Sustainable Operations and Maintenance of Water Supplies:

A Conceptual Model for Engineers and Development Workers

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No matter how technically feasible the project may be, it can only succeed if the villagers are truly interested in it, and concerned enough to provide the long-term maintenance necessary to keep the system in working condition.

Thomas D. Jordan Jnr. [1984].

PREFACE AND ACKNOWLEDGEMENTS

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Finally, to my Lord and God, for your strength, power and life you give.

> Jesus answered, "Everyone who drinks this water will be thirsty again,
> but whoever drinks the water I give him will never thirst.
> Indeed, the water I give him will become in him a
> spring of water welling up to eternal life." John 4:13 & 14.

ABSTRACT

There have been major problems with the sustainability of many water supply projects in the Developing World. One major area that influences this sustainability is the ongoing operation and maintenance of the water supply. A number of different surveys have shown that within 12 months of a water project being constructed and handed over to the community or government water dept. between 30-70% are not functioning at all or are not producing their original design supply.

The purpose of the research was to produce a conceptual model that could be used by development agencies and engineers to increase the sustainability of water supplies.

A review of the literature revealed that the major factors influencing sustainable operation and maintenance of water supplies were, technology, infrastructure for parts, training of both agency and community in maintenance of the water supply, the source of funding for O & M, design, ownership and responsibility, and management. These factors were incorporated into a conceptual model, each factor fitting into one or more of the different stages of a water supply project, namely: 1. Planning; 2. Design; 3. Construction; 4. Transfer Ceremony; and 5. Operations. There were up to four major groups of people involved in this process, namely, an International Development Agency, a Government Water Dept., a Community Water Committee, and a Community or Users.

Surveys were conducted in Ethiopia, looking at both urban and rural water projects. The results were used to substantiate the model and/or to revise the model.

It was concluded from the survey that the following were influential upon sustainable operation and maintenance in Ethiopia: Community ownership does not equate to community responsibility for O & M; Training of the individual or group responsible for O & M is essential; A lack of infrastructure leds to O & M problems; And, community involvement in all stages of the water supply project is essential.

The revised conceptual model presents the processes and factors needed to instigate sustainable O & M of water supply projects in developing countries.

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GLOSSARY OF ACRONYMS

Agency	Refers to Government or Development Agency involved in Water Projects
APO	Asian Productivity Organization
AT	Appropriate Technology
CWS	Community Water Supplies
KHC	Kale Heywet Church
IDWSSD	International Drinking Water Supply and Sanitation Decade
IRC	International Reference Centre for Community Water Supply and Management
ISS	Informal Service Sector
ITDG	Intermediate Technology Development Group
LDC	Less Developed Country
NGO	Non Government Organization
ODA	Overseas Development Administration
O & M	Operation and Maintenance
RWS	Rural Water Supply
SIM	Society for International Ministries
SWRC	Social Work Research Centre
UNDP	United Nations Development Programme
UNICEF	United Nations Childrens Fund
USAID	United States Agency for International Development
VLOM	Village Level Operation and Maintenance
WASH	Water and Sanitation for Health Project
WHO	World Health Organization
WSSA	The Ethiopian Water Supply and Sewerage Authority
WS&S	Water Supply and Sanitation
WTP	Willingness to Pay (Survey)
WUA	Water User Associations

CHAPTER 1

INTRODUCTION

1.1 Water Supply Need

> A sheet of water is like a pane of glass - smooth, colourless, flawless. Dip your hand into it, bring it to your lips - no smell, no taste. And, almost before you have sipped, it has slipped through your fingers back into the lake. Almost the simplest substance on earth - just two molecules of hydrogen and one of oxygen - combine to make something hard and cold as ice, burning and ephemeral as steam, a sparkle of tiny droplets from the splash in a swimming pool. Or a hole of stinking black mud, a dark green pool at the bottom of a well, the yellow brown seepage from a hollow scratched in the dry river bed. Water drops from the skies, flows freely in rivers, burst from the ground. And there is more than enough for everyone. [Taylor, 1981]

Although there is enough water in the world for everybody, the distribution of water is not even, with extreme climates like Saharan Africa where the rainfall is minimal compared to the West Coast of New Zealand where it can rain every day. Because water is important to the survival of humanity, a good reliable source of water is needed. In high rainfall areas of the world, communities have a choice of whether to use surface water sources or high yielding and recharging aquifer's and have a sedentary lifestyle. Where rainfall is minimal several different sources may be used according to the time of year, and a nomadic lifestyle may need to be pursued for survival.

A good supply of accessible water attracts humans, and a community or nation can rise all fall depending on its availability. Because of technological changes over past years, water is now able to be used from deep underground sources, from oceans and seas and polluted sources that can be treated and used. Along with this the knowledge that a clean and reliable water supply can increase health and reduce the amount of disease had been discovered. Armed with these technological advancements the developed world had gone to the poorer and often less resourced countries of the world, to help them attain good water supplies, to benefit their people's health and to increase the productivity and economic benefits to these nations.

Many aid and development agencies, both government and non government from the west, invested millions of dollars into water supply projects. The thought behind this giving of funds and technology from the west varied, with political or humanitarian aims the most

prevalent.

1.2 Aid versus Development

It was believed that to give aid would be the catalyst for the changes needed for the developing world to become developed. This has unfortunately not been the case with many nations in the developing world becoming heavily dependent upon foreign aid and having gained no more opportunities for most of the people. A cause for this is due to the belief that development was a gradual movement of society towards modern society, and this change could be boosted by economic growth and a modernization of the society. In recent years this view has been overshadowed by the following view of development:

> People must be at the centre of development. Development has to be woven around people, not people around development. It has to be development of the people, by the people, for the people. [World Bank, 1991]

This means that development invests in peoples lives, health, education etc., with the people being given the choice in planning the goals of development and that development is aimed at meeting the needs of all the people. The second view is the one held in this thesis. These two views of development reflect the difference between what aid and what development is in practice as shown in Table I.

Aid/Relief		Development
Crisis	**Problem**	Poverty, poor resources
Survival	**Purpose**	Improvement
Giving	**Process**	Encouraging, awareness & mobilizing
External	**Input**	Mainly local with external help
Provider	**Relationship of Development Worker**	Trainer & facilitator
Immediate	**Time**	Gradual and longterm

Table I Comparison of aid/relief to development (Source: KHC/SIM Workshop on Development)

Even with this knowledge of what development is, the project activities of many development agencies was still aid based in practice throughout Africa as shown in the following figure.[1]

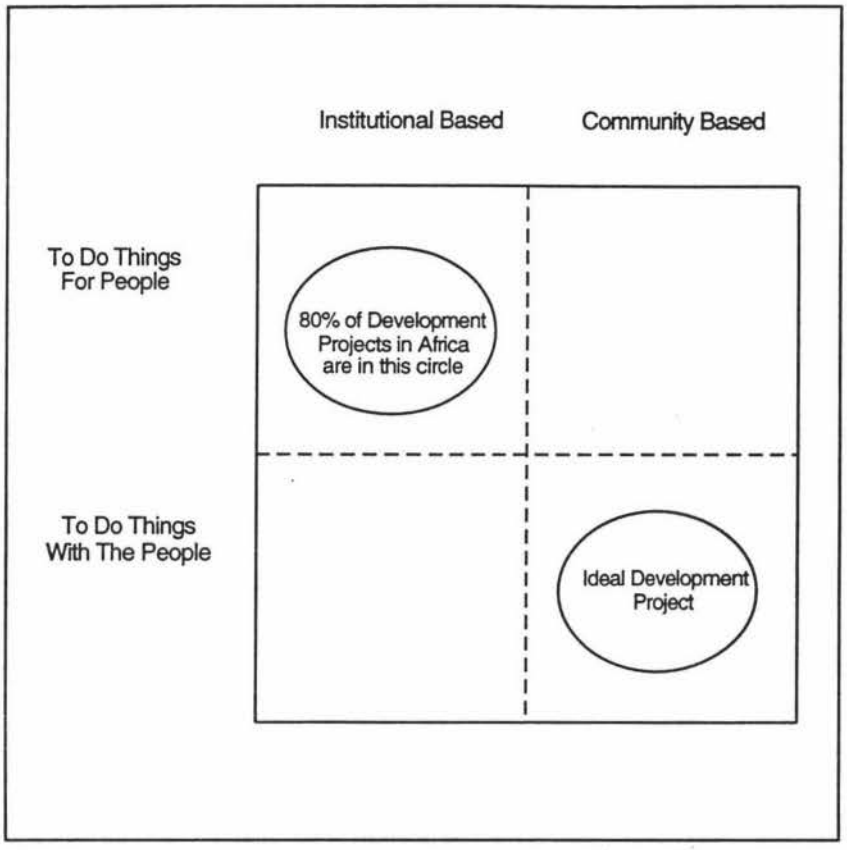


Figure 1 Development project aim (Source: KHC/SIM Workshop on Development)

Because most of the development projects were not really causing development but dependency, when the development agency removed its funding many projects failed. This was also true of water supply projects. It has been shown that within one year of water supply projects completion between 50-70% will fail or has reduced operational capacity.

Water is still needed in many communities in the developing world today, and the author believes there is still a role for development agencies to help communities meet this need. What then can be done to bring about development and increase the sustainability of the water supplies.

---

[1] This figure comes from a workshop on development held for KHC/SIM development staff attended by the author held in Dilla in Southern Ethiopia, over two days (1-2 July 1993). This figure was also used to help the participants to see whether the projects they were involved in were development based or aid/relief based.

1.3 Factors Crucial for Sustainable Water Supply Projects

Rondinelli [1991] determined that six sets of factors were identified as crucial to provide sustainability at the community level:

> Adequate incentives, sufficient skills and resources, appropriate processes for water systems operation and maintenance, effective interorganizational relationships, appropriate technology, and effective systems of monitoring, evaluation and feedback.

Harnmeijer and Sutton [1993] said that the measuring of sustainable water supplies can be shown by whether the community makes an effort to keep the water supply working. Thus an attempt to provide effective operation and maintenance (O & M) of a water supply by the community would show whether the water supply could be seen as sustainable and successful.

The challenges presented by the O & M of water supplies, being the place where technology and community meet face to face, and the success of this interaction determining sustainability displays the problem. This thesis attempts to address this problem with the provision of a model that could be used by development agencies to bring about this interaction and set up the appropriate processes for sustainable operation and maintenance at the community level. A conceptual model was chosen because it was seen to be lacking from the literature, also it could be a useful tool for development agencies to follow as they set up the appropriate structure to help communities' operate and maintain their water supplies.

The objectives of this study are given in chapter 3.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This literature review aims to present an overview of the major factors considered important in the operation and maintenance of water supply projects in the developing world. These factors will be covered individually, but it must be recognised that they cannot be taken in isolation because of an intertwining relationship between them. The major factors that influence the sustainable O & M of water supplies are: management and administration structure; beneficiary participation (with the issue of ownership discussed under these two sections); the choice of appropriate technology, and; infrastructure for parts, maintenance and training [Pacey, 1977b; Intermediate Technology Development Group (ITDG) Water Panel, 1980; Jordan *et al*, 1986].

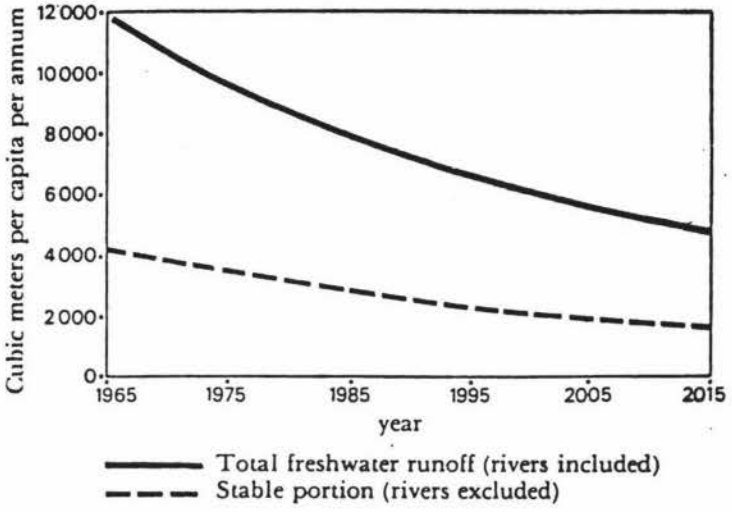
2.2 Historical Background to Water Supplies Projects

Water is seen as the most needed of all the natural resources that we have on this planet. The whole of humanity's existence is dependent on the fact that we have water to drink, to irrigate our crops, and to provide water for our animals. Since the dawning of time, people have prospered where there is a good supply of water, but have shifted or perished where there is little or no water. Thus a good water supply has been seen as the basis for humanity's sustenance and improvement [Saunders and Warford, 1976; Falkenmark and Lindh, 1976; Postel, 1984; Stern, 1985].

2.2.1 Available Water Resources

With three-quarters of the world covered in water there appears enough water, but 99 percent of the world's water is tied up in the world's oceans or polar caps. The 1 percent that is available for human usage cannot be totally used, as draining rivers, lakes and aquifer's dry is not desirable resource management. The amount of water available is about half a percent of the total approximately 38,000 cubic kilometres [Falkenmark and Lindh, 1976]. This water is the renewable resource that moves within the "hydrological cycle": water evaporates from the seas, rains on the land then flows down rivers, recharges aquifer's and eventually returns to the sea. Although useful for agriculture, all of the 38,000 cubic kilometres cannot be used for water supply purposes because 65 percent is unstable, being created by floods or monsoons and disappearing too quickly. The amount

of water available for use per capita per year for all human uses (water supply, irrigation and industry) can be derived from Figure 2.



Runoff in rivers and groundwater together constitute the water resources on which we depend for our water supply and irrigation. The amount of water available per capita decreases with the growth of population. A certain proportion of the water flow is available all year round (the stable part). The remainder is only available during the high-water periods (the flood part).

Figure 2. Water resources available for human activities (Source: Falkenmark and Lindh, 1976)

With the potential water resource available amounted to approximately 7,000 m^3 per year per capita in 1990. It is considered more than sufficient as the World Bank estimates that the average person needs approximately 25-45 litres per day to stay clean and healthy (9.5-16.5 m^3/capita/year) [World Bank, 1976]. If agriculture and industry requirements of water are added, the total figure needed is approximately 750 m^3 per capita per year [New Internationalist, 1990]. Despite the availability of the worldwide water resources, the distribution of the water resources is unequal across the planet, this is shown in Figure 3. This uneven distribution of the water resource effects two-thirds of the worlds population, many of whom live in the developing world [New Internationalist, 1981; Mangin, 1991]. Other problems facing available water resources for domestic water usage, include the salinization of surface and groundwater by irrigation [Agnew and Anderson, 1992]; industrial and agricultural pollution of fresh water resources; increased demand by both industry and agriculture for water; and, increased costs of implementing new water projects

[Biswas, 1991]. The present and future management of the worldwide total available water resource will be a major imperative for the provision of domestic water supplies and water for other users, stated Biswas.

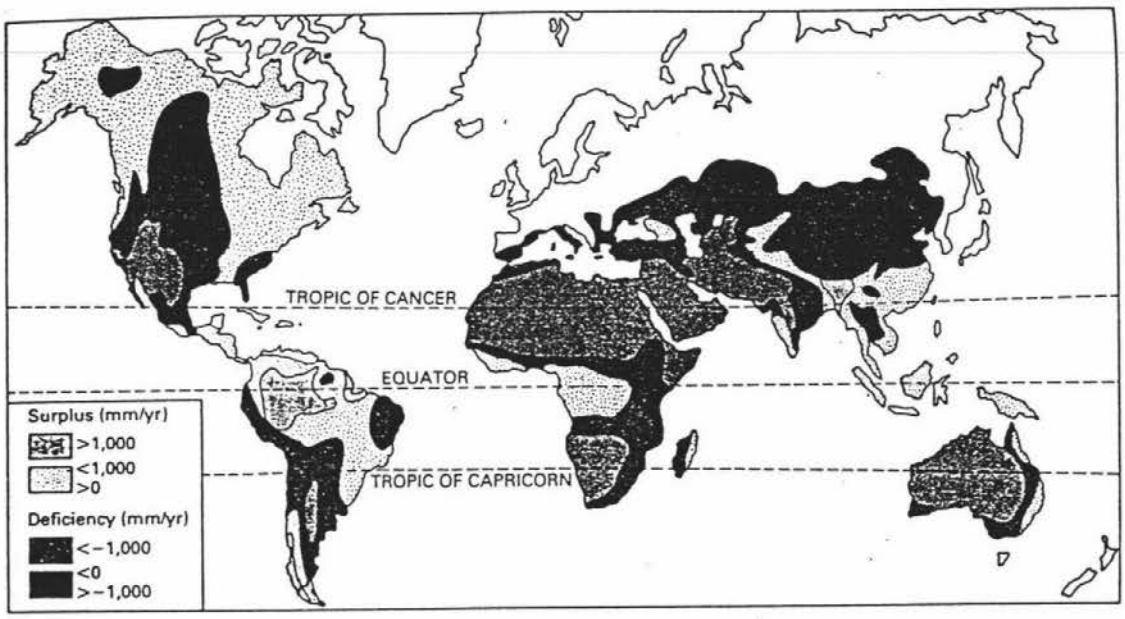


Figure 3. Areas characterised by water surplus and water deficiency (Source: Barrow, 1987)

2.2.2 Water Sources, Treatment and Technology

Historically water supplies came from surface water sources such as rivers, streams, lakes and dams, or from some form of hand dug well that used shallow underground water sources. These sources have been complemented in recent years by using new technologies to reach deep ground water by drilling borehole and using electric pumps to raise the water from depths of 100m or more. The use of desalination plants, particularly in oil-rich Middle Eastern countries helped solve some of the lack of natural water sources in these areas. Precipitation enhancement, cloud seeding and aquifer recharging have been also used to increase surface and groundwater supplies [Agnew and Anderson, 1992].

In the past 150 years technological development has produced various forms of filters, chemicals and processes to remove health threatening and unwanted particles and organisms from the water. These advances are due to the understanding that as much as 80 percent of all diseases are water related [New Internationalist, 1981] (cf Appendix 1). Much of this technological advance occurred in the developed nations of Europe, USA,

Japan and Australasia. It was believed in the immediate postwar years that this Western technology, wisely used could solve all the worlds' problems. It could feed a growing population for all the foreseeable future; it could clothe and house the world's people, give them water and maintain their health. But what offered so much promise has not been realized. While this technology saved lives and gave the developed world a good quality of life, many developing nations were not receiving the same benefits from this technology [Pacey, 1977b]. Water supply projects followed this trend, being a major focus in the work of International, Government and Non Government Organizations (NGOs) aid and development agencies along with the governments of the developing world. These groups put much effort into water supply technology. But various factors worked against this technology, resources were limited, the technology was inappropriate too many situations, water projects were often centred on towns and cities because of the cheaper costs per capita due to population density (also because of the high growth rates in urban areas due to rural-urban migration post World War II), the view that the water drunk in rural areas was safer to drink, and the political influence of those living in urban areas [New Internationalist, 1981; Development Studies, 1992].

2.2.3 International Drinking Water Supply and Sanitation Decade

In 1980 the United Nations General Assembly launched the International Drinking Water Supply and Sanitation Decade (IDWSSD) to meet the challenge of providing safe drinking water and sanitation to over half of the developing world's population (approximately a third of the world's human population). This decade had successes and failures. Seven hundred and fifteen million new users of clean water supplies were furnished [Appleton and Black, 1990]. However, in 1990, between 800 million [Mangin, 1991] and two billion [Newson, 1992] people remained without access to safe and sufficient water. The situation was generally worse in rural areas where between 50% [New Internationalist, 1990] and 65% [Mangin, 1991] of households lacked access to safe and convenient water sources. Vincent [1991] commented that in the Western Asian region there had been a 28% increase in coverage of rural areas during the decade, but the numbers that remained unserved had increased by 5%. Another factor that deflated the successes of IDWSSD was that so many water supply projects ceased to exist or were incapable of providing water for parts of the year [Churchill *et al*, 1987; Rondinelli, 1991; Mangin, 1991; among others]. The sustainability of water projects and IDWSSD should be based upon the

following:

> The success of a rural water development programme ought to be measured by the number of properly functioning schemes, schemes that satisfy both social and economic needs of the people, and not by the sheer total of installed water schemes. - [Kauzeni, 1983]

O'Rourke [1992] believed that IDWSSD suffered from an identity crisis about how to reach the objective, health for all, and whether water and/or sanitation was the most needed service/s that led to that objective. Also some unrealistic expectations were envisioned for the Decade. Mangin [1991] noted that international assistance to water programmes was less than 10% of the total funding for aid and development during IDWSSD and support for it had been at best lukewarm. Perhaps the most important lesson to be learnt from the Decade was the realization that no simple or general package could provide a solution for all developing countries water and sanitation needs, but a country and culturally specific solution needed to be applied [O'Rourke, 1992]. There arose from the Decade and for the Decade several new areas of research: new types of pumps developed, the evolution of community management, women's involvement, Village Level Operation and Maintenance (VLOM), appropriate technology and the like, which would be beneficial to developing nations' long-term water needs [Sharp, 1984; van Wijk-Sijbesma, 1984; United Nations Development Programme (UNDP) and the World Bank, 1987; McCommon *et al*, 1990; among others]. IDWSSD has been extended until the year 2000, under the title, Health (and Water and Sanitation) for all by the year 2000 taking the areas of the 1980's research and successes to try to meet this objective [Appleton and Black, 1990].

2.3 Water Supply Projects: Design Considerations

When designing water supply projects for developing countries, there is a minimum of five major components that are essential to the system's long term viability, four of these components would be found in water supplies in developed countries as shown in Figure 4.

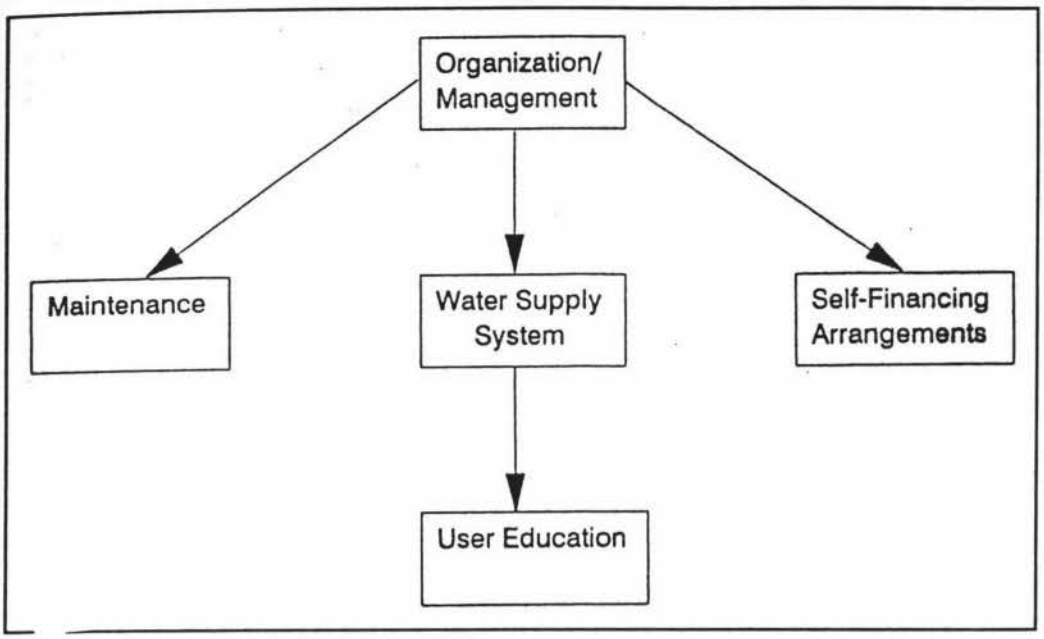


Figure 4. Minimum requirements for a water supply project (Source: Dworkin, 1982).

Water supply projects in developing countries have in the past forty years been the domain of foreign based consultants and engineers, who brought with them skills and technology that fitted well into a developed country setting. Unfortunately the skills, the technology and the mindset of the engineer led to major problems in water supply projects. These problems were related to the technology, which the engineer was familiar with, and often those making decisions in the developing country also wanted to be identified with this modern technology. Other problems affecting the choice of technology included, the "safe" water mindset of the engineer also the codes of practice and professional conventions that the engineer took for granted. This generally leads to over-designed and inappropriate water supplies. The engineer also did not often know some of the other factors that affect the design, construction and ongoing O & M of water projects in developing countries, which he/she would not have considered in a developed country [Reid, 1982]. Figure 5 shows eight separate and often conflicting factors that the design engineer would not normally face in a developed country. E.F. Schumacher's work, `Social and economic problems calling for the development of intermediate technology', developed the idea of appropriate technology in the mid 1960's (this was later reprinted in Small is Beautiful [Schumacher, 1973]). Since then more thought has been put into the technology being used by many of the major development agencies, but many of the above factors that have led to problems are still relevant.

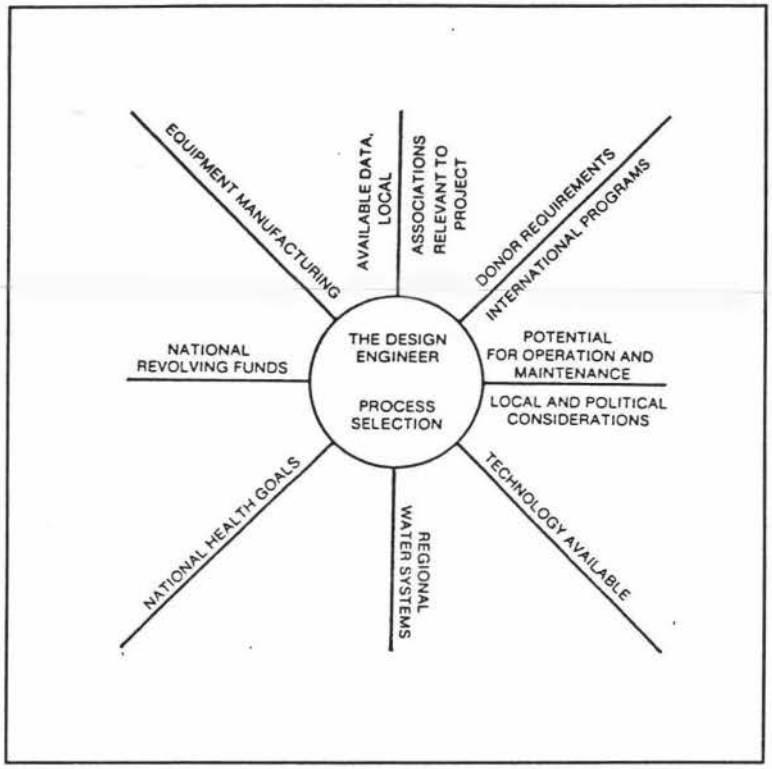


Figure 5. Conflicting elements that affect the engineer working in an LDC situation. (Source: Reid, 1982)

These eight factors are considered important for the engineer to grasp fully to be able to meet the modern day goal of sustainability also for successful design of water supplies to meet the needs of the beneficiaries into the foreseeable future.

2.4 Water Supply Projects: Management Considerations

The management of the water supply project and the ongoing management of the water supply is an equally important consideration as the design of the project. The design and management of the water supply are closely linked, and together they provide the basis for sustainable water supplies. Until quite recently the management of water supplies had often been the domain of government departments because many water project programmes emanated from development policies set by the government [Schultzberg, 1978]. This had typically proved to be frustrating because the management infrastructure of the systems was either poorly setup, virtually non existent or in many cases inflexible and unable to meet the many issues involved [Bottrall, 1978]. Major problems were experienced in the terms of the life expectancy of the water supply, with statements being made like, ... the World Bank estimates water systems in the Third World are breaking down faster than

they can be constructed [New Internationalist, 1981].

In the past 15 years there has been a call for a different type of water supply management that of community management, which is seen as the potential saviour of many water projects that would have failed under government management [Dworkin, 1982; Williamson, 1983; Churchill *et al*, 1987]. The decentralization of management to the community has been advocated by many different consultants. In a recent work by Rondinelli, he put forward several factors for improving the water delivery service and maintenance of the water supply through the decentralization of management.

> Six sets of factors that are crucial to the success of community management are identified: adequate incentives, sufficient skills and resources, appropriate processes for water systems operation and maintenance, effective interorganizational relationships, appropriate technology, and effective systems of monitoring, evaluation and feedback [Rondinelli, 1991].

Several of the above factors appear in the design process as well. The need to seriously weigh the aspects that appear in both management and design engineer major factor lists should be borne in mind, especially if the desire is for sustainable and successful water supply systems[1]. This literature review is focusing on one factor that appears in both the management and the design engineers considerations that of appropriate processes for sustainable water supply O & M.

2.5 Definitions

Operation and maintenance are two distinct processes that take place once the water supply project has been constructed and the water supply system is being used by the beneficiaries. The activities of O & M are defined as:

> *Operation* refers to activities and resources used in making a machine, a piece of equipment, or a larger production system do the work it is intended to do. To operate satisfactorily, capital assets must be in a condition to do their intended work when `turned on' and given the necessary complementary inputs of labour, energy and raw materials. All types of capital assets tend to suffer a reduction in their ability to do work, or will break down entirely, unless special efforts are made to maintain or to restore their capacity. The periodic inspection, replacement or repair of

[1] *There are no successful projects, only those with less problems than others.* A.O. Hirschman quoted by [Smillie, 1991]. This is a important thing to remember when looking at sustainable O & M.

damaged or worn parts, lubrication, removal of unwanted internal waste buildup, protective painting, etc., are what we mean by *maintenance* [Cairncross *et al*, 1980].

Cairncross continued, that there are two types of maintenance, preventative maintenance conducted to prevent or lessen the risk of breakdowns, and corrective maintenance performed when a breakdown occurs. An example of the amount of maintenance on a handpump is shown in Figure 6 (also Appendix 2).

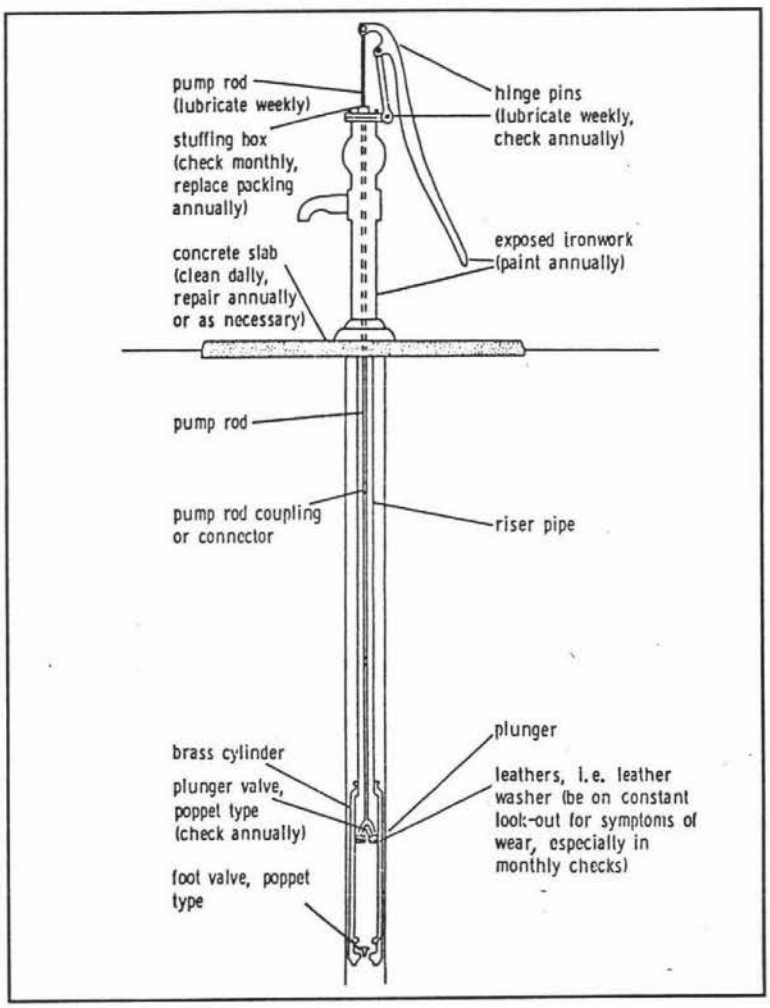


Figure 6. Maintenance points on a simple handpump (Source: Pacey, 1977a)

2.6 Problems Due to Neglect of O & M in Water Supply Projects

A major problem facing sustainability of water supplies in developing countries is the lack of O & M. It is difficult to find villages where systems are working precisely as planned (both technically and financially), and it is common to find relatively new systems that are not functioning with up to 70 per cent failure within a year of installation [Saunders and

Warford, 1976; Overseas Development Administration (ODA), 1985; Churchill *et al*, 1987; Rondinelli, 1991; among others]. O & M failure and difficulties within water supply systems arise from a few differing factors. Hodgkin [1989] noted five areas creating difficulties in Yemen:

- Fuel and oil for operation
- Spare parts, either in the country or at the local level
- Skilled mechanics
- Financial resources
- Well-trained operators

Other difficulties experienced include, lack of management and administrative structures at national and/or user levels [Yacoob and Warner, 1989]. A need for clear guidelines of responsibility for O & M when both users and water project agencies are involved, along with the need for clear O & M programmes [Cairncross *et al*, 1980]. Lack of planning for O & M particularly in the design and funding stages by the water project agencies [WHO, 1987]. The use of inappropriate technology in many situations of failed water supply projects [ITDG Water Panel, 1980]. Beneficiaries lacked involvement in the overall planning, implementation and management of the water supply project [Rondinelli, 1991]. Lack of ownership or acceptance of the water supply by the users [Mujwahuzi, 1983]. A shortage of skilled or trained operators, along with a lack of training programmes [Reid, 1982]. Poor infrastructure for communication of problems to water agencies, so maintenance could be undertaken [van Damme, 1981]. Other water related projects also suffer from similar problems as shown by the U.S. General Accounting Office [1983] report to USAID, suggesting stronger commitments to O & M when involved in irrigation schemes in developing countries. These O & M difficulties of water supply projects will be discussed in more detail in the following sections of this literature review.

