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A REASSESSMENT OF ECONOMIC CRITERIA FOR RURAL WATER SUPPLY IMPROVEMENTS: A CASE STUDY OF KENYA

Louis Thomas Bates

Department of Forestry and
Environmental Studies

Date: April 22, 1987

Aproved:

David H. Newman

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SANITATION (IRC)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the department of Forestry and Environmental Studies in the Graduate School of Duke University

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TABLE OF CONTENTS

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SANITATION (IRC)

LIST OF TABLES

LIST OF FIGURES

Chapter One

PROBLEMS ASSOCIATED WITH RURAL WATER SUPPLIES

1.1 Introduction

Water is perhaps the most vital natural resource required for human survival. Studies have shown that we can live without food for at least two weeks, but without water, death may occur within a few days (White et al. 1972, p.6). Quality of life is also significantly threatened when water supplies are either severely limited or contaminated by various pathogens or parasites. Inadequate and unsafe water supplies adversely affect the lives of well over a billion people located primarily in the rural regions of developing countries throughout the world (Wiseman 1986, p.7). The consequences of the current global water crisis range from dehydration and debilitating disease to insufficient water inputs for agricultural and industrial production. The issues relevant to rural water development include the provision of basic human needs as well as general strategies for economic development.

The topic of rural water supply improvements is particularly relevant now as we are in the final third of the United Nations International Drinking Water Supply and Sanitation Decade (hereafter referred to as the Decade). The original goal of the Decade was to provide adequate water supplies and sanitation for third world populations throughout

the world by 1990. This target has since been revised as an eventual achievement for all participating countries (Agarwal et al. 1981, pp.1,117).

The concerted effort among international development organizations toward the goal of improved water supplies has already generated water supply improvements in numerous developing countries. By 1985, 530 million additional people had received reasonable access to safe drinking water; however, approximately 1.2 billion people remain with inadequate or unsafe water supplies (Wiseman 1986, p.7). While the number of people served by improved water supplies has increased dramatically to this point in the Decade, so too have the populations of most developing countries. Unless the rate of population growth is more closely matched by an increased rate of water supply improvements, goals set by the United Nations and individual governments are unrealistic.

Midway through the Decade, development researchers recognized several constraints which limit the progress of water supply improvements. These constraining factors continue to persist and include: 1) funding limitations; 2) insufficient operation and maintenance allowances; 3) lack of trained personnel; and 4) inadequacy of cost recovery policies. Other constraints such as inappropriate technology, lack of planning and design criteria and inadequacy of legal structures were once obstacles in the development process but are no longer considered significant constraints (Wiseman

1986, p.7).

For African countries, funding limitations are identified as the most serious constraint to the establishment of future water development projects (WHO 1986, p.7). In order to promote the beneficial impacts of improved water supplies to the greatest number of people, limited financial resources must be invested judiciously. Problems related to the economic feasibility of rural water supply projects have persisted for decades despite sizable national and international funding efforts. Many of the economic questions which are asked today concerning rural water development were similarly presented 20 years ago at the International Conference on Water for Peace in Washington D.C. (Water for Peace 1967, vol.6, pp.617-749). The methods of economic evaluation and analysis of rural water supplies have changed very little during the past 20 years. However, media attention and international development programs have increased the awareness and urgency of the need to improve water supplies. Given the magnitude of the Decade's goals and limited investment resources, it is useful to take stock of available economic analytical tools and determine their applicability to the current situation.

This study focuses on the water resource needs of the rural populations of Kenya with specific attention given to water supplies for domestic and small farm utilization. More particularly, this study examines the economic criteria on which the selection of rural water supply systems are based.

The purpose of this investigation is also to determine an appropriate method of evaluating the improvements associated with rural water supply development with respect to Kenya's rural water development policies and programs.

Kenya was selected as a case study for several reasons. First, the Kenyan government has, in cooperation with the United Nations Water Decade, made rural water supply improvements a development priority and has received rural water development aid from numerous international agencies. Second, Kenya is currently experiencing significant shortages of adequate water coverage in its rural sector. Third, Kenya faces tremendous obstacless in its water development effort due to hydrological conditions, a high population growth rate, and limited development resources. Finally, while there are certain aspects of water development which are unique to Kenya, the Kenyan example is applicable to other developing countries.

1.2 Rural Water Needs

The selection and use of a rural water source will vary according to the availability, reliability, quantity and to some degree, the quality of the existing water supply.[1] These factors also represent the issues of primary interest concerning rural water supply improvements (Feachem 1977, p.77). It is useful to examine these factors from the rural consumer's perspective. In most developing countries, including Kenya, women and children are the primary collectors

of water outside the home (White et al. 1972, p.62). In the context of a rural situation, a mother or child might ask the following questions as they set out to collect water:

availabilty - How far will I have to walk?
How long will it take?

reliability - Will there be water once I get there?

quantity - If there is water, then how much?
How much will I be able to carry back?

quality - How does the water look, smell, taste?

These particular questions would probably be most applicable to a distant traditional source of water such as a river, stream, pond, spring, or hole dug in a dry river bed. Other situations involving improved water sources such as protected wells or springs, handpump systems, or gravity fed piped systems may also be found in many rural areas. In any case, the answers to the above or similar questions will determine 1) how much time and energy will be expended during the collection process, 2) how much water will be collected, and 3) the benefits or ill effects which may result from water

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1. The quality of the water is an important aspect in terms of user well being, however, it will be assumed that the consumer probably does not have full knowledge of the water's quality or need for disinfection. Therefore, the consumer will make the decision to use or not to use a particular water source based on incomplete information regarding water quality.

use.

Once water is transported to the home it may be used for several purposes including drinking, washing, cleaning and even limited application to small farms for crops and livestock. Water use can be categorized and ranked according to absolute need. In their book Drawers of Water: Domestic Water Use in East Africa, White, Bradley and White (1972) divide consumption priorities into three basic categories: physiological survival, hygiene, and amenities. Water used solely for drinking and cooking may require less than 10 liters per day per person and would fall under minimal survival needs (also commonly referred to as basic human needs). Water used for cleaning and washing of the hands and face, foods, cooking utensils, along with other sanitary practices involve an increased volume of water above the bare minimum and is included in the hygiene category. According to White and others, all other water uses are understood to represent amenities as they are by definition, non-necessities.

While these divisions are helpful in determining water needs, there is a risk of possibly excluding other important categories of water use. It would seem that a fourth category -- agricultural water use -- should be added to the list. This additional category is useful because a high proportion of the rural populations of developing countries rely heavily on some form of agricultural production. For example, the rural population in Kenya in 1985 accounted for approximately

84 percent of the country's total population (Finland International Development Agency (FINNIDA) 1985, p.1). In 1980, Kenyan agricultural workers accounted for nearly 80 percent of total labor force and farmed primarily small acreage plots (Gillis et al. 1983, p.487). Farms of both high and medium productive potential have demonstrated average water consumption rates for farming purposes ranging from 100 liters per day (for farms of less than 2 hectares (ha)) to 1000 liters per day (for farms greater than 4 ha) (Carruthers 1973, p.71). While irrigation is not required in all agricultural regions, production depends on the provision of sufficient water supplies. Also in many areas of Kenya, dairy and pig farming comprise a large part of the agricultural economy. Kenya Water Development Division surveys indicate that livestock consume an average of 75 liters per day per head of grade cattle.[2] Because such a substantial portion of the Kenyan rural economy is based on agricultural production, it would be incorrect to assume that agricultural forms of water consumption provide only an amenity value.

