	1	3	2	3	3	3	1	3	**2.38**
Average Score		1.9	2.2	2.6	2.3	2.4	2.4	2.5	1.9	2.9	2.5	2.7	2.1	2.4	
V. Environmental Sustainability	a. How many households are using the handpump?	2	1	3	2	1	1	3	1	3	3	3	3	3	
	b. How far is the furthest household from the pump?	1	3	3	1	2	2	2	1	3	3	2	2	2	
	c. How often do they use the pump (How many times do they come to fetch water)?	1	1	2	1	2	2	2	3	2	2	2	2	2	
	d. How long do they have to wait at the pump before they can fetch water?	3	3	3	2	2	3	2	2	2	2	2	3	2	

	e. Do the users like the taste of water?	3	3	3	3	1	1	2	3	3	3	3	3	3	
	f. Does the taste/colour of the water change with the season?	3	3	3	3	1	1	1	3	3	3	3	3	3	
	g. Does the water quantity from the pump vary with the season?	3	3	3	3	3	3	3	3	3	3	3	3	3	**2.37**
Average Score		**2.3**	**2.4**	**2.9**	**2.1**	**1.7**	**1.9**	**2.1**	**2.3**	**2.7**	**2.7**	**2.6**	**2.7**	**2.7143**	
	Overall Average Score	**1.8**	**2**	**2.5**	**2.3**	**2.4**	**2.1**	**2.4**	**1.8**	**2.8**	**2.5**	**2.5**	**2.3**	**2.4038**	

Z - Zamsif	1 - Chongwe District Civic Center
U - UNICEF	2 - Chongwe Basic School
O - Oxfam	3 - Chongwe Community School
K - KWF	4 - Chongwe Show Ground
AD - ADB	5 - Luangwa Main Market
GD - Gwembe Development Project	6 - Kabila Fishing Camp
J - JICA	7 - Hotela Village
Af - Africare	8 - Indeco Milling Compound
W - WaterAID	9 - Mwanachilenga
CI - Care International	10 - Kandoko
IM - India Mark II	11 - Libubi
AV - Afridev	12 - Shachibondwe

Appendix C.3: Evaluation Score Grid for Handpump Users (Central Province)

	PROVINCE	CENTRAL PROVINCE												
	DISTRICT	KABWE				CHIBOMBO				MUMBWA				
	IMPLEMENTING AGENCY	Z	AD	Z	AD	AD	AD	K	K	Z	J	J	J	
	PUMP LOCATION	13	14	15	16	17	18	19	20	21	22	23	24	
	PUMP TYPE	IM	IM	IM	IM	IM	IM	IM	IM	IM	AV	AV	AV	Mode
I. Financial Sustaibility	a. Did users participate in planning of financing arrangements?	3	1	2	1	2	2	3	3	3	3	2	3	3
	b. Did users pay towards capital cost?	1	1	1	1	1	3	1	1	3	3	3	3	1
	c. How much do handpump users pay currently towards handpump use?	3	3	3	2	2	2	2	2	3	3	3	2	3
	d. Are users willing to pay i.e. happy with the service level?	3	3	2	2	2	2	3	3	2	2	2	2	2
	e. Can users afford to pay the user fee i.e. what is average income level for users?	2	2	2	2	2	2	3	3	2	2	2	2	2
	f. How is money collected (e.g. is it collected every month from everyone or when one can afford to pay/ is it paid in cash, in kind or both/who collects it/ who keeps the account)?	3	3	2	2	2	2	2	2	3	2	2	2	2
	g. Where is the money kept (in the bank / with the caretaker / headman / CBO)?	3	3	3	3	2	2	2	2	2	2	3	3	3
	h. Is there sufficient revolving fund for O&M?	3	2	2	2	2	2	2	2	2	2	2	2	2
	i. Who pay for major replacements?	3	3	3	3	3	3	3	3	2	2	3	3	3
	j. Are finances accounted for and if so to whom and how often i.e. is there an auditing system in place?	3	3	3	3	1	3	2	2	3	3	3	3	3