2.7 Management and Administrative Structures

In all societies, human activity has a management and administrative structure. Management and administrative structures are needed in all development activities to ensure the completion and positive accomplishment of the activity. The role of the manager is often described as the exercise of four functions, planning, organizing, leading and controlling with respect to five assets, money, methods, materials, men and machines as shown in Figure 7 [Spencer, 1981].

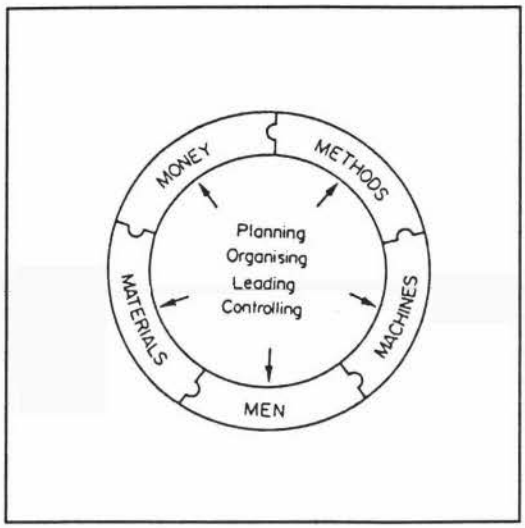


Figure 7. A model of the manager's role (Source: Spencer, 1981).

This is true of water projects as well, Mohammed [1986] quotes that the degree to which a water supply system fulfils its function depends almost directly on the efficiency and effectiveness of its management. Regarding O & M of water projects, Austin and Jordan [1987] quote effective management as the keystone of any O & M programme, by establishing an environment by which the O & M of a water supply can be implemented and maintained. Yacoob and Warner [1989] said that the primary breakdown and misuse of water supply systems are the lack of effective institutional arrangements for community management. Many more maintenance difficulties arise from institutional or financial shortcomings than from technical problems with the pumps themselves [UNDP and the World Bank, 1987]. The groups that could be responsible for the management of O & M are:

- water agency fully responsible
- another agency (e.g. health)
- local/district government
- local water committee representing users
- community member serving as manager
- private owner responsible
- traditional community leadership
- combinations of the above [Whyte, 1986]

These management groups fall into two main categories, institutional management and

community management[2]. The focus here will be on the cooperation and relationship between the two.

2.7.1 Resource Management

Water resource management is an important first step in the management of O & M of a water supply project. It especially affects the sustainable operation of the water project because the water resource has demands placed upon or expected of it by the project administration and the users to provide sufficient water. Various authors have seen that water resource management is an important step in the move towards sustainable development [Postel, 1984; Biswas, 1991; Oyebande and Balogun, 1992; Kirmani, 1991]. The management of water resources is the domain of international, bilateral and governments and their agencies [Falkenmark and Lindh, 1976; United Nations Water Conference Secretariat, 1978; Biswas, 1991; Oyebande and Balogun, 1992]. Water resource management being part of the centralized management structure for water projects is involved in providing encouragement, legislation, training and education to community's and users along with local and/or regional water management structures, thus providing for the long term maintenance of the water resource [Oyebande and Balogun, 1992]. The centralized management role to ensure continuing effectiveness of existing water systems must systematically assess operation compared with intended performance and initiated actions to remedy deficiencies in the system, thus providing a sustainable water supply for the length of the project and beyond [Cox, 1987].

2.7.2 Institutional and Centralized Management

Traditional involvement in the O & M of institutional or centralized management has often been expected in water supply projects. This is especially the case when the local community has little or no involvement (or ownership) in the water supply project [International Reference Centre (IRC), 1988a; Rondinelli, 1991; among others]. The O & M responsibility for the project is thus often seen as the responsibility of the institution that established the scheme [Watt, 1977; UNICEF and WHO, 1979a; Mujwahuzi, 1983; Rondinelli, 1991; among others]. Due to the high failure rates of water supply projects there has been increasing support for the management and servicing of O & M to be

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[2] Community management within the context of this thesis primarily refers to the community water committee.

moved from centralized water agencies to local or user responsibility, which are believed to be more successful [World Bank, 1976; Cairncross *et al*, 1980; WHO, 1981; van Damme, 1981; Gow and Morss, 1988; Rondinelli, 1991; and others].

Although many authors report that decentralization of management is the only successful model for O & M, some authors believe there is a need for strong central and regional management structures along side a decentralized structure. O'Rourke [1992] put forward the reason for the push to have community management of water supplies is to bypass the weak and inefficient government institutions, which may have achieved the IDWSSD target. But O'Rourke reasoned it would not be sustainable without strong local and national government water sector institutions. Yacoob [1989] agreed with him to some extent, and said that the circumventing of government institutions may increase a project's efficiency but does not enhance its long term sustainability. She continued that community management of water projects is a necessity but should work within the resources of national and local governments, even if organized and sponsored by NGOs or development agencies.

O'Rourke continued in his article even more cynically by saying that community participation and community management have rarely been a component of water and sanitation systems in the West, why then are western donor agencies so enthusiastically imposing it on other cultures, without sound research or proof that it is a viable option?

Taking these views into account that there are major problems with institutional management of water supplies, which O'Rourke admits too, these need to be dealt with to increase sustainability of O & M.

2.7.2.1 Problems and Failures of Institutional and Centralized Management

The problems and failures of institutional and centralized O & M management that the literature presented were as follows:

1. The idea of maintenance as a means of preventing breakdowns was lacking. Administrators confused maintenance with repair [Pacey, 1977a].

2. In many developing countries the weakness of the government institutions and infrastructure was seen as a major problem [World Bank, 1976; van Damme, 1981; Churchill *et al*, 1987; Rondinelli, 1991]. This was particularly seen in rural areas where the failures of water supplies are out of the sight of government officials, and do not affect the more politically powerful and wealthy urbanites [Development Studies, 1992]. Governments often provide adequate services in urban areas, due to the economy of scale, also because resources are more readily available [World Bank, 1976; UNICEF and WHO, 1979a; van Damme, 1981; WHO, 1987; Churchill *et al*, 1987]. Churchill *et al* [1987] believed that the centralized management structure cannot be expected to achieve levels of efficiency and effectiveness beyond that of the central government structures, thus institutional changes are unlikely to resolve all the problems that O & M faces. In Ethiopia for example, the reason for the centralized agency failure to respond to the O & M needs of rural communities was because there was no money generated from these systems unlike those in the towns [Mangin, 1991].

3. Along with the weakness of the governments institutions and infrastructure another major problem is the number of government agencies involved in water supply projects, who often compete with one another [World Bank, 1976; Saunders and Warford, 1976; Schultzberg, 1978; Dworkin, 1982; Rondinelli, 1991]. This has created confusion about who is responsible for O & M, doubling up of precious resources, along with one agencies work being often negated by another [UNICEF and WHO, 1979a; Mohammed, 1986]. There are cases of proliferation of similar activities within the same water department, for example in Tanzania there is six divisions, these different divisions were doing similar jobs creating both confusion for the personnel and to the water users [Mujwahuzi, 1983].

4. The choice of technology has also created failures, with officials choosing inappropriate technology due to the expectation that the latest and greatest technology from developed countries must be best. This has led to the unavailability of parts, a lack of skilled and qualified technicians, and a shortage of finance for parts [Saunders and Warford, 1976; Reid, 1982; WHO, 1987; Austin and Jordan, 1987].

5. Planning for an O & M infrastructure has been lacking, for spare parts, equipment, workshops, alternative sources of energy, communications and transport at the design stage of water supply projects [Saunders and Warford, 1976; Harlaut, 1976; UNICEF and WHO, 1979a; WHO, 1987]. The ITDG Water Panel [1980] believe that future planning for O & M is the most important factor in the planning, design and construction stages of a water project, so that the technology chosen can be maintained and operated to its optimum, yet it is so often overlooked.

6. There is more prestige and glamour (and political effect) if the government expenditure is put into construction than into the O & M of water projects [Saunders and Warford, 1976; Austin and Jordan, 1987].

7. Finally, the actual costs of O & M are often not realised by the governments financial advisors and treasury departments, thus the tariffs applied to the users of the water supply do not cover the costs of the O & M [Saunders and Warford, 1976]. These authors suggest that a charge be made for O & M that actually covers the costs, but because of the inadequate levels of O & M actual costs would be hard to actually set, with the actual costs being significantly higher than generally estimated. Jordan and Wyatt [1989] produced a report that is useful for estimating the O & M costs step by step covering the following cost elements: labour, materials, chemicals, utilities, transport, private contractors, and others for both rural and urban water supply systems.

2.7.2.2 Role of Institutional and Centralized Management in O & M

Although decentralization has become fashionable [Conyers, 1983], a role for government and institutional management exists for the successful O & M of water projects and it is essential [Yacoob, 1989; Yacoob and Rosensweig, 1992]. The role of government and institutional management has changed though from one of direct management of O & M to that of promoter, facilitator, trainer, etc. [Briscoe and de Ferranti, 1988; Yacoob and Rosensweig, 1992]. The following areas have been suggested as the scope and responsibility of a centralized management structure for O & M.

The setting out of O & M policies is the first responsibility of the centralized management structure [Cairncross *et al*, 1980]. There are two direct maintenance policy areas suggested

by Cairncross *et al*:

i) Is the main objective preventative maintenance, corrective maintenance, or a deliberate balance between them?

ii) Is maintenance assumed to be almost entirely a responsibility of the water agency or is it deliberately shared, to the maximum extent feasible, with village authorities or users?

The total management of O & M by the centralized structure is suggested in cases where decentralization is not possible, or as the best method that suits the local conditions (ie. technical skill, education and income) [Saunders and Warford, 1976; Report by Working Group Two, 1984; IRC, 1988a]. Donaldson [1977] suggested that this practice should be applied where a number of families are scattered in a rural area, with no formal community structure. Saunders and Warford [1976] suggested another view when a centralized system of O & M is used, the setting up of a community advisory committee so that there is some sense of community ownership and a concern to see the water system operates correctly.

The area that centralized management structures should be most responsible for is the infrastructure. Infrastructural organization should start in the planning stages of water supplies by looking at the design, technology and the style of management structure that can best achieve the goal of sustainable O & M [van Damme, 1981; Austin and Jordan, 1987; WHO, 1987; Briscoe and de Ferranti, 1988].

Also part of the infrastructure is the establishment of a training programme for the local and regional maintenance people and local management committee (cf Section 2.10.3 and Figure 8) [Kalbermatten *et al*, 1980; Dworkin, 1982; Jordan *et al*, 1986; WHO, 1987; Churchill *et al*, 1987]. This includes the creation or strengthening of community organizations to take effective responsibility for O & M [Rondinelli, 1991].

Activity	Weeks from Beginning
Develop problem-solving skills	1-6
Provide health and sanitation eduction	7-24
Raise money for operation and maintenance fund	7-20
Manage O & M fund	
Arrange for maintenance	10-20
Develop guidelines for using water system	20-24
Prepare for construction	21-24

Figure 8. Activities during the training phase for the village water committee (Source: Yacoob and Rourke, 1990)

A centrally administered technical support unit along with a good stock of spare parts is needed to provide parts and expertise in problems with water supply [UNICEF and WHO, 1979a; WHO, 1981; Kalbermatten *et al*, 1980; Dworkin, 1982; WHO, 1987]. Suitable procedures need to be set in place for purchasing parts at realistic prices along with a good transport and communication system for getting parts and service to the system in a reasonable time [Dworkin, 1982; WHO, 1987]. A data system should also be set up to record work orders, parts purchased, and a history of each water system needs to be kept [Austin and Jordan, 1987].

O & M schedules according to the type of water system being introduced need to be established for the local operators to follow (cf Appendix 2) [Kalbermatten *et al*, 1980; Dworkin, 1982; WHO, 1987]. Austin and Jordan [1987] said that standard operating procedures clarified all O & M responsibilities. Activities are listed and the procedures specified about when an activity is necessary and who is responsible for it. They continue that the delegation of authority, decision-making responsibility, and lines of communication are also needed to be defined.

Responsibility for O & M should rest with one organization to reduce doubling up of resources and to achieve greater efficiency [Saunders and Warford, 1976; Dworkin, 1982]. The centralized management system should encourage, and the government may need to legislate the standardization of equipment to lessen the diversity of equipment and parts needed [Cairncross *et al*, 1980; Austin and Jordan, 1987; UNDP and the World Bank,

1987; McPherson and McGarry, 1987]. The UNDP-World Bank project to develop VLOM handpumps could be useful for governments in deciding what handpumps are the most reliable to be maintained at the local level, reducing government costs [UNDP and the World Bank, 1987]. A good example of this is in Zimbabwe, where the use of Blair handpump for shallow wells and Zimpump for deep wells is encouraged by the government [McPherson and McGarry, 1987; Morgan, 1990].

Finding and helping local communities and users with funds for O & M is considered an important role to be played by the central management [UNICEF and WHO, 1979a; van Damme, 1981], along with the education and motivation of the users about the need for continual O & M of the water supply [Kalbermatten *et al*, 1980; Dworkin, 1982; WHO, 1987; Briscoe and de Ferranti, 1988]. Jordan *et al* [1986] said that before the water project is even started the planner should address the following two issues regarding O & M funding:

- How much will is cost to operate the system?
- Can the consumers and government afford this cost?

If the answer is negative to the second question, Jordan *et al* suggested that the project either be redesigned or abandoned, if not, the results would be a poorly operated and maintained water system. They continued that the whole issue of funding O & M needed to be discussed thoroughly with the community, including the ability and willingness of the community too pay, how the funds will be collected, banked and saved.

Finally the role of the centralized management structure is to monitor that the O & M schedules, the local management responsibilities and the overall objectives of the water project are being met [Kalbermatten *et al*, 1980].

To achieve these centralized management structure objectives there would need to be considerable improvements and performance by the government and its institutions. O'Rourke [1992] believes that a more serious attempt at institutional building is needed which can accommodate realistic inputs from communities and the private sector. He goes on to say that development funds should be put into local government training, thus providing for the long term sustainability of a number of water projects instead of just performing one off projects. He concluded that community participation and management are needed but is not sustainable by themselves without strong institutional support in the

water sector. There are other O & M management areas that need to be pursued to increase and enhance the longevity of water supply projects working alongside institutional management.

2.7.3 Decentralized Management

In recent years the cry for decentralization of projects from central management has continued, and many see it as the best form of management for O & M. Some would say that decentralization of responsibility for O & M is the only way for successful water supply [World Bank, 1976; Schultzberg, 1978], and is particularly needed for rural communities distant from urban areas [WHO, 1987]. But what is decentralization and what types of decentralized management of O & M are perceived? The Collins Concise dictionary describes decentralization as the reorganization of a large organization into smaller autonomous units. There are two forms of decentralized management that can be envisioned or are in use for O & M of water supplies, they are regional institutional management (including local government) and the community/user management of O & M [Donaldson, 1977; Schultzberg, 1978; Dworkin, 1982; Vaughn *et al*, 1984; Cromwell, 1992; Rondinelli, 1991]. Donaldson [1977], UNICEF and WHO [1979a], Baldwin [1983], Mujwahuzi [1983] and Vaughn *et al* [1984] show that there is a need for and examples of both regional and community or user management along with the role of centralized management (see Appendix 3). The focus here will be on the management role of the community or users, as the role of regional management is often similar to that of central management, and their objective is often to encourage, train and implement the central management's objectives [UNICEF and WHO, 1979a].

2.7.3.1 Problems Facing Decentralized Management

If decentralization is deemed the best way for management to achieve sustainable O & M of water supply projects there are several problems to be faced for it to become successful:

1. Gaining political support for decentralized management for O & M of water supplies was a major hurdle to be overcome [Gow and Morss, 1988; Briscoe and de Ferranti, 1988; Mangin, 1991].

2. The government often lacked the capacity at national and local level to encourage and foster decentralized management [Briscoe and de Ferranti, 1988]. The following quotation shows this failure of governments and international development organizations to do this:

> Governments and international organizations still attempt to use planning and management techniques to *control* development activities rather than to facilitate and encourage flexibility, experimentation, and social learning that are essential in implementing development projects successfully. - [Rondinelli, 1982]

3. Another factor that caused problems was what role both the centralized and decentralized management should play in O & M (cf Section 2.7.2.2) [Cairncross *et al*, 1980; Briscoe and de Ferranti, 1988; Yacoob and Rosensweig, 1992].

4. Gow and Morss [1988] along with Cromwell [1992] noted that a strong decentralized structure is dependent upon a strong central structure that, as previously mentioned, is a major weakness in LDCs (cf Section 2.7.2.1).

The policy of decentralization is a core requirement for what has been identified as the key for the move to sustainable water supply systems (particularly of rural water projects), community management [McCommon *et al*, 1990; Rondinelli, 1991].

2.7.4 Introduction to Community Management

The role of communities in management has evolved over the past three decades, from the obtaining of free labour to that of full involvement in the planning, construction and O & M in water supply projects [Briscoe and de Ferranti, 1988; Rondinelli, 1991]. Many writers argue that community managed O & M tends to be far more reliable than government or centralized O & M management [Dworkin, 1982; Williamson, 1983; Churchill *et al*, 1987; among others]. Before looking at some of the changes over the past few years in the role of community management, it is necessary to define what it is and distinguish it from community or beneficiary participation. McCommon *et al* [1990] takes it to mean, that the beneficiaries of rural water supply and sanitation have responsibility,

authority and control over the development of such services[3]. During the mid 1980's there was a move from the practices of the late 1970's and early 1980's, which involved the community in some areas of the consultation process along with the training of local operators [Yacoob, 1989]. This new practice saw the community take control of the management, ownership, use and O & M of the water supply [McCommon *et al*, 1990; Yacoob and Rosenweig, 1992] (cf Appendix 4). Community management of water supplies and sanitation (WS&S) since 1983 has been a focus of many authors, some examples are [Williamson, 1983; Yacoob, 1989; McCommon *et al*, 1990; Rondinelli, 1991; Yacoob and Rosensweig, 1992]. The push towards community management was supported by the objectives of the IDWSSD as shown in United Nations Water Conference of 1977 Plan of Action, where one of the four priority areas was:

> Communities must be provided with effective education on domestic hygiene and must be motivated and involved as appropriate at every level of the programme. This involvement by the community needs to be in the following areas: planning, construction, operation, maintenance and financing of services, and the monitoring and safeguarding of the quality of the water supply. (Priority area for action No.4 [WHO, 1981])

The plan went on to recommend that national governments set up structures that support and encourage community participation in all areas of WS&S.

O'Rourke [1992] postulated that IDWSSD was a watershed in the whole process towards community management of water supply projects. If this is true then the above writers, many of whom are involved in some of the major development and funding agencies, which took the IDWSSD seriously picked up this new approach and advanced it (taking the ideology of the agencies they belonged too).

Dr. May Yacoob, Director of WASH Projects and one of the most proliferate writers on community participation and management cited that history demonstrates that for centuries rural communities have managed their own scarce water resources. They had established

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[3] McCommon *et al* [1990] define responsibility, authority and control as follows:

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

rules for water use and roles for water resource maintenance [Rondinelli, 1991]. When water systems management became the responsibility of national governments during and after the colonial period, the water management capabilities of communities were considerably weakened and ignored [Briscoe and de Ferranti, 1988]. Thus it could be said that community management of water supply projects and their O & M is a return to centuries old traditions, and that IDWSSD was a catalyst for this.

The degree of community management responsibility for O & M ranges from total responsibility that is either fostered by government or by development agency policy [Mujwahuzi, 1983a; UNDP and the World Bank, 1987; Briscoe and de Ferranti, 1988] through to some areas of O & M management responsibility being dependent upon the community's skills and competence [Cairncross *et al*, 1980; Report by Working Group Two, 1984; Mohammed, 1986; among others]. It must be noted that several writers commented that there were few truly independent community managed schemes, most are dependent on some form of institutional support [Yacoob, 1989; Vermillion, 1991; O'Rourke, 1992]. Table II shows the full range of potential community management of water projects, from marginal involvement in management too full involvement in management.

McCommon *et al* [1990] commented that O & M management responsibility by the community becomes recognizable at level two in Table II. Although recognizable at this level, it was also said that community's are seldom prepared to take full responsibility for system maintenance, at this level.

Level	Responsibility	Authority	Control	Management Capacity
I	External agency; little community responsibility	External agency; informal community consultations	External agency; limited community participation	Insufficient
II	External agency; community responsible for operation	External agency; limited formal role for community institutions	External agency; moderate community participation	Limited
III	Joint; community responsible for O & M	Joint; collaborative role for community and agency	Joint; strong community participation and limited community management	Moderate
IV	Community; external support	Community; external support	Community; external support	Sufficient
V	Full community responsibility	Full community authority	Full community control	High

Table II. Levels of community management (Source: McCommon et al, 1990)

There are different degrees of technology used in water supply schemes, which require different styles of community management. Figure 9 shows a variety of water schemes that can be found in developing countries that require different management skills and training to sustainably operate and maintain. They range from the least complicated class of individual management to a comprehensive management structure that involves highly skilled professionals [White *et al*, 1972].

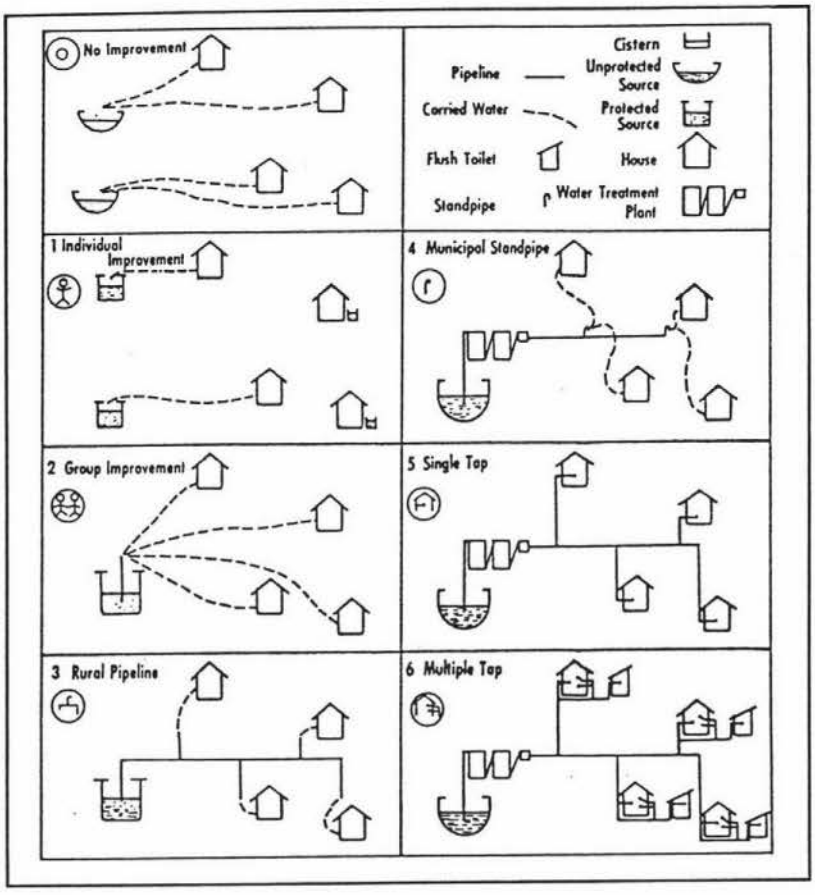

Figure 9. Types of water improvements (Source: White et al, 1972)

Building on this there are a variety of groups within the community involved in the management of O & M of water supplies. These different groups involved include irrigation water user associations (WUA) [Asian Productivity Organization (APO) Secretariat, 1991], VLOM [UNDP and the World Bank, 1987; McPherson and McGarry, 1987], urban users [Hollnsteiner, 1979], rural and village communities and users [Mohammed, 1986; UNDP and the World Bank, 1987], rurban[4] villages [Donaldson, 1976], women [Elmendorf and Isely, 1982; Narayan-Parker, 1988], and traditional community management [Whyte, 1976; Anon, 1978].

2.7.4.1 Problems Facing Community Management of O & M

Community management of O & M is confronted by several challenges, which will affect the future sustainability and function of the water supply system.

[4] The term rurban is a combination of urban and rural developed by rural sociologists to designate small but concentrated populations [Cardenas, 1979].

The first challenge is that of political will to promote community management (cf Section 2.7.3.1) [Dworkin, 1982; McPherson and McGarry, 1987; IRC, 1988a; Briscoe and de Ferranti, 1988; McCommon *et al*, 1990; Rondinelli, 1991; among others]. As Abrahamson [1970] pointed out successful community development demands far more than participation by locals, it needs government support and encouragement to work. Yacoob and Rosensweig [1992] suggested seven keys to supporting successful community management at government level:

- Division of responsibilities for operations and maintenance
- Water quality monitoring
- Legal status of the community water users associations
- Regulatory provisions to ensure that the community water user's associations are carrying out their responsibilities
- Ownership of the physical assets
- Community responsibility for managing the system
- Consequences of failure to manage the system effectively (cf Appendix 5)

The issue of ownership was considered by Yacoob and Rosensweig the most important factor for the community taking responsibility for the O & M of the water supply. This issue will be discussed further under Sections 2.7.4.2 and 2.8.6.

Another problem that community managed O & M needs to overcome is when the government water department is not sure how to incorporate community involvement and management (and are unwilling to cooperate due to perceptions of users as ignorant) [Yacoob and Rosensweig, 1992]. This becomes a larger problem when community management had not been officially included in the terms of reference or job description of the water department, as in Tanzania [Mujwahuzi, 1983a; Mujwahuzi, 1986]. This is a delicate matter. Yacoob and Rosensweig [1992] pointed to the necessity of incentives for the water department workers involved. These need not be monetary incentives. In a report by [Sara and Grey, 1990] the following ideas were presented as incentives:

- Holding extension officers accountable for holding a number of community meetings and reporting back the results of the meetings.
- Supportive supervision and regular training of extension officers.
- Providing community organizations with training in the evaluation of the extension officers.

The management of O & M responsibility needs to be carefully defined by the development agency or government water department (Agency)[5], otherwise the success of community management would be in doubt [Cairncross *et al*, 1980; McCommon *et al*, 1990]. Cairncross *et al* [1980] and Jordan *et al* [1986] suggested that a series of questions need to be asked of the Agency about what levels of community involvement are available for managing water supplies. Then suitable arrangements could be made to prepare the structure for what would be the community management responsibilities (cf Appendix 6). These management responsibilities then need to be accepted by the community or the water projects sustainability and O & M will be in doubt [Wood, 1983; Yacoob, 1990; among others]. Agarwal *et al* [1980] said that one of the major challenges is to get the users to take responsibility for the water system and thus O & M, rather than the Agency being responsible. This requires a change of attitude in the community that the Agency or the government will do it all [IRC, 1988a]. A positive attitude is a necessary requirement for the Agency to encourage community involvement otherwise the transfer of responsibility will be hindered [Report by Working Group Four, 1984; IRC, 1988a]. Once understood what the responsibilities are for the O & M of the water supply, only then should the management and ownership be fully assumed by the community also when the following three conditions are set in place:

- spare parts are available
- the community is prepared to handle routine maintenance
- back up support is available to the community for complex repairs and maintenance [Yacoob, 1989].

The responsibilities of community management for O & M will be discussed in detail in Section 2.7.4.3.

The role of training of the community to be managers of the water supply had been overlooked in some cases because of a view that romanticized the community as a cohesive, capable and having a will that does not exist anywhere in the developed or developing world [Briscoe and de Ferranti, 1988; Schoeffel, 1992]. Dworkin *et al* [1980] stated that the failures of community management of O & M are due in part to underestimating the need for training. IRC [1988a] pointed out, few communities could

[5] The use of Agency defines where either an aid agency or/and a government water department would fulfil this role within this literature review.

run a modern water system without support through training and backup of the Agency. The training of community management of O & M is discussed in Section 2.10.3.2.

Another problem that faces community management of O & M, is the time and cost that it takes to build up the required management techniques and skills [McCommon *et al*, 1990; Yacoob and Rosensweig, 1992]. Costs for the community management approach to water supplies are initially more expensive due to the high cost of building human resources. But costs decline over the long term as the local commitment helps to keep overall O & M costs down [McCommon *et al*, 1990]. The role of the Agency has to be changed from being totally responsible for the systems O & M to that of being involved in organizing, training and facilitating communities (groups or individuals within the communities) to be responsible [McCommon *et al*, 1990] (cf Section 2.7.2.2).

Community conflicts and influential groups (eg. elites) can have an impact on the management of O & M, especially when they exert more influence than the water committee in the community [Jackson, 1979; Sunman, 1983; McCommon *et al*, 1990; and others].

Among the most important factors that need to be found out in the early planning stage of the water project, is the question, whether the beneficiaries need the water supply project [Wood, 1983; McPherson and McGarry, 1987]. Pacey [1977a] suggested that a water project should not start until the community formulated a request for help to install a water supply, thus showing a desire for the project (cf Section 2.8.1). Matango and Mayerle [1971] note that in self-help projects in Tanzania, nearly all the projects face problems of O & M, which could be simply overcome by planning. This planning should include they stated, choosing the right design and materials, provide the right training and enough funds for O & M.

The management of the funds for O & M is a sensitive issue, and requires a structure where the community members can determine that the funds are well accounted for, also allowing the Agency to monitor the use of funds [Yacoob and Rosensweig, 1992].

2.7.4.2 Ownership

Yacoob and Rosensweig stressed that ownership is the most important factor to achieve community responsibility for O & M, and preferably legal ownership is needed (cf Section 2.8.6). Most authors that support community management of O & M believe that ownership of the water supply project is the most important component in creating sustainable water systems [Report by Working Group Four, 1984; Liebenow, 1984b; Lawrence, 1986; IRC, 1988a; Yacoob, 1990; Rondinelli, 1991; Yacoob and Rosensweig, 1992; among others]. Problems can occur even when a government is committed to community management, especially when the ownership of the scheme is not handed over to the community in some official and legal way. This problem occurred in Tanzania where the government encouraged and promoted community management of water schemes, particularly the development and O & M of the schemes, but without the transfer of ownership to the users [Mujwahuzi, 1983a; Mujwahuzi, 1986]. Cleaver [1991] said that the view that acceptance of responsibility would lead to the concept of ownership was not always substantiated, by the case studies undertaken. The owner of the system was still perceived as the governments, especially if the pump broke down. Thus legal ownership by the community, needs to be clearly established to avoid the problem of who is responsible [van Wijk-Sijbesma, 1984]. McCommon *et al* [1990] suggested that ownership of the water scheme should be handed over to the community when the system is completed and functional. This may be as some form of system opening day and/or legal transfer of ownership to the users (cf Section 2.8.6) [Whyte, 1983; van Wijk-Sijbesma, 1984; Yacoob *et al*, 1987; Rondinelli, 1991].

Having established and dealt with the problems that community management of O & M can face, it is necessary to establish what the responsibilities and role of the community water committee are.

2.7.4.3 Responsibilities of Community Management (Water Committee)

The responsibilities of the community water management committees for O & M will differ, this depends on the type of water system put in place along with the degree to which the Agency has devolved responsibility [van Wijk-Sijbesma, 1984; McCommon *et al*, 1990]. And as Yacoob and Rosensweig [1992] pointed out, and as previously mentioned under Section 2.7.2.2, communities on their own cannot perform all O & M

functions.

There is some debate about the level of education and skills needed for community management of O & M. Saunders and Warford [1976] believe that the handing over of O & M too relatively uneducated community management committee raises the likelihood of the system failing. Whereas Donaldson [1976 & 1977] said that with proper guidance and training, poorly educated community leadership could make meaningful choices, motivate others and provide the leadership required for success in administrating and managing the water project including O & M. It must be said in defense of Saunders and Warford that they point to the fact that many failures due to community management have been accompanied by the reluctance of the water agencies to provide their best people for training the local users.

The responsibilities of the local water committee will, as mentioned previously, be different depending upon the situation, but the following extensive list of community management responsibilities for O & M provided by [Whyte, 1986] (cf Appendix 3) would cover most types of water supply projects from basic water source improvement in a village to the more technologically demanding projects where pumps, treatment, pipelines, and taps are used (as shown in Figure 9):

Community Management Responsibilities [White, 1986]

- Reporting periodically to agency
- Reporting urgent problems immediately
- Arranging collection of taxes, water charges, etc. (cf Section 2.8.4)
- Developing and applying regulations
- Keeping archives, log books
- Organizing demonstrations and official visits
- Selecting and appointing operators and other staff
- Delegating responsibilities to operators
- Training of operators
- Supervising operators
- Paying operators
- Keeping accounts
- Dealing with user complaints
- Advising on proper use of facilities
- Organizing community contributions for upgrading, extension and repair of facilities
- Arranging community labour

The above list of management responsibilities was supported by a large number of authors, some of whom were [UNICEF and WHO, 1979a; Sunman, 1983; Donaldson, 1984; Report by Working Group Two, 1984; Mohammed, 1986; Yacoob and Roark, 1990]. One area that Whyte's list lacked was the need for keeping a record of the replacement parts in stock within the community. Also where additional parts are stocked and can be ordered for water system if needed [Yacoob and Rosensweig, 1992]. Tayler [1983], mentioned that towns in Sudan faced major repair problems due to two main reasons, one of which was the difficulty in obtaining parts and materials for the water supply systems. As Yacoob [1989] mentioned in Section 2.7.4.1 management of the water supply should only be fully assumed once three conditions are set in place, one of which is the availability of spare parts. This is dependent on a centrally administered technical support unit with a good stock of spare parts and expertise in the problems that are part of water supply O & M [UNICEF and WHO, 1979a; Kalbermatten *et al*, 1980; Dworkin, 1982; among others] as discussed in Section 2.7.2.2. The infrastructure needed for parts will be discussed in more detail under Section 2.10.1.

The following sections are focused on the different groups within the community that could be involved in management of O & M.