Average daily water use varies significantly, depending on the urban or rural nature of the location and the possible uses of available water. In Nairobi, average daily consumption is greater than 150 liters per person. In contrast, average daily per capita water use is just over 5

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2. This consumption rate applies to livestock in general where 1 adult grade cattle = 3 local cattle = 15 smallstock. Information taken from Carruthers, 1973. Original source, Kenya Water Development Division, 1971.

liters in the rural town of Mutwot (White et al. 1972, p.119). The amount of water required by a large high potential farm is similarly greater than that of a small low potential farm.

Water quality requirements also differ. Water used for human or livestock ingestion should be relatively free of microbial pathogens in order to minimize the chances of illness and death due to contaminated water. Potable water, however, is not required for farm irrigation, and water of lower quality levels could be used for watering crops. It would be useful for purposes of consumption evaluations and corresponding water quality requirements, if distinctions could be made for domestic and livestock use as opposed to water used for small scale crop irrigation. Unfortunately, in rural situations, such distinctions usually do not exist, and the use specific consumption of water cannot be determined (Stern 1978, p.21). For the remainder of this paper, water supply improvements will refer to the provision of potable water which may be applied to both domestic and agricultural uses.

For whatever purpose water is consumed, water use patterns vary significantly both inter- and intraregionally. Site specific rates of water consumption will depend on the factors of: 1) water availability, reliability, quantity, and quality; 2) the diversity of available water uses and applications; 3) the degree of water supply improvements which have already been established; and 4) the cultural and traditional practices related to water use. The questions surrounding

water use and rural water development are of a multidisciplinary nature, and rural water supply problems are not limited to the economic realm. Other relevant fields of investigation include the perspectives of sociology, anthropology, engineering, public health and epidemiology. While this study looks specifically at economic analysis, several sections will include discussions of these other disciplines. This study is not intended to be a comprehensive evaluation of rural water supply improvements; rather it represents a single economic inquiry with limited coverage of these other components of rural water supply development.

1.3 Assumptions

The following assumptions are basic to water supply improvements. They are not necessarily original but deserve more attention than they have received from previous authors on this subject. For reasons of convenience and brevity, it will be assumed that water supply development and improvements are directed toward rural communities unless noted otherwise. Whenever such improvements are discussed the following assumptions will be understood to hold true:

1) There is a need for the water supply improvement. This assumption might at first appear to be self-evident. However, this point should not be too quickly overlooked or accepted. Development of any kind will bring about change for the targeted community, presumably for the better. Water supply

improvements are intended to to increase the community's economic development and general well-being. But the results of the improvement may not be entirely beneficial as they could threaten or disrupt channels of local authority (Whyte and Burton 1978, p.123) or actually cause an increased incidence of certain diseases. If the existing water supply is sufficient for a given community for purposes of health and productivity, then perhaps the improvement should be postponed until increased need becomes more evident. Unless the improvement is based on actual need, water development projects may be unproductive and possibly even detrimental to social stability and community health.

2) <u>The recipient community wants the improvement</u>. This assumption follows as a corollary to the first, because theoretically as the perception of the need for improvement increases so should demand. The ultimate success or failure of many development efforts may depend on whether or not this assumption is satisfied. The probability that rural water development objectives such as improved health and welfare are met is significantly reduced unless the community enthusiastically supports the project (Saunders and Warford 1976, p.128). Several researchers believe that water supply and sanitation improvements, health education and efforts to increase community participation should be combined as an integrated package of development inputs to increase consumer demand for and understanding of the development project

(Carruthers and Brown 1977, and Widstrand 1978). Based on this assumption, educational efforts should be made concomitantly with water supply improvements and participatory strategies should be augmented. But regardless of whether demand for the improvement is based on consumer knowledge, understanding, participation or traditional values and beliefs, consumer demand is a necessary prerequisite for a successful water development project.

3) The demand for improved service can somehow be measured or otherwise adequately estimated. If demand for the improvement cannot be measured or estimated, then the previous two assumptions are reduced to theoretical speculation. It is difficult to determine demand for water supply improvements within the rural sector where measurable economic activity and information are limited, the characteristics of individual rural communities vary significantly, and there is limited development precedent on which demand can be based. Unless demand is known or can be reasonably estimated, investments will probably not correspond with community needs. This will lead to either 1) an over-investment, where scarce financial resources (of local, national, or international origin) or skilled labor could have been more productively applied to water development elsewhere or to another type of project altogether, or 2) an under-investment, in which the goals of improved health and economic productivity would not be fully realized.

4) The recipients of the improved service are to some degree "better off" as a result of the improvement. This is perhaps the most broadly assumed of all the beliefs surrounding water supply improvements. Government officials and researchers have been quick to accept this assumption and call for the immediate implementation of water supply projects. Carruthers (1973) gives an example of this in quoting a Professor of Community Health in Kenya as stating that "there is no medical need to demonstrate once again the public health value of a safe domestic [water] supply in any community. This can be taken for granted in Kenya, in fact, is accepted by the health authorities of this country." To be sure, unsafe water supplies represent a threat to human health, but the converse that safe water supplies will improve health does not necessarily follow (Carruthers 1973, p.73). The tentative relationship between water quality and health was recently illustrated by Esrey and others (1986), in a study of village water supply improvements in Lesotho. They found that although pathogen contamination was lower at the point of collection of improved water supplies, the incidence of diarrheal disease in infants was not significantly reduced. This provided evidence that either the water from the improved source was recontaminated before ingestion, or that the pathogens infected the children through means other than ingested water.

In addition to health improvements, researchers have

asserted that numerous other benefits may be attributed to water supply improvements including time and energy saved, improved hygiene, increased income, increased agricultural development and a more diversified subsistence. While water supply improvements have the potential for improving the health, economic and social situations of rural populations, there is reason to question the extent of the betterment due to water supply improvement alone. It will be assumed, however, that certain benefits, although possibly limited, do result for the consumer.

5) Investment in rural water supply improvements is justifiable. This assumption simply acknowledges that there will be trade-offs involved in any investment. In the particular case of rural water supply improvements, investors must determine if: 1) rural regions, as opposed to urban areas, warrant the investment of scarce capital and skilled labor resources, and 2) water supply improvements, in contrast to education, sanitation or agricultural improvements, should receive priority in the schedule of development activities. This is not to say that rural water supply improvements are made to the exclusion of urban water development or alternative rural development projects as these efforts can be made concurrently.

1.4 Plan of the Paper

In the following chapters several different aspects of

water supply improvements will be investigated. Chapter 2 is devoted to a discussion of the economic considerations generally applied to water supply analysis. This includes project evaluation methods such as cost-benefit and cost-effectiveness analysis, current research within the field of these evaluations, a continued discussion of rural water investment strategies, and other related economic issues. Chapter 3 includes background information on the climate and hydrology of Kenya leading to a discussion of Kenya's water development policies and programs. Finally, Chapter 4 contains a brief summary of this study along with comments on its relevance to rural water development policy in Kenya and research needs for water project evaluations in deveeloping countries in general.

Chapter Two

ECONOMIC CONSIDERATIONS OF RURAL WATER SUPPLY IMPROVEMENTS

2.1 Introduction

Economics can be broadly understood as the study of allocating limited resources among competing demands. In relation to rural water supply investments in developing countries, the allocation process involves limited investment resources such as capital and skilled labor to develop scarce natural sources of water. The judicious management of both natural and investment resources is required if increased economic development, improved health and general well-being are to be attained within the rural sector.

The purpose of this chapter is to address the economic considerations pertinent to rural water supply improvements in developing countries and particularly in Kenya. Attention will be given to: 1) rural development investment strategies; 2) the benefits and costs associated with rural water supply improvements; and 3) the economic evaluation of these improvements.