	k. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in financial management? How many?	3	1	2	1	1	1	1	1	3	3	3	3	1	
	Average Score	**2.7**	**2.3**	**2.3**	**2**	**1.8**	**2.2**	**2.2**	**2.2**	**2.5**	**2.5**	**2.5**	**2.5**	**2.182**	**2.31**
II. Technical Sustainability	a. Were users involved in choice of: level of service/handpump?	1	1	1	1	1	1	1	1	1	1	1	1	1	
	b. Did users participate in planning, monitoring and control of construction and handpump installation process?	3	1	2	1	2	2	3	3	3	3	2	1	3	
	c. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in O&M of the handpump? How many?	3	2	3	2	3	3	3	3	3	3	3	3	3	
	d. Does anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) carryout preventive maintenance and how often?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	e. What are the common O&M problems with the pump and how often?	2	2	2	1	3	3	3	3	2	1	2	1	2	
	f. What do users do when the pump breaks down?	3	3	3	3	3	3	3	3	3	2	3	3	3	
	g. What level of skill do the users possess in repair of handpump (e.g. repair of cylinder assembly)?	3	3	2	2	3	3	3	3	3	3	2	2	3	
	h. How long does the pump typically remain broken before it is repaired?	2	1	2	1	3	3	3	3	2	1	2	1	2	
	i. Do they have the tools to do maintenance and repairs?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	j. Are spare parts available and affordable when needed?	3	2	2	1	3	2	2	2	2	2	2	2	2	
	k. Who does the major repairs?	3	3	3	3	3	2	3	3	2	3	3	3	3	
	l. Does the handpump produce sufficient water?	3	3	3	3	3	3	3	3	3	3	3	3	3	**2.47**

	Average Score	**2.7**	**2.3**	**2.4**	**2**	**2.8**	**2.6**	**2.8**	**2.8**	**2.5**	**2.3**	**2.4**	**2.2**	**2.75**	
III. Institutional Sustainability	a. Who owns the handpump?	3	3	3	3	3	3	3	3	2	3	3	3	3	
	b. Is there a formal organisation responsible for managing the handpump.	3	3	3	3	3	3	3	3	3	3	3	3	3	
	c. How are the rest of the community's views incorporated in decisions?	3	3	3	3	3	2	3	3	3	3	3	3	3	
	d. What system is in place for O&M (centralised/decentralised)?	3	3	3	3	3	3	3	3	2	2	2	2	3	
	e. Who selected the pump technician?	3	3	3	3	3	3	2	3	3	3	3	3	3	
	f. Does the community have any system of communication with the local authority or the implementing agency?	1	1	1	1	3	2	2	3	3	3	3	3	3	
	g. Does the community have any pump performance monitoring and evaluation mechanism?	1	1	1	1	1	2	2	3	3	2	2	2	1	**2.62**
	Average Score	**2.4**	**2.4**	**2.4**	**2.4**	**2.7**	**2.6**	**2.6**	**3**	**2.7**	**2.7**	**2.7**	**2.7**	**2.714**	
IV. Social Sustainability	a. What was the source of water before the handpump was installed?	2	3	3	3	2	2	3	2	2	2	3	3	2	
	b. Were they happy with the water source?	3	3	3	3	2	3	2	3	2	2	3	3	3	
	c. Did anyone explain why they should abandon their water source for the handpump?	3	2	2	2	3	2	3	3	3	3	3	3	3	
	d. Who and how was the pump brought to the community?	2	2	2	1	2	3	3	3	3	3	1	1	3	
	e. What role did they play in bringing the handpump water supply to the community?	2	2	2	1	1	2	1	2	2	2	2	1	2	
	f. Are they happy with the location of pump?	3	3	3	3	3	3	3	3	3	3	3	2	3	
	g. Are there any restrictions to access the pump?	3	2	2	2	3	2	2	3	3	3	3	3	3	
	h. Is the pump easy to operate?	3	3	3	3	3	3	2	2	2	1	2	1	3	