2.7.4.4 Lessons From Irrigation WUA Involved in Management of O & M

> Engineering is not the fundamental problem underlying irrigation development in the LDCs. Engineering principles are known and can be adapted, but the major problem... is to discover ways to utilize farmer clients' more effectively in operations and maintenance and in development programs which will create rural transformation. - Aaron Wiener, *ICIDD Bulletin* quoted by [Freeman and Lowdermilk, 1991].

As can be seen by the above quotation O & M is a major factor in irrigation management and sustainability. What lessons can be learnt from irrigation systems management of O & M and applied to water supply projects?

Irrigation user groups[6] have been involved in O & M for thousands of years. For example in the letters of Hammurabi who was a king in Babylon around 2000 B.C., a law of

[6] The literature on O & M of irrigation systems is extensive, this literature review will be focusing on some of the general trends in O & M management of irrigation systems, and in particular WUA.

Hammurabi states that if a man neglects to strengthen his bank of the canal and waters carry away the meadow, the man whose bank the breach is opened shall render back the corn that he has caused to be lost [Hansen *et al*, 1979].

The recent trend towards community based water user associations (WUA) has either been traditionally based as in Indonesia, Malaysia, the Philippines, Thailand, Japan, Sri Lanka, in much of India, Pakistan, parts of Africa and Latin America [Barrow, 1987; Wisner, 1988; Ore and Rochabrun, 1990; Bagadion and Korten, 1991], or have been a recent introduction promoted by governments or development agencies [U.S. General Accounting Office, 1983; Bagadion and Korten, 1991]. Coward and Ahmed 1979] showed for example that in parts of Bangladesh the village leadership committee is responsible for all management within the village cooperative, this includes the operation of the irrigation system. The participation from irrigation users is by electing staff for the operation of the irrigation system during the cropping season, sending these staff for training, and paying their wages. Whereas in Nepal, village irrigation schemes and some larger schemes, O & M management is handled by the WUA only [Alwis, 1991]. In some countries WUA have been highly successful in managing irrigation systems, including aspects of O & M [Gill, 1991]. Thompson [1991] said that farmers had very real abilities to solve local water problems in water management, and have solved O & M problems, such as water allocation and distribution. A study of WUA managed schemes in Nepal demonstrated that the WUAs with a reasonable level of organizational capacity were able to realize five significant areas of management and maintenance:

1) mobilize significant amounts of labour and money on a continual basis for maintenance and operation,
2) resolve local conflicts over water,
3) allocate and distribute water equitably,
4) enforce rules, and
5) coordinate cropping patterns and planting dates to optimize the efficient use of available water [Baxter and Laitos, 1988].

Unfortunately while some studies have given successful examples of WUA, others have not. The great expectations of WUA in the management of irrigation systems in Asia including O & M, has not been fulfilled in many cases [Johnson, 1991; Vermillion, 1991].

Lessons learnt from WUA management of O & M in irrigation that can be applied to water supply projects were as follows:

Tasks in O & M

- To arrange labour and distribute the physical and financial liabilities among the members.
- To settle disputes among members.
- To carry out work according to standards and specifications.
- To maintain proper records of materials used.
- To arrange periodic cleaning, maintenance and repair of the watercourse [Gill, 1991].
- Manage and raise funds for O & M [APO Secretariat, 1991].
- Sharing the water.
- Maintaining the water source [Stern, 1988].

Problems

- Low level of participation in the planning and O & M of the irrigation system.
- Inequitable distribution of water to all the users.
- Lack of training for WUA in management and how to operate and maintain the irrigation system.
- Rationalization and collection of water rates/charges [APO Secretariat, 1991].
- Lack of legal back up to WUA authority [Alwis, 1991].
- Problem of obtaining parts [Sagardoy, 1982].
- Problems of planning of maintenance funds [Johnson, 1991].
- Insufficient attention to the institutional environment in which irrigation takes place has created in some cases defects in O & M.
- The need for a specially designed management system created by the way an irrigation scheme physically links a number of farmers. This necessitates authority resting with the WUA.
- Where O & M responsibilities were shared with the Agency, three problems arose:
  - Vague or indefinite regulations or instructions about the share of responsibilities.
  - Absence of a common meeting point for discussing and settling differences.
  - Absence of an effective WUA to represent users interests.
- User motivation for O & M that was stifled by interference from a central government or external agency [Stern, 1988].
- Modernization of irrigation systems can destroy well established and effective management of O & M if done without including users [Ore and Rochabrun, 1990].

Successes

- That traditional systems were able to operate and maintain complex irrigation systems by themselves without outside help [Ore and Rochabrun, 1990].

- Water has often been a source of conflict, the use of WUA have been able to reduce this problem.
- WUA has encouraged a responsible behaviour by the farmers.
- Some of the best irrigation systems in the world are run by WUA.
- Focus on management as an important factor in sustainable irrigation schemes.
- Change in policy by governments to include more self-reliant roles for WUA.
- O & M has been successfully managed by WUA [Alwis, 1991].
- WUA establishment are required for loan disbursement from the development agency.
- WUA was found to be the most important element for successful operation of irrigation management in the Citanduy project in Indonesia.
- Collection of user fees by WUA [U.S. General Accounting Office, 1983].
- Involvement of WUA from the beginning of the irrigation project.
- Development of the capacity for management in established and new WUA.
- Authority given to the WUA for O & M [Bagadion and Korten, 1991].
- Mobilize significant amounts of labour and money on a continual basis for O & M.
- Allocate and distribute water equitably.
- Enforce rules [Baxter and Laitos, 1988].
- A charter specifying the rule's behaviour within the WUA [Freeman and Lowdermilk, 1991].

Research and Implementation Needed for Further Success

- Determination of technical, financial and managerial skills required for an effective WUA.
- Research to figure out the optimum area for a WUA to manage.
- Research into effective charging and collection of water use charges.
- Determining the priority of the maintenance tasks [Johnson, 1991].
- Research into the sociological, cultural and economic explanations for WUA lack of success [Bromley *et al*, 1980].
- Building of the necessary institutional capacity through O & M training (management, technical training and equipment maintenance).
- Estimating the life-of-system O & M costs.
- Provide monitoring and early warning of O & M funding shortfalls.
- Priority consideration of O & M requirements during project design.
- Appropriate transition from construction to O & M.
- WUA is tailored to meet the specific needs of the locality, eg. local custom, religion, ethnic background etc.
- Have a strong organizational structure that can establish discipline and ensure equitable distribution.
- WUA needs to be convinced of the benefits and advantages of the irrigation system and the importance of O & M.
- WUA participation is needed in the system's design and construction to help sense of ownership [U.S. General Accounting Office, 1983].

- Research into making O & M of the system easier for the users, for example by replacing a component in a pump instead of dismantling the part to be overhauled [Brabben, 1992].

The above findings show that irrigation O & M problems correspond to those experienced in water supply projects. The successes have come about by similar processes and the areas that need to be more fully researched and implemented prior to successful WUA management of O & M are comparable. Thus, research into these areas will be of benefit to O & M of water supplies.

Because there are some differences between urban and rural water projects, the following looks at the management responsibilities for O & M of each.

2.7.4.5 Urban Community Management of O & M

Within an urban area one is likely to find a number of different types of water systems [Makinwa-Adebusoye, 1988]. White *et al* [1972] pointed out the African city embraces all six classes of improvements, and unimproved water sources for the residents to use (cf Figure 9). The reason for the diversity of water systems found in urban areas, is often socioeconomic, where the wealthy and more politically active have piped and tap water, while the poor rural immigrant to the city is often dependent upon standpipes or an unimproved water supply [Lee, 1969]. This is shown in the following graph (Figure 10), where water planning for cities in various countries differentiate between those in poor housing and those in good housing.

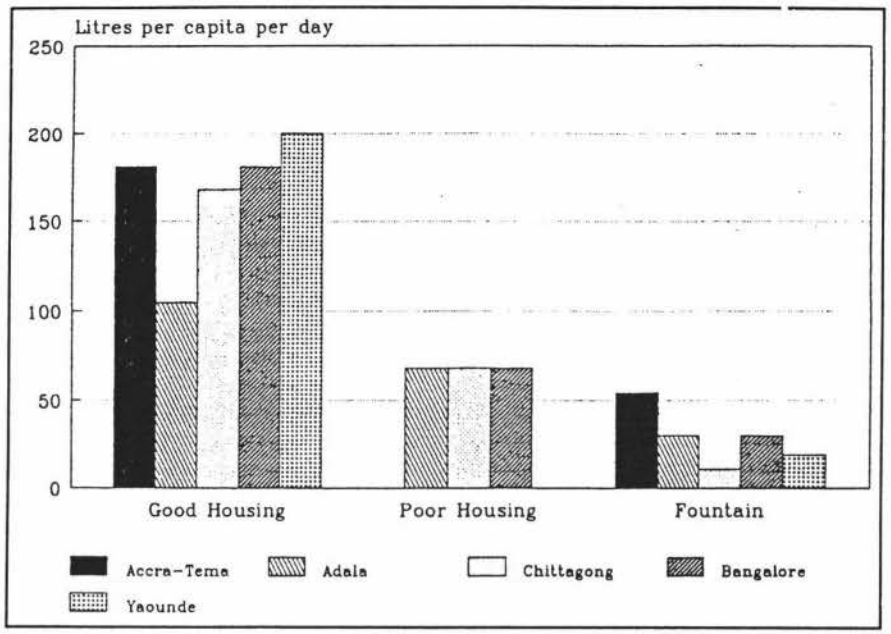

Figure 10. Proposed and planned levels of water consumption in selected cities (Source: Lee, 1969)

It is often presumed that the management of O & M of urban water supplies could probably cope with more sophisticated water supply systems being used [WHO, 1987]. Unfortunately O & M management is as lacking in urban areas as it is in rural areas. Agarwal *et al* [1980] quoted the director of National Environmental Engineering Research Institute of India who says the operational, maintenance and management of water supplies systems in the country are far from satisfactory. Agarwal also noted an Indian government report that admitted most water works are poorly maintained. Richardson and Harris [1986] point out that the need for improvements in maintenance is dependent on improvements in operational management in urban water systems, the same as for rural systems.

Management of O & M in urban areas has usually been the responsibility of local government of centralized water agencies [WHO, 1987; Makinwa-Adebusoye, 1988]. There have been some projects where the Agency showed the residents how to conserve and maintain the pipes and standpipes in an attempt to improve O & M in poorer urban areas [Hollnsteiner, 1979; Rondinelli, 1988]. Rondinelli [1988] said that the encouragement from local government and public agencies to allow voluntary and community groups' to participate was an effective means to sustainability of the project.

Hollnsteiner [1979] pointed to the fact that effective grassroots management of O & M of the standpipe or tap outlets would only happen when the community had a stake in all the decisions about the placement of the outlets etc. Also, where there was a clear understanding of responsibility and shared control of the setting up and evaluation processes. Montgomery [1988] picked this up and pointed to the informal service sector (ISS) as a factor working alongside the Agency, helping to fulfil the urban service delivery and maintenance of social services, including water supplies. In Malawi the outlets in poor urban areas were managed by a tap committee, these were established after local leaders invited families to join a tap-user group, who then appoint a tap committee and signed a contract with the water agency [IRC, 1988a]. The responsibilities of the tap committee were as follows:

- carry out small repairs.
- keep water points clean.
- see that regulations on use are observed.
- organize labour for big maintenance jobs.
- select a person to be trained in maintenance of pipes etc.

The problems that faced this level of management of O & M in urban areas are the same as those discussed in Section 2.7.4.1, with two additions. The tap committee tended to impose the regulations instead of taking their own well-considered decisions, thus the need of training for the committee was seen as essential [IRC, 1988a; Montgomery, 1988]. The second problem is the forming of water user groups where no cooperation was found in the community [Pickford, 1982]. This final point seems a major factor in the success or failure of sustainable O & M in very poor urban areas, yet little is written about it.

2.7.4.6 Rural Community Management of O & M

The difference between management of O & M of rural water supplies and those found in urban areas is due to the fact that the water source is traditionally for multiple use. The rural water source is often used for washing, drinking, stock-watering and irrigation, which adds to the management difficulties of the water supplies O & M [Wisner, 1988]. Wisner went on to say that often the Agency was more single purpose management orientated, i.e. domestic water supply only, thus creating problems for the local user in understanding how to manage the water system, when the source was formerly used for several uses. However, the focus here will be on domestic water supplies. Many problems that face

management of O & M in rural water supplies are directly related to the lack of community and user involvement as mentioned in Section 2.7.4.1.

There are various types of management systems found in rural areas of developing countries ranging from, three-tiered maintenance systems in India and Zimbabwe [Baldwin, 1983; Cleaver, 1991]; a one tiered system in India [Gray, 1984; Roy, 1984]; management of O & M at community level such as through the VLOM proposal [UNDP and the World Bank, 1987]; rurban programmes in Latin America [Donaldson, 1976 & 1977]; or, joint responsibility between Agency and community as in Togo or Colombia [Briscoe and de Ferranti, 1988; McCommon *et al*, 1990]. The following are the management responsibilities of O & M for these programmes.

2.7.4.7 Three Tiered Maintenance Programmes

The three-tiered maintenance system in India consists of a village caretaker, a block inspector-mechanic with tools and a bicycle for every 60 to 100 villages, and a four-man mobile unit at district level (5 to 10 blocks) which includes a workshop and a spare parts stock of new and reconditioned parts. Management responsibilities at the community level are very minor indeed being performed by the handpump caretaker. These include the following responsibilities:

- housekeeping jobs around the pump, to prevent stagnant ponds for mosquitos to breed
- simple health education
- notify block mechanic and/or the mobile team by preprinted card when problems occur
- minor mechanical operations
- responsible to block development officers not to a village level authority [Baldwin, 1983].

The three tiered system in Zimbabwe is almost identical to that found in India. But the first tier involves the users in a waterpoint committee, usually consisting of four members, of whom one or two are the pump caretakers. The waterpoint committee responsibilities are similar to the responsibilities of the caretakers' role in India. The main responsibilities involved include organizing a roster for the cleaning of the pump and surrounds, and notification of breakdowns to the higher tiers. In reality the committee often handed over responsibility to local leaders who did most of the organizing. In this case there would

be a need to look at the policy recommending committees, and look at dynamics of the community life [Cleaver, 1991].

The sustainability of the three-tiered system as it is outlined above, is in some doubt. In fact Cleaver said that the community responsibility for O & M ceases when the water supply broke down in many cases in Zimbabwe, because the community did not own the system thus the responsibility for repairs were seen as the Agency's. Roy [1984] pointed out that often the upper two tiers did not respond to repeated calls from the community in India, thus the handpump is out of use for months. It was also seen as an example of being designed by people who had no confidence in the skills available in rural communities.

2.7.4.8 Single Tier Maintenance Programmes

Due to the failure of the three-tiered system in some states of India, the Social Work Research Centre (SWRC) in Rajasthan, proposed a one tier system where the village was responsible for the maintenance of the handpump. The total responsibility for O & M was the community's, this included the following:

- the choosing of a rural youth to be responsible for the care of the handpump
- sending the youth away to the training programme and provided with a loan to buy the tools needed
- if the youth does not perform he can be replaced
- the youth would be paid according to the number of handpumps he cared for, and an allowance for the spare parts he installed, when his yearly certificate was signed by the local leader
- all minor and major maintenance was done by the youth, according to a guidebook that also states all the responsibilities and functions of the caretaker
- the community is willing to pay for the maintenance

The value of the one tier programme is that maintenance is a community responsibility, and that the person responsible for maintenance is always available [Roy, 1984].

2.7.4.9 Village Level Operation and Maintenance - VLOM

UNDP and the World Bank, in a project to increase the reliability of handpumps and to enable community water supplies (CWS) to be managed by the community, introduced the idea of VLOM. The success of VLOM as a way for local communities to manage their

CWS, meant that the concept of VLOM was extended, the letter M included Management of maintenance. The VLOM concept including the added management ideas were as follows:

- Easily maintained by a village, requiring minimal skills and few tools;
- Manufactured in-country, primarily to ensure the availability of spare parts;
- Robust and reliable under field conditions;
- Cost effective;
- Community choice of when to service pumps;
- Community choice of who will service pumps; and
- Direct payment to repairers by the community.

The responsibilities of O & M management by the community were clearly defined under VLOM, with the Agency being involved in the training of water committee members in simple accounting and financial management, along with the training of the caretakers and maintenance personnel and the establishment of a spare parts distribution system [UNDP and the World Bank, 1987].

2.7.4.10 Joint Responsibility for O and M - Community and Agency

The scope of responsibilities for the Agency and the community in joint management of the O & M of water supplies has been discussed in Sections 2.7.2.2 and 2.7.4.1. The O & M management responsibility needed to be carefully defined by the Agency and accepted by the community, otherwise the success of community management will be in doubt [Cairncross *et al*, 1980; Wood, 1983; Yacoob, 1990; McCommon *et al*, 1990]. Appendix 6 of this thesis outlines the questions that the Agency should deal with before joint responsibility can be pursued effectively.

The levels of joint responsibility range from Rurban programmes in Latin America to those of moderate responsibility as shown on Table II Level III, in Section 2.7.4. In the rurban programme the community sets up a water committee, which is involved from the construction stage. The water supply system that the water committee are responsible for may include, a protected spring, a pumped well, a treatment plant, a distribution system, with 80% of the population having house connections, and a small number of standposts. The management responsibilities for O & M of the water supply are as follows:

- day-to-day operation
- administration and financial matters
- collection of O & M funds from community

- oversee maintenance of system

For the community to be able to manage the system a training course was organized for the water committee members, and during the first six months of operations the Agency kept a close watch on their activities. The water system was also dependent on the fulfilment of the management and other responsibilities by the national and regional structure above the community level (cf Appendix 3) [Donaldson, 1976 & 1977]. Donaldson pointed out that this system would not work in a dispersed population, due to the nature of the delivery of water to the homes.

McCommon *et al* [1990] presented the relationship between the water agency and the community in Togo of O & M management as follows. The Agency established a water committee, who were trained by the Agency, who in turn trained others in the community. The management tasks of this committee in relation to O & M of water supplies consisted of the following:

- training programme for pump technicians, village women, etc.
- management of the pumps
- create and manage a pump maintenance fund
- coordinate village health activities

The Agency spent an entire year in promotion work in the community before the water project started. Also, the Agency provided a regional mobile repair team for those tasks outside the communities scope. It was estimated that 25% of the project budget was spent on training and extension services.

In Colombia the management responsibilities for O & M are clearly spelt out for both the community and the Agency. Management responsibilities of the community were as follows:

- elect a water committee
- raise funds for O & M
- oversee all O & M
- ensure system rules are obeyed

The Agency responsibilities were in promoting the need for O & M, training, planning and helping supervise O & M activities. If O & M was outside the scope of local operators they sent the technical assistance necessary, usually a commercial firm [Briscoe and de

Ferranti, 1988]. Briscoe and de Ferranti noted that the major weakness with this structure was in the area of financing which the water agency was not particularly well-suited due to it being a technical agency.

There are two other types of community management groups involved in O & M that also need to be considered, that of traditional management systems and women as managers.

2.7.4.11 Traditional O & M Management

> I am not digging into such things because I think the old ways are necessarily better then the new ways, but I think there may be some of the old ways that we would be wise to look into before all knowledge of them disappears from the earth - the knowledge, and the kind of thinking that lay behind it. - Robertson Davies, *The Rebel Angels* quoted by [Smillie, 1991].

Traditional management of water sources has been in existence for thousands of years [Whyte, 1976; Rondinelli, 1991]. Rural communities had established rules for water use and roles for water resource maintenance [Rondinelli, 1991]. The varieties of traditional management are as many as the number of different cultures [Whyte, 1976]. As previously mentioned in Section 2.7.4.6 the water in rural communities is often multiple use. Wisner [1988] detailed that in Africa where this happens, systems of social control for the access of livestock for example, ensure culturally agreed standards of maintenance and cleanliness and mobilize community labour for the maintenance and extension of the systems. Wisner went onto say that there were at least 13 indigenous irrigation management systems not counting the flood based systems.

An example of a traditional management system is the *falaj* or *qanat* that has existed for irrigation and domestic water purposes for 1,500 to 2,000 years in Oman [Sutton, 1984] (cf Figure 11). The management responsibilities of O & M in the *falaj* system may be performed by one man through to a committee depending on the size of the *falaj*. The responsibilities of the usual four person *falaj* committee towards O & M are:

- The administrator is responsible for the maintenance of the falaj, policy decision on repair work, ownership and rental of water rights and the distribution of these.
- The treasurer responsibility is with receiving funds for O & M.
- The two foremen are responsible for the work of the maintenance team, with one specializing in above ground work and the other in underground work. They assess the timing and needs of O & M within the system.

The *falaj* system is an integral part of the village life, thus it has a management system that is acceptable and sustainable. Sutton noted that the *falaj* system was an imposed technology on the traditional society, which modern technology exponents should look at, especially how it was integrated into the village society and use it to integrate new technology into developing societies.

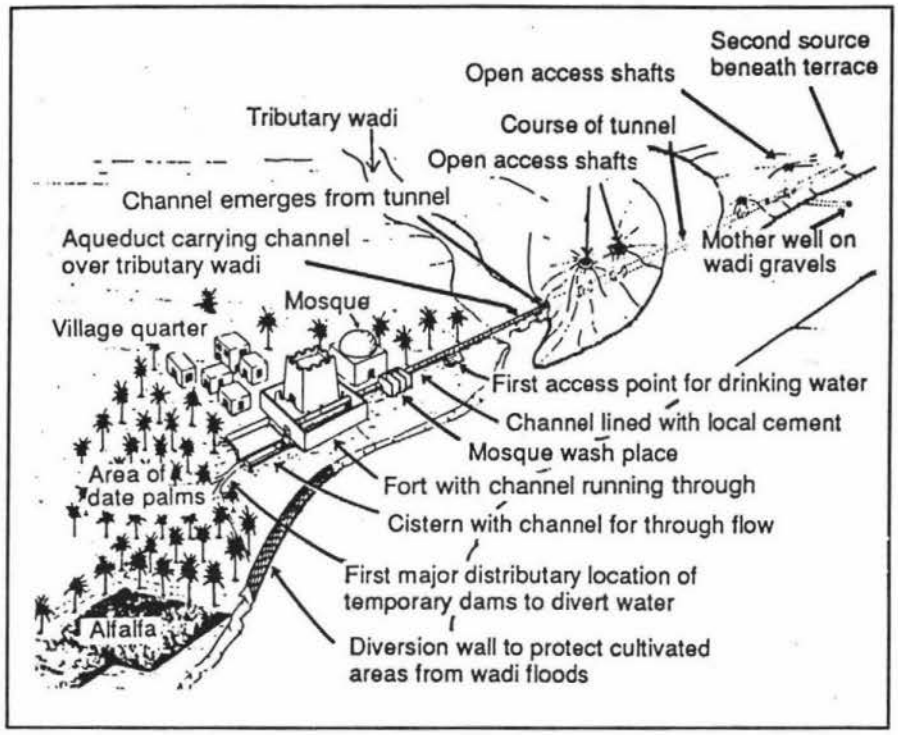

Figure 11. Sketch of a typical small *falaj* (Source: Sutton, 1984).

Whyte [1976] pointed out that the traditional management systems took into account the values and understanding of the users, thus O & M management could be added, and become an integral part of modern water supply systems as it was in traditional water supplies. The need for research into these traditional systems is an important factor in the sustainable management of O & M.

2.7.4.12 Women as O & M Managers

In villages in the Indian state of Haryana a young bride who enters the home of her husband's family for the first time is greeted at the door by her mother-in-law who places a pot of water on her head as a symbol of marriage. The collection of the family's water is the most visible role of women in the community [van Wijk-Sijbesma, 1987].

Water collection has traditionally been the work of women in many countries throughout the world, yet until the mid 1970's women had been excluded from dialogue on the improvement of water supplies, the implementation, management and arrangements for O & M [Hannan-Andersson, 1985]. Since the mid 1970's the role of women in water projects has come alive in the literature, the following short list of authors has produced work in this area [Elmendorf and Isely, 1982; Ahlberg, 1983; Elmendorf, 1984; Hannan-Andersson, 1985; van Wijk-Sijbesma, 1985; van Wijk-Sijbesma, 1987; INSTRAW, 1991] and many others develop the role of women in water projects in more general works, ie. WASH reports, USAID reports, IRC papers etc.

The starting point for most of the literature is the involvement of women as traditional managers of the water supply, and thus O & M [van Wijk-Sijbesma, 1985; Narayan-Parker, 1988; Yacoob and Roark, 1990; among others]. There is evidence that women were involved in management of O & M in traditional societies, and in a far more comprehensive role than previously realized [van Wijk-Sijbesma, 1985]. van Wijk-Sijbesma pointed to several traditional management systems of O & M by women, for example in Samoa traditional women societies were responsible for maintenance of domestic water sources and sanitation or in Sri Lanka the shared community wells were maintained by the women and children.

In recent years many development agencies and governments have been encouraging women to be more involved in the management of development projects including water projects, and in some cases this is a requirement of aid [Gachukia, 1979; Report by Working Group Four, 1984; Yacoob, 1989; Yacoob and Roark, 1990; among others]. Isely [1985] stated that there were two major prerequisites to successful water and sanitation projects, community participation and the involvement of women. What then are the management responsibilities that can be placed upon women in the terms of O & M of water supplies?

van Wijk-Sijbesma in Table III presents' the areas in which O & M and management responsibilities have been performed by women. These are comparable to the management responsibilities of O & M of any group in developing country communities.

Site management
- as individual users
- as members of user organizations
Caretaking
- as members of male-female teams with culturally appropriate division of tasks
- as caretakers doing both technical and non-technical tasks
Local administration
- as members of local management committees
- in parallel management committees for men and women
Self-sufficient systems
- services operated, managed and maintained by women

Table III. Forms of participation of women in local management and maintenance (Source: van Wijk-Sijbesma, 1985)

In the management of O & M, a major problem is the collection of funds for the ongoing sustainability of the water supply. When women were involved in the water committee, they often held positions that were responsible for collection of these fees as shown by the following two examples.

> In Panama... several communities were having problems collecting water fees, women emerged as local leaders and successfully managed the collection process.
>
> In two divisions in Colombia, 43 out of 374 administrative committees have a woman member. Of these, 42 hold the position of treasurer and one is president [van Wijk-Sijbesma, 1985].

To conclude this section on the management of O & M of water supply projects, it is fitting that the role of women has been discussed since they are the most directly affected by the strength of management of O & M of water supplies.

Because women are faced more directly than men with the problems of water supply and sanitation, they can be a substantial driving force behind the installation and maintenance of facilities.

(Source: van Wijk-Sijbesma, 1987)

2.8 Community Participation

> Community participation is the buzz-word today. It is a rare international aid official who does not state that without community participation, drinking water and sanitation programmes will fail [Agarwal *et al*, 1980].

This statement seems to be quite true given the number of articles written about community participation involvement in water projects alone, the following select list over the past three decades represents this conviction [Misra, 1975; Anon, 1978; Miller, 1979; Feachem, 1980; Agarwal, 1981; Whyte, 1983; Sunman, 1983; Mujwahuzi, 1983a; van Wijk-Sijbesma, 1984; Gray, 1984; Drucker, 1985; van Wijk-Sijbesma, 1985; Omambia, 1986; Mujwahuzi, 1986; Whyte, 1986; Bannerman, 1986; Mohammed, 1986; Lawrence, 1986; Donnelly-Roark, 1987; Yacoob *et al*, 1987; McPherson, and McGarry, 1987; Narayan-Parker, 1988; IRC, 1988a; Yacoob and Warner, 1989; Yacoob, 1989; Narayan-Parker, 1990; Yacoob and Roark, 1990; Bah, 1992; McPherson, date unknown].

The idea of community participation[7] has been in existence for over forty years [McCommon *et al*, 1990]. However there has been a semantic problem in defining the term "participation" [Jackson, 1979; Agarwal *et al*, 1980; McPherson and McGarry, 1987; O'Rourke, 1992]. Along with this McPherson and McGarry pointed to another problem of community participation that of the meagre amount of literature defining how to carry out community participation. Although three recent works defined how to set in motion community participation [Donnelly-Roark, 1987; IRC, 1988a; Yacoob and Roark, 1990]. These authors refer to many studies that describe the benefits derived from community participation. The following benefits as shown in Table IV are seen to arise from the involvement of the community in the water project.

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[7] The use community participation in the context of this section will cover both beneficiary and user participation.

Narrow short-term benefits	-	Participation reduces the costs of improved facilities;
	-	With participation, more people can be served;
	-	Participation encourages adaption to local knowledge, needs and circumstances;
	-	Participation increases the chance of proper use and continuous functioning of improved facilities;
Broad long-term benefits	-	Participation can be a catalyst for further socio-economic development

Table IV Reasons for community participation in low-cost water and sanitation projects (Source: International Reference Centre, 1988).

The push to display benefits may be to show that participation is the way ahead for sustainable water projects. Some would argue that it is only an icon which planners bow to but do not actually practice [Drucker, 1985]. This however has not answered the question "what is community participation?" The World Bank has defined it as an active process under which the beneficiary's influence the direction and execution of development projects rather than merely receiving a share of project benefits [McCommon *et al*, 1990]. Simpler definitions are, the people who are to benefit from the project should be involved in its implementation [McPherson and McGarry, 1987], or people helping themselves [Miller, 1979]. Oakley and Marsden [1984] presented a range of seven different views that reflect the dominant thinking on participation, from a general view where the participation is limited to a rethink of participation which champions the achievement of gaining power over the direction of the life for the participants (cf Appendix 7). The following definition is one that includes both O & M and sustainability into it:

> Participation is the learning process by which communities control and deal with technology, change and development. It is a necessary component of every water-supply project that has maintenance and long-term sustainability as its objective [Donnelly-Roark, 1987].

The learning and involvement of the participants in water supply projects should include all of the following stages, designing, construction, maintaining, supervising and evaluating the water supply [Churchill *et al*, 1987] (also cf Appendix 8).

Since community participation can assume a diversity of forms [IRC, 1988a], the following will look at the main categories and generalisations of community participation in water projects deemed successful. These are as follows:

1. First is the water supply a "felt need" by the community [Isely, 1985; INSTRAW, 1991; among others].
2. Selection of community water committee [Finau and Finau, 1983; Omambia, 1986; among others].
3. Involvement in the planning, design, location and the technology used for the water supply system [Owusu, 1986; ODA, 1985; among others].
4. Understanding of responsibility among the members of the community for O & M of water supply [Karp and Cox, 1982; Donnelly-Roark, 1987; among others].
5. Provision of labour, materials and funds for water supply for construction [ODA, 1985; McPherson, date unknown; among others].
6. Discussion on how to provide funding for O & M [IRC, 1988b; among others].
7. Ownership of the facilities [Anon, 1978; Mujwahuzi, 1986; among others].

Some of the above responsibilities and roles have already been discussed under institutional and community management responsibilities (as can be seen these factors are closely interrelated), but all of the above will be outlined in the following sections as they relate to the sustainable O & M of water supplies. To make the above factors effective all the user groups in the community need to be involved in the decision making, especially women [Andersson and Hannan-Andersson, 1986; Bannerman, 1986; among others]. The Agency should also be able to train both the local maintenance personnel and water committee. This requires that the Agency personnel be motivated and able to incorporate the participatory involvement of the community into the water supply project (cf Sections 2.7.2.2 and 2.10.3) [Yacoob and Roark, 1990; Mangin, 1991; among others] (also cf Appendix 9).

2.8.1 The Priority of the Water Supply for the Community

Although it may be considered common sense to assess the community's needs before planning or setting up a water project, it is not always done [INSTRAW, 1991]. This first step, the move away from the Agency deciding that a community needs a water project to that of the community formulating a request for help in installing their new water

supply is important [Pacey, 1977a]. McPherson [date unknown] agreed with Pacey that this is the vital first step: does the community really want the facilities? The evidence revealed that when a community has made the decision to have a new water supply system, the system tended to be successful because it was valued [Dworkin, 1982]. The Agency's role will become complicated especially if the community shows little interest or apprehension about the project.

To encourage the need for the project the Agency is involved in two actions (if it decides that a project is beneficial). First it does a socioeconomic survey, and if the need for a water supply project is paramount from this then the second action can start. This survey should endeavour to find out six important factors, and should if possible survey all potential users of the project, especially women if it is culturally acceptable. The following are the six factors to be determined, many of which relate to sustainable O & M.

a) How interested are the potential users in the proposed facilities? Are they enthusiastic and anxious to be included in the project, or only mildly interested? Did the interest come from the whole community or from a few politically visible individuals? The answers to these questions will determine what effort will be needed to promote the technology and the project.

b) Are the users able and willing too pay part of the costs? In many rural villages in poorer countries people have no cash income and are unable too pay. The ability to pay needs to be accurately assessed. If the people are asked to contribute more than they are able, the project may be seriously jeopardized.

c) Is the community willing to contribute materials and/or labour to the construction of the facilities? Are they informed of the continuing cost of O & M? Again, this needs to be accurately assessed.

d) How much spare time do the users have to work on the project? Can they combine their regular routine with working on the project? Are they too tired after a day's work?

e) Do the people possess any skills which could be used in the project? Are any of them capable and willing to be trained as artisans, technicians or better managers of household water supply and sanitation?

f) Is the proposed technology acceptable to the users? Is it compatible with their social and cultural beliefs and views? Are there any obvious changes or adaptions which would make it more acceptable? [McPherson, date unknown]

Secondly, a promotion campaign is undertaken to convey to the community the project and their need for participation [McPherson, date unknown] (cf Appendix 10). This promotion may be handled by some of the potential users as in Guatemala [Karp and Cox, 1982]. From this promotion, if the community perceived a need and made a decision for the water project, then O & M would probably be sustained because they had made the decision, rather than it being imposed upon them [Whyte, 1976; UNICEF and WHO, 1979a; McPherson and McGarry, 1987; Bah, 1992; among others].