These economic considerations represent a subset of the more important economic aspects relevant to rural water development. This is not a comprehensive list of all economic considerations, nor is the analysis of these issues necessarily original (with the possible exception of the last section). In the progression toward any goal, it is useful to take stock of the knowledge and understanding which has been

previously gathered. This study is preceded by numerous others (see White et al. 1972; Saunders and Warford 1976; and Carruthers 1973) which offer more detailed discussions of the economics of rural water supplies. The objective of this chapter is to synthesize and examine these earlier studies in order to determine the most appropriate variables and methods of evaluating rural water development projects.

2.2 Rural Development Investment Strategies

There are numerous opinions concerning rural water development strategies. These strategies are based primarily on either economic, social or political criteria. Economically driven investments include cost minimization concerns to growth point or growth pole strategies. Socially motivated objectives focus on the provision of humanitarian needs which do not necessarily coincide with the most economically efficient solutions. Political incentives underly most, if not all, investment decisions in attempts to appease the politically influential members of society. To a certain extent, development analysts must consider each of these three strategies in the determination of rural water supply investments. This section examines the economic and social strategies of water development investments by contrasting growth point investments with the basic needs or worst first approach.

The growth point strategy is based on the assumption that spatially concentrated investments result in a higher degree

of economic development than sparsely distributed investments. Densely populated areas are the most likely targets of this investment approach in order to take advantage of possible economies of scale and to maximize the number of people served with a given level of investment. Followers of this argument contend that if economic growth is the desired project goal, investments are most effective where complementary infrastructure such as roads, education and sanitation facilities (including water supplies) and market places already exist or can most easily be established. For water supply improvements, this would mean that investments are most effective where health related activities such as improved sanitation and health education are also in place in order to maximize potential health benefits.

The logical extension of the growth point argument is that the majority of investments should be directed toward urban areas. However, less extreme growth point advocates may also include certain rural towns in which complementary inputs are already in place. An important consideration of this strategy is that development would tend to occur only where previous development and economic progress has already been established. For example, consider two Kenyan towns, Nanyuki and Kitui, and a hypothetical amount of water development funds which can be allocated to either town but not both. Nanyuki is a relatively well developed town located in central Kenya with good roads, sufficient transportation services, numerous shops and stores, limited light industry and a generally strong economic base. Nanyuki has an adequate water

supply for its current needs but city planners anticipate increased industrial demand and have requested financial assistance from the central government to increase storage capacity.

Kitui is a smaller and more remote town in central eastern Kenya. Many of its roads are neither paved nor maintained. Transportation is sporadic and unreliable. Economic activity in and around Kitui is generally slow and its population is spread thinly throughout the surrounding area. The region is extremely dry and many of the women and children spend several hours each day collecting water for domestic needs. There is strong community support for improved water availability, but any delivery system will involve significant costs.

Assuming that both projects involve equal costs and that funds cannot be effectively shared between Nanyuki and Kitui, the question of which project to choose is a difficult one for a development analyst. The growth point strategist, however, would select Nanyuki as the best option due to the physical and economic characteristics discussed above. Theoretically, after the provision of a sufficient investment stimulus in areas similar to Nanyuki, development would continue in a self-perpetuating cycle. But strict adherence to growth point theory excludes communities like Kitui which have experienced little or no prior development. Growth point advocates respond that the economic progress experienced in high potential development areas would spread over time to less prosperous areas; a theory also refered to as the trickle down

approach to economic development.

The worst first strategy offers a definite contrast to the growth point argument. As suggested by its name, a worst first policy serves the most impoverished and least developed regions such as in the case of Kitui. These programs may involve partially or fully subsidized projects, technical assistance or specialized education. By directing investment funds to the poorest communities, this policy can be viewed in two ways. First, it is a means of redistributing wealth from urban to rural areas, since most rural populations tend to be significantly poorer than their urban counterparts.[1] A second perspective suggests that increased rural investments provide greater development potential and economic incentive for rural areas.

The worst first strategy is not entirely comparable with the growth point strategy as the worst first strategy relates to basic human needs which are not economically driven. The economic merits of the worst first policy may initially appear to be lacking when compared to the growth point strategy, because growth point policies seek to maximize economic efficiency (i.e. maximize the net benefits accrued from an investment) and generally demonstrate a higher average rate of return than a worst first strategy. But the value of worst first efforts should not be rejected solely on the basis of

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1) Impoverished populations are not limited to rural regions. Urban squatter settlements such as Kenya's Mathari Valley, located within Nairobi, are common in most developing countries. However, the rural regions in Kenya contain the majority of the poorest populations (Barnes 1984, p.5).

investment return criteria. The evaluation of projects aimed at assisting the rural poor should be measured accordingly -- how effectively do these projects provide the basic needs they are intended to provide?

The point here is not necessarily to promote one strategy over another, because both are considered valid relative to their objectives. The preceding discussion simply distinguishes between the two development strategies and explains that their objectives are geared toward notably different goals. Having considered these development alternatives, an important issue remains -- which policy is most appropriate for promoting Kenya's goals for rural water supply improvements?

As discussed in the previous chapter, Kenya hopes to provide adequate water supplies for its entire population by the year 2000. The objective of providing water for all gives rise to substantial constraints which are possibly at odds with neoclassical microeconomics. That is, in the attempt to provide water for all, situations will arise where the measurable marginal social benefits of improving rural water supplies will be less than marginal social costs. Traditional economic theory suggests that investments should be limited to those projects demonstrating positive economic returns. Economic analysis may reveal that relocating rural populations to growth point centers would be more economically efficient than providing improved water supplies to Kenya's most remote inhabitants. However, given the socially motivated goal of complete water service coverage and the magnitude of Kenya's

rural population growth potential, Kenya's national water development plan must somehow incorporate the possibly inefficient rural regions. This does not necessarily mean that Kenya's policy makers should be committed only to worst first strategies, but the pusuit of growth point approaches alone would disregard Kenya's most needy populations. A rurally oriented water development program is in keeping with the goals set by both the Kenyan government and the United Nations Water Decade.

2.3 Benefits, Costs and Economic Impacts of Water Supply Improvements

2.3.1 Introduction

From an economic perspective, the justification for water supply improvements, like any other development projects, are based primarily on the benefits associated with the investment, considered relative to the project costs. However, the economic impacts of water development are often not altogether clear and in many cases may never be fully known. Even in situations where information is available and accurate, the final measures of benefits and costs may not be available for many years after the project is completed (Briscoe et al. 1986, p.15). In such situations, the economic impacts of water projects are limited to predicted values. This is especially true in the rural regions of developing countries where important information is even more scarce (White 1978, p.14). Researchers frequently must rely

on statistical estimations and extrapolations to fill information gaps. Such compromises are often inevitable, thus making it all the more important to identify and evaluate the most meaningful variables related to the project in question.

In his study of the economics of community water supplies in Kenya, Carruthers (1973, pp.28,29) delineates the most commonly recognized benefits associated with water supply improvements and separates them into the categories of direct benefits, first order benefits, and second order benefits. Table 2.1 restates these categories with examples of the benefits associated with each benefit group.

Table 2.1 Benefits of Rural Water Supply Improvements

direct benefits	reduced time and energy required for water collection; increased water availability; improved water quality and reliability of supplies.
first order benefits	labor released; better quality of labor; improved hygiene and health.
second order benefits	higher family income; increased leisure; more and better crops; improved livestock production; long term improvement in family planning through a perceived permanent reduction in infant mortality.

Source: Carruthers 1973, pp. 28,29.

According to Carruthers's assessment, there is a possible causal relationship between these benefit groups, beginning with direct benefits. Given this supposition, consider the following scenario. A water development project locates standpipes[2] throughout a village community where the people had previously relied on a single distant water source. The time and energy saved as a result of the improved system could release labor locally. This in turn could increase productivity which could then lead to increased per capita income. Carruthers acknowledges that the first and second order benefits are conditional and plausible only if necessary complementary inputs and other specific preconditions already exist. This point must be emphasized. To assume that the first and second order benefits will be achieved is misleading and possibly inaccurate.