	i. Who gets the water from the pump to the household (women/children/men)?	3	3	3	3	3	3	3	3	1	1	3	3	3	
	j. What benefit(s) has the handpump water supply brought to them?	3	3	3	3	3	2	1	3	2	1	2	2	3	
	k. Do they feel the handpump water supply should be paid for?	3	3	3	3	2	3	3	3	3	2	2	1	3	
	l. Are users happy with the way their money is used?	3	3	3	3	1	2	2	2	3	3	3	3	3	
	m. Do men and women participate equally in the affairs the pump?	3	3	3	3	3	2	1	2	2	1	2	1	3	
	n. What do they think is the problem with the pump?	3	2	2	1	3	3	3	3	3	3	3	3	3	
	o. Where do they get water when the pump breaks?	3	3	2	2	3	2	1	2	2	2	2	2	2	**2.44**
	Average Score	**2.8**	**2.7**	**2.6**	**2.4**	**2.5**	**2.5**	**2.2**	**2.6**	**2.4**	**2.1**	**2.5**	**2.1**	**2.467**	
V. Environmental Sustainability	a. How many households are using the handpump?	1	2	1	1	3	3	3	3	2	1	2	2	1	
	b. How far is the furthest household from the pump?	1	2	1	1	2	2	2	2	3	3	3	3	2	
	c. How often do they use the pump (How many times do they come to fetch water)?	1	2	2	2	2	2	2	2	2	1	2	2	2	
	d. How long do they have to wait at the pump before they can fetch water?	1	1	1	1	2	1	1	1	3	3	3	3	1	
	e. Do the users like the taste of water?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	f. Does the taste/colour of the water change with the season?	3	3	3	3	3	3	3	3	3	3	3	3	3	

	g. Does the water quantity from the pump vary with the season?	3	3	3	3	3	3	3	3	3	3	3	3	3	2.38
	Average Score	**1.9**	**2.3**	**2**	**2**	**2.6**	**2.4**	**2.4**	**2.4**	**2.7**	**2.4**	**2.7**	**2.7**	**2.429**	
	Overall Average Score	**2.6**	**2.4**	**2.4**	**2.2**	**2.4**	**2.4**	**2.4**	**2.6**	**2.5**	**2.4**	**2.5**	**2.4**	**2.577**	

Z - Zamsif	13 - Kaputula Compound
U - UNICEF	14 - Kamushanga Compound
O - Oxfam	15 - Makukula Compound
K - KWF	16 - Nakoli Compound
AD - ADB	17 - Liteta Palace
GD - Gwembe Development Project	18 - Mushingashi
J - JICA	19 - Muundu
Af - Africare	20 - Chitanda Palace
W - WaterAID	21 - Mumbwa Prison Compound
CI - Care International	22 - Mumbwa Market
IM - India Mark II	23 - Mumbwa Slaughter House
AV - Afridev	24 - Chitambala Village

Appendix C.3: Evaluation Score Grid for Handpump Users (Southern Province)

	PROVINCE	SOUTHERN PROVINCE												
	DISTRICT	SINAZONGWE				CHOMA				MONZE				
	IMPLEMENTING AGENCY	GD	GD	GD	GD	O	O	O	O	U	U	U	U	
	PUMP LOCATION	25	26	27	28	29	30	31	32	33	34	35	36	
	PUMP TYPE	IM	IM	IM	IM	IM	IM	IM	IM	IM	IM	IM	IM	Mode
I. Financial Sustaibility	a. Did users participate in planning of financing arrangements?	1	1	1	1	3	3	3	3	3	3	3	3	3
	b. Did users pay towards capital cost?	1	1	1	1	3	3	3	3	3	3	3	3	3
	c. How much do handpump users pay currently towards handpump use?	3	2	2	1	3	2	3	3	3	3	3	2	3
	d. Are users willing to pay i.e. happy with the service level?	3	3	3	1	3	2	3	3	3	3	3	2	3
	e. Can users afford to pay the user fee i.e. what is average income level for users?	3	3	3	3	3	2	3	3	2	2	2	2	3
	f. How is money collected (e.g. is it collected every month from everyone or when one can afford to pay/ is it paid in cash, in kind or both/who collects it/ who keeps the account)?	3	2	3	1	3	2	3	3	3	3	3	3	3
	g. Where is the money kept (in the bank / with the caretaker / headman / CBO)?	3	2	3	1	3	3	3	3	3	3	2	2	3
	h. Is there sufficient revolving fund for O&M?	2	1	1	1	3	2	3	3	2	2	2	2	2
	i. Who pay for major replacements?	2	2	2	3	3	2	3	3	2	2	2	2	2
	j. Are finances accounted for and if so to whom and how often i.e. is there an auditing system in place?	3	3	3	3	3	3	3	3	3	3	3	3	3