2.8.2 The Selection of the Community Water Management Committee

The role, responsibilities, training, problems and types of water management committees have been discussed in Sections 2.7.4 through 2.7.4.12. The selection of the communities water committee will have a significant effect upon the sustainability of the water supply [McPherson and McGarry, 1987; Yacoob, 1989; among others]. The committee may be established by local leaders, as in Malawi [Bharier, 1979]. The water committee may be an established group in the community involved in other activities, eg village elders, health committee, womens organization, etc [UNICEF and WHO, 1979a; Isely, 1985; Briscoe and de Ferranti, 1988; Yacoob, 1989; among others]. In other cases the water committee may be a newly established group, where a wide spectrum of the community is represented, eg. traditional leadership, women, clergy, technical people, etc elected by the community to this position [UNICEF and WHO, 1979a; van Wijk-Sijbesma, 1984; McCommon *et al*, 1990; among others].

The Agency is involved in advising the community on the role and responsibilities of the water committee (this will be determined by the type of system being established and the level of community management responsibility (cf Table II and Figure 9)). From this the community can make an informed decision about choosing the people that could probably handle these responsibilities [Yacoob and Roark, 1990]. If a new committee is established, the Agency may need to spend some time working through the relationship of the committee with already existing authority structures, to avoid competition [van Wijk-Sijbesma, 1984].

2.8.3 The Community's Involvement in Planning, Technology, Location and Design

The community's involvement in planning, design, location of the water supply system outlets and the type of water supply technology will influence the sustainability of the project and thus O & M, due to the community feeling that it is their project [McCommon *et al*, 1990].

A survey of the community is useful in the planning stage. This survey could be organized by the water committee, by the community leaders [McPherson, date unknown], or by the Agency [IRC, 1988a]. The following tasks need to be carried out:

- Identify the local problems and organization of the community, and the culturally acceptable forms of womens involvement [IRC, 1988a].
- Reveal the ability and willingness to pay for the construction and O & M costs along with the type of system that the people want [Briscoe and de Ferranti, 1988].
- Identify the water sources that are presently being used or the place where the water outlet/s are acceptable and wanted by the community [Pacey, 1977a].
- A clear understanding of the plans the Agency has, and a discussion in the community if it is feasible [ODA, 1985].
- In some projects, as in Guatemala, the water committee is fully acquainted with its responsibilities for the water supply [Karp and Cox, 1982].

The right of the community to make a knowledgeable choice of the technology that could be used for their water supply, with associated costs is important [Yacoob, 1989]. The technology option gives the community a choice in what direction it wants to go with its water supply. It also revealed the type of system that would most likely be used, operated and maintained [Hughes, date unknown]. Women especially need to be consulted, since they are often the main users of the water supply, about their preferred types of technology and their main uses, eg washing, small gardens needing water, cooking, etc [INSTRAW, 1991]. The technology choices are determined by the water source available, the type of treatment (if necessary) and the type of water outlets wanted as shown in Figure 12.

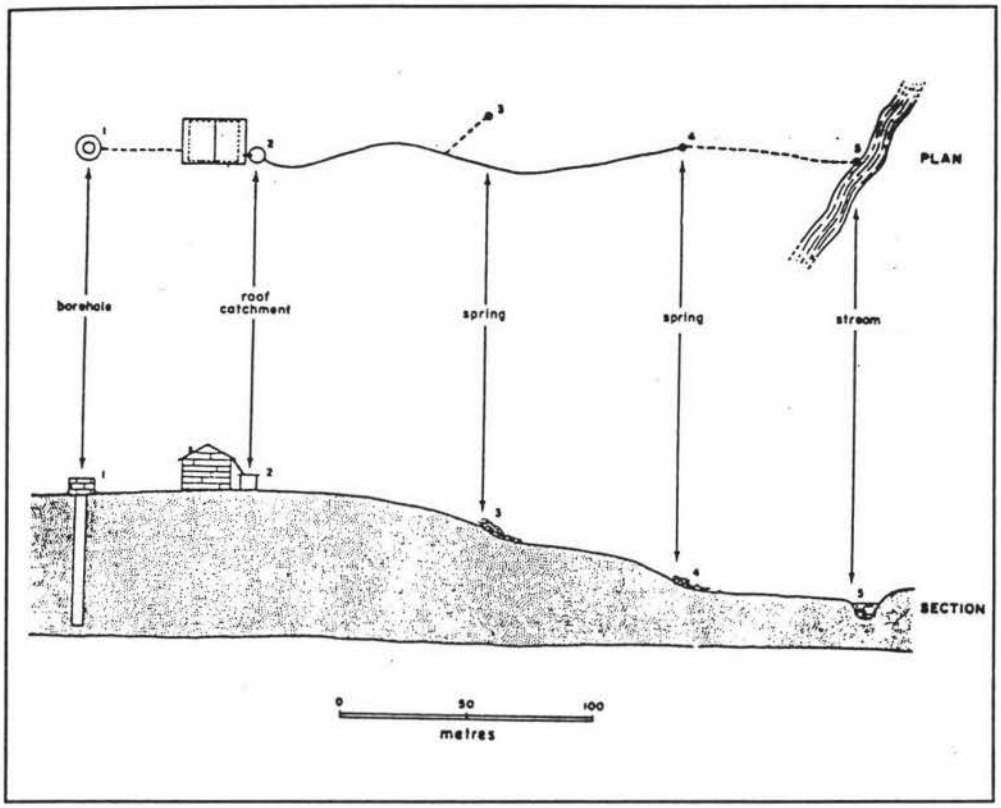

Figure 12 Alternative water sources for a sample household in Ganda territory, Uganda (Source: White et al, 1972)

The technology eventually chosen may not be the first choice of the community's due to financial constraints, but an alternative can be offered by the Agency (with appropriate discussion) that in the future could be adapted to the first choice [Whyte and Burton, 1977]. Evaluations of water projects have shown that the choice of technology that was built on existing technology is the most sustainable [Beyer, 1976].

Often the most appropriate technology chosen by the users is based on cultural practices, family needs, religious beliefs and economic circumstances [Rondinelli, 1991]. Whyte and Burton [1977] also noted that the choice of technology cannot be taken in isolation from socio-economic criteria. Bajard *et al* [1981] agreed and pointed to the fact that often the technology is planned for without sufficient reference to the local socio-economic context.

The choice of technology affects the design stage of the project and vice versa. The community's involvement in the design stage may be found by a "willingness to pay" survey. This helps to discover the type of system the community wants and can afford

[Hughes, date unknown]. Though it must be noted that willingness to pay (WTP) surveys are good for revealing the communities' preference for services, it is not so precise in revealing the actual ability to bear both construction and O & M costs [Yacoob, 1990]. The community involvement in the design stage may be performed by the water committee, because in many cases most communities would not have sufficiently informed people in design. The water committee are often considerably better informed and trained (by the Agency) are able to make recommendations about design changes, being aware also of the users needs and requirements [Yacoob, 1989].

The Agency's responsibilities in the planning, design, location of the water outlets etc is more of a consultancy role. The Agency should be able to give direction, motivate the people to make choices, train the community through the water committee in areas of design, planning and survey techniques, and give technical assistance about the types of technology available and what is suitable for the situation [Briscoe and de Ferranti, 1988]. The acceptance of the community's involvement in these stages, especially the design stage will involve a change in attitude by the design engineer, but in respecting the community's values and knowledge, he/she will design the system with them instead of for them, thus raising the people's positive attitude to the system [Whyte, 1976].

2.8.4 Responsibility for O & M Understood in the Community

> Sustainable projects continue to be perceived as the major indicator of successful sector development. Community acceptance of responsibility for system operation, maintenance and management appears essential to sustainability [Yacoob, 1990].

Responsibility is an important factor in the long-term sustainability of the water project, and in particular O & M. Donnelly-Roark [1987] commented that true community participation that impacts sustainability does not start with the people willing to mobilise and organise themselves to support the project. But rather on the following:

> Focus on responsibility entails, first of all, an exchange of information between community and project so that the implications of the improved source in terms of use, maintenance, and sustainability, both economic and managerial, are well understood. Second and most important, a focus on responsibility entails negotiation of who is responsible for what, based upon an adequate understanding of the long-term implications [Donnelly-Roark, 1987].

The first factor has been discussed in some detail in Sections 2.7.4 - 2.7.4.12, the following focus here will be on the responsibilities of the community and Agency relating to O & M[8]. The communities' responsibilities are as follows:

- Know that they are responsible for providing the O & M for the water supply (up to a certain agreed level), not the Agency [Cairncross *et al*, 1980; McPherson and McGarry, 1987]. This includes knowing the financial costs, the impact on existing cultural customs, and the changes, including increased skills that will be needed to operate and maintain the system [Donnelly-Roark, 1987].
- Nomination and selection of community based maintenance and caretaker personnel, usually more that one to prevent future problems of maintenance personnel leaving community [Matango and Mayerle, 1971; Owusu, 1986].
- Providing funds for ongoing O & M, and possibly some funds towards extensions and new projects [Wood, 1983; Yacoob and Warner, 1989]. Discussion on how to raise the funds is also important [IRC, 1988b] (cf Appendix 11). Yacoob [1990] presented a list of ways of raising the needed funds for O & M and construction by using local structures and resources:
    - collection of zakat, an Islamic obligation for causes benefiting the general community
    - collection of community contributions from the sale of agricultural products (such as rice, coffee, coconuts, bananas)
    - collection of stones, sand, bamboo, and other locally available materials for use in construction
    - organizing community production of bricks for spring catchment or reservoirs
    - sale of livestock
    - community hunt and sale of unendangered wild animals (for example, wild boar)
    - fund-raising shows such as traditional puppet shows
    - sale of water to farmers for irrigation of vegetables and to other community people for drinking.
- The community needs to decide on the payment for O & M staff [Williamson, 1983; ODA, 1988].
- Select the water committee who will oversee all O & M and management of water supply [UNICEF and WHO, 1979a; McCommon *et al*, 1990].
- Ensure water use rules are followed [Briscoe and de Ferranti, 1988].

[8] It has been assumed that the availability of people with enough technical skills or desire to be trained to meet the O & M skills needed [Report by Working Group Two, 1984].

The Agency also has major responsibilities in this area as follows:

- Training the community and in particular those selected by the community how to operate and maintain the system [UNICEF and WHO, 1979b; Karp and Cox, 1982].
- Provide tools for the community maintenance personnel [Yacoob and Rosensweig, 1992].
- Back up support to community when repairs etc are beyond their capacity [Pacey, 1977a; ITDG Water Panel, 1980].
- Provide an infrastructure to supply parts when needed, including communication [UNICEF and WHO, 1979a; ODA, 1985].
- Monitor and motivate the community when enthusiasm fades for O & M [IRC, 1988a; Rondinelli, 1991].
- Arrange a written contract between the community (usually signed by the water committee) and the Agency, which details the responsibilities of each partner, especially in O & M, funds to be raised, who will do major repairs [Yacoob and Roark, 1990].

Thus the sustainability of water projects will be determined by the degree to which communities and agencies can provide O & M, and have worked through the issues of who is responsible for what in O & M [Yacoob and Rosensweig, 1992].

2.8.5 Community Provision of Labour, Materials and Funds for Construction

The community's involvement in construction and provision of materials has often been seen as the way to cut water project costs [McCommon, 1990]. But if the community is to be involved to a greater extent, for example training in semi-skilled work, the willingness to be involved in O & M is often increased also, thus the system becomes more sustainable [ODA, 1985]. Often the water committee arranged with the community what to bring, the days that each member of the community was to work, provision of food and accommodation for Agency staff [Yacoob and Roark, 1990]. The community must be informed of the costs and benefits of participating before signing the contract of responsibility between themselves and the Agency, and construction starting. It is also believed that this contribution of labour created a sense of ownership and responsibility [Mujwahuzi, 1983]. Mujwahuzi noted that this was found lacking when the facilities were not actually handed over to community ownership as in Tanzania.

The agency's responsibilities in the construction stage to support community participation as shown in the Figure 13 checklist from [Yacoob and Roark, 1990].

CHECKLIST

When construction is about to begin the agency personnel...

- ✓ Trains the water committee to supervise construction.
- ✓ Orients the drillers and rig operators to the project.
- ✓ Provides liaison between water committee and the engineer.

When the construction stage actually begins, the project engineer...

- ✓ Assists the water committee to lay out labour requirements and scheduling.
- ✓ Delegates the community leaders authority over the work crews.
- ✓ Arranges for quality control of construction.
- ✓ Ensures that persons responsible for O & M are involved in construction.

Figure 13. (Source: Yacoob and Roark, 1990)

The involvement of the community members chosen to be the O & M personnel in the construction stage gave them an understanding of the system as it was put together, and parts that will need to be looked after etc (cf Appendix 2) [Karp and Cox, 1982; Williamson, 1983; among others].

The following example of a community's involvement in a shared responsibility for a well construction gives an idea of the community participation in construction of a successful water project in Sierra Leone:

i. The women in the village were responsible for preparing meals for labourers.

ii. Provision of sand, gravel and stones were undertaken by the teenagers in the village, under the leadership of the head of one of Gbonombu's agricultural labour groups. Such labour groups have been very effective, more generally in solving agricultural labour bottleneck's and seasonal shortages in rural Sierra Leone, since the household cannot provide labour on time for various agricultural tasks.

iii. The assistant chief was responsible for providing accommodation for the well digging team.

iv. Each household in the village provided two labourers to assist well digging. At the same time, the household providing labour on a particular day also took responsibility for providing food for the well digging team.

v. The head woman is responsible for the general cleanliness of the well. The well is usually opened at about 7 a.m. and closed at about 7 p.m. every day. A lock and a fence have been installed to keep domestic animals away [Bah, 1992].

2.8.6 Community Ownership of the Facilities

All of the above factors culminate in this one. Responsibility suggests a sense of ownership. With the transfer of ownership of the water system legally helps the community to see that the responsibility for O & M is theirs [Yacoob and Rosensweig, 1992]. As mentioned in Section 2.7.4.2 ownership is seen as the most important factor in sustainable O & M of water supplies, all the participation by the community up to this stage leads to this point. Here the community receives the total project as theirs [Karp and Cox, 1982]. Often there is a transfer of ownership ceremony, or water system opening to which the community invites other communities, and in some instances certificates are issued to those involved [Yacoob *et al*, 1987]. This may be also an annual event to help keep participatory enthusiasm in the water supply.

2.8.7 Problems Facing Community Participation

> Community participation and community management have rarely been a component of water and sanitation systems in the West. Then why are western donor agencies so enthusiastically imposing it on other cultures, without sound research or proof that it is a viable option? [O'Rourke, 1992]

Community participation has critics like O'Rourke who have valid arguments that need to be addressed. The following have been suggested as areas of concern that diminish the effect of community participation:

- Lack of participation of women in decision making and practical involvement [van Wijk-Sijbesma, 1985; INSTRAW, 1991].
- Unrealistic expectations of the community to demonstrate cohesion, capacity, and a will that does not exist in either developing or developed countries [Briscoe and de Ferranti, 1988; O'Rourke, 1992].
- The spirit of participation is lacking within the Agency, therefore the encouragement of community participation is highly unlikely [Gow and Vansant, 1983; Mangin, 1991].
- No benefits for participation are seen by the community [Cleaver, 1991].

- If the community's responsibilities are ill defined this leads to poor community participation [Cairncross *et al*, 1980; McCommon *et al*, 1990].
- Lack of training for Agency staff in implementing community participation [McPherson and McGarry, 1987].
- Improper organization and planning can lead to failure even in community participatory projects [McPherson and McGarry, 1987].
- Other problems are similar to community managements (cf Section 2.7.4.1).

The concept that just adding community participation to a water project would affect success is of doubtful value. The planning and organization of community participation are needed to be seriously dealt with so that the sustainability of water projects will not be in doubt, but rather lead to success [McPherson and McGarry, 1987].

To finish this section on community participation a quote from J.K. Nyerere, *Freedom and Development* quoted by [Omambia, 1986].

> **People cannot be developed; they can only develop themselves. For a while it is possible for an outsider to build a man's house, an outsider cannot give the man pride and self-confidence in himself as a human being. Those things a man can create in himself by his own actions. He develops himself by what he does; by making his own decisions, and by his own full participation - as an equal - in the life of the community.**

2.9 Appropriate Technology and Technology Transfer

> A price has to be paid for everything worthwhile; to redirect technology so that it serves man instead of destroying him requires primarily an effort of the imagination and an abandonment of fear. - *E.F. Schumacher* quoted by [Smillie, 1991]

The definition of technology according to Webster's dictionary is, the science of technical processes in a wide, though related, field of knowledge. Another meaning is the totality of the means employed to provide objects necessary for human sustenance and comfort

[Henry, 1978]. Webster's also defines technology transfer as, a transfer of technical knowledge generated and developed in one place to another in order to achieve some practical end. Another view that focuses on technology transfer to LDCs is, the acquisition, development and utilization of technological knowledge by a country other than that in which this knowledge originated [Madu, 1989]. These two definitions bring together the following definition of technology transfer:

> Transfer also means more than simply offering the technical material, either verbally or in writing. The baton is not fully transferred until the next runner has it firmly in his grasp and is proceeding on his own towards the finish line [Hotes, 1973].

For many centuries technology transfer has been a part of human existence, through trade and migration, art and religion, encouraged and discouraged by governments and educational institutions, stolen, copied and sometimes developed through independent invention. War has played a major part in the development and retardation of technology [Smillie, 1991]. The process of technology transfer is shown in Figure 14.

Similarly people have been adopting appropriate technology (AT) since the beginning of civilization, by developing in a gradual way the potentials and strengths of the community, with the resources available [Dunn, 1979]. In recent times though there has been a major push for appropriate technology within the development field, though it initially was called intermediate technology by the founder of the modern AT movement, E.F. Schumacher. He suggested that a more appropriate type of technology was available that was not necessarily modern or traditional, but intermediate, one that made maximum use of local resources and required low capital investment that would benefit the people who most needed it and was easily available to them [Pacey, 1977b].

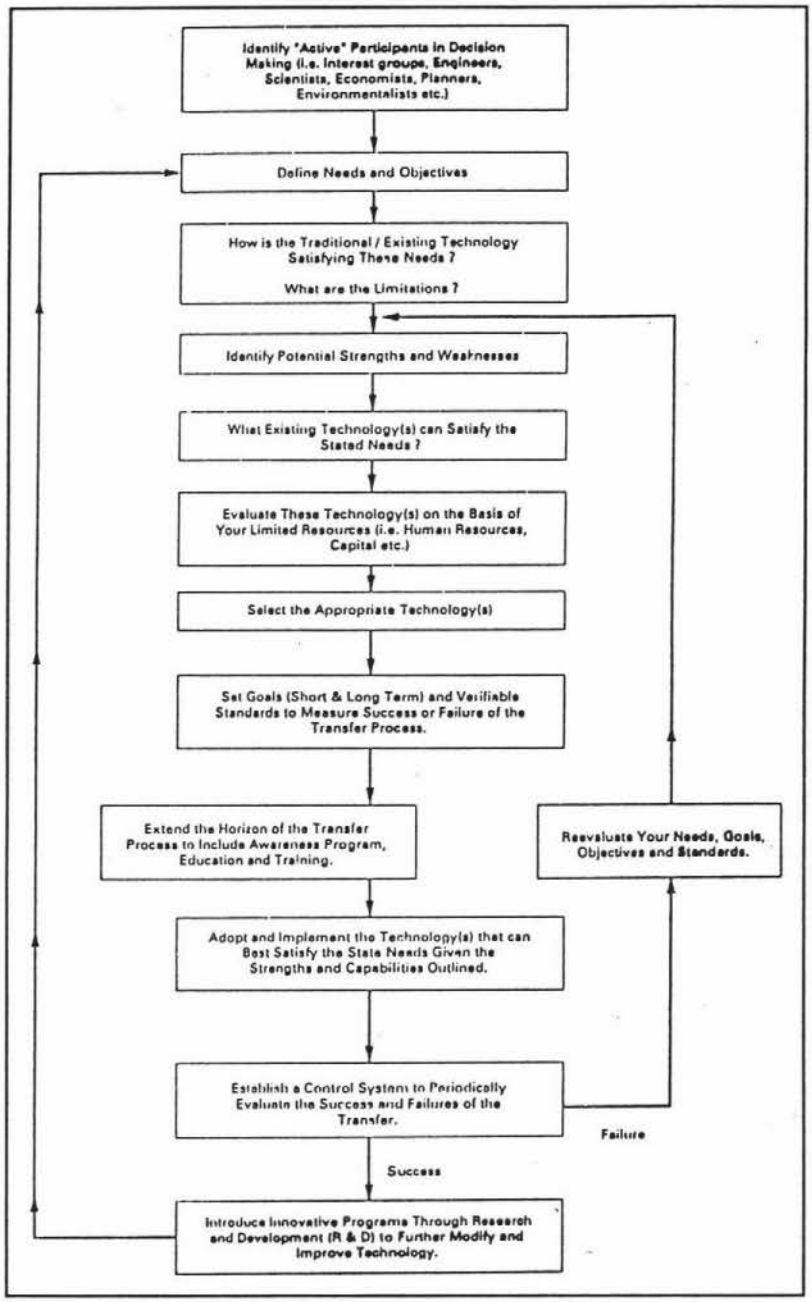

Figure 14 The technology transfer process (Source: Madu, 1989)

Appropriate technology is not simply defined because what is appropriate to one group is not appropriate to another [Carr, 1981; Pickford, 1982; O'Rourke, 1992]. One definition is the process or technique which provides a socially or environmentally acceptable level of service or quality of product at the least social cost [O'Rourke, 1992]. It is easier to detail what AT should encompass, as follows:

1) The provision of employment.
2) The production of goods for local markets.
3) The substitution of local goods for those previously imported and which are competitive in quality and cost.
4) The use of local resources of labour, materials and finance.
5) The provision of community services including health, water sanitation, housing, roads and education [Dunn, 1979].

2.9.1 The Need for Appropriate Technology in Water Supply Projects

> If the airplanes in which we travelled to a meeting had the same failure rate as most of the technology that has been applied in the last decade in rural water programmes, 50% of us would not have reached our destination [Henry, 1978].

There are volumes of works written on appropriate technology as shown by this short list that covers the past two decades [Schumacher, 1973; Beyer, 1976; Fussell and Quarmby, 1977; Herrera, 1978; Henry, 1978; Dunn, 1979; Kalbermatten *et al*, 1980; Carr, 1981; Reid, 1982; International Labour Organization, 1985; Roling, 1985; Stern, 1985; Batchelor, 1985; Anon, 1986; Hartung, 1986; Willoughby, 1990]. As well as this most works directly related to water supplies in developing countries discuss the need for appropriate technology [Karp and Cox, 1982; van Wijk-Sijbesma, 1985; Yacoob and Roark, 1990; Rondinelli, 1991; among many others]. But why do they believe AT is the answer to the needs of water supply projects?

Burton [1974], Pacey [1977b] and Stern [1985] pointed to the fact that technology was seen as the promised land in the ability to solve all the problems of delivering safe water supplies to the world. Unfortunately, technology has not offered the hope that it promised.

Spencer [1981] gave the reason for technology failure as the inappropriateness of unsuitable water supply systems and equipment being introduced into developing countries. The planners had not allowed for the requirements for maintenance, parts replacement, manpower deficiencies, costs of imports, inadequate infrastructure to operate and maintain the system and equipment (as shown in Plate 1).

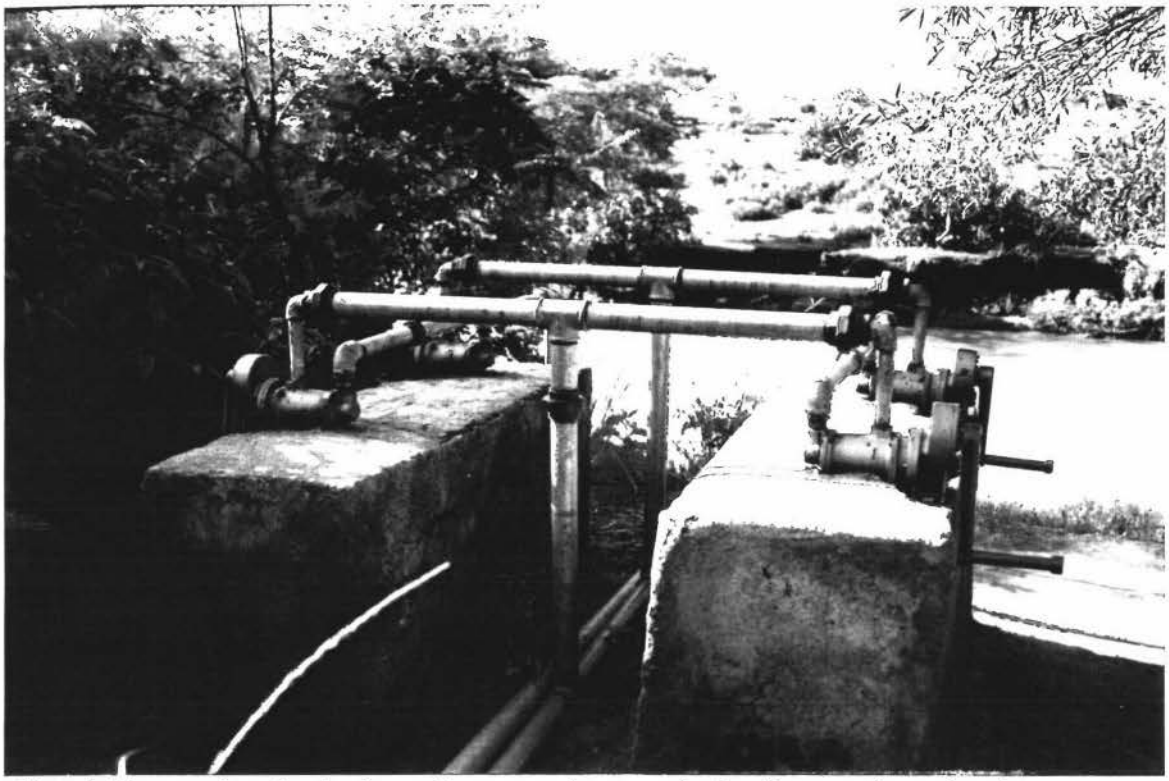

Plate 1. The promise of technology when appropriate organization for operation and maintenance is lacking. A series of handpumps for an irrigation system that no longer works (Source: The author)

Agarwal *et al* [1980], Whyte. and Burton [1977] and UNICEF and WHO, [1979a] noted that often the technology that was inappropriate had not taken into account the social and economic realities of the communities it was being introduced too. Bajard *et al* [1981] said that it was not generally recognized that western technology, although efficient in the short term is sociologically brutal and not necessarily the best solution to the water problem. They continued that the technology is often planned without sufficient reference to the local context: means and resources available, needs, local customs, educational/motivational requirements, etc. Whyte and Burton [1977] also commented that the introduction of a new water system introduces a new social order to the community, commonly in two directions:

> (a) altering the balance of power within communities - often the traditional leaders to the literate and politically sophisticated:
>
> (b) altering the external relations of the community - usually towards increased dependency on the national and regional government and a decreased ability to act independently in relation to other communities.

The failure to maintain the water systems can often be diagnosed as an adherence to their pattern of social relationships to which the new system was insensitive and disruptive. Most AT selected by the users, as previously stated in Section 2.8.3 by Rondinelli [1991], was based on the existing cultural practices, family needs, religious beliefs and economic circumstances.

Agarwal *et al* [1980] and UNICEF and WHO [1979a] also commented that many modern technologies were not designed for the geographic, climatic and environmental constraints that are found in developing countries.

Another factor that has led to the call for the use of AT is that officials in water agencies and governments chose inappropriate technology due to the expectation that the latest and greatest technology from developed countries must be best [Saunders and Warford, 1976; Reid, 1982; WHO, 1987; Austin and Jordan, 1987]. This is due in part to the fact that water supply projects in developing countries have in the past 40 years become the domain of foreign based consultants and engineers, who bring with them skills and technology that fits well into a developed country setting. Unfortunately these skills, technology and mindsets have also been passed on through higher education etc to many national water agency personnel. Thus the technologies that engineers particularly are familiar with are often over-designed and inappropriate for many water supply projects in developing countries [Reid, 1982].

The reason some authors promoted the use of AT, was to encourage the community to reach their potential and develop skills to meet their own water needs, which imported technology does not bring, so the goal of community development is obtained [Schumacher, 1973; de Mattos, 1979; Dunn, 1979; Scott-Stevens, 1987].

The last determinant that leads to the choice of AT is the factor of sustainable O & M of the water supply by the community [Reid, 1982; WHO, 1987; Wiseman and Eberhard, 1988; Rondinelli, 1991].

2.9.2 The Strengths of Appropriate Technology in Water Supplies

Appropriate technology and the transfer of AT from the developed countries have been promoted as the way forward in meeting the water needs of the developing world [Burton, 1974; Pacey, 1977b; Dunn, 1979; Barrett and Pescod, 1982; WHO, 1987; Fairburn and Wise, 1989; Brabben, 1992; among others]. The following points were seen as AT answers to water supply projects, and what it should encompass:

- be as inexpensive as possible without jeopardizing the effectiveness of the improvements sought;
- be easy to operate and maintain at the village, community, or municipal level, and not demand a high level of technical skill or require a massive deployment of professional engineers;
- rely on locally-produced materials rather than on externally provided equipment and spare parts, where this is practical;
- make effective use of local labour, especially in areas where there is a surplus of labour;
- facilitate and encourage the local manufacture of equipment and parts under the leadership of entrepreneurs;
- facilitate the participation of village communities in its operation and maintenance; and
- be compatible with local values (including socio-economic and cultural) and preferences [WHO, 1987].

The transfer of this appropriate technology is important for the above points to become effective in the community. The use of local forms of media and people familiar with the customs are the best ways of helping the message get across on how to use the technology across [WHO and UNICEF, 1979a]. UNICEF initiated Project Support Communications activities to inform the community, about the technology, how to use it in a proper way, along with promoting the local manufacture of equipment, O & M and the development of skills.

Appropriate technologies range from the most sophisticated water delivery system to low cost traditional water systems, and often a blending of the two is the best solution [Barrett and Pescod, 1982; Liebenow, 1984a]. Some good examples of appropriate technology are found in the following list:

Handpump wells;
gravity water schemes;
Protected springs;
Subsurface dams;
Rainwater catchment;
Simple water treatment methods, i.e. slow sand filters [McPherson and McGarry, 1987].
Communal standpipes;
Private yard taps; and
House connections [Rondinelli, 1991].
Archimedean screw pump;
Water ladder (dragon's spine);
Chain and disk;
Shaduf;
Persian wheel;
The dall;
Swing basket; and
The mot [Dunn, 1979; Barrow, 1987].

The type of energy creation technology used to lift and provide water was considered also, as this affected the appropriateness of the system. Energy sources may include gravity, hydraulic power, internal combustion engines, electricity, hand-pumps, animal traction, biogas, wind and solar power [Dunn, 1979; Karp and Cox, 1982].

A good example of appropriate technology is the Iraqi sand filter (Figure 15) which was designed to avoid the cost of importing expensive equipment. The plants are built for less than half the cost of the imported materials, because the frills and gadgets were dispensed with. The plant was also appropriate because it was designed for the silty conditions of the Iraqi rivers, and able to be operated and maintained by locally trained personnel [Smethurst, 1988].

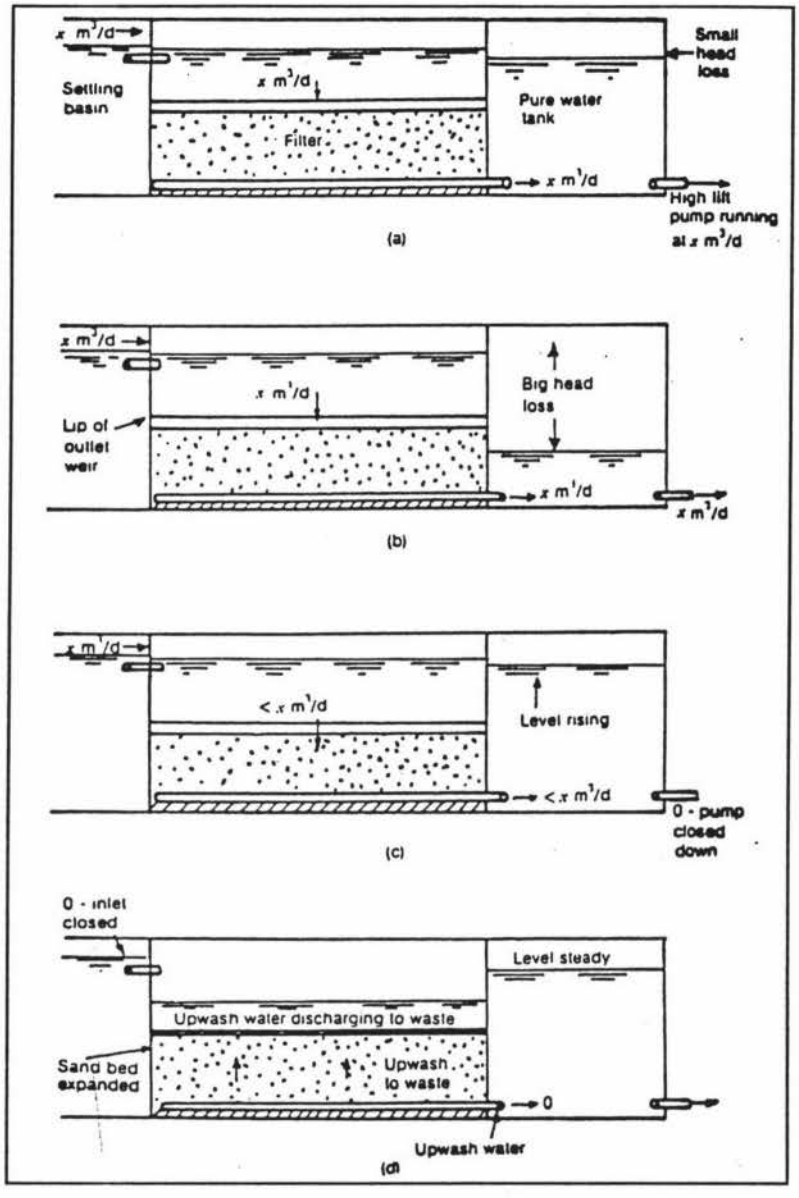

Figure 15 Iraqi type filter: (a) running with filter clean; (b) running with filter dirty; (c) shut down in preparation for washing; (d) during washing. (Source: Smethurst, 1988)

The choice of technology also affects the ability to sustainably operate and maintain the water supply; WHO [1981] saw AT as the way to reach the goal of IDWSSD also to meet the problems faced by lack of sustainable O & M:

> Installations should be simple to operate and maintain using knowledge available in the villages and small town concerned. Technologies should be chosen that economise on foreign exchange and encourage local employment.