2.3.2 Health Benefits

Health benefits have generally been assumed to result from water supply improvements, but this assumption has been recently challenged. Certain studies demonstrate that while improved water supplies reduce the incidence of cholera and typhoid, the incidence of diarrhea for children is not significantly affected (Esrey et al. 1986, Briscoe et al. 1986, p.54). These studies provide evidence that pathogen

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2) The term standpipe refers to a public tap, spigot or hydrant which is available free of charge or for some fee (White et al. 1972, p.3).

levels in drinking water may be reduced by improving water supplies, but this reduction alone does not lead to reduced morbidity rates for all water-related and water-borne diseases. (For an explanation of these and other disease groups related to inadequate water supplies, see Table 2.2.)

Other problems encountered in determining specific health benefits of water supply projects are due to several possible confounding variables including health education and improved sanitation facilities. If these additional efforts precede or are concurrent with the water supply improvements it becomes difficult, if not impossible, to isolate the benefits which result solely from the water project.

This was the case in the Zaina water project, one of the most extensively studied projects in East Africa. The project began in the early 1960's near the town of Nyeri, Kenya. The Zaina scheme introduced concrete-slab pit latrines and a health education program simultaneously with a gravity-fed chlorinated water supply system. Therefore, while certain health improvements did follow, the improvements could not be separated among the three different variables (White et al. 1972, pp.154, 155).

Inadequate and contaminated water supplies are commonly cited as major causes of diseases associated with water. Studies have shown that there are numerous sources of microbial pathogenic infections other than water use and ingestion. So there is reason to doubt that water-related diseases will disappear once water supply improvements are established (White et al. 1972, pp.185,188).

Table 2.2 Disease groups and specific diseases related to inadequate and contaminated water supplies

Disease Group	Diseases
<u>water-borne diseases</u> (water acts as passive vehicle for the infecting agent; also due to poor sanitation)	Cholera Typhoid Giardiasis Infectious hepatitis
<u>water-washed diseases</u> (caused by inadequate quantity of water and poor personal hygiene; also associated with improper human waste disposal)	Scabies Trachoma Amoebic dysentary Hookworm Leprosy
<u>water-based diseases</u> (caused by infecting agents spread by contact with or ingested with water; essential portion of infecting agent life cycle takes place in aquatic host; also related to improper waste disposal)	Schistosomiasis Dracunculiasis (guinea worm) Bilharzia
<u>water-related vectors</u> (spread by insects which live close to water, especially flies and mosquitoes near stagnant pools)	Yellow fever Malaria Onchocerciasis Sleeping sickness

Source: Hofkes 1983, p.10.

Ironically, water development projects can actually worsen the health condition of the community served. Without proper drainage, water will collect providing breeding areas for malaria and other microbial contaminants. Also, without adequate management and supervision, extensive piped systems may serve as conduits of water-borne disease. This is not to say that water supply improvements do not provide an increased health potential. Rather, these improvements are an integral component in improved community health, and potential health impacts should be examined in the context of conclusive epidemiological studies and realistic expectations. In general, it is more difficult to measure the health benefits of water supply improvements than the initial water-related health problems. Whether the difficulty is due to problems in locating appropriate or comparable study areas, determining proper experimental design, or isolating the benefits directly related to improved water supplies, information on water supply induced health benefits remains incomplete (Cairncross et al. 1980, p.77).

2.3.3 Quantity and Quality Considerations

The quantity and quality of a water supply are critical aspects of the system's ability to provide a healthy living environment for a given community. Water quality information is reported less often than quantity information and is frequently neglected altogether in the data gathering process (Donaldson 1984 p.42). Both the quantity and quality of water

will affect consumer health, but researchers do not agree as to which of these parameters should be more highly stressed in the evaluation of improved water supplies.

As shown in Table 2.1, water quantity and quality are related to water-washed and water-borne diseases respectively. Therefore, increased water quantity or improved water quality will affect two different disease groups. If either of these disease groups is predominant within a community, the decision to focus on the related improvements may be relatively clear. However, such obvious distinctions are uncommon, and usually one goal must be selected over another based on budget constraints rather than epidemiological information.

Ideally, both quantity and quality improvements should be made together, as this would provide more potential benefits than either singly emphasized improvement. This is often not economically feasible for most rural villages so that trade-offs between quantity and quality will necessarily occur. When this is the case, Feachem (1977, p.86) suggests that increased quantity should receive priority over quality improvement. He bases his argument on two points. First, low income communities suffer from high morbidity due to fecal-oral infections which are both water-borne and nonwater-borne. By improving water quality, the water-borne transmission of several diarrheal diseases may be reduced, but the nonwater-borne transmission will most likely remain. Second, water-washed diseases, such as nonwater-borne diarrhea and skin and eye infections, are also major causes of morbidity. These diseases, however, "are reduced by increasing the quantity,

availability and reliability of the water supply almost irrespective of its quality".

In 1971 the World Health Organization (WHO) issued a list of water quality standards and suggested they should be administered globally for developed and developing countries alike. WHO's intentions were presumably to encourage governments and donor agencies to provide all people with access to equally safe drinking water. The opposite effect, however, resulted for many communities.

WHO and other health monitoring agencies use Escherichia-coli (E. coli) as an indicator bacteria of fecal contamination of water (Hofkes 1981, p.43).[3] According to the WHO standards, if one or more fecal coliforms per 100 ml is detected, the infected water supply should be declared undrinkable and require disinfection (WHO, 1985, p.3). Particularly in a rural environment, strict adherence to this standard would mean that a significant percentage of existing water supplies in developing countries should be condemned (Biswas 1981, p.159). WHO recognized these standards as being overly stringent, especially for developing countries. In 1983 therefore, it renamed its "standards" as "guidelines" (WHO 1983). This simple rephrasing has permitted more flexible water quality levels within countries which are now able to set their own perhaps more realistic water quality standards. The guidelines are now perceived as long-term goals rather than rigid standards.

The decision to promote increased water quantity over improved quality remains debatable and is best determined by

site. The most appropriate action depends on several factors including the amount of available investment funds, the size of the population involved, the pre-improvement measurements of water quantity and quality and the existence of other development priorities (Biswas 1981, p.159). Incremental water quality improvement is advisable in certain cases when strict goals cannot be immediately attained. In this way, quality improvements can be checked and verified (Cairncross 1980, p.73). Concurrent investigations could also be conducted to determine nonwater supply routes of pathogenic infection. Until all sources of microbial contaminations are identified and addressed through appropriate sanitation measures, water quality improvements will only provide a partial solution to rural community health problems.

2.3.3 Labor Supply Benefits

Just as health benefits often cannot be linked solely to water supply improvements, the first and second order economic impacts are similarly difficult to attribute to water development alone. While it may be safe to assume that water supply improvements will result in time and energy savings for the water collector, it does not necessarily follow that the potential labor supply released will be applied to the most

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3) Several aspects of water quality can be evaluated. Of these, *E. coli* levels are probably the most commonly cited. Other important quality measures include additional microbiological agents, along with chemical and physical characteristics such as turbidity, color, taste, and odor. This paper discusses *E. coli* levels as a general indicator of water quality.

productive available opportunities. The productive potential of increased time and energy will depend on the following variables: 1) who is affected; 2) what, if any, productive alternatives exist; and 3) the incentives and level of understanding concerning these productive opportunities.