	k. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in financial management? How many?	2	2	1	3	3	3	3	3	3	3	3	3	3	2.52
	Average Score	2.4	2	2.1	1.7	3	2.5	3	3	2.7	2.7	2.6	2.5	3	
II. Technical Sustainability	a. Were users involved in choice of: level of service/handpump?	1	1	1	1	1	1	3	3	1	1	1	1	1	
	b. Did users participate in planning, monitoring and control of construction and handpump installation process?	1	1	1	1	2	3	3	3	3	3	3	3	3	
	c. Did anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) receive training in O&M of the handpump? How many?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	d. Does anybody from the users (caretaker/member of the handpump committee/ pump technician(s)) carryout preventive maintenance and how often?	3	2	2	3	3	3	3	3	2	3	2	1	3	
	e. What are the common O&M problems with the pump and how often?	1	1	1	1	2	3	2	3	1	2	1	1	1	
	f. What do users do when the pump breaks down?	3	3	3	1	3	3	3	3	3	3	3	3	3	
	g. What level of skill do the users possess in repair of handpump (e.g. repair of cylinder assembly)?	3	3	3	2	3	3	3	3	3	3	3	3	3	
	h. How long does the pump typically remain broken before it is repaired?	2	2	2	2	2	3	3	3	2	1	1	1	2	
	i. Do they have the tools to do maintenance and repairs?	3	3	3	2	3	3	2	3	2	2	2	2	3	

	j. Are spare parts available and affordable when needed?	3	1	1	2	3	3	3	3	3	2	3	1	3	
	k. Who does the major repairs?	2	2	2	2	3	3	3	2	2	2	2	2	2	
	l. Does the handpump produce sufficient water?	3	3	3	3	3	3	3	3	3	3	3	3	3	2.38
	Average Score	2.3	2.1	2.1	1.9	2.6	2.8	2.8	2.9	2.3	2.3	2.3	2	2.333	
III. Institutional Sustainability	a. Who owns the handpump?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	b. Is there a formal organisation responsible for managing the handpump.	3	3	3	3	3	3	3	3	3	3	3	3	3	
	c. How are the rest of the community's views incorporated in decisions?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	d. What system is in place for O&M (centralised/decentralised)?	3	3	3	3	3	3	3	2	3	3	3	3	3	
	e. Who selected the pump technician?	3	3	3	3	3	3	3	2	3	3	3	3	3	
	f. Does the community have any system of communication with the local authority or the implementing agency?	3	3	3	1	3	2	1	3	3	3	3	3	3	
	g. Does the community have any pump performance monitoring and evaluation mechanism?	2	2	2	1	1	2	3	1	1	1	1	1	1	2.7
	Average Score	2.9	2.9	2.9	2.4	2.7	2.7	2.7	2.4	2.7	2.7	2.7	2.7	2.714	
IV. Social Sustainability	a. What was the source of water before the handpump was installed?	1	3	3	1	2	2	2	2	2	2	2	2	2	
	b. Were they happy with the water source?	3	3	3	1	2	3	2	3	2	2	2	2	2	

	c. Did anyone explain why they should abandon their water source for the handpump?	3	2	2	1	3	3	3	3	3	3	3	3	3	
	d. Who and how was the pump brought to the community?	1	1	1	1	2	2	3	2	2	2	2	2	2	
	e. What role did they play in bringing the handpump water supply to the community?	1	1	1	1	2	2	3	3	2	2	2	2	2	
	f. Are they happy with the location of pump?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	g. Are there any restrictions to access the pump?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	h. Is the pump easy to operate?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	i. Who gets the water from the pump to the household (women/children/men)?	3	3	3	3	3	3	3	2	3	3	3	3	3	
	j. What benefit(s) has the handpump water supply brought to them?	3	3	3	1	3	3	3	3	3	3	3	3	3	
	k. Do they feel the handpump water supply should be paid for?	3	2	2	3	3	3	3	3	3	3	3	2	3	
	l. Are users happy with the way their money is used?	3	3	3	3	3	3	3	2	3	3	3	3	3	
	m. Do men and women participate equally in the affairs the pump?	3	3	3	3	3	3	3	3	3	3	3	3	3	
	n. What do they think is the problem with the pump?	2	1	1	1	3	2	2	2	2	2	2	1	2	
	o. Where do they get water when the pump breaks?	3	3	3	2	2	3	3	3	2	2	2	2	3	2.55
	Average Score	**2.5**	**2.5**	**2.5**	**2**	**2.7**	**2.7**	**2.8**	**2.7**	**2.6**	**2.6**	**2.6**	**2.5**	**2.467**	
V. Environmental Sustainability	a. How many households are using the handpump?	2	2	2	1	1	2	3	2	2	3	3	3	2	