How does AT effect the sustainable O & M of water supplies?

2.9.3 Appropriate Technology for Sustainable O & M of Water Supplies

Pacey [1977b] and McPherson and McGarry [1987] said that the concept of appropriate technology is not the type of technology, but rather the choice of technology and the criteria needed to make sound choices. Rondinelli [1991] as previously discussed, pointed to the fact that the most effective technologies were those that the users chose and preferred. Often the technology chosen was an improvement or an upgrade of technology already used, which had proven to be most effective [McPherson and McGarry, 1987; Rondinelli, 1991; O'Rourke, 1992]. Also Rondinelli commented that the designers of successful water projects did not make technology their primary objective, or allow it to dominate their thinking, but were more concerned with O & M requirements in their selection of technology. These choices are in effect related to how well the transfer of information on the various technologies is presented to the users [Austin and Jordan, 1987]. This transfer of information to the community may come through several different avenues during the promotion stage of the project, and particularly to the water committee who will usually make the final decision (cf Section 2.8.1 and Appendix 10).

The following are the critical questions that need to be asked in choosing AT equipment and systems for the sustainable O & M of water supply projects:

- Can the equipment be maintained by the water agency technicians or private workshops in the country with the existing level of expertise?
- Are spare parts for equipment available and affordable?
- Can locally produced materials be used in the construction of the project?
- Are test equipment and proper tools available to maintain efficient equipment operation?
- Are adequately trained people available to operate and maintain equipment? [Austin and Jordan, 1987].
- The hydrological and topographical situation;
- The quality of the water;
- The community preferences for the outlet sites and type of system;
- Assumptions are needed to be made about population trends, so system can be adapted [Yacoob and Roark, 1990];
- Climatic and environmental constraints [UNICEF and WHO, 1979a].

There is also a need to make sure that the appropriate technology chosen is suitable to be operated and maintained by women [Carr, 1981; Hannan-Andersson, 1985; INSTRAW, 1991; among others].

The selection of technology by the community helps the community to own and take responsibility for O & M [Schoeffel, 1992; Yacoob and Rosensweig, 1992; among others]. As mentioned in Sections 2.7.4.2 and 2.8.6 ownership is seen as the most important factor in sustainable O & M of water supplies.

2.9.4 Problems Facing Appropriate Technology for O & M of Water Supplies

The appropriate technology lobby has gained powerful allies in the past 30 years from groups such as WHO, UNDP, World Bank and USAID among others, yet this has also stimulated an anti-appropriate technology group, particularly from engineers and developing country officials. This group argues that AT is to ensure that the developed countries stay technologically in power. The evidence to supporting such a suggestion is weak, but the impression that these major organizations give of promoting one kind of technology while enjoying the comforts of another gives some credence to this thinking [Fussell and Quarmby, 1977]. Schumacher [1973] presented a good answer to this: that the potential for appropriate technology lies in the fact that it is there to help developing nations gain their independence from developed nations and transnational companies.

McPherson and McGarry [1987] noted that as many AT projects fail as high-cost engineering projects fail, and the same factors for failure have been notably similar to those of high-tech technologies, namely:

- lack of funds
- lack of user support
- absence of an operation and maintenance programme; and
- poor project organization and management.

These problems have been discussed in detail under the prior sections on management and community participation. Wood [1983] said that because of the simplicity of AT there was a danger that because there maybe no need for staff, fuel or chemicals etc, then the system may be forgotten and expected to continue indefinitely without attention of any kind.

Pacey [1977b] identified a related problem that of AT support failure. He believed that there was a need to accompany the selection of an AT with the creation of the appropriate organizations, including training facilities, infrastructure for parts, etc (cf Plate 1). Also the idea of the water supply as a part of one system that includes agencies, health services, community organization, individuals and technology needs to be grasped by the designer (which is quite different to engineering thinking in developed countries).

A major problem that faces the use of AT is the assumption that it will provide all the answers to the problem of O & M. The developing world is littered with the debris from failed experiments in AT [McPherson and McGarry, 1987]. One problem related to the amount of different technologies available that has been created is the major difficulty to institute the proper infrastructure and support for O & M, because of all the different systems available [UNDP and the World Bank, 1987; McPherson and McGarry, 1987]. This has been overcome in Zimbabwe where the government has encouraged the use of only two different types of handpumps, depending on the depth of the water source [Morgan, 1990].

The point that appropriate technology literature reveals is that it is only part of the answer to successful O & M of water supplies. Rather AT needs to be set alongside the need for successful technology transfer and implementation, community participation, management both by the Agency and the community and the need for a supportive infrastructure [McPherson and McGarry, 1987; Schoeffel, 1992].

To finish this section on appropriate technology a quote from Schumacher:

If you want to go places, start from where you are.
If you are poor, start with something cheap.
If you are uneducated, start with
something relatively simple.
If you live in a poor environment, and poverty makes
markets small, start with something small.
If you are unemployed, start using your labour power; because any
productive use of it is better than letting it lie idle.
In other words, we must learn to recognise the boundaries of poverty.
A project that does not fit, educationally and organizationally,
into the environment, will be an economic failure
and a cause of disruption.

2.10 Infrastructure for Parts, Maintenance and Training

> An effective pump system is not simply a technological object but a conglomerate of technology, institutions and people - individuals who must plan, design, manufacture, finance, purchase, install, operate, maintain, oversee and use the pump. This often neglected concept is an important reason why as many as 40 to 80 percent of pump systems are inoperative within three years of their installation [McJunkin, 1975].

Infrastructure for parts, maintenance and training is the responsibility of the water agency [ODA, 1985; Briscoe and de Ferranti, 1988; Yacoob, 1989; Yacoob and Roark, 1990; among others]. This has been discussed previously in the section on institutional management, but since it is often a neglected factor [Saunders and Warford, 1976; Harlaut, 1976; UNICEF and WHO, 1979a; WHO, 1987; among others], it will be discussed in more detail in this section. Hodgkin [1989] as previously mentioned noted five areas (cf Section 2.6) that created major difficulties for sustainable O & M, of which the following four are infrastructural problems:

- Fuel and oil for operation
- Spare parts, either in the country or at the local level
- Skilled mechanics
- Well-trained operators

Yacoob [1989] as previously noted in Section 2.7.4.1 that the community should only assume full responsibility for O & M when three conditions were met, all of which are related to an established infrastructure for parts, maintenance and training:

- spare parts are available
- the community is prepared to handle routine maintenance
- back up support is available to the community for complex repairs and maintenance.

Infrastructural problems have also been created by the options of technology available and by imported technology. This has led to the unavailability of parts, a need for large volumes of parts due to the variety of technology being used and the lack of skilled and qualified technicians due to the different systems [Saunders and Warford, 1976; Spencer, 1981; Reid, 1982; WHO, 1987; Austin and Jordan, 1987; among others].

A lack of thought and planning for O & M infrastructure at both the planning and design stages has also created sustainability problems for O & M of water supplies [Harlaut, 1976; UNICEF and WHO, 1979a; ITDG Water Panel, 1980].

The final problem that face's infrastructure is the poor levels of maintenance being performed by Agency staff, especially when repeatedly requested by the community to come and repair the system that was beyond their own capacity to repair [Mangin, 1991].

What can be done to prevent and/or reduce these problems of weak infrastructure for parts, maintenance and training?

2.10.1 Infrastructure for Parts

As has been already mentioned the major problem with the parts' infrastructure of water supply systems is the lack of parts availability because they are imported. For example [Tayler, 1983], mentioned that towns in Sudan faced major repair problems due to the difficulty in obtaining parts and materials for the water supply systems. Also there are major problems in many developing countries in the terms of communications and transport, especially for those living in rural areas [Saunders and Warford, 1976; Spencer, 1981; Reid, 1982; Austin and Jordan, 1987; WHO, 1987; Mangin, 1991; among others].

WHO [1987] and Austin and Jordan [1987] proposed an answer to the part's problem that locally-produced materials should be relied on rather than externally provided equipment and spare parts, where this is practical. The facilitation and encouragement of local manufacture of equipment and parts under the leadership of entrepreneurs should also be pursued.

Another way to reduce the difficulties of spare parts is the standardization of the equipment used, as previously mentioned under institutional management [Cairncross *et al*, 1980; Austin and Jordan, 1987; UNDP and the World Bank, 1987; McPherson and McGarry, 1987]. WHO [1987] notes that this has been difficult to achieve in many countries due to the numbers of donors involved in aid and development, and in reality would not be achieved until local production could be established.

Before selecting a technology for water supply projects there needs to also be identification of the community and nation's infrastructure such as roads, communications, availability of a power source, etc. [Warner, 1984]. For example, Mangin [1991] says that the physical infrastructure of Ethiopia needs to be worked upon. This he says will be a

massive feat and require massive amounts of finance. He goes onto say unless the resources are available, then the strategy for rural water supplies may need to change by moving from new supplies too simply improving the existing water supplies (cf Figure 9, example's 1 and 2). This is less costly, and reduces the problems facing construction, supervision and spare parts.

If there is a reasonable physical infrastructure within the country, then suitable procedures need to be set in place for purchasing parts with a good transport and communication system for getting parts and service to the system in a reasonable time [Dworkin, 1982; WHO, 1987]. A data system should also be set up to record work orders, parts purchased, and a history of each water system kept, to enable the budgeting of and ordering of parts [Austin and Jordan, 1987].

2.10.2 Infrastructure for Maintenance Support

A centrally administered technical support unit along with a good stock of spare parts is needed to provide expertise in problems with water supply has been a major problem in LDCs [UNICEF and WHO, 1979a; WHO, 1981; Kalbermatten J.M. *et al*, 1980; Dworkin, 1982; WHO, 1987].

Part of the problem is the lack of clear responsibilities of who should do what when the community is also involved in O & M [Cairncross *et al*, 1980; McCommon *et al*, 1990; Yacoob and Rosensweig, 1992; among others]. Clear guidelines should be set in place [Yacoob and Roark, 1990]. The responsibilities should involve the following six factors:

- Back up support to community when repairs etc are beyond their capacity [Pacey, 1977a; ITDG Water Panel, 1980].
- Provide an infrastructure to supply parts when needed, including communication [UNICEF and WHO, 1979a; ODA, 1985].
- Monitor and motivate the community when enthusiasm fades for O & M [Kalbermatten *et al*, 1980; IRC, 1988a; Rondinelli, 1991].
- A support team should be set up of roving operation and maintenance advisors and monitors for completed projects.
- Provide technical assistance through a support unit. Maintain a stock of spare parts administered by the support unit.

- Monitor the operation and quality of service, disseminate information, and provide continuous training programmes for community workers and local staff [Kalbermatten *et al*, 1980] (also cf Appendix 12).

Another part of the problem is lack of incentive, training, accountability, corruption, low wages and morale of the national water agency to provide maintenance backup [WHO, 1987; Austin and Jordan, 1987; O'Rourke, 1992]. Yacoob and Rosensweig [1992] as already noted, pointed to the necessity of incentives for the water department workers involved (cf Section 2.7.4.1).

A major problem is that very little funds are put into O & M by governments and donors [Saunders and Warford, 1976; Austin and Jordan, 1987; among others]. Thus the ability of the Agency to provide maintenance support is overwhelmed [Austin and Jordan, 1987]. This can be overcome by the community receiving the water supply system paying for all or part of the O & M costs (dependant upon the communities relative income) [Wood, 1983; Yacoob and Warner, 1989; among others].

2.10.3 Infrastructure for Training

The training of community personnel for O & M is a major factor of the water agency's responsibilities especially under a community based O & M water supply system [UNICEF and WHO, 1979a; Briscoe and de Ferranti, 1988; Yacoob and Roark, 1990; among others]. As has been discussed in community management, beneficiary participation and appropriate technology sections there are many areas in which training of the community needs to take place. The focus here will be upon O & M personnel and community management training.

2.10.3.1 Community O & M Personnel Training

The setting up of training programmes needs to be promoted by the government, both for community O & M personnel and for the water agency personnel [van Damme, 1981]. Training of the community O & M personnel begins during the construction phase of the water project [Kalbermatten *et al*, 1980; Tayler, 1983; Rondinelli, 1991; McPherson, date unknown; among others]. Pacey [1977a] notes that in Tanzania for example, a village nominates a person who goes to a training course for two weeks. Hodgkin [1989] presented the following training course as applicable to community based O & M

personnel in Yemen:

- basic theory of diesel engine and diesel generator operation
- Basic theory of pump operation (vertical turbine or electrical submersible as appropriate)
- Proper use of hand tools
- Common engine and pump problems, their symptoms, and appropriate solutions (This is not intended to teach operators to perform repairs but to help them identify problems and the sort of mechanic who should be summoned)
- Warnings about tasks which should not be attempted by the operator
- The importance of properly functioning water systems to the health of villagers and
- A listing of operator tasks including how and how often to change oil and filters, repair taps and pipelines, etc (cf Appendix 2).

The tools needed for the O & M tasks were then provided to the trained operator. It should be noted that women should also be chosen to be operation and maintenance personnel [Hannan-Andersson, 1985; van Wijk-Sijbesma, 1985; INSTRAW, 1991; among others].

The training of the community based O & M personnel depends also on the training of the Agency staff involved [van Damme, 1981; McPherson and McGarry, 1987; Hodgkin, 1989; among others].

2.10.3.2 Community Management Training in O & M

The training for community management as a major role by the water agency is seen as essential in sustainable O & M [Wood, 1983; Briscoe and de Ferranti, 1988; McCommon *et al*, 1990; Yacoob and Roark, 1990; Rondinelli, 1991; Yacoob and Rosensweig, 1992; among others]. Training the community managers in the management of O & M of the water supply by the Agency is needed in the following areas:

- Training in the area of basic problem-solving [McCommon *et al*, 1990].
- Training in the area of managerial, organizational, financial and administrative skills [Briscoe and Ferranti, 1988].
- Training in the area of how to raise money for the O & M fund [Yacoob and Roark, 1990].
- Understanding of the technical options available for a water supply and the O & M needed for each needs too given to the community water committee, so that the

choice of water supply technology can fit into the community's infrastructure and used sustainably and to its full design capacity [Yacoob and Roark, 1990].

- Training guidelines for maintaining and using the water system, thus affecting both the sustainability and O & M of the system, and who to turn to for repairs beyond the scope of the community [Yacoob and Roark, 1990].
- During the planning, design and construction periods appropriate management techniques need to be evolved for the community to manage the water supply [Pickford, 1982].

As can be seen many factors that appear under infrastructure are parts of the institutional management and Agency responsibilities, thus they need to be helped to be able to fulfil this role, by international groups [Briscoe and de Ferranti, 1988].

To finish this section a quote from Galbraith [1973], which sums up the need for action to be taken to address the problems facing O & M of water supply projects:

I want to change things. I want to see things happen.
I don't want to just talk about them.

2.11 O & M Models

The literature revealed two models showing the interrelationship of O & M to other components of sustainable water supply projects. The first is a diagram from the work by [Pacey, 1977a], *Hand pump maintenance in the context of community well projects*. He stated that the diagram shown in Figure 16 serves mainly to symbolise the large diversity of requirements necessary for a successful project. It revealed a large number of activities done by the community, and the water committee that are not technological. These needed to be seriously considered, as the engineering of a water supply should always try to relate to the local social structure of the community.

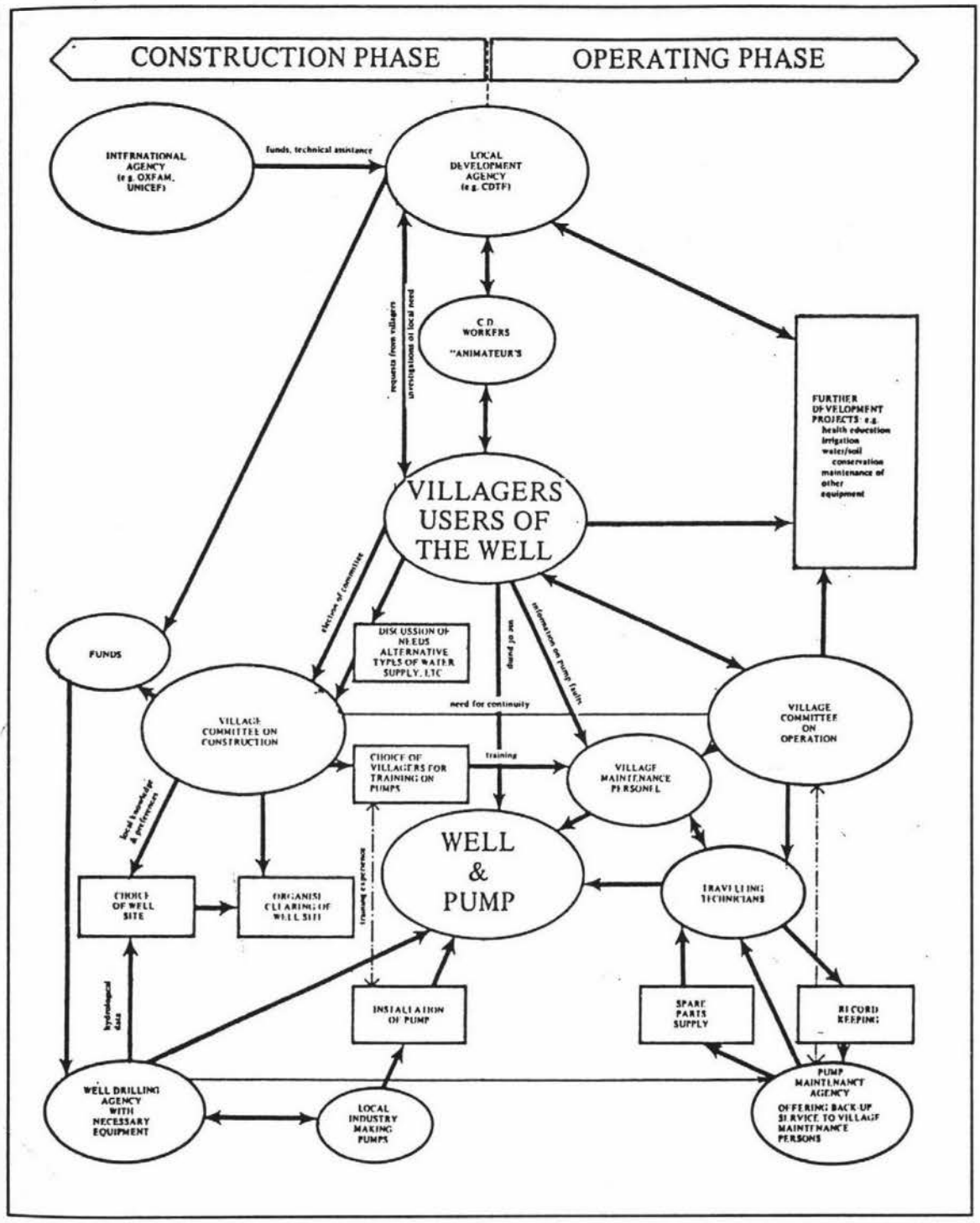

Figure 16 (Source: Pacey, 1977a)

The second model related to O & M of water supplies in the literature was an assessment guide for the planning and assessing the operation and maintenance component of water supply projects by [Jordan *et al*, 1986]. This assessment guide was based on a series of iterative questions concerning the O & M capacity of the community and development

agency. The authors stated the purpose of this was to help the project planners pinpoint the problem areas of O & M and to develop strategies for incorporating solutions into the project design. The authors presented that there were seven different elements that affect the sustainable O & M of a water supply:

- Institutional capacity
- Systems operations and maintenance
- Spare parts and supplies
- Logistics
- Finance
- Records
- Human resources and training (cf Appendix 13 for a detailed explanation of these elements)

The authors noted that there are other areas that have an impact of O & M that was not covered in the guide, such as the design of the water system, construction, water quality, health education and social factors. The guide covered four different types of water supplies systems commonly found in LDCs:

1. Reticulated systems fed from either springs or streams.
2. Water systems' using handpumps.
3. Water systems using electrically powered pumpsets drawing from groundwater sources.
4. water systems requiring treatment works.

2.12 Conclusions from Literature Review

The literature has shown a trend towards greater consideration of the whole issue of O & M of water supplies. The literature presents the view that community management and participation are keys to sustainable O & M, especially if women are involved, and a lot of effort has been put into the virtues of this approach. Much of the literature also argues that O & M will also be improved with the use of appropriate technology. The strengthening of institutional management and roles of centralized water agencies was discussed by some authors, in particular the need for the institution to move from a hands on approach to a support and consultancy role in water projects, and in particular O & M. There seemed to be a lack of material on the need for a strong infrastructure for parts. Although training was mentioned by a number of authors, little mention was made of the practice of actually training both the community and the water agency staff in O & M. Even with the push to community management and participation, appropriate technology etc, some authors mentioned that there still appeared to be a large number of water projects failing due to poor O & M. Austin and Jordan [1987] said that, problems of O & M cannot be solved simply by implementing a training programme or a spare-parts logistics system. In addition to O & M, the entire planning, design, construction, and management structures must be considered. The process must be assessed in its entirety. A detailed model or flow chart of how O & M fits into the whole water project cycle and what needs to happen at each stage was found to be lacking, although both of the models in Section 2.11 go someway down this track.

CHAPTER 3
OBJECTIVES

The literature review revealed that there was no detailed model or programme for water projects in the area of sustainable operation and maintenance of water supplies in developing countries. The need for a model for engineers and development workers to follow gave rise to the following objectives:

1. To conduct an extensive survey of the literature relating to O & M of water supplies, to find out the major factors and groups involved in providing sustainable O & M.

2. From the literature to find a model that has been used for providing O & M of water supplies.

3. To construct a model if no model was discovered in the literature; the model to be based on the currently available literature.

4. To substantiate the model through interviews and surveys of those involved in water projects. These interviews and surveys would include the following two groups, development agencies; community members and users of the water supplies.

5. To create a new model or revise the original model from the information received from the interviews and surveys.

6. To describe the processes by which sustainable O & M of water supplies can be put into water development projects.

7. To provide an extensive reference list of the various publications on the subject.

Chapter 2 examined the current literature (objective 1) and presented the various theories and practices necessary to achieve sustainable water supplies in developing countries. The

literature review revealed that there was no appropriate model for O & M, so objective 2 was dismissed, therefore objective 3 was ventured upon in chapter 4.

To substantiate the model (objective 4), surveys were undertaken, the results and discussion of these surveys in comparison to the model are shown in chapter 5. The conclusions and the model revision appear in chapter 6 (objective 5).

The process of establishing sustainable O & M of water supplies (objective 6) is discussed in chapter 7, along with further recommendations. The bibliography provides an extensive reference list on the O & M of water supplies (objective 7).

3.1 Limits of Study

The study was performed in Ethiopia over an 11 week period, with most of the time spent by the author working on urban and rural water projects. The shortage of time particularly in Addis Ababa, led to a lack of interviews able to be obtained from development agencies. The study was also limited to the problems of O & M within Ethiopia, which may be different because of cultural, geographical and political factors to other developing countries. This limitation is also possible because the community/user surveys were performed in a small area among two tribal groups in Southern Ethiopia, which have different characteristics to other tribal groups within Ethiopia.

CHAPTER 4

SUSTAINABLE OPERATIONS AND MAINTENANCE MODEL

4.1 Background to Material Used for the Model

The core material used for the development of the model comes from the literature survey. Major trends and factors were selected out of the literature and then put into one or more of the five different stages as shown below. The selection of the factors for the model was based upon two criteria: First, both the literature and the author assumed the factor to be important to the overall sustainability of the water supply. Secondly, the selection of a factor was determined by whether the community or its selected water committee would have an important role to play in the management, planning and physical involvement in the water project if it was included. The model also included the need for the government water department (or development agency) to have an ongoing relationship with the community after the project is constructed and the responsibility for O & M is handed over to the community. This relationship should include the following responsibilities: providing parts; technical help with some of the complex tasks of maintaining a water system; training both O & M personnel and water committee members; and, have a monitoring role over the water supply. This idea goes against the usual trend being advocated by a large amount of the literature where the community is totally responsible (cf Section 2.7.2.2).

The process of setting up a water project involves several different stages that development agencies and engineers recognise. These processes can cover more than one stage, and more than one stage can occasionally be happening at any one time. The model presents that there are four groups involved in the water project, they are, the community, the development agency, the government water department, and the community's water committee. Each of these groups has been assumed to have different roles and responsibilities at the different stages of the water project.[1]

[1] The development agency and the government water department can do both roles, but the model assumes that the development agency will be involved specifically in the first four stages and hands over the responsibility for the water project to the water department at the transfer stage.

4.2 Factors Included in the Model

PLANNING	DESIGN	CONSTRUCTION	TRANSFER	OPERATIONS
Discussion between the agency, community & water committee: - ownership - responsibility - need for water? - funding O & M - committee role Community selects water committee Agency trains the water committee Agency discusses the infrastructure needed with Govt water dept	Community, committee and Agency choose: - technology - type of system Agency continues to train committee	Training of selected locals in O & M* Community participation Agency continues to train committee	Ownership ceremony Reiteration of responsibilities for O & M	Committee discuss with community rules for use of water supply The Committee oversees: - parts in stock - maintenance personnel - O & M - monitoring of the resource - contacts water dept when parts or technical assistance is needed Water Dept provides: - the necessary infrastructure - technical assistance when needed - continues training of O & M personnel - monitor & consult the committee

* selected by the water committee. Usually people with some technical skills ie. Blacksmiths, electricians etc.

4.3 The Most Important Factors for Sustainable O & M

The following factors were deemed to be the most important for O & M in the model: Ownership; Community involvement; Training of the water committee and O & M personnel; Knowledge of O & M responsibilities; Funds for O & M; And, the need for a strong infrastructure for parts and support for the sustainable O & M.

4.3.1 A Diagram of the Models Most Important Factors & Interrelationships

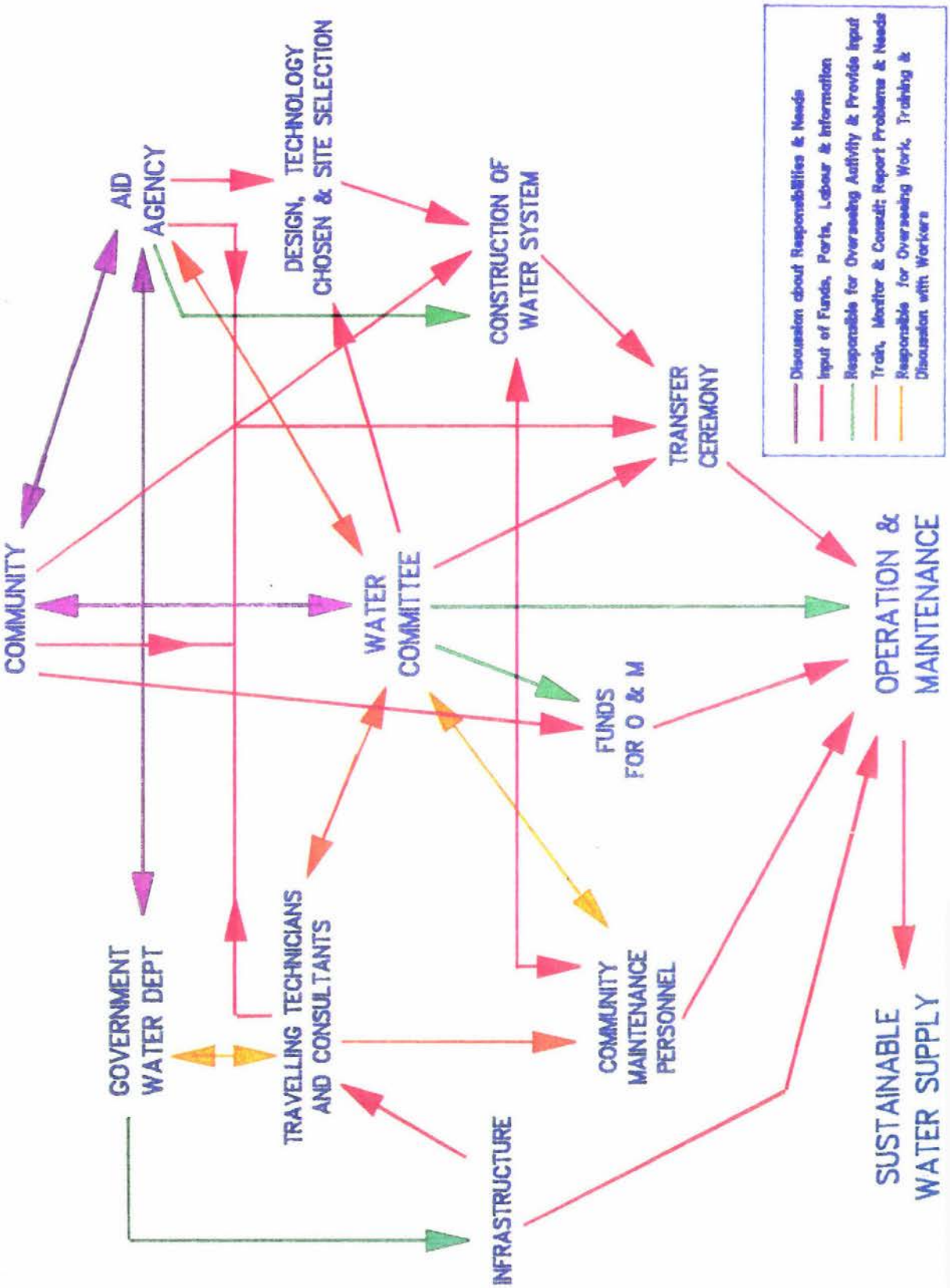

Figure 17 A diagram of the Model

4.4 The Model Explained

The following is an explanation of the role each of the four groups' plays at the five stages of the model.

4.4.1 Planning Stage

Community

- approaches development agency[2] about the need for water in the community.
- discussion with development agency.
- select community water committee.

Development Agency

- discussion with the community covering the following areas:
  - investigates the need for water in the community.
  - who will be the owners of the water supply? - (usually the community).
  - who will be responsible for O & M, and in what areas if there is joint responsibility (commonly the water department or development agency will have travelling technicians to perform complicated maintenance procedures beyond the capability of the community).
  - the need for a community water committee, how it should be selected, what their role is.
  - who will provide funds for the water supply project, who will pay for the O & M costs.
- after the selection of the community water committee, discussion with the water committee on its role.
- training of the water committee in the following areas[3]:
  - analyse priority water problems.
  - establishing an O & M fund.
  - adopting rules on the use of the water supply.

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[2] The development agency may be a local or international NGO, or a multilateral development agency. This model assumes that it approaches a development agency although the water department can provide a similar role.

[3] Training of water committee would probably continue over the first 3 stages of the water supply project. Also the agency could be involved in evaluating and offering other training to the water committee during Stage 5 if the government water department is not involved.

- preparing the community for construction.
- health issues, and how to pass this information on to others.
- management and administration of the funds and the water supply.
- selecting community maintenance personnel - derived from [Yacoob and Roark, 1990].

- notify government water department of the community request for a water supply.
- discussion with the water committee and the government water department on the infrastructure needed for the O & M of the water supply, ie parts, communication, transportation, foreign exchange for imported parts (it is assumed in this model to be the water department's responsibility, but it can also be performed by the development agency).
- discuss with the government water department who will assume responsibility for ongoing monitoring along with technical help and consultation to community for the sustainable O & M of the water supply after construction (it is assumed in this model that this will be the water department responsibility, but sometimes it is carried out by the development agency).
- sign a contract with the community[4] and water department, which details what each is responsible for, both in the construction and the ongoing maintenance of the water supply.

Water Committee

- involved in discussion with the development agency.
- start to be trained by the development agency.
- responsible to the community.

Government Water Department

- inform the development agency of any legislation involving water supply projects, ie. there may be laws requiring the setting up of a water committee, types of technology allowed.
- discussion with the development agency on infrastructure after the water

[4] Usually signed by the members of the water committee on behalf of the community.

project is constructed, particularly on funds needed for importing parts, how the parts will be delivered to the communities, how will the community order the parts, etc.

- discuss with the development agency who will assume responsibility for ongoing monitoring along with technical help and advice for the community.

4.4.2 Design Stage

Community

- involved in survey with the water committee on possible sites for water points, sources, technology of the water supply.

Development Agency

- continuation of training the water committee.
- discussion with the water committee about the best site, design and technology of the water supply. To provide the best possible system, which is sustainable using the available resources. Also one that could achieve a good level of local involvement of O & M. The government water departments' regulations on possible technology that could be used are presented, in particular types of handpumps.
- design the water supply with the water committee.

Water Committee

- survey of community about what type of water supply wanted, the best sites and possible sources for the water supply, which are then discussed with the development agency.
- continuation with training on their role and responsibilities.
- help design the water supply with the development agency.

4.4.3 Construction Stage

Community

- involved in the construction of the water supply under the supervision of the water committee and development agency. Involvement in construction helps the community develop a sense of ownership of the water supply.
- individuals from within the community are chosen for training by the water committee and development agency as community maintenance personnel.

Development Agency
- continuation of training of the water committee.
- oversee construction of the water supply.
- train the individuals chosen for maintenance of the water supply at the community level.

Water Committee
- continuance of training by development agency, along with experiencing the water supply being put in, with the development agency pointing out areas where O & M problems can occur within the water supply system.
- involved in the selection of community maintenance personnel.
- possibly go to the training put on for maintenance personnel, so that they know what the maintenance personnel should be doing to maintain the water supply.