Women and children are the primary drawers of water from sources outside of the home. In Africa, women are also largely responsible for the seasonal activities of planting, cultivating, and harvesting crops. Depending on the season, a woman's extra time, resulting from water supply improvements, could be productively applied to these agricultural activities. This alternative use of time however, has not been observed in many cases. For example, Warner (1969) surveyed women in nine Tanzanian villages about what they would do if they had more available time. Less than half indicated they would spend it in agriculturally related work. Also, in Kenya's Zaina water project, investigators found that women tended to allocate the time saved from water collection to domestic rather than agricultural work (Carruthers 1973, p.35). This is not to say that domestic activities and leisure are without value, but such activities are probably not as economically productive as the alternative opportunities which many researchers have assumed (Saunders and Warford 1976, p.73).

2.3.4 General Economic Impacts

A 1969 survey compared the economic progress of two adjacent communities, Kabare and Inoi, in the Kirinyaga

District of Kenya's Central Province. Both towns are located at the same elevation, experience similar weather and cropping patterns, and have comparable populations in terms of size and tribal composition. Kabare received a reticulated water system in 1961.[4] Individual connections were located within the boundaries of each Kabere farm. Inoi, on the other hand, received no such improvements and was used as the control community in the survey. The main hypothesis tested was that a community which had received water supply improvements would be expected, given sufficient time, to demonstrate a higher degree of economic progress than a similar community without improvements. The survey results were surprising in that the level of average farm income for the Inoi farms was actually 20 percent higher than the Kabere farms of the same size (Carruthers 1973, p.37). These results may reflect improper survey methodology (e.g. there was no indication of pre-improvement income levels) or insufficient time allowed for significant economic progress to have occurred. Nevertheless, these results provide reason to question the assumption that increased economic progress will necessarily result from water supply improvements.

Livestock farming provides another example of benefits which cannot be definitively attributed to improved water supplies. Returning to the Zaina project example, the number of cattle increased in the project area by 66 percent from

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4) A reticulated water system involves a grid of pipes which transport water within the area of water supply coverage.

1961 to 1965, but this increase is not significantly different from the increased number of cattle in the control area, Tetu. Milk sales appear to be the only divergent variable between the two areas, and the existence of factors such as milk marketing cooperatives, rather than water supply improvements, may explain this difference (Carruthers 1973, p.36).

There has been some speculation that water supply improvements may also impact certain demographic trends such as rural to urban migration. This trend is particularly pronounced in Kenya. From 1973 to 1983 Kenya's urban areas experienced an average annual growth rate of 8.0 percent (World Bank 1985, p.216). The hypothesis is that rural water supply improvements will provide increased employment opportunities and productivity in rural areas, thus motivating rural inhabitants to remain at home rather than seek higher paying jobs in the cities. This potential migration reversal is of national relevance and is intuitively appealing, but there is little empirical evidence to support this assertion (Saunders and Warford 1976, p.79).

In addition to the apparently limited positive economic impacts, water development may actually create negative effects in the form of reduced per capita income. Circumstances representative of a rural environment indicate that net income may be reduced as a result of water development. Given a situation where a rural water user has a low cash income, if the user is charged a cash fee or taxed for access to a new water supply, his net cash income will decrease. It is assumed that the user will behave rationally,

in his best interest, and spend his money accordingly. So by purchasing or not purchasing water, the user is as well off as he perceives himself to be. The point here is not to examine the rural consumer's economic behavior or incentives to purchase water. Rather, the point is that if one of the goals of a water improvement project is to increase local cash income, this goal may not be achieved, at least not initially. Moreover, it is possible that the present level of income may deteriorate as a result of the project.

The purpose of the preceding discussion of this section is not intended to persuade the reader that the benefits related to water supply improvements are negligible or extremely limited. There are several benefits which may initially occur and numerous others which may occur in the long term. But it is very important to stress the conditional nature of the indirect or secondary (earlier referred to as first and second order) benefits. Unless the necessary infrastructure is in place or certain preconditions are met, the more advanced benefits pertaining to improved health and economic development are based on misleading speculation and will rarely be realized.

Consumer benefits can alternatively be examined in terms of reduced consumer costs. Consumer or user cost for water come in various forms: 1) cash payment for water use; 2) the time or effort required in water collection; or 3) the incidence of related illness and disease from water use. According to Feachem (1977, p.79), the fundamental aim of water supply improvements in low income communities should be to

reduce these costs to the consumer whether they be in the form of cash, time, or poor health. However, the cash economies of many of Kenya's rural villages are commonly either limited or undeveloped, and cash is seldom exchanged in order to gain access to an unimproved water source. Therefore, a reduction in cash payments is probably not the most appropriate means of evaluating consumer cost reduction in rural areas.

Using the incidence of illness and disease as indicators of reduced cost may also be inappropriate. If improvements in health are not due solely to water development, then it would be incorrect to assume that health improvements provide a representative measure of cost reduction. If one assumes that at least some portion of improved health can be attributed to improved water supplies, it also follows that consumers would spend less time in a condition of poor health, (Saunders and Warford 1976, p.46) thus allowing more time to be invested in possibly more productive activities. If less time is spent in a state of ill health, then time savings can conceivably be used as an indicator of user cost reduction. Water supply improvements typically reduce the user's distance travelled in water collection, which is also related to time and energy savings, thus making the variables of time or energy even more appealing as indicators of user cost reduction.

Several studies have attempted to estimate the monetary cost of water collection in terms of cost of the calories of energy expended during the collection process. (Feachem 1973, White et al. 1972) This estimate requires the following information: 1) distance travelled during water collection;

2) amount of energy expended in that process; 3) amount of a staple food necessary to supply the energy; and 4) price of that amount of food. Other variable factors include the collector's body weight, and the slope and roughness of the terrain, (Saunders and Warford 1976, p.94).

While it may be useful to identify these factors related to the sources, costs, and uses of caloric energy, this combined information offers dubious insights and applications to the cost of water supply improvements. Most rural inhabitants rely to some degree on subsistence agriculture in which families produce and consume much of their own food. Assigning specific prices to "home grown" produce could easily over- or underestimate its marginal value to the producer/consumer. The valuation of staple foods may vary significantly among different individuals depending on access to markets. Averaging may provide some compensation for this valuation dilemma, but such estimations can present additional problems. The calculations of caloric expenditure which are subsequently converted into monetary units involves using estimates to determine other estimates. For these reasons cost estimation based on energy expended will probably not result in accurate and reliable cost measures.

If energy is disregarded as an estimate of project cost, the variable of time becomes the most plausible indicator of cost. The ramifications of the decision to rely on time measurements will be discussed further in the section of water development project evaluations.

2.3.5 Water Development Project Costs

The costs of water supply improvements are closely related to the resultant project benefits. Without the initial investment in water development, few if any water related benefits will occur. Project costs can be broken down into financial or accounting costs and opportunity costs. Financial costs include fixed, variable and recurrent costs. Fixed costs remain constant regardless of how much of the capacity of the system is utilized. Such costs could include expenses related to reservoir construction, bore-hole drilling, spring capping or protection, or handpump installation. There can be significant economies of scale such that by increasing a system's capacity, average costs tend to decrease. Because of these economies of scale, larger projects are often favored over smaller ones which in turn may convince development analysts not to support investments in small rural water supply projects.

Variable costs depend on the daily utilization of capacity and are, for the most part, predictable and easily incorporated into the schedule of project costs. For chlorinated water systems, for example, the variable costs include the costs of the chlorine used in the process of water purification. As more water is processed through the system, more chlorine is required; variable costs are therefore a function of production, or in this case, volume of water flowing through the system.

Unlike fixed and variable costs, recurrent costs are unpredictable both in terms of timing and magnitude. Heller

(1979) cites the failure to plan for and set aside sufficient allowances for recurrent costs as the reason for the demise of many development projects. The costs related to project operation and maintenance typically make up the largest portion of recurrent costs and are considered to be among the major constraints facing rural water supply improvements (Wiseman 1986, p.7). Numerous sophisticated pumping systems are left inoperative for months, because repairs and spare parts are not budgeted. Regardless of how technically appropriate or economically efficient a project is, without adequate allowance for operation and maintenance costs, original project expenditures might have been better invested in alternative projects.