	b. How far is the furthest household from the pump?	2	1	1	2	2	1	1	2	1	1	1	1	1	
	c. How often do they use the pump (How many times do they come to fetch water)?	2	3	3	2	2	2	2	2	2	3	3	3	2	
	d. How long do they have to wait at the pump before they can fetch water?	2	2	2	3	2	2	2	3	2	2	2	2	2	
	e. Do the users like the taste of water?	1	2	2	1	3	3	3	3	3	3	3	3	3	
	f. Does the taste/colour of the water change with the season?	1	2	2	1	3	3	3	3	3	3	3	3	3	
	g. Does the water quantity from the pump vary with the season?	1	3	3	3	3	3	3	3	3	3	3	3	3	**2.27**
	Average Score	**1.6**	**2.1**	**2.1**	**1.9**	**2.3**	**2.3**	**2.4**	**2.6**	**2.3**	**2.6**	**2.6**	**2.6**	**2.571**	
	Overall Average Score	**2.4**	**2.3**	**2.3**	**2**	**2.7**	**2.6**	**2.8**	**2.8**	**2.5**	**2.6**	**2.5**	**2.4**		

Z - Zamsif	25 - Sinazongwe Village
U - UNICEF	26 - Salaula Village
O - Oxfam	27 - Tusombane Village
K - KWF	28 - Sinazongwe Basic School
AD - ADB	29 - Batoka Market
GD - Gwembe Development Project	30 - Pemba Settlement-Libingi
J - JICA	31 - Kasiya Rural Health Centre
Af - Africare	32 - Muyuni Farmaers Group
W - WaterAID	33 - Ngoma Community
CI - Care International	34 - Mapunu Community
IM - India Mark II	35 - Mayuyu Village
AV - Afridev	36 - Chikwalila Community

Appendix D: List of Organisations/Agencies/Communities/ Private Companies Contacted

Appendix D.1: National Policy Agencies

National Policy Agency	Persons Interviewed	Position
Ministry of Local Government and Housing	Mr. F. Sichilongo	Principal Water Engineer
	Mr L. Kanowa	Public Health Officer
Ministry of Energy and Water Development	Mr. A. Lusaka	Deputy Director of Water Affairs
Ministry of Environment and Tourism	Mr. L. Aongola	Director of Planning
National Water Supply and Sanitation Council	Mr P. Banda	Chief Inspector
Ministry of Health	Mr. Nyirenda	Environmental Health Specialist
Ministry of Community Development and Social Welfare	Mr. Patrick Chooye	Director of Department Community Development

Appendix D.2: External Implementing Agencies

External Implementing Agency	Person Interviewed	Position
Zambia Social Investment Fund (Zamsif) – World Bank	Mr. W. Ilunga	Technical Manager
	Mr. J. Wamulume	Water and Sanitation Engineer
UNICEF - Zambia	Dr. G. Zulu	Head, UNICEF WASHE Program in Zambia
WaterAid – Zambia Office	Mr. I Mbewe	Water and Sanitation Engineer
KFW-GAUF - Zambia	Mr. Zyambo	Rural Water Supply Specialist
Oxfam - Zambia	Ms. Chimfwembe	Head, Water and Sanitation
Care International - Zambia	Mr. A. Mapulanga	Technical Services Coordinator
Africare - Zambia	Mr. A. Phiri	Water and Sanitation Officer
Japan International Cooperation Agency (JICA)	Mrs. J. Tembo	Water and Sanitation Officer

Appendix D.3: Government Implementing Agencies (District Councils)