4.4.4 Transfer Ceremony

Community
- community takes over the responsibility for the water, and acknowledges its ownership of the water supply, including raising funds to O & M the water supply.
- celebrate the completion of a new water supply for the community.
- public declaration to use the water supply responsibly and to help maintain it.

Development Agency
- reminds the community and the water committee along with the water department,[5] of their responsibility for operating and maintaining both the water supply and the water resource.

Water Committee
- a public declaration of their acceptance of their responsibility to manage both the water supply and water resource.
- community maintenance personnel acknowledge responsibility to maintain the water supply under the direction of the water committee.

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[5] In the case of the water department being responsible for the infrastructure and support in a consulting and technical role.

Government Water Department - public declaration of its responsibility in the terms of technical help and advice to the community in the O & M of the water supply and water resource. Also, its responsibility for the necessary infrastructure to keep the water supply in working order.

4.4.5 Operations Stage

Community
- discuss with water committee the rules for the use of the water supply to meet needs in the community.
- inform maintenance personnel when there are problems with the water supply.
- provide funds for O & M.

Development Agency
- project evaluation of the water project, especially its sustainability.

Water Committee
- discuss with community the rules for operating the water supply. Oversee that these rules are followed.
- administer and oversee the funds for O & M.
- manage and oversee the maintenance personnel.
- keep an inventory of parts in stock.
- provide the community with health information about the need for clean water, and how to stay healthy.
- contact the water department when parts and/or technical help is needed to maintain the water supply.
- monitor the water resource and make adjustments to the rules for use of the water supply to meet the resource circumstances with directions and help from the Government water department.

Government Water Department
- monitor the community to see all is going well.
- oversee the monitoring of the resource.
- provide technical assistance for maintenance jobs beyond community ability when asked by water committee.

- provide the infrastructure to supply parts when requested by the water committee.
- provide consultants for problems faced in managing the water supply.
- provide ongoing training to community maintenance personnel and to the water committee when requested.

CHAPTER 5

DATA COLLECTION AND ANALYSIS OF SURVEYS

5.1 Method of Data Collection from Development Workers

A participatory approach was adopted for the collection of data. This approach had as its basis the interviewee discussing their full opinion without interference from the interviewer. The people interviewed were from some of the main water development agencies in Addis Ababa, Ethiopia. Eight of the thirty-seven agencies involved in some form of water development in Ethiopia were interviewed. The development workers were asked what their agency's policy was towards creating sustainable O & M of their water supplies. On two occasions the development agency had no set policy on O & M, so the interviewee was asked what the standard practices were or if they had a personal view on what the policy should be. A question asked directly was, "what they thought were the most important factor/s overall that were necessary for sustainable O & M?" This information was checked off a prepared list based off the authors' model, which included what stage of the water supply project the factor should be introduced as defined by the model (cf Appendix 14). At different times the author prompted the interviewee about some points for clarification, but interruptions to the interviewees expressions were kept to a minimum.

5.2 Analysis Method for Development Agency Survey

Because the information collected was a series of opinions and policies the following method of interpreting the results was devised: From the data given the author ranked the factors in each stage. These rankings were divided into two groups per stage: Group one included the three factors which the development workers rated as most important for sustainable O & M; group two included other factors that ranked below the top three in that stage. Because of the low number of interviews obtained, groupings of percentages of ranked factors were made. These groupings of percentages were then divided into four levels. The four levels were as follows:

Level 1: $\geq$ 50% in Group 1 were defined as a major factor.

Level 2: = 37.5% in Group 1 were defined as a moderate factor.

Level 3: = 25% in Group 1 and had also been included as a factor in Group 2 were defined as a minor factor.

Level 4: ≤ 25% in Group 1 but have not been included in Group 2, and all other factors that 12.5% in Group 1 and/or only appear in Group 2 were defined as other minor factors.

5.3 Results

The results are shown in Appendix 15. From these results the following relationships within sustainable O & M are shown in diagrammatic form, for each of the five stages of the model.

Stage 1: Planning Stage

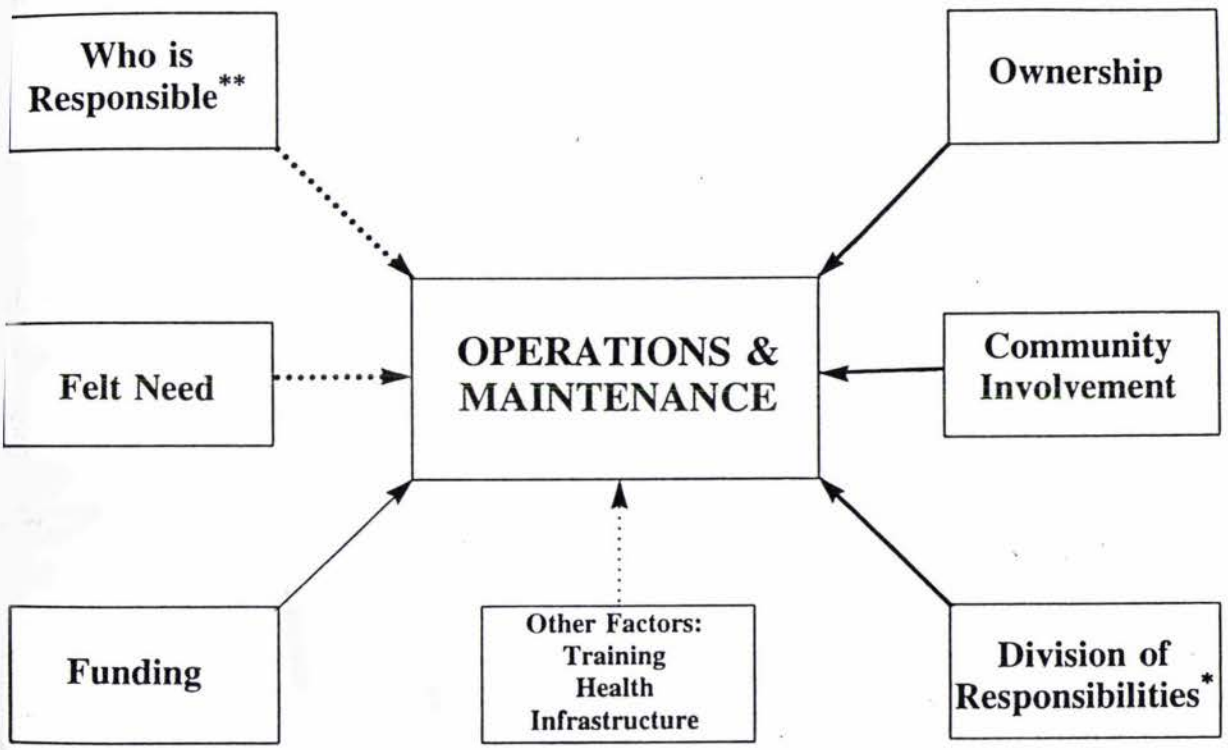

Figure 18 Stage 1 results from development agencies

Level 1:	———	≥ 50%
Level 2:	•••••••	= 37.5%
Level 3:	———	= 25%[1]
Level 4:	·····	≤ 25%[2]

[1] Includes all of Group 1 that have been also included as a factor in Group 2, were defined as a minor factor.

[2] Includes Group 1 but have not been included in Group 2, and all other factors that 12.5% in Group 1 and/or only appear in Group 2 were defined as other minor factors.

* Division of responsibility, refers to when both the community and the development agency or govt water department are involved in O & M of the water supply.

** Who is responsible refers to the situation when the community owns the water supply, but the responsibility for O & M and management of the water supply is handled by a group within the community, a private individual and/or the agency.

Stage 2: Design Stage

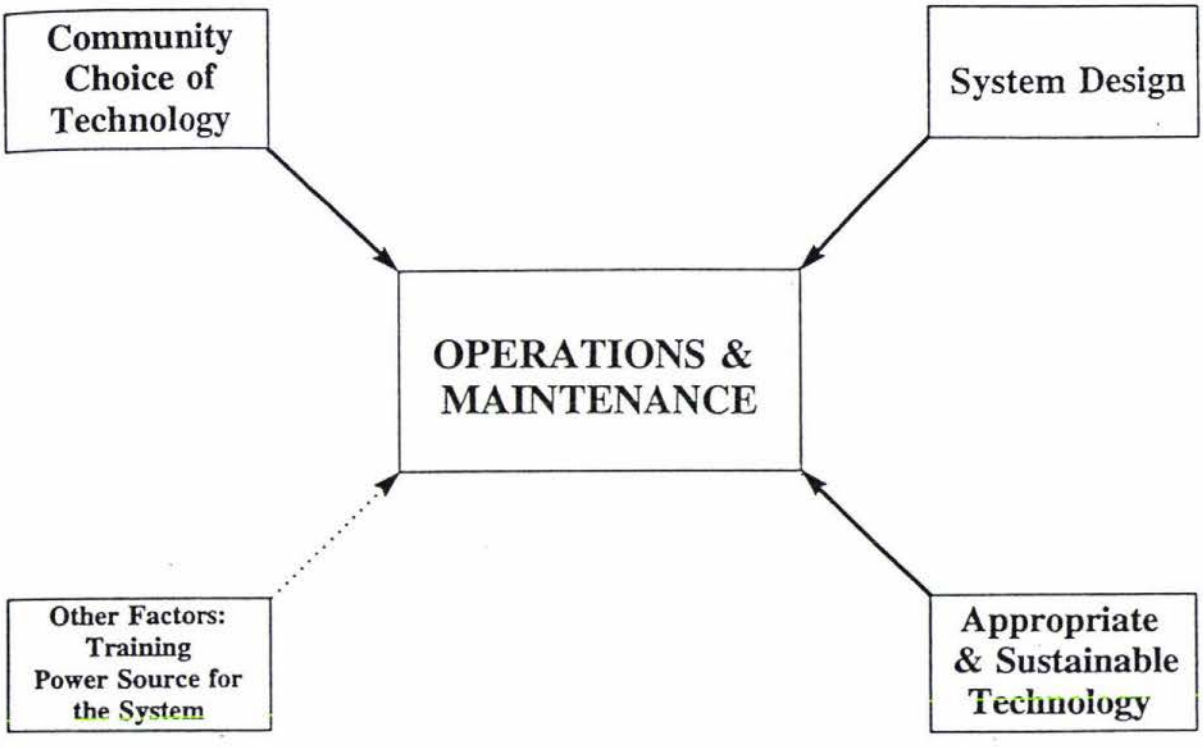

Figure 19 Stage 2 results from development agencies

Stage 3: Construction Stage

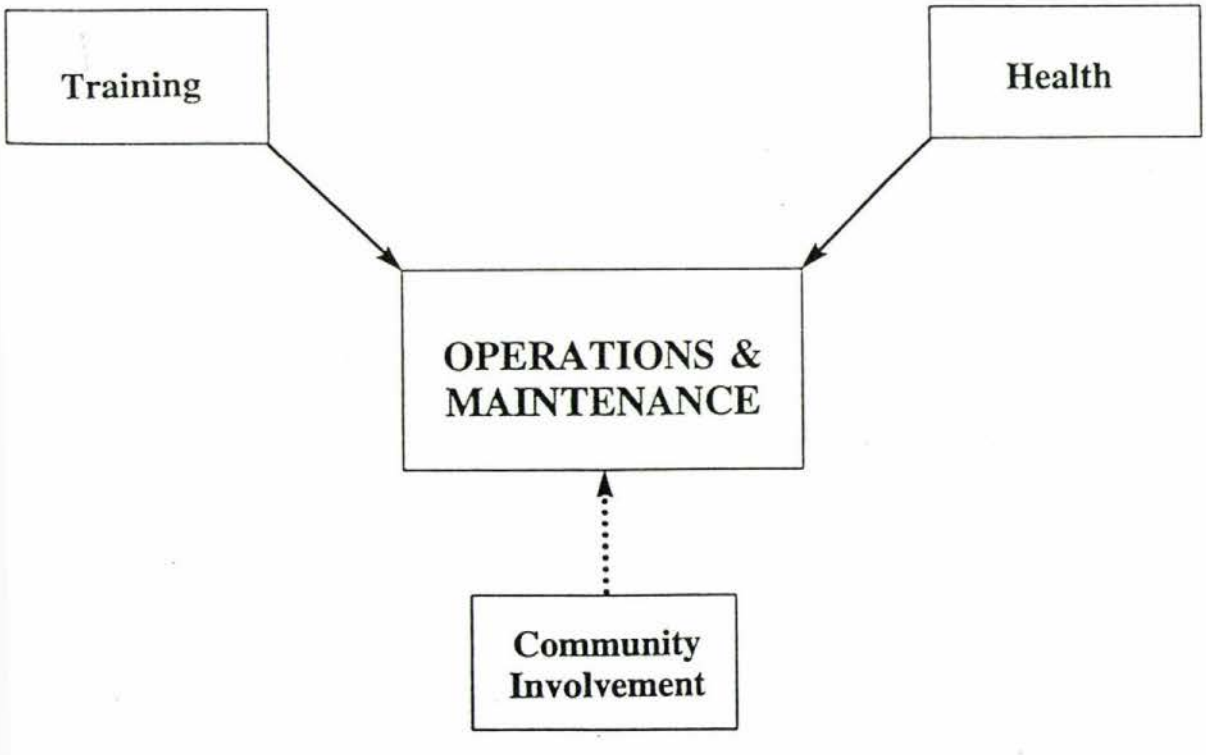

Figure 20 Stage 3 results from development agencies

Stage 4: Transfer Ceremony Stage

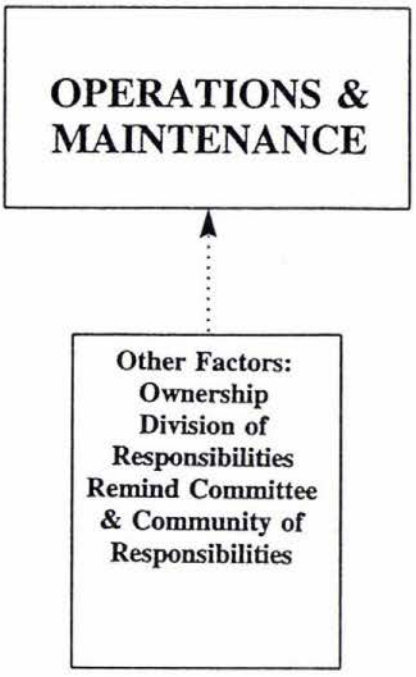

Figure 21 Stage 4 results from development agencies

Stage 5: Operations Stage

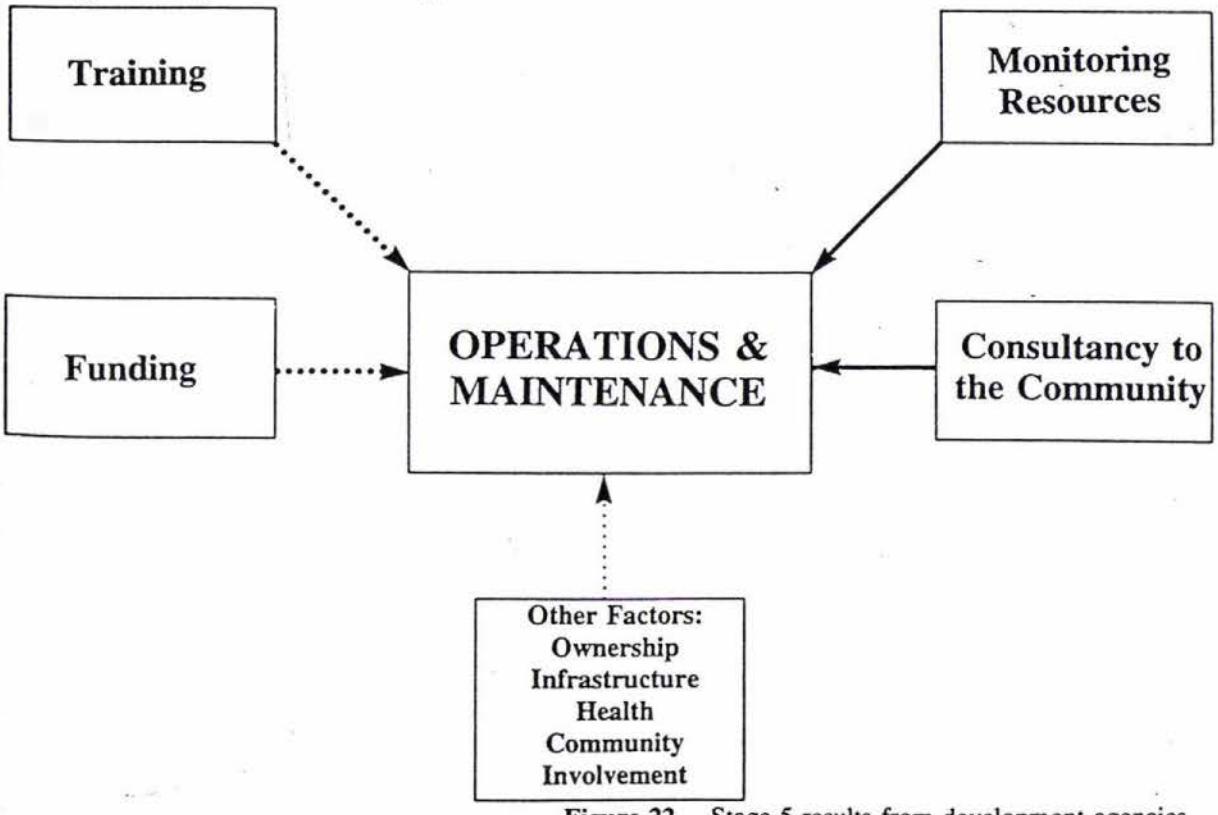

Figure 22 Stage 5 results from development agencies

The factors that the development workers rated as the most important overall for sustainable O & M in order of merit were:

ownership/responsibility

training

felt need

funding

Good communication and discussion between all the parties involved in the project were also seen as essential for the overall sustainability of the project, many of the agencies stated. It was believed, that without this involvement many projects would not be completed, or if completed would not still be operating in the future.

5.4 Discussion

5.4.1 Introduction

In the following discussion of the results from the surveys with the development agencies, the author was seeking to compare these results to the author's model developed from the literature (Chapter 4). Although some factors mentioned by the development agencies were similar, do they correspond in significance and in meaning at each stage to that of the model? To answer this question the similarities and differences of the information obtained when compared to the model were discussed separately for each stage.

5.4.2 Stage 1: Planning Stage

The model presented many factors at the planning stage, which were as follows: discussion between the community and the agency on the following subjects, ownership, division of O & M responsibility, funding for O & M, and the water committees' role. Also included at this stage was the community's initiative too present to the agency a need for a water supply, along with training of the water committee by the development agency or water department and the infrastructure needed for sustainable O & M.

5.4.2.1 Similarities to the Model

Much of what happens in the planning stage centres around the discussion between the agency and the community about several issues relating to the water supply . Almost all of the agencies (6) said that discussion and good communication with the community were major factors to the overall sustainability of the project. This as the model displays is very

important at Stage 1 of the project, where some major issues affecting the O & M of the water supply were discussed. What then are the similarities to the model?

Community involvement in many areas of the planning stage was seen by five of the agencies as a most important factor. All the agencies considered that community involvement was a necessity at stage one. The first factor presented by the model, was the community taking initiative and approaching the agency with their felt need for a water supply. This was shown to be a major factor in the literature review (Section 2.8.1). Fifty percent of the agencies mentioned it as a factor in the planning stage, with three agencies noting it in their top three factors in stage one.

Ownership was a major discussion issue in the model and in the literature (Sections 2.7.4.1 and 2.8.6). It was rated the most important factor in the planning stage by the development agencies, with 75% ranking it among the top three factors. The discussion of ownership was an important factor brought out by the development agencies. The agencies that ranked it in their top three factors made comments such as:

> `It is the key issue in the long term sustainability of the project, which the community owns the water supply, instead of the agency, especially in the terms of O & M responsibility.'

or, `Ownership is essential to O & M by the community.'

Another major issue in the planning stage was the discussion directly related to who would be responsible for the O & M of the water supply. The model proposed that this be an important factor at this stage. Half the development agencies ranked this as one of their top three factors at the planning stage. In the model presented, this discussion was to involve the most likely water supply system scenario for the community (the type of water system for the community may have been discussed, although it comes under stage two in the model). Besides this, the question was asked, who would be responsible for O & M? Either the community or the agency could be fully responsible, or joint responsibility between the agency and the community is possible for the O & M of the water supply. Almost all the agencies (75%) wanted to make it clear at this stage who would be responsible for the O & M of the water supply. Five of the agencies said that at this stage it was necessary to make it clear that the community would be totally responsible for the

O & M of the water supply. The other agencies took responsibility for almost all the maintenance of their systems. In this situation the community was responsible for operating the system, usually by providing a caretaker.

The provision of funds for O & M is another area of discussion at the planning stage according to the model. In the data from the agencies all of them believed that discussion of funding should happen in the planning stage. Two of the agencies believed it to be a major factor. In the model, the need for discussion about how much of the O & M costs the community would be expecting to provide, is part of the planning stages discussion between the agency and the community. Five of the agencies expected the community to pay all the O & M costs. One agency expected the community to pay all the running costs and part of the costs of new parts. Another agency set a biannual fee that the community was expected to pay towards O & M costs. The final agency subsidised the cost of running the system, but charged the users a set fee for every bucket (this fee was approximately 1/16 of the actual O & M fund needed).

The model postulated that community involvement in the selection of a water committee was an important factor in the sustainability of the project if the community was going to be responsible for O & M. Only one agency said that the community should be involved in selecting the water committee at this stage (this was the only agency even to talk about the selection of the water committee by the community). Seventy-five percent of the agencies noted that there was a water committee with which they dealt at the different stages of the project. One agency noted that there was a government directive that all communities should set up a water committee. This agency continued that although they encouraged the community to have a water committee (they said they did not force it upon the community), they had found from their experience that 50% of their water projects had no water committee and that 50% of these projects failed. Thus, the importance of a water committee to the sustainability of the O & M of the water supply may be a major factor.

5.4.2.2 Differences to the Model

The factors included in stage one from the development agencies that were different to those in the model were: Training, the committee's role, who is responsible for management and O & M, infrastructure and health.

Training of the water committee was seen as a lessor priority at the planning stage by the development agencies than the model perceived it to be. Only two of the agencies actually started training of the water committee in Stage 1 although these two agencies ranked it within their top three factors. Training became a more important factor in the following two stages of the water project for the agency's. The model and the literature deemed the training of the water committee as a most important factor in sustainable O & M (Section 2.10.3.2). This was not reflected in the responses to the most important factors overall to sustainable O & M, as only 25% of the organizations included training.

From the information given by the agencies, there was little discussion about the role of the water committee, which the model considered to be an important factor in the management of O & M.

A major difference between the model and the data collected was the importance of infrastructure. In the model infrastructure was an important factor to the sustainability of O & M, and was a particularly important consideration by both the development agency and the government water department. From the development workers data, it was only a minor factor in the planning stage with only two agencies noting it as a factor in this stage. Some reasons for this were that most of the development agencies had set up their own infrastructure to provide parts and communication of O & M problems. Imported parts for the water supply systems were brought in duty free by the development agencies. Many of these agencies had, under the former regime, handed over all O & M responsibility to the government water department, which had failed as far as they where concerned. One agency which was talked to, but not involved in the survey, noted that from 1986 75% of the water projects handed over to the government water agency had failed. The hands-on approach by the agencies was reflected in their lack of thought about what would happen to their infrastructural system if this situation recurred. Only one agency interviewed was concerned about this factor, mainly because it was being pulled out of all water work in Ethiopia by its Government. This agency was handing all of it's water projects over to the government agency it had been working in partnership with. They were particularly concerned about whether the foreign exchange needed to import parts for the maintenance of several thousand water systems was going to be available. Another agency was also concerned about the need for foreign exchange to

provide parts. This agency would have preferred to buy locally produced water systems, but the local manufacture of handpumps had proved to be unreliable. It was stated, most of the locally produced handpumps had broken in the first week of use.

Four of the development workers also noted that the need for a clear understanding of who was responsible for O & M of the water supply in the planning stage was important. This often needed clarification, they said. The following scenario is an example: when the community owns the water supply, but the responsibility for maintenance and management was handled by a group or individual within the community, for example a private contractor or a water committee. These development groups considered that this was an important factor in the planning stage especially for the community, to know the situation of who is responsible for maintaining and managing the water supply. The agencies also suggested that the person/s who were to maintain the system were to be found at this stage. One agency in particular stressed that its preferred maintenance personnel were private contractors.

One development agency's emphasis in the planning stage was on the issue of health, and how the water supply would benefit the community. The development worker said that if the community took hold of the health issue they would be more willing to keep the water supply in good order. Health was not seen as an important factor for the model although it is included in the training of the water committee.

5.4.3 Stage 2: Design Stage

In the model's design stage the community comes face to face with the technology that will deliver their water. Factors needed in this stage are related to the technology: the communities choice of the technology to suit their particular needs, appropriate & sustainable technology, the design of the system and the training of those who will manage the system. What similarities and differences existed between the information from the development workers and the model?

5.4.3.1 Similarities to the Model

The design of the water system was a combination of the community, water committee and the agency input within the model. From the data given by the development workers, 50%

of the agencies presented to the communities a list of possible water supply systems that were available, and could be used in their situation. Two agencies said that the system chosen was based upon what the community could afford. One agency said that the choice of technology was dependent upon the type of system that could be used: if handpumps for example, they were given an option of different types. In the cases where a pipeline was involved the agency provided and made the decision about the design of the pipeline. In one case the agency decided the design of the water supply, with little input from the community. Two of the agencies were only involved in urban systems: design was their responsibility in conjunction with the local water authority who approved the water point.

Discussion about the placement of the water supply was not mentioned by 75% of the agencies. They may have assumed that discussion with the community and the water committee would cover this issue. The need for discussion is important for avoiding major O & M problems like wells being placed on top of hills or cultural factors such as putting a water point in a burial ground etc.

The choice of appropriate technology as a major factor in the sustainability of the water supply was mentioned in 50% of the replies by the development workers. Appropriate technology as defined in Section 2.9 is not necessarily a traditional technology, but rather a technology that fits the situation both technically and culturally. All of the agencies said they used AT when it was a viable option for the delivery of water. One agency stressed that the AT chosen should be dependent upon the skills available within the community, who could be contracted to maintain the system. This agency continued to say that in their experience, when advanced technology was used it was often easier to obtain money from the community.

5.4.3.2 Differences to the Model

There is only one main difference between information from the development agencies in comparison to the model: the training of the water committee. In the model the training of the water committee continues to be a high priority during this stage. From the information collected only two agencies where involved in the training of the water committee. The reasons for this may be that a greater emphasis by the development agencies is put on training at the construction stage (Stage 3). This is where most of the

agencies were involved in the training of the water committee along with the training of maintenance personnel and caretakers. Another reason is that it is only a short stage, and the design of the water supply system after discussion with the community and the water committee is usually done by the agency.

5.4.4 Stage 3: Construction Stage

The model suggested that there are three major components at the construction stage that affect the sustainable O & M of the water supply. These factors are, training of local maintenance personnel and caretakers, the continual training and completion of the training of the water committee and the community participating in the construction of the water supply. What are the similarities and differences that the development agencies note at this stage?

5.4.4.1 Similarities to the Model

The training of the communities water committee was actioned by six of the agencies at this stage. Five agencies ranked it in their top three factors at this stage. The training of the water committee was in the following areas:

Management and administration (six agencies)
Dealing with funds (six agencies)
Health (five agencies)

The training of local caretakers and maintenance personnel was commented on by five agencies. Two agencies said they trained technicians, all five agencies stated that they trained caretakers.

5.4.4.2 Differences to the Model

There are several differences to the model from the data from development agencies. They are as follows: the issue of health, community participation in the construction, selection of community technicians and caretakers.

Health was stressed by five agencies as an important factor in the construction stage. The focus by all these agencies' was the need for good health, and the importance of the new water supply in promoting this. One agency sent a health worker along with the construction team to educate the community about health issues in relation to the water

supply. The other agencies did not comment on who passed on this health information to the community. Health, as previously mentioned by one agency, was important to O & M, as it gave the community a good reason to have a good reliable, safe water supply[1]. Another agency was involved in training community health workers that were responsible to the water committee.

Community participation in the construction stage, according to the model, is part of encouraging the community to take ownership of the water supply. Ownership of the supply is an important factor in O & M of the water supply. Only three of the agencies discussed community involvement at this construction stage directly, with the community being involved in helping through labour, mainly to reduce costs for the community. In one case the community was expected to provide labour as an indication of their commitment to the project. One agency used the construction phase as a way to encourage skills in the community, to benefit the community and to help in the O & M of the water supply.

The selection of the caretakers and the maintenance personnel was not discussed by most of the development agencies. One agency selected the choice of technology for a community based upon the skills available within the community, ie if there was an electrician then possibly the community would be offered the option of an electrical pumped system. In the model these people are selected by the water committee from people within the community with some technical skills or potential.

5.4.5 Stage 4: Transfer Ceremony Stage

The transfer ceremony stage in the model is the stage where the ownership and responsibility for the water supply project moves from the agency to the community. It is also seen a time for celebration for the completion of this important community resource [Yacoob *et al.*, 1987]. Did the development agencies have a transfer ceremony?

5.4.5.1 Differences to the Model

Only two agencies discussed a transfer ceremony. The group/s who would be responsible for O & M of the water supply and the community's ownership for the water supply was

[1] Safe in this context means that the water was clear of any disease causing pathogens.

reiterated to all those present at the ceremony. One of these also reminded the community and the water committee of their responsibility to use the water supply properly. As the development agencies were not directly asked about any transfer ceremony, this may have influenced the data. Another reason was possibly that the agencies had not considered that a transfer ceremony was important for the community to take ownership of the water supply and the responsibility for the O & M of the water supply as it had been clearly spelt out in the planning stage.

5.4.6 Stage 5: Operation Stage

The model presented a large number of factors that need to be considered and actioned in the operations stage of a water supply project. These factors were the actual working out of the O & M of the water supply. Factors in this stage in the model included the following: Community rules on use of water supply, the water committee overseeing the maintenance personnel, parts, O & M, monitoring of the resource, and contacting the agency when parts or technical assistance is needed. The water department is responsible for the infrastructure needed to provide parts and technical assistance and ongoing training of O & M personnel. The water department is also involved in monitoring and consulting the water committee. The development agency was involved in evaluating the project. What are the factors that are similar to and different from the development agencies information and the model?

5.4.6.1 Similarities to the Model

In the model the water department took over many of the responsibilities for the ongoing relationship between the community and an outside agency. The discussions with the development agencies revealed many of them were heavily involved in this stage, although some handed over the responsibility to the water department. Because of this, if the agency was performing a similar role to the water department at this stage it has been classed as similar to the model.

Fifty percent of the agencies were involved in providing advice to the community water committees. This advice covered the following areas:

Technical problems (two agencies)
Bookkeeping and administration (three agencies)
Resource management (one agency)

Three of the other four agencies were also involved in providing advice, but not to water committees. One group was involved in consulting to the government water department, another was a consultant directly to the users, because the scheme was based upon private individual users. The final agency was a consultant only to the local church group whom it operated through.

Half the agencies noted that the monitoring of the resource was an important factor at this stage. One agency was directly involved in the monitoring of the resource, while two agencies had handed it over to the Government water department, whose responsibility it was under their contract. The other agency had handed over the monitoring of the resource entirely to the community.

Continual training of the water committee and O & M personnel was expressed by three of the agency's. Two of these three agencies noted that training was a most important factor overall for the sustainable O & M of the water supply. These agencies did not say on what basis they continued training.

Funding for O & M was seen as an important factor by three agencies in the operations stage. One agency, as previously mentioned, noted that the community needed to provide a set sum (500 Birr approximately $US100) twice a year for maintenance of the supply. The other two agencies that mentioned funding for O & M at this stage were also involved in providing the bulk of the O & M for the communities they serviced water supplies.

5.4.6.2 Differences to the Model

There was no comment on the role of the water committee at this stage of the model, in relation to its responsibilities for the O & M of the water supply. This could be because their role had been discussed earlier with the agency. Secondly, there was no questions asked of the development agencies in the terms of what the water committee's role would be, because of the participatory approach adopted. Although it must be said that 75% of the agencies expected the communities to be totally responsible for the O & M of the water supply or at least responsible for the day to day running and maintenance. Two agencies monitored the role of the water committee, with one specifically saying that the bookkeeping was the main area that they monitored.

The infrastructure needed for the provision of parts, technical help etc. was discussed by only two agencies. Both agencies had handed over this responsibility to another party, either the government water department or a local NGO. One of these agencies noted that they provided the basic parts for the system to the community that would keep the system operating for two years. Five of the other agencies commented that if the local community had real problems with parts and technical problems they would try to help.

Other areas that the development agencies commented on that were different to the model at this stage were: health, community involvement and ownership. The issue of health was noted to be an important factor at this stage by one agency. This agency said that the health information needed to be continued into the operating stage, so that people would understand the importance of the water supply for their good health. They did not say who was to provide this input. In the model the water committee would be involved in providing health information into the community.

The community should be involved heavily in the O & M of the water supply at this stage, even when other people within or outside the community are responsible for it, stated one agency. In the model this is reflected when the community, by using the water supply correctly, inform the local water committee or maintenance personnel when there is a problem. The other agencies lack of comments can only be surmised on, but possibly the expectations of community ownership and a water committee being responsible for O & M that this would happen.

Two of the agencies brought up the issue of ownership as a factor in the operations stage. This was not discussed in any further detail. The ownership of the water supply was seen as a most important factor to the overall sustainability of the water project by these two agencies.

5.4.7 Overall Factors for Sustainable O & M

The overall factors provided by the development agencies, as essential to the sustainable O & M of water supplies, were similar to those presented by the model. The model presents that the most important factors were: Ownership, community involvement, training of the water committee and O & M personnel, knowledge of O & M responsibilities, funds

for O & M, and, the need for a strong infrastructure. The agencies noted three of the factors from the above list as important to the sustainable O & M of water supplies: ownership, training and funds. The differences were the following: "felt need", knowledge of O & M responsibilities, responsibility when not the communities, community involvement, and a strong infrastructure.