Saunders and Warford (1976) state that even the poorest communities should be responsible for providing the costs of operation and maintenance for their water supply system. This idea has been applied during the Decade through the concept of village level operation and maintenance (VLOM) popularized through United Nations and World Bank water projects (Farrant et al. 1986, p.29). Projects incorporating VLOM emphasize technical and financial propriety. Researchers also believe that VLOM promotes community participation and responsibility for the water project as well as the continuous operation of the system (Saunders and Warford 1976, p.108).

2.4 Economic Evaluations of Rural Water Supply Improvements

Once the benefits and costs of rural water supply improvements have been identified and if they are quantifiable, it is possible to evaluate the project and compare the results with other alternative investments. The extent to which these values can be quantified will largely determine which evaluation methods are most meaningful for purposes of economic analysis. The analysis of development projects allows researchers to determine the most efficient and effective allocation of investment funds and to compare alternative projects. This section looks at two methods of water project evaluation: 1) cost-benefit analysis; and 2) cost-effectiveness analysis; and explains the basic mechanics, problems and uses of each in relation to water supply improvements.

2.4.1 Benefit-Cost Analysis

Benefit-cost analysis is a method of economic evaluation whereby the total discounted benefits associated with a project are considered relative to the discounted total costs. If the result is positive using net present value (NPV) calculations, or greater than one using benefit-cost ratio (BCR) calculations, the project may be deemed worthy of investment. If, on the other hand, the result is negative or less than one, the project may be judged economically inefficient, because project costs are greater than project benefits. The benefit-cost calculations are shown in Table 2.3.

Table 2.3 Benefit-Cost Calculations

Present Value of Benefits = PVB

$$PVB = \sum_{n=1}^{T} B_n \left[\frac{1}{(1 + r)^n} \right] \quad (2.1)$$

Present Value of Costs = PVC

$$PVC = \sum_{n=1}^{T} C_n \left[\frac{1}{(1 + r)^n} \right] \quad (2.2)$$

where B_n = value of benefit in period n
C_n = value of cost in period n
r = discount rate
n = number of years or interest bearing periods
T = project life in years or interest bearing periods

Net Present Value (NPV) = PVB - PVC (2.3)

if NPV > 0 then accept project

if NPV < 0 then reject project

Benefit-Cost Ratio (BCR) = PVB / PVC (2.4)

if BCR > 1 then accept project

if BCR < 1 then reject project

The calculations are a basically straightforward process. The more important and usually more difficult step occurs in the identification, quantification and monetary valuation of specific benefits and costs. This is a challenging task in the context of rural water supply improvements. The benefits of health improvement, a potentially more productive labor force, time and energy saved, and so forth, are not easily quantified and even less amenable to conversion into monetary values (World Bank 1986a, p.2.8.). Statistical information for health improvements, economic growth and other water related impacts are also often incomplete and misleading (White 1978, p.14). Time saved due to improved water supplies remains one of the few factors definitively linked to rural water projects.

The World Bank (1986a) reached similar conclusions concerning time savings resulting from water supply improvements. Their study discusses a benefit-cost model of rural water supply systems. In their analysis, collection time equals the sum of travel time, queue time, and fill time. The actual cost of water is then estimated by multiplying the collection time by the value of water collector's time. As a result of this calculation, the time saved due to an improved water source, representing the benefits of the improved supply, can be expressed in monetary units. These benefits may then be compared directly to the cost of a given supply system such as a handpump, yard tap, or standpipe in the form of NPV or BCR analysis.[5] The costs included in these

calculations are 1) the capital costs of equipment; 2) the costs of operation, maintenance, and repair; and 3) the cost of collection in terms of value of time.

The decision of what value to assign to time is important to the validity of this benefit-cost model. If time is overvalued for a certain water project then the benefits associated with that project are overstated. Similarly, if time is undervalued, projects worthy of financial support may be misjudged as being inefficient in generating net benefits. The average value of time used in the World Bank model appears to have been selected somewhat arbitrarily. They use an average value of time equal to 0.125 dollars per hour for a prototype village. Other time values ($0.05 and $0.25) are also used in the model in order to test the model's sensitivity with respect to changes in the value of time (World Bank 1986b, p.A-23). The selection of a particular time value will clearly affect the outcome of the benefit-cost analysis, yet there are no definitive criteria offered in the explanation of the model as to how this value could accurately be determined in regionally specific situations. The World Bank researchers acknowledge that accurate time values are difficult to ascertain and suggest that when value estimates

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5) These different systems are distinguishable and defined as follows: A handpump is a manually operated system which draws water from a well or shallow aquifer, usually located in an area freely accessible to the public. A yard tap is understood to be located on a family's privately owned property, whereas a standpipe may be located on private or public property, and its water is usually available to the local community.

are unobtainable, the model should be used to determine the least cost system for water supply improvements (World Bank 1986a, p.2.14).

At issue here is the concept of opportunity cost -- the value of an alternative investment (or activity) to which resources could have been applied. The foregone investment represents an opportunity which is lost because an alternative investment was chosen, and a cost is associated with this lost opportunity. A woman, in choosing to collect water, commits her time to that task and is denied other opportunities, such as collecting fuelwood. Whatever value is attributed to fuelwood collection represents an opportunity cost. The difficulty in evaluating opportunity costs lies both in identifying the specific missed opportunities, and in determining the actual value of the highest valued opportunity.

Opportunity costs are closely related to another economic concept known as a shadow price -- the price assigned to a resource, such as time, which reflects the true scarcity value of the resource (Harberger 1976, p.12). In an urban setting the value of a laborer's time is represented by the wage one earns or could earn if employed. Given that the marginal revenue product[6] of labor in the rural sector is typically lower than in urban areas, it would be incorrect to assume that rural laborers should receive the same wage (Gillis et al. 1983, p.139). The shadow price of the rural laborer is often lower than the market price, because rural areas contain a relatively large amount of unemployed and underemployed

labor (Harberger 1976, p.12). For this reason, the rural wage is adjusted to reflect the marginal value of labor. This adjustment has the subsequent effect of lowering project costs thereby increasing the project's NPV and BCR.

Exchange rates may also require adjustments before analysts can make accurate investment decisions. Many developing countries have overvalued exchange rates due to import tariffs, duties and licensing. Overvalued exchange rates discourage exports and encourage imports, because the value of the local currency is overstated relative to foreign currency (Gillis et al. 1983, p.441). Similarly, interest rates may be below the opportunity cost of capital because of government intervention in capital markets or the availability of international development funds (Gillis et al. 1983, p.355). Taken together, overvalued wage rates, overvalued exchange rates and undervalued interest rates will favor capital intensive investments. This may result in the misallocation of valuable resources. Also, labor intensive projects may be more appropriate for many developing countries experiencing employment problems.

Selection of the discount rate also warrants attention. According to Harberger (1976 p.4) "the discount rate used in cost-benefit analysis should reflect the marginal productivity of capital in the economy as a whole." Depending on what

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6) The marginal revenue product is defined as the change in revenue which results from the increase of a single factor input of production, in this case labor, while holding other factors of production constant (Gillis 1983, p.138).

discount rate is chosen for purposes of benefit-cost analysis, the outcome of the analysis will vary. A low discount rate will result in NPV and BCR analyses favoring projects with high initial costs and a long expected project life. This type of cost structure is characteristic of most rural water supply projects. On the other hand, a higher discount rate tends to support projects where the majority of the costs will be incurred in the future (Carruthers and Browne 1977, p.134). In most cases, researchers assume that the marginal productivity of capital is the same in all sectors of the economy; however, when market imperfections exist, rates of marginal productivity will differ from sector to sector. These market imperfections are commonly assumed to be insignificant (Harberger 1976, p.4). The selection of a discount rate for project evaluations may determine whether or not a project receives funding. To the extent that the marginal productivity of capital can be determined within individual sectors, an appropriate discount rate can be determined and applied accordingly.