Province	Government Implementing Agency	Persons Interviewed	Position
Lusaka	Chongwe District Council	Mr. N Mwalukanga	Deputy Director of Works
	Luangwa District Council	Mr. Kamambi	Officer in Charge – District Water and Sanitation
	Kafue District Council	Mr. P Hang'andu	Director of Works
Central	Kabwe Department of Water Affairs	Mr. Phiri	District Water Engineer
	Chibombo District Council	Mr. C Mukuka	Deputy Director of Works
	Mumbwa District Council	Mr. I. Liusha	District Environmental Health Officer
Southern	Sinazongwe District Council	Mr. O. Muuka	Council Secretary
	Choma Department of Water Affairs	Mr. M. Phiri	Provincial Water Engineer
		Mr. J. G. Phiri	District Water Engineer
	Monze District Council	Mr H. Chiinzila	District Water and Sanitation Officer

Appendix D.4: Community Handpump Sites

District	Handpump Sites Visited	Handpump Type and Condition	Implementing/Funding Agency
Chongwe (semi-urban area)	Chongwe Community School	India Mark II - Working	ZAMSIF,
	Chongwe Basic School	India Mark II - Not Working	Africare
	Chongwe Civic Centre	India Mark II - Working	Africare
	Chongwe Show Ground	India Mark II - Working	Africare
Luangwa	Luangwa Market	India Mark II - Working	Luangwa District Council ZAMSIF
	Kabila Fishing Camp	India Mark II - Working	Luangwa District Council ZAMSIF
	Hotela Village	India Mark II - Working	Luangwa District Council/JICA
	Indeco Milling	India Mark II - Working	Luangwa District Council/JICA
Kafue	Mwanachilenga	India Mark II - Working (rehabilitated)	JICA
	Kandoko	India Mark II - Working	JICA
	Libubi	India Mark II - Working (rehabilitated)	JICA
	Shachibondwe	India Mark II - Working	JICA
Chibombo	Liteta Palace	India Mark II - Working	DWA/ADB
	Mushingashi	India Mark II - Working	DWA/ADB
	Muundu Clinic	India Mark II - Working	Chibombo District Council /KFW
	Chitanda Palace	India Mark II - Working	Chibombo District Council/KFW
Kabwe	Kaputula	India Mark II - Working	ZAMSIF
	Makukula	India Mark II - Working	ZAMSIF
	Nakoli	India Mark II - Working	DWA/ADB
	Kamushanga	India Mark II - Working	DWA/ADB
Mumbwa	Mumbwa Prisons Compound	India Mark II - Working	ZAMSIF,
	Mumbwa Market	Afridev -Working	Mumbwa District Council/JICA
	Mumbwa Slaughter House	Afridev - Working	Mumbwa District Council/JICA
	Chitambala Village	Afridev - Working	Mumbwa District Council/JICA

Sinazongwe	Salaula Village	India Mark II - Working	Sinazongwe District Council/Gwembe Development Project
	Sinazongwe Village	India Mark II - Working	Sinazongwe District Council/Gwembe Development Project
	Sinazongwe Basic School	India Mark II - Not Working	Sinazongwe District Council/Gwembe Development Project
	Tusombane Village	India Mark II - Working	Sinazongwe District Council/Gwembe Development Project
Choma	Pemba Settlement-Libingi	India Mark II - Working	Oxfam
	Muyuni Farmerss Group	India Mark II - Working	Oxfam
	Kasiya RHC	India Mark II - Working	Oxfam
	Batoka Market	India Mark II - Working	Oxfam
Monze	Chikwalila Community	India Mark II - Working	UNICEF
	Mayuyu Village	India Mark II - Working	UNICEF
	Mapunu Community	India Mark II - Working	UNICEF
	Ngoma Community	India Mark II - Working	UNICEF

Appendix D.5: Private Companies and Research Institutes

Company	Main Business
Aquagro Limited	India Mark II, Afridev handpump and spares dealership and other agricultural machinery dealers
Saro Agricultural Equipment	India Mark II, Afridev handpump and spares and other agricultural machinery dealers
AFE Zambia Limited	India Mark II, Afridev handpump and spares and other agricultural machinery dealers
TDAU- University of Zambia Lusaka.	Technology research institute including handpumps and agro-processing equipment