"Felt need" was presented by two agencies as an important factor to sustainable O & M, because they believed that if the community was prepared to go to some lengths to get a water supply project, they would be prepared to go to similar lengths to keep in working order.

The knowledge of who is responsible for O & M by both the water committee and the agency was considered as very important by the model, but it was not considered so by the agencies. The model believed that clear knowledge of who was responsible for what maintenance responsibilities would provide for a system of maintenance that worked. If it could be maintained locally, it would be performed and not left for the agency or Government to do. Seventy-five percent of the agencies said that it should be clear in the planning stage who would be responsible for different O & M tasks. The model therefore is assumed to be incorrect in presenting that clear O & M responsibilities are set out as an important factor.

The agencies presented the need to consider the responsibility for the water supply as something different to ownership of the water supply. Fifty percent of the agencies noted that responsibility was an important overall factor to sustainable O & M. They believed this because often responsibility for O & M is not the community, but rather a group or individual inside or outside the community. They believed that the community needed to know who was responsible for maintaining and managing the water supply. The model had not covered this area nor considered it as a major overall factor. But the model does present that in all the stages there is a place for community involvement, and at the transfer stage, a clear presentation of who would be responsible for O & M.

The model presents community involvement as an important factor to sustainable O & M. Although the agencies do not mention this as an overall factor, they all considered that the

community should be involved, and it was a major factor in stage 1 for the agencies. Many of the agencies noted that the community should be involved in most stages of the water supply project, though the level of commitment differed. It could be assumed therefore that the model is correct in presenting community involvement as an important overall factor.

In the model the need for a strong infrastructure is seen as essential to the sustainability of the water supply project. The need for strong infrastructure is as follows: The need for providing parts, training of O & M personnel, foreign exchange for importing parts from overseas if necessary, technical assistance, and the need for a good communication system. Only two agencies in total discussed infrastructure at all. It was not seen as a priority by the agencies as stated in Section 5.4.2.2. This aspect of the model was not supported by the agency's responses, whereas the author's interpretation of the literature meant that infrastructure should be a important factor to sustainable operation and maintenance of water supplies.

5.5 Survey and Discussion of Four Water Supplies

5.5.1 Background to the Communities

The communities chosen for the survey of their knowledge concerning O & M of their water supply system come from the Sidamo Region of Southern Ethiopia. The communities surveyed included the town's Yirga Chaffe and Haru. A rural community called Dokicha, and a handpump on the roadside outside Yirga Chaffe going towards Dilla. These communities were between 400 and 450 km south of Addis Ababa (Figure 23) (Plates 2 to 5).

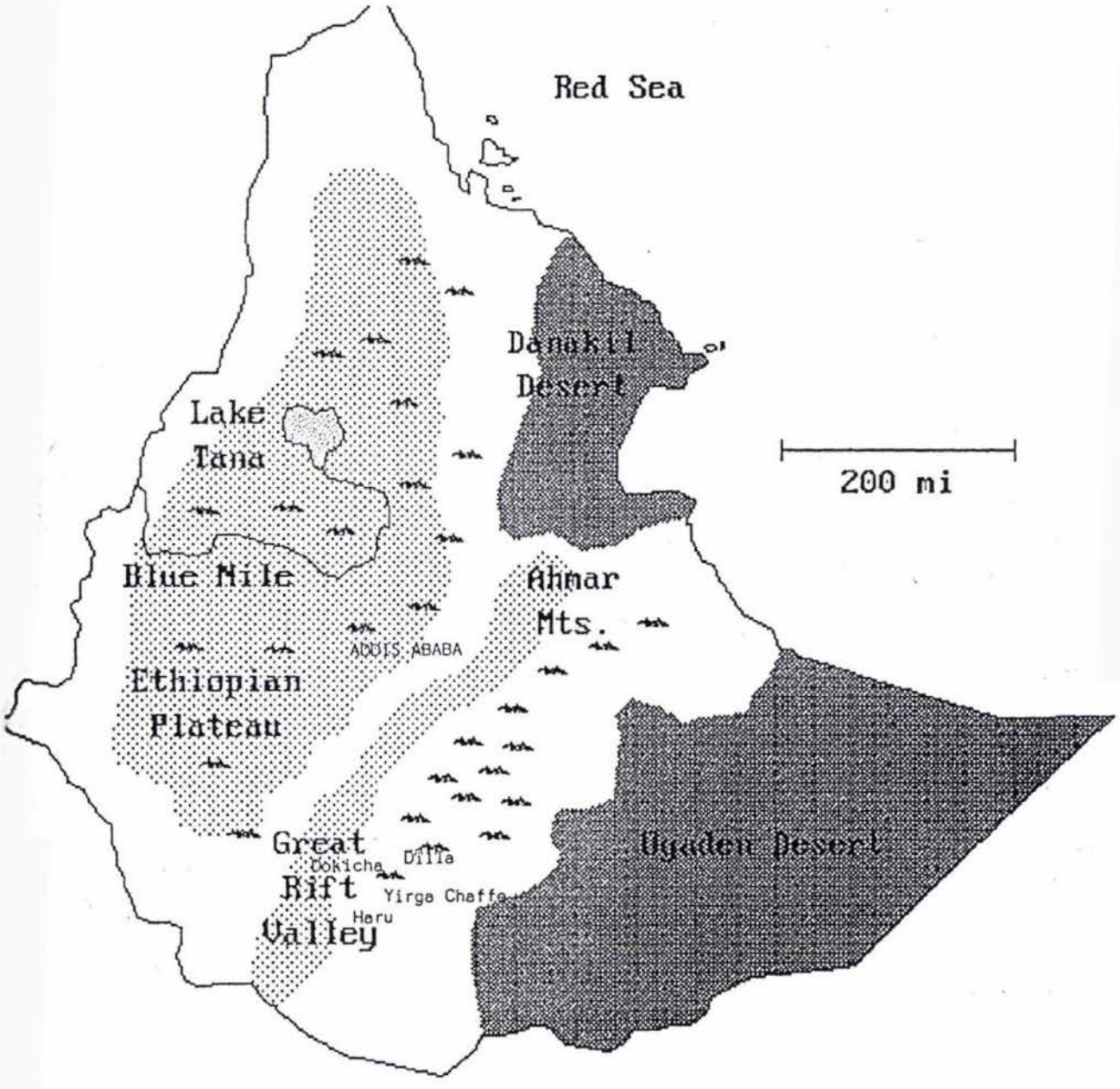

Figure 23 A map of Ethiopia, showing Yirga Chaffe, Haru and Dokicha (Source: PC Globe)

Plate 2 A view of Yirga Chaffe (Source: The author)

Plate 3 A view of Haru (Source: The author)

Plate 4 A view of Dokicha (Source: The author)

Plate 5 A handpump similar to the one the used by those surveyed beside the road outside Yirga Chaffe (Source: The author)

5.5.1.1 Yirga Chaffe

The township of Yirga Chaffe had a population of approximately 12,000 people which where served by a water supply project completed in 1986. It is on the main road south from Addis Ababa. The need for water was brought to the attention of an development agency by the local government administration. At the time people in the community were using as their water sources, either the local river (Plate 6) or shallow hand dug wells (Plate 7) which were between 1.5 and 2 metres deep (because of the very high water table in the area). High levels of pollutants in both sources of water were reported.

The town is surrounded by hills with several large springs that were available to be used as a clean source of water (Plate 8). These springs were capped and 7.5 km of pipe was laid to distribute the water to 17 public water points throughout the township, along with private points for hotels, schools, town hall, etc. A storage tank was used to help feed the gravity system to several points. The cost of the system was approximately 105,000 Birr ($US50,000).

The community's involvement in the water supply included, all the manual labour, fencing and planting seedlings around the distribution points. After the construction of the water supply the responsibility for O & M was handed over to the government water department (WSSA) under the usual contract at the time. WSSA maintenance teams for the southern region was based some 2½ hours drive North of Yirga Chaffe on a tarsealed road. WSSA policy of charging the community for water to pay for the maintenance was not well received by the community, and many went back to their former water sources. Within two years of construction the first water points were inactive (Plate 9). By July 1993, there was only two public points still operating. One of these points was on the edge of one of the major market places in the town. People coming to town to sell their wares would buy water from this point. The other point operating was near the prison and town administrative centre, these users were prepared and able to pay WSSA to use these points. Many private points were still working as they were also prepared to pay WSSA for the water. WSSA dismantled part of the pipe system so even if they were encouraged to repair the system so all the points were operating again it would not be a simple operation.

Mangin [1991] in his article on water supply failure in Southern Ethiopia notes that when

the system did not generate revenue for WSSA, the staff and management had few incentives to operate and maintain the system. He noted that in his study there was not one case of a broken rural water system that had been put back into operation by WSSA.

Plate 6 The river used as a water source in Yirga Chaffe (Source: the author)

Plate 7 Handdug well outside of a home in Yirga Chaffe (Source: The author)

Plate 8 One of the springs used to supply water to Yirga Chaffe (Source: The author)

Plate 9 One of the many inactive water points in Yirga Chaffe (Source: The author)

5.5.1.2 Haru

The township of Haru had approximately 4,000 people who would benefit from its construction in November 1988 when the water supply project was completed. The township of Haru is approximately 30 minutes' drive from Yirga Chaffe on a shingle and mud road. The town leadership approached an development agency with the need for clean water in the community. The water supplies used by the community at the time were a capped spring by a river 700 metres down a steep hill from the township which supplied dirty water during the rainy season. Most of the community though used the river for their water source, which became undrinkable during the coffee season due to washing of the coffee.

The agency designed a gravity fed system from a large spring 2.5 km away from the town (Plate 10). The system included a large storage tank, and nine public distribution points, with one private point for the health clinic. The community was to supply most of the manual labour, of which they eventually only contributed 50%, they helped select the distribution points and fenced those points off.

The water engineer found out after the system was installed that the community did not believe that the system would work. This scepticism arose due to a ridge being between the spring and the town, because how could water travel uphill? Because of this the majority of the people did not help build the system. On completion of the system the agency did not hand over the O & M to WSSA as was the usual practice, but kept it as their responsibility.

In July 1993, all the points were still working, but not as originally designed, only one point still had a tap handle. The water was turned off at the storage tank, and was only operating twice daily where the original design was for the system to be operating continuously. Maintenance problems observed included, no taps (Plate 11), distribution pipes exposed to traffic (Plate 12), and leaking pipes and valves (Plate 13). Six weeks before the survey was undertaken, the community had no water for four weeks due to roots in the spring blocking the pipe (Plate 14). The agency was not told of this problem until the town supply had not been working for three weeks. The lack of communication and the lack of responsibility by the community leadership may be the reason for these these types of maintenance problems. Although there are several problems the system is continuing to supply the community with clean water.

Plate 10 Part of the spring that supplies Haru (Source: The author)

Plate 11 No handles on the taps, note the barbed wire around the tap (Source: The author)

Plate 12 Pipes have become exposed to vehicle and pedistrian traffic (Source: The author)

Plate 13 A leaking valve, one of the areas of maintenance needed at Haru (Source: The author)

Plate 14 A spring blocked by roots from vegetation (Source: The author)

5.5.1.3 Dokicha

Dokicha is a small rural village with approximately 20 households. This community was approximately 2½ hours from a tarsealed road by four wheeled drive vehicle. The need for a water system in this community was because the spring (Plate 15) that currently provided water to the community was approximately 1 km from the main grouping of houses. Additional impetus came from the fact that there was a major market held there and the large number of people coming from the surrounding areas needed water.

The need was passed onto an development agency by the leaders of the local church. This system was in the process of being constructed when the author was visiting the area during July 1993. The system was a gravity feed system with two distribution points. This community was helping dig the trenches (Plate 16), lay the pipe, and paid 25% of the cost towards putting in an optional storage tank. The leadership of the community also set up a water committee of seven people after a suggestion from the agency, four men and three women. These people would be trained by a member of the water team of the development agency, particularly the women members (the trainer was a woman from the same tribal group). The community was to be encouraged to maintain the entire system themselves because of the isolation of the community. Also because this tribal group still killed people from other tribes, including foreigners.

Plate 15 The spring at Dokicha surrounded by bush (Source: The author)

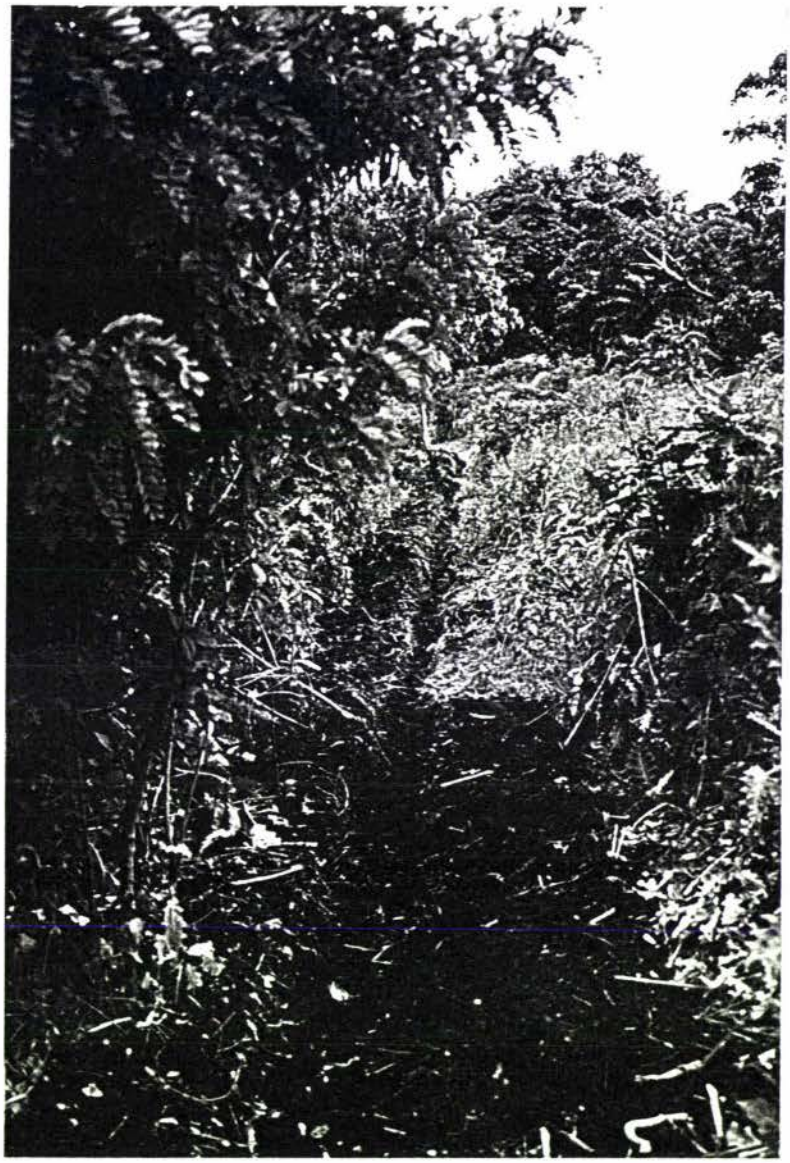

Plate 16 Trenches being dug for pipes to be laid in at Dokicha (Source: The author)

5.5.1.4 The Handpump

The handpump was one of several thousand in the southern region, WSSA estimates that it is responsible for at least 4,000 handpumps in this region (Plate 5). This handpump chosen was on the main road between the township of Yirga Chaffe and the larger town of Dilla. It was close to other water sources, including a river, and approximately 5 other handpumps were within 1 km of this site. The handpump was put in by a development agency, in the past six to seven years. This agency still maintains the handpump, with the users usually contacting the agency within hours of it breaking down. There was no one responsible for operating, running or keeping the handpump clean.

5.6 Survey Results

Surveys were prepared for the four different water supplies systems to find out what the users knew about their water supply and how it was looked after (the surveys are in Appendices 16 to 19). Although each survey was different, some questions were relevant across all of the systems. One hundred and fifty people in total were surveyed that used the four systems. 101 people from Yirga Chaffe (68%), 28 people from Haru (19%), 10 from Dokicha (6%) and 11 from the handpump (7%).

Nine areas that were relevant to the development and the discussion of the worth of the model have been selected from the surveys. These nine areas were collated from the questions asked to the four water supplies.

Area 1. *Who owns the water supply?*

The Community	132 (88%)
The School	2 (1%)
The Development Agency	5 (3%)
The Water Authority (WSSA)	6 (4%)
The Government	3 (2%)
Other	2 (1%)

Area 2. *Is the water point working?*

Yes		56 (37%)
No		94 (63%)
	Period Not Functioning	
	≤ 2 months'	3 (3%)
	≤ 6 months'	7 (7%)
	≤ 1 year	2 (2%)
	≤ 1.5 years'	8 (9%)
	≤ 2 years'	19 (20%)
	≤ 2.5 years'	16 (17%)
	≤ 3 years'	18 (19%)
	> 3 years'	17 (18%)
	Don't know	4 (4%)

Area 3. *Is there a manager, overseer or water committee for the water points?*

Yes	27 (18%)
No	120 (80%)
Don't Know	3 (2%)

Area 4. *Do you or did you pay for water from the water point?*
(This question was not asked of the people in Dokicha.)

Yes	51 (38%)
No	82 (62%)
Total answers	133

Area 5. *Would you pay to keep the water point in good working order?*
(This question was not asked of the people using the handpump or in Dokicha.)

Yes	109 (85%)
No	5 (4%)
Don't know	14 (11%)
Total answers	128

Area 6. *Were you involved in the construction of the water supply?*
(Not asked directly of the community at Dokicha, but some said they were involved in the construction process)

Yes		115 (86%)
No		18 (14%)
Total answers		133
Reason for being involved in construction		
	To use it	38 (33%)
	Directed by Leaders	31 (27%)
	No reason	46 (40%)

Area 7. *What is needed to keep the water point working?*

Fence		134 (89%)
Guard		134 (89%)
Overseer		81 (54%)
Other		43 (29%)
	Other factors brought out by survey	
	A lock	20 (47%)
	Funds	6 (14%)
	Money collector	6 (14%)
	Community watch/guard point	5 (11%)
	Responsible person/operator	3 (6%)
	Water committee	2 (4%)
	Responsible organization	2 (4%)

Area 8. *Is there anyone to tell if the system is not working?*

Yes	42 (28%)
No	104 (70%)
Don't know	3 (2%)

Area 9. *Is there anyone responsible for O & M?*

Yes	35 (23%)
No	111 (74%)
Don't know	4 (3%)

5.7 Discussion of Results

5.7.1 Ownership

The question of who owned the water supply, shows that across all the different systems approximately 90% of those asked believed that the community was the owner of the water supply system. Almost all of the other answers given by the respondents received water from water points that were often part of the public systems, but were often in places such

as the school, army HQ's, etc. The ownership question is an important factor in the model and the literature for sustainable O & M (Sections 2.7.4.2, 2.8.6 and 4.4.1). Although it was commented to the author by an development worker, community ownership of the water supplies in the region was a usual response from the community. The ownership of a large public asset like a water supply, was often believed to be owned by the whole community. But when it came to responsibility for the water supply, this was not seen as the communities responsibility. The responsibility should be someone else, either the kebele, WSSA or the development agency, the development worker stated about the communities view. The view of ownership within the model assumes that the community takes some responsibility for the care and O & M of the water supply, although the overall responsibilities will be the water committees, who work for the community. Responsibility for O & M will be discussed in further detail under the following areas.

5.7.2 Is the Waterpoint Operating?

The survey across the four water supplies showed that of the possible number of 29 water points that could be working, only 13 were working at the time of the survey. Of those not working details from the respondents showed that for 74% of them believed that the water points had been out of action for two years or more. All the respondents who noted a period for the water point being broken were from the township of Yirga Chaffe. The respondents that said, I do not know how long the water supply was out of action, were all from Haru. This response was more from hearsay within the community that one of the points was out of action, because all of the points were operating at the time of the survey and had been operating for some time previously. This question in relation to the model, shows that within two years of the water supply being constructed in Yirga Chaffe that parts of the system were not working. Questions of why and how can the model reduce or lessen this failure rate of a simple gravity feed system? Why had the system broken down in Yirga Chaffe? The major reasons, were seen as the community not being prepared to pay for the use of the system, especially since it was easy to go back to former sources of water. This community was not surveyed and included in the initial planning for and discussions about the water supply, was it a "felt need" for the community etc. Community involvement was minimal, with people being encouraged to provide labour for the construction of the system (discussed in more detail in a following area). There was no health information to tell the community about the poor quality and health hazards of

the handdug wells and streams[2]. The model and the literature show that in the planning stages the community needs to be involved in all of these factors needed to avoid and alleviate these problems that faced the water supply at Yirga Chaffe.

5.7.3 Is There an Overseer, Manager or Water Committee?

The model and the literature tender the position that management of the water supply by a committee, group or an individual is essential to the overall sustainability of water supplies (cf Sections 2.7 and 4.4). From the surveys there was only one community that had a water committee, Dokicha. All of the other positive responses came from people surveyed in Yirga Chaffe. Most of these respondents said that WSSA oversaw the water points in the town when it was working, a small number said that it was managed by the kebele. Of the respondents 80% said that there was nobody who was responsible for managing and looking after the water system. The fact that there was only one water committee for the four systems, reflects the lack of community input that is essential to the sustainability of the systems. The model presents that the water committee needs to be trained to manage the water system, to oversee the correct use of the water system, to make sure it is maintained and to organize the provision of enough funds (see the following areas on payment for use) to keep the system operational. If the system breaks down as in Haru, there is no-one to tell, because there is no management structure (ie. no one responsible). Eventually four weeks after the town had no water the development agency was contacted to fix the supply (a simple operation of removing roots from the spring). Another problem that the lack of a management structure included here, is that the agency expected some payment towards costs of fixing the supply. Because there was no management structure in place and no payments by the community for the use of the system, there was no funds too pay the small charge. An overall management structure and responsibility are needed in any community; the model uses a water committee to do this. The committee in the model is who the community reports to when there is a problem with the water supply and takes full responsibility to make sure the supply is being maintained and operated correctly. This models the western approach of rural and town councils who manage and operate and maintain the water supply for the community.

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[2] The information on the pre-construction period was sourced from the development agency who developed the project.

5.7.4 Payment for the Water Used

The payment for the use of the water supply, is a method that can be used to fund the O & M of the water supply. Although the question was asked of the people in Yirga Chaffe, Haru and the users of the handpump, only the people in Yirga Chaffe had ever been asked to pay to get water from the system. So of the 101 people surveyed in Yirga Chaffe, 51% had paid when the system was operating. In the model payment for the use of the water supply shows that the community has taken on some responsibility for O & M. This does not appear to be the case in Yirga Chaffe, some commented that the cost was too much (approximately 10 Ethiopian cents for three buckets). Others commented that some got the water free and others had to pay. The community had not expected to pay for the use of the water supply when it was built, so they refused to pay and went back to their old water sources. This reveals a lack of consultation with the community by the development agency and WSSA during the planning stages. In the model the community and the water committee need to know the costs that are to be their responsibility for the running of the water supply right at the beginning of the water supply project, in the planning stages. Also, how they are going to raise these funds to pay for these costs?

5.7.5 Would You Pay to Keep the Water Supply Working?

This question reflects the value that the users have in the water point. The survey showed that in both Yirga Chaffe and Haru 85% of the users would be prepared to pay some fee towards keeping the water point in good order. This result was surprising because only five of those asked said no, to any payment for keeping the water supply working in good order. Results from the surveys show that these two communities saw that having a water supply in good working order was a benefit to their lives, and that a small payment was necessary to achieve it. The surveys show that the communities were happy to pay something for a reliable and good water source, but this does not necessarily equate to the taking on the ownership and responsibility for the water supply as the model presented.

5.7.6 Were You Involved in the Construction of the Water Supply?

The question was asked to find out the involvement of the community in all the stages up to and including construction of the supply. From the data gathered 86% of those who were asked this question were involved in the construction process. Information from the development agency involved the construction of these systems, said that there was little

community involvement from Haru due to factors discussed in Section 5.5.1.2. It is probable that those that said yes to this question (particularly the don't knows) were not involved but saw members of their community involved. There are two reasons for being involved, the people wanted to use it, or the village leadership directed them to be involved. Other involvement by the communities in the stages up to construction, included both the communities of Haru and Dokicha selecting the sites where the water points should be. No other involvement from members of the community was sort apart from these. The model recommends that the community be involved in selecting a water committee, to represent them and to manage the water supply system for the community. The community needs to be asked what type of water supply they want (what type of technology). This was shown by the lack of interest by the community in Haru, with the gravity feed system, because they believed it could not deliver water to the town, although the need for water was there. This lack of interest changed after the system was seen operating. The fears of the community about the system design, the type of system, how it would be maintained was never discussed with the community. Many problems experienced during the construction at Haru could have been alleviated by discussion with the community/users. The belief that the community being involved in construction would therefore take on responsibility and ownership for the water supply, was shown to be incorrect by this question. Community involvement in other areas before the construction phase, is necessary to water supply sustainability and community responsibility.

5.7.7 What is Needed to Keep the Water Supply Working?

This question was aimed at finding out the areas that the users of the four systems thought were important to the O & M of the water supply and comparing it to what was important in the model. The two areas that featured the highest, from the surveys and from across all the different systems was the need for a guard and a fence, 89% of the people believed that these were essential to keeping the water supply in good working area. Neither of these areas was included in the model. Security of the waterpoint appears a major priority looking at all the areas mentioned, with 134 people mentioning the need for a fence and a guard, 20 people mentioning the need for a lock, and another five people expected the community to be responsible for guarding the water point. The security need for the supply is shown by the missing taps that both the Haru and Yirga Chaffe systems experienced. Another area that the surveys brought up was the need for an overseer, with

81 (54%) of people believing that this was a necessity for a good working water supply. Another two people noted the need for a water committee and a further five people said there was a need for a responsible person or operator. The model presented the water committee as the responsible person/s to oversee the water supply, the surveys show that over 50% of the users believe that there is a need for someone responsible for making sure the water supply is maintained and managed. The model also presents the need for someone to be responsible for operating the system. The need for funds and the collection of these funds was mentioned by only six people each. Thus the priority of money to keep the system in good working order, was not seen as very high, although the question about paying for keeping the water point in good working order showed that 85% of the respondents would be prepared to pay. Only two people noted that a responsible organization was needed to keep the water point in good working order. The model presents the need for a strong responsible organization is required to provide the necessary infrastructure for parts, training and support to the community to operate and maintain their water supply.

5.7.8 Is There a Contact Person When the System Breaks Down?

This question was to find out the maintenance structure available to the users when there were problems with the water supply. Twenty-eight percent of those surveyed noted that there was someone to tell when there was a problem, all of the people that used the handpump and were surveyed at Dokicha knew that there was someone to tell. Most of the people said that there was nobody to tell when the system broke down. In the model, the community is informed who to tell at the ownership transfer ceremony as well as through the selection of water committee members. The surveys show also that there was little input into the community in the terms of involving the community in discussion about the system. Although in the case of Dokicha the community being smaller, many knew who to tell if the system broke down. This information was more from communication among the users, than from discussion with the community members in the planning stages.

5.7.9 Is There Anyone Responsible for O & M?

Responsibility for O & M was another question aimed at finding out the local structure for maintenance. Of the 35 people (23%) who said that there was somebody responsible for

operation and maintenance, all of these people pointed to either the development agency of WSSA as the people responsible for this. This would appear to show that there was no local responsibility for O & M for any of the four water supplies. In the model the community supplies local people to be trained in maintaining and operating the water supply, these people may already have many of the skills needed. This dependence on outside organizations for O & M means situations such as occurred at Haru can occur regularly, whereas if there was local personnel for maintenance the system may have only been out of action for a day or two.

CHAPTER 6

CONCLUSIONS AND MODEL REVISION

6.1 Introduction

The object of the surveys was to discover the most important factors needed for O & M of water supplies so that the model could be validated and/or corrected. Because there were different types of surveys for the development agencies and the communities, they were considered separately, then a general conclusion was made. From these conclusions revisions to the model were made. It must be noted that the conclusions are based on the information from the agencies and communities in Ethiopia thus cultural, environmental and political factors will have influenced the information given. Therefore, the conclusions may have to be adapted if they are to be applied to other cultural settings and political climates. New factors that the surveys brought out will are also discussed.

6.2 Conclusions from the Survey of the Development Agencies

From the results and discussion of the survey of the development agencies the following conclusions were drawn:

6.2.1 Community Involvement in All Stages of the Water Supply Project is Essential

This involvement, needs to be fostered right from the beginning of the project, with the community expressing its need for a water supply through to the community being committed to supplying funds and labour for the O & M of the water supply.

6.2.2 It is Important to Appreciate the Difference Between Ownership and Responsibility

It is often assumed that ownership would also equate with responsibility for O & M; several agencies believed that the issue of responsibility for O & M was separate. They suggested that a group or an individual should assume the responsibility for effective O & M to occur in the community. This in effect means that although the community may be the owners of the water supply, their only responsibility for O & M is proper use of the water supply and informing the individual or group responsible when problems occur. It can be concluded then that there is a move away from community responsibility for water projects, to a western model of local body authority or private agencies being responsible for public service management and O & M.

6.2.3 There is a Need for an Individual or Group to be Responsible for O & M of the Water Supply

A clear understanding of what the responsibilities of the group or individual for managing and O & M the water supply, need to be clearly set down in the planning stages of the project, and reiterated at the transfer stage. This group or individual is to be responsible for the management of the water supplies O & M and providing a structure for the daily and corrective maintenance to take place (cf Appendix 2). Training of this group or individual to do this becomes a major factor for sustainability of the water supply.

6.2.4 Training of the Individual or Group Responsible for O & M is Essential.

Training is important for the water committee, with training in administration, dealing with funds, health issues, interpersonal relationships and leadership. This training is also an important factor for development, where some members of the community learn and develop skills to be able to make decisions in the future.

6.2.5 That the Agencies Lacked Foresight for Dealing with Infrastructural Aspects of O & M

Without a strong infrastructure within the country, major problems will occur if there was no planning for a parts and support infrastructure. Infrastructure is especially needed for the communication of problems and needs. A strong infrastructure, for supporting the O & M of water supply projects' is needed, especially in Ethiopia where the government water department has been unreliable in supporting community water supplies. Communities with water supplies need to have a structure they can trust to supply them the parts and help they need. It could be concluded that a infrastructure needs to be set up in conjunction between the government water department and the development agency, with the development agency helping to strengthen the government water department administration and support to the community water supplies.

6.3 Conclusions from the Survey of the Communities

From the surveys of the communities three conclusions may be drawn.

6.3.1 Community Ownership was Important to the Communities But it Did Not Equate to Community Responsibility for O & M

The author believed that what many people in these communities were saying was that a structure to maintain the water supply was needed. This structure involved either a water committee or some individual responsible for the water supply who can be informed easily by the users if there are problems. The structure would be responsible for providing routine maintenance. This conclusion was also reflected with many interviewees saying that they would pay a small fee to use the water supply if it was kept in good running order. Thus the system advocated by the communities would reflect many structures found in the west, as previously mentioned under Section 6.2.2.

6.3.2 Community Involvement in all Stages of the Water Supply Project is Essential

The lack of community involvement in the planning process was one major factor in the failure of the system at Yirga Chaffe where there was little or no information gathered from the community and the O & M problems in Haru. The lack of information to and involvement from communities leads to many of the O & M problems that face water supplies and eventually to the failure of the systems. Furthermore the community needs to be involved in expressing the problems of the water supply with someone local they can identify with and may have elected to a committee for responsibility for the water supply. It can also be concluded that many problems faced by these communities were directly related to the development agencies holding a view of setting up a technical water supply system and then leaving, rather than encouraging the communities through their selected representatives to be involved in making decisions for themselves, being involved and responsible, and developing abilities through training. This is a move from an aid giving situation to a development building situation, where the community grows and gains skills to face new situations.

6.3.3 A Lack of Infrastructure Led to O & M Problems

The lack of a communication structure and no individual or water committee for the community to inform when there were problems led to the problems faced in Haru. The author believes that the agencies have to take some responsibility for setting up of a communication structure, a water committee, and training these people along with local technicians to fix minor problems. It can be concluded that in the case of Haru if this

structure was set in place by the development agency, then the problems faced could have been dealt with, without weeks of no water. This could also be true for many other water projects that face O & M difficulties.

6.4 Overall Conclusions

Four areas that stand out from the above conclusions are:

* Community ownership does not equate to community responsibility for O & M.
* Training of the individual or group responsible for O & M is essential.
* A lack of infrastructure leads to O & M problems.
* Community involvement in all stages of the water supply project is essential.

From this it can be seen that the major issues facing O & M are issues not of technology, but of planning. They involve people from the agencies and government water departments having skills in training people, involving people and helping people to make decisions for themselves. The planning includes the setting up of structures for supporting the local organizations involved in O & M, by providing a communication system for problems and needs to be passed on to the supporting agency, along with a parts supply and delivery system. The involvement of the community ensures cultural factors are not overlooked and the real needs of the majority of the community are met, along with developing skills that can be used for future problems. This involvement by the community needs to include the community selecting people to be their representatives, so that problems with the water supply can be passed on. Involvement also develops responsibility for the water supply, even if the community is only involved in informing the water committee of any problems, their involvement will help to ensure that even this simple task will happen. The issue of ownership differing from responsibility, is one that reflects that people in the developing world are no different to those in the west, where the belief that public utilities are owned by the community, but the responsibility rests with a local authority for O & M. It could be implied from the community surveys that the communities were willing for this pattern of structure, with many willing too pay to use a well-maintained water supply. Finally, the surveys do show that water supplies in most cases must be managed and as much as possible maintained at the community level, with support from outside groups to ensure that the system is sustainably maintained. The

community/users need to have some local person or group to whom they can share the problems, who can also do something about the problems.

What changes then are needed to be made to the O & M model?