Benefit-cost analysis is a useful analytical tool but may be limited to more developed areas with extensive economies and markets which are at least close to competitive (Butcher 1967, p.691). Hufschmidt and others (1983 p.5) offer two reasons why researchers should have modest expectations concerning the usefulness of benefit-cost analysis in project evaluations. First, economic valuation relies significantly on the understanding and measurement of the variables associated with a project's potential benefits and costs.

This information is limited in developing countries and even more so in rural regions. Second, existing conceptual and empirical methods for assigning monetary values to nonmarket goods and services are imperfect. In light of these informational and methodological shortcomings, other evaluation techniques should be considered for rural water supply improvements.

2.4.2 Cost Effectiveness Analysis

Cost-effectiveness analysis provides an alternative to benefit-cost analysis in the economic evaluation of rural water supply systems. The cost-effectiveness method involves determining the cost of a water supply improvement relative to some verifiable and quantifiable water project achievement. The achievement, such as an increased quantity of water, is usually expressed as a certain volume of water provided on a per capita basis which is calculated in the following way:

Per Capita Cost / Per Capita Daily Volume of Available Water (2.5)

In general, this is a more simplistic method of evaluation relative to the benefit-cost approach. For this reason, cost-effectiveness analysis is sometimes more appealing, because it involves a more manageable amount of verifiable data. This method is not without its problems though, as it only measures project cost relative to some measure of achievement. The achievement of an increased volume of water, for instance,

conveys only a limited amount of information indicating only improved water availability. The cost-effectiveness approach does not offer a means of interpreting the achievement as an actual economic benefit. The economic benefits do not enter the analysis and can only be extrapolated from previous studies or estimated based on intuition and judgment.

The simplicity and straightforwardness which accounts for the initial appeal of cost-effectiveness are also reasons for its analytical limitations. Cost-effectiveness analysis, like benefit-cost analysis, necessarily involves the use of shadow pricing and discounting and therefore is subject to similar problems of price and rate selection. In spite of these problems and limitations, cost-effectiveness analysis provides basic measurements of improvements and therefore may enhance the decision making process (Carruthers and Brown 1977, p.144).

2.4.3 An Alternative Approach to Water Supply Improvement Evaluations

It is useful to develop alternative methods of evaluating the economic performance of water supply systems, given that there exist certain rural water projects that do not lend themselves to conventional benefit-cost analysis. The cost-effectiveness approach provides one such alternative but typically does not convey information sufficient for investment decisions or comprehensive comparative analysis. This section offers a variation of the cost-effectiveness

approach; one which could prove useful for purposes of project evaluation and comparison.

Throughout this paper, rural water supply improvements have been discussed as an ultimate project goal. It is perhaps more useful to view these improvements in relative terms -- the extent to which a given community's water supply has actually improved. For instance, how many households[7] are served by the improved system? How much more water is available as a result of the supply improvement? To what extent has the water quality improved? How much has collection time been reduced? The answers to all of these questions can be measured directly and are useful in the assessment of project performance. These improvements can be weighed relative to project costs in order to determine a measure of economic performance.

The variables of concern could be determined in the following manner:

Costs -- capital and recurrent costs inclusive of operation, maintenance and repair costs.

Number of Households Served -- number of families served by the improvement.

Quantity Increase -- volume of water available per household before improvement, subtracted from

7) The number of households are used here instead of a general population figure, because the impact on households serves as a suitable substitute for the population at large and provides even more meaningful information in terms of cost calculations. In Kenya, the household is also commonly referred to as a "compound" which may consist of several building structures used for cooking, sleeping or storage. A compound often includes relatives of either the husband's or wifes's extended family.

available after improvement.

Quality Improvement -- ex post *E. coli* levels in drinking water, subtracted from ex ante *E. coli* levels.

Time Saved -- time spent per household collecting water after improvement, subtracted from time spent after improvement.

Once these variables are determined, they could be presented in the following format:

Average per household costs with respect to --

-- average per household volume increase

-- level of quality improvement

-- average per household time saved

Some explanation for the selection of these particular criteria are in order. Households, as opposed to per capita measurements are used to represent the consumer entity primarily for cost purposes. Individual households, or families, will ultimately bear the cost of unsubsidized water supply improvements. The inclusion of children (and other nonincome earners) can cause per capita cost figures to be misleading. The use of increased per household measurements of water volume is also intuitively appealing, because in addition to per capita consumption, water may also be applied to various domestic uses best measured at the household level.

Water quality measurements are frequently omitted from water project evaluations either because adequate testing

facilities are unavailable or water quality levels are known to fluctuate and are therefore inconsistent from one period to another. In response to the need for improved water quality information, portable field testing equipment has recently been developed and successfully operated in developing countries (Pardcn 1986). Also, regardless of (and because of) water quality fluctuations, the monitoring of water quality remains a useful and important evaluation criterion. Unless the evaluation method presented in this section demonstrates a positive measure of quality improvement, the community may have been better off to have relied on its original unimproved source of water.

The measurement of time saved due to an improved water supply concurrently incorporates other criteria as well. It would be redundant and possibly even incorrect to rely on measurements of reduced distance travelled in the water collection process; first, because the distance travelled does not reflect the gradient or roughness of the terrain; and second, even though an improved supply system may be located nearer to a household, the women and children may conceivably spend more time collecting water as it is relatively more abundant and conveniently located than before.

This method of evaluation will not result in a single empirical figure and thus cannot be used as an absolute indicator of a project's performance. The point here is not necessarily to resolve an investment decision directly through quantitative analysis, but rather to provide the most useful information on which appropriate policy and investment

decisions can be based.

Just as any evaluation method will be incomplete and possibly misleading, this new approach also has its shortcomings. According to Hufschmidt and others (1983 p.63), using cost-effectiveness analysis, the economically efficient solution is found by minimizing the cost of attaining the project goals. In this case, the goals are increased water quantity, improved quality and time savings. The problem of multiobjective water resource projects is in determining which project system delivers the best combination of the various objectives.

There are several ways of ranking the various project objectives. One method is termed satisficing. This method requires that the analyst set minimum (or maximum) acceptable values for each objective, such as water quantity and quality guidelines, and use these values as guidelines to determine whether or not a project is acceptable. Another method involves lexicographic ordering, in which the analyst ranks the objectives according to predetermined priorities. For example, increased water quantity may be more important to a community than improved quality. Using lexicography, water quantity would be given a higher priority than quality levels. Once the relative weights of the objectives is determined, the projects can then be evaluated based on the objective values each project demonstrates subject to the ranking constraints (Loucks et al. 1981, pp.210,211).

Both satisficing and lexicographic ordering assign weights to project objectives. This necessarily involves

value judgments and therefore a shift from economic to political analysis. While this alternative approach to project evaluation is not as economically rigorous as conventional benefit-cost analysis, it does address the important aspects of water quantity, quality and availability. The interface of economics and politics is unavoidable in water development planning and policy.

Chapter Three

RURAL WATER DEVELOPMENT IN KENYA: GOALS AND REALITIES

3.1 Introduction

There are two distinct aspects of any development policy: 1) that which is stated and included in government documents such as a five year development plan; and 2) the actual implementation (or lack thereof) of the policy. It is the possibly divergent nature of these two aspects which can cause the failure of an otherwise well intended policy. This chapter examines Kenya's rural water development policies and programs. The first three sections focus on: 1) the availability of water resources in Kenya; 2) the populations currently affected and unaffected by improved water supplies; 3) the national and international institutions related to rural water supply development. These sections provide background information on Kenya's water resources within an institutional framework, leading to a discussion of the stated goals and realities Kenya's rural water development efforts.