6.5 Changes to the O & M Model

The model in many areas reflects many of the practices and comments made by the surveys of the development agencies and the communities. Some changes need to be made in the area of responsibility for O & M, with the water committee or some individual assuming most of the responsibility. This is more of a fundamental shift from the community being responsible for O & M, with the water committee being the group handling this responsibility to the water committee or an individual being totally responsible. The area of training and information provided for the community and the water committee or individual needs to be developed, especially helping people to gain skills. Input into the infrastructure by the development agencies needs to be increased by working alongside the government water department to provide a reliable service to those responsible for O & M. The final factor that should be considered influential to the model revision is, what is the objective for the water project? I should be that of development of the community, rather than just providing the community with a water supply.

The revised model is on the following page.

6.5.1 A Diagram of the Most Important Factors in the Revised O & M Model

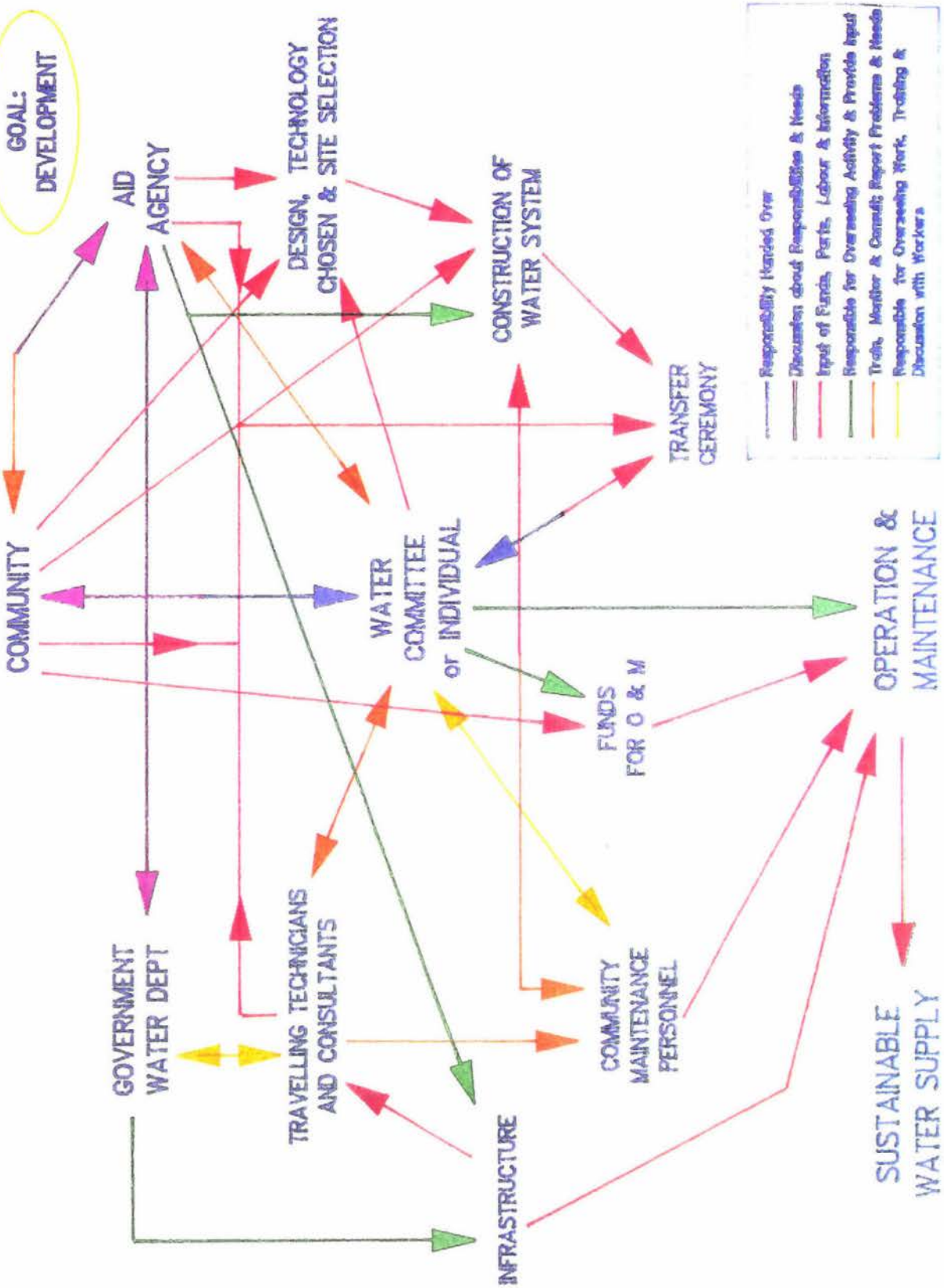

Figure 24 Revised diagram of the Model

CHAPTER 7
RECOMMENDATIONS

Based on the results of this study the following recommendations are made:

7.1 Pre-planning Stage

7.1.1 That Training Staff from Development Agencies and Govt. Water Departments be Undertaken for Community Involvement

This training could include some or all of the following list to work with the community, rather than for them:

1. The general phases (stages) of water projects
2. Advantages and disadvantages of various types of water projects
3. Project benefits: Hygiene education and community participation
4. Facing resistance in introducing innovation
5. Levels of community participation, and how to encourage participation
6. Community water committees
7. Role and development (including training) of water committee
8. Role of development worker or water department consultant etc.
9. Establishing collaboration from community leaders
10. Preparing agreement documents
11. Financial management
12. Community-level maintenance
13. Training water committee and local maintenance personnel
14. Planning meetings
15. Conflict resolution
16. Communication techniques and group dynamics.
17. Ongoing training of water dept. and development agency staff. Derived from Yacoob & Roark [1990].

This means that development workers, government extension workers and consultants become facilitators rather than people who have all the answers and will do all the work.

7.1.2 That Planning for Infrastructural Needs Between the Development Agencies and Government Water Departments Occur

The government water department should set guidelines or rules for the types of pump system that can be used, to avoid the need for large stocks of various parts for many different water systems. The importation of parts needs to be handled by one agency (for all water projects within the country), possibly the government water department, with funding from the development agencies, the government and the users. A communication system needs to be established so that the water committee or local maintenance personnel have a reliable system for ordering parts and asking for technical help when needed.

7.1.3 That the Water Project Goal Should be Community Development not Aid

The difference can be shown by whether the community takes an interest in the project and those responsible in the community operate, maintain and manage it sustainably after the agencies have left.

7.2 Planning Stage

7.2.1 That Community Involvement, with the Community Need for, the Water Supply is Essential to Water Project Sustainability

Community involvement can be fostered by a series of group discussions (groups may be village leaders, men, women, and youth) of what are their needs, to find out what are the most important needs within the community. This also is a check to whether those from the community who approached the development agency with a need for a water supply actually represented the community. Discussions should also cover the community's responsibility, for funds for O & M, for involvement in construction and O & M, and the role of the water committee or individual responsible for management and O & M.

7.2.2 That the Development Agency Personnel's Role is to Facilitate Rather Than Make Decisions

7.2.3 That Training of the Water Committee or Individual is Essential as They Will Assume a Large Amount of Responsibility for the Sustainability of the Water Supply

The water committee or individual, the development agency, the community and the govt

water department's roles during this stage are more fully covered in Chapter 4.

7.3 Design Stage

7.3.1 That Technology Used Should Follow Government Guidelines

The design stage should follow the outline set in Chapter 4.

7.4 Construction Stage

7.4.1 That Health Education is a Motivator for Development. It is Important for Water Supply Sustainability Because it Gives a Valid Reason for Caring and O & M of the water Supply

The author believes that health education can also provide the community with motivation for other development projects that will benefit the communities and individual's health and welfare, which works towards the goal of community development.

Other factors in this stage are outlined in Chapter 4.

7.5 Transfer Stage

7.5.1 That the Author Believes It is an Important Factor for Developing Responsibility for O & M by all the Groups Involved

The transfer stage is a time of celebration for the new water supply and a public declaration by the community, water committee or individual and the agencies involved of their commitment to help operate, maintain and manage the system.

7.6 Operations Stage

7.6.1 That Training Should Continue in this Stage for Those Involved in O & M and Management of the Water Supply

Other factors recommended for this stage follow those that are found in Chapter 4.

7.7 Overall Recommendations

7.7.1 That Training is a Necessity for Those Involved in the O & M and Management of the Water Supply and also for the Users

Training is an ongoing process, with not only the agencies being involved but also the water committee or individual and the maintenance personnel training new replacements.

Training for the users would be particularly in the areas of health input and community interaction.

7.7.2 That Community Involvement is a Major Key for Sustainability

The community being involved right from the beginning stages with expression of need for water through to being committed to help maintain the water supply by correctly using it and providing funds towards its O & M reflects the importance of their involvement. It also is development because the community makes the decisions about the affects that the water supply will have on their lives.

7.8 Suggestions for Further Research

The development agencies involved only from Ethiopia means that there may be a bias, along with the need to survey development agencies and communities in several different countries to see what factors are relevant for O & M in a variety of situations.

Government water agencies in various countries need to be interviewed to see how they provide O & M, especially how they set up a communication system to provide parts and technical help to community water supplies.

The model needs to be used in a trial situation, to see if there can be any improvements and whether it can be validated in practice in a variety of situations.

Finally, a survey of communities and development agencies is needed to see if a transfer ceremony is an important factor for sustainable water supply projects.

Millions of dollars every year are spent on water supply projects in the developing world, with the failure rate of between 30-70% this would seem a waste of money. The author's desire is that this thesis will contribute in a small way to improving the sustainability rate of a much needed resource for communities in the developing world.

APPENDICES

Appendix 1 Diseases Related to Deficiencies in Water Supply or Sanitation

Appendix 2 Schedule for Maintenance of Simple Borehole Pumps

Appendix 3 Functions of Various Levels of a Typical Rural Water Programme

Appendix 4 Three Approaches to Implementing Drinking-Water Systems

Appendix 5 Indicators of National Readiness to Support Community Participation

Appendix 6 Questions About Responsibility for Managing Water Supplies

Appendix 7 The Dominant Views on Participation

Appendix 8 Community Participation Activities Associated with Successful Rural Water and Sanitation Projects

Appendix 9 Community Participation - The Self-Help Model

Appendix 10 Communication, Motivation and Promotion by the Agency to the Community

Appendix 11 Main Questions for Village Decision Making on Maintenance Financing

Appendix 12 Institutional Support Structure to the Community

Appendix 13 Key Elements of Operation and Maintenance

Appendix 14 Survey of Development Agencies

Appendix 15 Results from Survey of Development Agencies

Appendix 16 Survey of Dokicha

Appendix 17 Survey of Haru

Appendix 18 Survey of Yirga Chaffe

Appendix 19 Survey of Handpump

Appendix 1

Diseases Related to Deficiencies in Water Supply or Sanitation

(Source: Saunders and Warford, 1976)

Group	*Diseases*	*Route leaving man*[a]	*Route entering man*[a]
Waterborne diseases	Cholera	F	O
	Typhoid	F, U	O
	Leptospirosis	U, F	P, O
	Giardiasis	F	O
	Amoebiasis[b]	F	O
	Infectious hepatitis[b]	F	O
Water-washed diseases	Scabies	C	C
	Skin sepsis	C	C
	Yaws	C	C
	Leprosy	N(?)	?
	Lice and typhus	B	B
	Trachoma	C	C
	Conjunctivitis	C	C
	Bacillary dysentery	F	O
	Salmonellosis	F	O
	Enterovirus diarrheas	F	O
	Paratyphoid fever	F	O
	Ascariasis	F	O
	Trichuriasis	F	O
	Whipworm (*Enterobius*)	F	O
	Hookworm (*Ankylostoma*)	F	O, P
Water-based diseases	Urinary schistosomiasis	U	P
	Rectal schistosomiasis	F	P
	Dracunculosis (guinea worm)	C	O
Water-related vectors	Yellow fever	B	B mosquito
	Dengue plus dengue hemorrhagic fever	B	B mosquito
	West-Nile and Rift Valley fever	B	B mosquito
	Arbovirus encephalitides	B	B mosquito
	Bancroftion filariasis	B	B mosquito
	Malaria[c]	B	B mosquito
	Onchocerciasis[c]	B	B *Simulium* fly
	Sleeping sickness[c]	B	B tsetse

Appendix 1 (cont'd)

Faecal disposal diseases	Hookworm (*Necator*)	F	P
	Clonorchiasis	F	Fish
	Diphyllobothriasis	F	Fish
	Fasciolopsiasis	F	Edible plant
	Paragonimiasis	F, S	Crayfish

a. F = faeces; O = oral; U = urine; P = percutaneous; c = cutaneous; B = bite; N = Nose; S = sputum.

b. Though sometimes waterborne, more often water washed.

c. Unusual for domestic water to affect these much.

Definition of the five groups:

Waterborne diseases

Water acts only as a passive vehicle for the infecting agent. All of these diseases depend also on poor sanitation.

Water-washed diseases

Lack of water and poor personal hygiene create conditions favourable for their spread. The intestinal infections in this group also depend on lack of proper human waste disposal.

Water-based diseases

A necessary part of the life cycle of the infecting agent takes place in an aquatic animal. Some are also affected by waste disposal. Infections spread other than by contact or ingestion of water have been excluded.

Diseases with water-related insect vectors

Infections are spread by insects that breed in water or bite near it. Adequate piped supplies may remove people from biting areas or enable them to dispense with water storage jars where insects breed. Unaffected by waste disposal.

Diseases related to faecal disposal and very little affected by water more directly

These are one extreme of a spectrum of diseases, mostly water washed, together with a group of water-based type infections likely to be acquired only by eating uncooked fish or other large aquatic organisms.

Appendix 2

Schedule for Maintenance of Simple Borehole Pumps

(Source: Pacey, 1977a)

Daily Tasks:

1. Lock and unlock the pump at hours agreed by the village.
2. Clean the well-head.

Weekly:

1. Thorough clean-up of pump, well-head and surroundings.
2. Oil or grease all hinge pins, bearings and sliding parts, after checking that no rust has developed on them.
3. Record any comments from users about irregularities* in working tightness of parts, leaks from stuffing box, (fall-off in water raised). Correct these where possible.

Monthly:

1. If necessary, adjust the stuffing box or gland (this does not apply to the Craelius pump). Usually this is done by tightening the packing nut. This should not be too tight - there should be a slight leak when the adjustment is correct.
2. Check that all nuts and bolts are tight, and check that there is no evidence of loose connections on the pump rods.
3. Check for symptoms* of wear at the leathers, noting any comments from users about any falling off in water raised. If the pump fails to raise water when working slowly (e.g. at ten strokes per minute), replace the leathers.
4. Carry out all weekly maintenance tasks.

Annually:

1. Paint all exposed parts to prevent development of rust.
2. Repair any cracked concrete in the well-head and surrounds.
3. Check wear at handle bearings and replace parts as necessary. On the Craelius pump, worn bushes can be replaced by short sections of pipe of suitable diameter.
4. Check plunger valve and foot valve, replace if found leaking.
5. Check the pump rod and replace any defective lengths or connectors.
6. Replace packing at the stuffing box or gland (does not apply to the Craelius pump).
7. Carry out all monthly maintenance tasks.

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* Typical symptoms are as follows:

A. Noisy working or tightness of parts usually indicates faults with the top-end mechanism, though stiffness may be due to tight-fitting leathers, or noise to a badly fixed pump rod slapping against the side of the riser pipe.

B. If the pump delivers a reduced amount of water, this may be due to worn leathers, or less often, to faults with valves or a leaking cylinder.

C. If the pump handle works easily but no water comes, it may be due to any of the factors listed in B, or to the well drying up, or to a blockage at the foot valve, or if the handle moves with no resistance at all, it may mean the pump rod has broken.

Appendix 3

Functions of Various Levels of a Typical Rural Water Programme

(Source: Donaldson, 1984)

National	Provide a financing channel for national counterpart funds, international loans, national grants and local contributions
	Develop norms and policies (technical and administrative)
	Supervise execution of national plan
	Conduct long-range planning
	Coordinate construction efforts
	Supervise regional programmes
	Exercise overall financial control
	Provide technical and administrative assistance
	Provide training
Regional	Supervise programme execution
	Carry out design (in case of larger countries only)
	Supervise construction, operation and administration of projects
	Undertake community promotion and supervision of projects
Local	Administration of system
	Operation of system
	Maintenance of system
	Collection of water rates

Appendix 4

Three Approaches to Implementing Drinking-Water Systems

(Source: Williamson, 1983)

	Agency-managed (centralized)	Limited community-involvement (people's participation)	Community-managed (decentralized)
Flow of Ideas	Agency ☞ Community	Agency ☞ ← Community	Agency → ☜ Community
Basic assumption	Local people know nothing and can't learn new things	Local people have knowledge which can be used in design. They can also provide labour for construction	Local people have management skills and quickly learn needed technical skills
How need is realized	Agency decides community needs water	Local political official decided community needed water	Community realizes own need
Who makes decisions	Agency	Agency and local leaders	Community
Strategy	Survey, design are done by agency staff. Little time is spent in community. Design is done in office	Survey is done by agency staff with advice given by local leaders on location of water sources, tank and tap stands. After design is completed in office it may be sent to community for information	Community asks agency for survey. Local people assist and understand survey. Community makes decisions about design. Design is prepared for community, everyone is able to understand
Construction	Construction is done by contractor hired by agency	Agency provides technician who organizes all work and does skilled work himself. Community provides voluntary unskilled labour	Agency provides technician who teaches necessary skills. Community organizes all work
Maintenance	Agency provides for maintenance by placing own staff to look after own system	Maintenance is left for community to work out	Maintenance is organized by community who have skilled persons able to make repairs
Approval of designs	Agency	Agency	Community and agency
Primary beneficiaries	Agency - its `good name' Contractor - profit	Agency - its `good name' Local political leaders	Community
End result	Dependence on agency	Continued lack of initiative	Self-reliance

Note: Agency refers to government or development agency which is implementing the drinking-water project.

Appendix 5

Indicators of National Readiness to Support Community Participation

(Source: International Reference Centre, 1988)

1. Acceptance by national government of basic literature and philosophy of community participation
2. Media releases supporting community participation.
3. Governmental publications supporting community participation.
4. Permission for/support of demonstration projects involving community participation.
5. Political party approval of community participation.
6. Inclusion of community participation in national health and economic policy.
7. Organizational/agency readiness to integrate activities and respond to community requests.
8. Revision of educational curriculum to integrate activities and respond to community requests.
9. Legislation action or executive orders (statutes, rules, regulations) regarding community participation.
10. Willingness/capability to decentralize planning and decision-making.
11. Budgetary/fiscal allocations or incentives for community participation.

Appendix 6

Questions About Responsibility for Managing Water Supplies

(Source: Cairncross et al, 1980)

1. What are the present arrangements for managing the construction and maintenance of water supplies in villages, and are supplies under some kinds of management better maintained than others?
2. How can one account for the effectiveness or ineffectiveness of water supply maintenance?
3. Do local participants have adequate power and authority to be able to carry out the tasks that are expected of them?
4. Does local participation have undesirable side effects for village life, like increasing conflict or increasing disparities of wealth and influence?
5. Should the water agency give greater support to local initiatives or should it take over more responsibilities from the villages?
6. Can the water supply agency respond adequately to community demands without losing the power to maintain priorities in resource allocation, and has it established adequate controls upon local initiatives?

Appendix 7

The Dominant Views on Participation

(Source: Oakley and Marsden, 1984)

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a. Participation is considered a voluntary contribution by the people to one or another of the public programmes supposed to contribute to national development but the people are not expected to take part in shaping the programme or criticising its content.

b. Participation means ... in its broadest sense, to sensitise people and, thus to increase the receptivity and ability of rural people to respond to development programmes, as well as to encourage local initiatives.

c. With regard to rural development... participation includes people's involvement in decision-making processes, in implementing programmes...their sharing in the benefits of development programmes, and their involvement in efforts to evaluate such programmes.

d. Popular participation in development should be broadly understood as the active involvement of people in the decision-making process in so far as it effects them.

e. Community involvement means that people, who have both the right and the duty to participate in solving their own health problems, have greater responsibilities in assessing the health needs, mobilizing local resources and suggesting new solutions, as well as creating and maintaining new organizations.

f. Participation is considered to be an active process, meaning that the person or group in question takes initiatives and asserts his/her or its autonomy to do so.

g. ...the organized efforts to increase control over resources and regulative institutions in given social situations, on the part of groups and movements of those hitherto excluded from such control.

Appendix 8

Community Participation Activities Associated with Successful Rural Water and Sanitation Projects

(Source: International Reference Centre, 1988)

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1. **Community mobilization and organization:** Community participation means involving as many community members as possible by providing an institutional vehicle through which they can act.

2. **Project negotiations:** Communities need to communicate their preferences and have a say in the type of projects to be considered. Their input may be given in consultations between community leaders and agency officials or in public discussions within committee meetings. It may consist of formal bargaining on issues such as project design, community contributions, and external assistance.

3. **Community operation:** Community organizations are usually elected or appointed committees. Their potential operating effectiveness depends on the degree to which they are allowed to function in project development.

4 **Training:** Training is necessary for system managers, committee members, and all others involved in project implementation. Although some training may be required from external sources, community members themselves should trained to pass on their skills to others.

5. **Hygiene and user education:** Hygiene and user education help to instill responsibility for the system and a feeling of control over the environment in the minds of the participants. Training should be participatory and practical, rather than didactic and theoretical, and it should encourage behavioural changes in order to maximize health benefits.

6. **Community contributions:** Community must contribute to the development and operation of their projects if they are to feel that they own the resulting system. Contributions including monetary investments, materials, equipment, and labour, as well as committee membership and general participation in project-related meetings.

7. **Cost recovery:** The community should interpret cost recovery as an obligation to meet its share of the costs of the project. In particular, the community must meet any obligations to external agencies.

8. **Operations and maintenance:** To the extent possible, communities should accept and exercise responsibility for operation and maintenance. Caretakers and repair crews should be well trained and responsible to a community-based institution.

Appendix 9

Community Participation - The Self-Help Model

(Source: Overseas Development Administration, 1985)

Activity	Central Authority	Branch Office* district or region	Community
Establish Priorities	Allow priority for self-help		Choose 'felt-need'
Plan	Prepare project plans incrementally (muddle through)	Encourage and examine application from communities for assistance	Establish local organization
Fund	Disburse central grants and donor funds	Collect self-help contributions, prepare project memoranda	Raise funds and make labour available
Implement	Provide central technical advisory unit, purchase	Provide technical supervision	Contribute labour under supervision or hire local contractor
Maintain	Provide maintenance funds (often neglected)	Employ maintenance staff (often neglected)	Provide occasional labour or services of a volunteer; alert branch office when necessary

* A well staffed and well supported branch office is absolutely essential to this model.

Appendix 10

Communication, Motivation and Promotion by the Agency to the Community

(Source: McPherson, (date unknown))

Communicating with Smaller Groups

- Visual aids: such as flip boards, blackboards and models etc
- Demonstration facilities: such as tours of operating water schemes
- Role playing: role playing maintenance of water systems and hygiene
- Individual discussions: talks with influential community members
- Meeting with individual users: gives a overview of the users opinions of the scheme, useful where a scheme requires an individual participatory response
- Letters to individuals: good for a small literate community

Communicating with Larger Groups

- Public meetings: describe the project to representatives of the community or too the whole community, good discussion benefits
- Handbills: good for a large literate community, ie urban areas
- Billboards: quality and location of the billboard are essential for communicating the message of key facts, good in urban areas
- Newspapers: an inexpensive method to reach large literate audiences
- Loudspeaker trucks: good way of reaching people in scattered areas quickly
- Radio: an excellent medium for providing information and changing attitudes, inexpensive and easily repeatable and reinforced
- Films, video and film strips: an expensive method but very useful in remote areas where this media is new
- Television: good method where available to reach large numbers
- Slide sound shows: good presentation of the technology, how the project works and how the community is involved, encourages discussion

Appendix 11

Main Questions for Village Decision Making on Maintenance Financing

(Source: IRC, 1988b)

Questions for discussion	*Options open to the village*
What costs to budget for?	Remuneration of scheme attendants Tools and spare parts for repairs Replacement of handpumps Extension of the system
What funds to use?	Village funds Voluntary contributions Regular user payments
What rates to set?	Flat rate (all pay the same) Weighted (according to benefit/payment capacity)
How to collect the money?	Fund raising on breakdown Taking money from a village fund Reserving part of village funds to establish a separate water fund Regular collection of household contributions
When to collect?	Monthly At the beginning of the financial year After harvest
Who collects?	Village water committee Handpump user group Community leaders
How to keep the money?	Village account Water account Who signs?
How to administer the funds?	Receipts for book-keeping Financial control User feedback
Who to administer the funds?	Village water committee Village accountant
How to pay the caretakers and/or area mechanics	Per job Per month Per year after harvest In cash/kind

Appendix 12

Institutional Support Structure to the Community

(Source: Kalbermatten, 1980)

1. Establish a support unit for water supply and sanitation in existing regional agencies or form an independent support unit. The staff will represent a mix of disciplines and will probably include engineers, hydrologists, a behavioural scientist, and economist, accountants, plumbers, mechanics, electricians, well drillers, purchasing agents, and health educators.

2. Establish design and operating standards and village selection/priority criteria, conduct specialized tasks such as hydrological surveys, management training/operating assistance, and the like.

3. Train community workers in low-cost water supply and sanitation technology and hygiene promotion and community organization.

4. Train community workers in health care and nutrition.

5. Canvass and organize selected communities. Plan, design, and implement prototype projects to complete training of community workers.

6. Assign community workers in teams to designated areas to canvass and organize communities.

7. Assist communities in construction facilities.

8. Maintain a limited number of community workers as roving operation and maintenance advisors and monitors for completed projects. Assign all other community workers to new areas where successful projects can be replicated.

9. Provide technical assistance through support unit. Maintain a stock of spare parts administered by the support unit.

10. Monitor the operation and quality of service, disseminate information, and provide continuous training programmes for community workers and local staff.

Appendix 13

Key Elements of Operation and Maintenance

(Source: Jordan *et al,* 1986)

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1. **Institutional Capability**

Both the governmental agency responsible for water and the community (or communities) receiving water service need to be actively involved in the water project if it is to be successful. The questions pertaining to this element focus on determining the commitment of the government and community to operations and maintenance of the systems.

2. **Systems Operation and Maintenance**

The key to ensuring effective equipment maintenance is to make certain that responsibilities are clearly defined and that maintenance personnel have the tools and skills to do their job correctly. It is also essential to schedule preventive maintenance.

3. **Spare Parts and Supplies**

Many water systems have failed because spare parts were not readily available to service equipment. Even the simplest water supply system requires a reliable source of supply for spare parts and other material needed to keep equipment in reliable operating condition. Numerous donors and many types of equipment have compounded the problem of spare parts and created the need for large and diverse spare part inventories. Because some parts may need to be imported the necessity for a reliable inventory is potentially even more urgent in developing countries.

4. **Logistics**

The questions concerning this element consider the need for vehicles and workshops dedicated to the maintenance function. It is not unusual for the same group within a water authority to be responsible for both construction and O & M activities. In these cases, vehicles are not reserved solely for O & M and frequently are unavailable when needed. Such a situation may result in a poor response to equipment problems and a lack of attention to preventive maintenance.

5. **Finance**

Before a water project is funded, the planner should address two issues relating to financing the recurring cost of the system as follows:

- How much will it cost to operate the system?
- Can the consumers and the government afford this cost?

Appendix 13 (Contd)

If the answer to the second question is negative, the project should either be redesigned (including the use of alterative financing) or abandoned. Project planners often assume that the host country is able to support O & M. If it is unable to do so, the result is poorly maintained water system.

6. **Records**

Up-to-date and accurate records need to be maintained for all water supply (WS) systems. The type and number of records and reports are determined by the type of system. For piped systems with a large number of electrically powered units, an automated information system may be appropriate. For one involving either handpumps or protected springs with piped distribution, the requirements for records are quite different, yet equally necessary. Records and reports provide:

- System control enabling responsible officials to know the operational status of the system(s)
- O & M information for maintenance personnel
- Equipment operating history
- Information on parts and or supplies in inventory

7. **Human Resources and Training**

Training programmes for equipment operations and maintenance are needed for all types of water systems. The technical content for training caretakers to maintain handpumps is, of course, less than for more sophisticated systems, but still must be planned. Training should be a continuing effort, particularly in LDCs where skilled technicians frequently learn a trade while employed by the water board and then seek higher paying work in the private sector. Ultimately, the success or failure of a water supply will depend on the people who have responsibility for operating and maintaining it.

These seven elements form the basis for a system of operations and maintenance. Each element must be investigated -- irrespective of the type of water system -- to ensure that O & M is adequately supported.

Appendix 14

Survey of Development Agencies

1. Introduction of the topic of O & M.

2. Personal view of the importance of O & M.

3. Development Agencies policy on involvement in O & M.

4. Factors that are considered important for sustainable O & M at the 5 different stages of a water supply project:

   i. Planning
   ii. Design
   iii. Construction
   iv. Transfer ceremony
   v. Operations

5. Ranking of above factors at each stage of the water supply project (#1 most important).

6. Ranking the importance of the following four groups at each stage of a water supply project (#1 most important); development agency, water dept, community water committee and community.

7. Factors that could not be left out of the O & M equation if money and resources were not available for complete list of factors.

Notes for the survey of Development Agencies

List of factors that I have considered important for sustainable O & M, from the perspective of the development agencies involvement.

1. View of sustainability:

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 14 (Contd)

2. View of technology

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

2a. Appropriate technology

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

2b. Community involvement in choice of technology.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

2c. Is the power source of the water supply considered.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 14 (Contd)

3. View of community involvement

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

4. Development goals

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

5. Good communication

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

6. Funding

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 14 (Contd)

If agency is involved in fulfilling some or all of the roles that are associated with the role of the national water department the following list of factors:

7. Planning stage of water supplies

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

8. Design stage of water supplies.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

9. Consultancy role.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

10. Training role.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 14 (Contd)

11. Staff training in community involvement etc.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

12. Infrastructure.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

13. Health factors.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

14. Know own responsibility for O & M when spread between community and agency.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 14 (Contd)

15. Monitoring of resource and community O & M responsibilities.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

16. Ownership of supply.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

2 other factors that were brought up frequently by Development Agencies were:

17 A felt need for water by the community.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

18. Responsibility for the water supply does not always equate to ownership.

i.	Included by development worker	Yes/No
ii.	Prompted by me	Yes/No
iii.	Classed as irrelevant	Yes/No
iv.	Classed as essential	Yes/No
v.	Stage in model	1 2 3 4 5
vi.	Other thoughts refer notes	Yes/No

Appendix 15

Results from Survey of Development Agencies

Stage 1 (percent)	**Group 1** Ranked 1-3	**Group 2** Ranked 4+
12.5	13	16,17,18
25	6,10	9,12
37.5	17,18	3,14
50	14,	
62.5	3	
75	16	6
87.5		
100		

Stage 2 (percent)	**Group 1** Ranked 1-3	**Group 2** Ranked 4+
12.5		2c
25	10	
37.5		
50	2&2a,2b	
62.5		
75	8	
87.5		
100		

Appendix 15 (Contd)

Stage 3 (percent)	**Group 1** Ranked 1-3	**Group 2** Ranked 4+
12.5		10
25		
37.5	3	
50		
62.5	10,13	
75		
87.5		
100		

Stage 4 (percent)	**Group 1** Ranked 1-3	**Group 2** Ranked 4+
12.5	18	
25	14,16	
37.5		
50		
62.5		
75		
87.5		
100		

Appendix 15 (Contd)

Stage 5 (precent)	**Group 1** Ranked 1-3	**Group 2** Ranked 4+
12.5	3,12,14	10,12
25	16	
37.5	6,10	9,15
50	9,15	
62.5		
75		
87.5		
100		

Appendix 16

Survey of Dokicha

Questions:

1. Is water one of the major needs in this community?
2. What do you know about the new water supply?
3. Do you know who is constructing and putting in the water supply?
4. Who do you think will own the water supply?
5. Is their anybody you can think of to tell if there is a problem with the water supply?
6. Do you know if their is going to be a water committee? If there is do you know anybody on it?
7. Who do you think will care for the water supply?
8. What are the most important things that will be needed for this water supply to keep working?

Appendix 17

Survey of Haru

Questions:

1. Did this community need this water supply? Why?
2. Who put the water supply in?
3. Who owns the water supply?
4. Do you pay any money for getting water from the taps? How much?
5. Is there a water committee? If there is name 2 people on it.
6. Does anyone take care of the water taps if they break?
7. Did you get involved in constructing the water supply? What did you do?
8. Are you happy with the water supply system? If not what do you want?
9. Did the community celebrate the opening of the water supply?
10. What happens when the water stops? Where do you get water from then?
11. Is there somebody to tell if the water stops?
12. Who pays to fix the taps, pipes, etc?
13. Would you consider paying a small fee each time you got water, to make sure the water point was in good working order?
14. How many water points are operating?
15. What are the most important things to keep this water supply going?
16. How many people in the town?
17. How long does it take to get water when everybody is getting water?

Appendix 18

Survey of Yirga Chaffe

Questions:

1. Where do you get water from? Do you pay for it? Do you obtain enough water?
2. Did you ever get water from the public water point? If you did why didn't you continue to use it?
3. Why doesn't the public water point work? How long ago did it work?
4. Would you use the public water point if it was reactivated? What if there was a small charge to use it?
5. Who owned the water point?
6. Did you get involved when the water supply was constructed? Why did you get involved?
7. Who was responsible for looking after the water point?
8. Who is the main overseer of these distribution points?
9. What do you think are the most important things to keep this water supply going?

Appendix 19

Survey of Handpump

Questions:

1. Do you use this handpump everyday?
2. Who constructed this handpump?
3. Who owns this handpump?
4. Do you pay to get water from it?
5. Is there a water committee in charge of handpump?
6. Is there somebody who cares for the handpump?
7. What do you do when the pump doesn't work? Do you tell anyone?
8. Who repairs the handpump?
9. Who pays for the repairs?
10. What do you think are the most important things to keep this water supply going?

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