3.2 The Availability of Water Resources

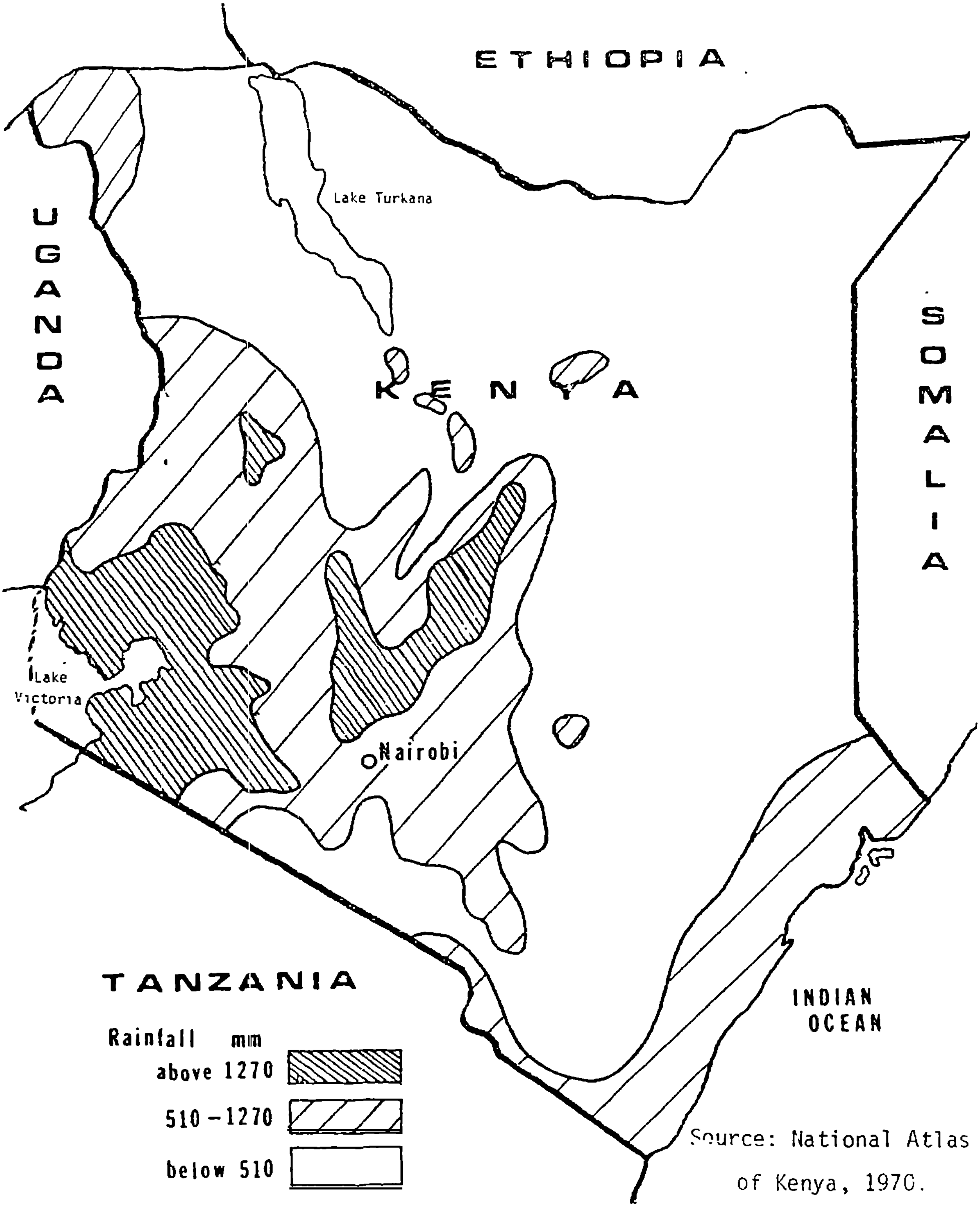
Kenya is a diverse country in its climate, ecosystems and hydrologic characteristics. A visitor's first impressions of Kenya in Nairobi may lead one to believe that the country is well endowed with water resources. Extensive piped water and sewer systems extend to the city limits of Nairobi, and roads and parks are lined with flowering shade trees. Nairobi's

tropical appearance, however, is not representative of the remainder of Kenya's 583,000 square kilometers.

Up to 80 percent of Kenya ranges from semiarid to arid desert conditions (Carruthers 1973, p.4). Groundcover is often sparse and limited to sun-bleached grasses and occasional thorny acacia trees. There are exceptions within this desolate environment. The Aberdare, Mt. Kenya, and Kakamega Forests are examples of more diverse ecosystems. But outside of urban centers and irrigated cropland, the majority of Kenya's landscape is dry and has limited agricultural productivity.

The main reason for the aridity of the land is sporadic and seasonal rainfall. The northern and eastern halves of the country receive average annual rainfall of less than 500 mm. The southwestern quarter is the only region that receives abundant rainfall; averaging up to 2000 mm locally (Dijon 1982, p.3). The extreme range of rainfall measures is partially due to wide variations in altitude (from sea level to 5200 m) and proximity to large lakes such as Lake Victoria. There are distinct rainy seasons in Kenya; the long rains usually occur between April and May and the short rains may fall between October and November (Heederick et al 1984, p.97). (See Figure 3.1 for Average Annual Rainfall Information.) These are only the expected rainy seasons for certain regions in Kenya, and the duration of these seasons is unpredictable. It is also not uncommon for certain regions to be without rain for more than a year.

Figure 3.1 Average Annual Rainfall Map for Kenya



Source: National Atlas of Kenya, 1970.

The arid conditions in Kenya are also related to evaporation rates ranging annually from 2000 to 2800 mm in the northeast and 1800 to 2000 mm in the southwest quarter. When annual evaporation rates are compared to annual rainfall patterns, it becomes clear why Kenya experiences hydrologic cycle deficits. Volcanic soils, located throughout the western and central regions also exhibit high rates of water infiltration in addition to significant evaporation.

There are five major river catchments in Kenya: 1) Lake Victoria, flowing to the Nile and eventually to the Mediterranean Sea; 2) the Athi and the Tana Rivers, flowing to the Indian Ocean; 4) the Rift Valley, containing several lakes including Lake Turkana; and 5) the Ewaso Ng'Iro River, leading to the desolate swamps of the northeast (Dijon 1982, p.2).

Kenya relies heavily on surface water supplies in the form of gravity-fed systems, especially for densely populated cities (Gunnell 1982, p.45). In 1980, 63 percent of Kenya's water supply systems utilized surface sources. Nearly half of these sources were rivers and lakes susceptible to fecal contamination (Dworkin 1980, p.18). Surface water systems are suitable to areas of well protected watersheds where flows are relatively constant and able to create sufficient head for conveyance. Such areas, however, are limited geographically and already used extensively by Kenya's major population centers. It is reasonable therefore to assume that other water sources must be tapped in order to provide for the more

remote and sparsely distributed populations.

Of the water resources available to Kenya, groundwater is the least utilized. Only 17 percent of Kenya's water supply was derived from wells in 1980 (Dworkin 1980, p.18). Groundwater supplies are available in varying degrees throughout Kenya in both confined and unconfined aquifers.[1] In most cases, access to these aquifers comes by way of drilling bore holes ranging in depth from a few meters to over 300 meters. Drilling costs are primarily a function of borehole depth and range from several hundred dollars to almost $100,000 per well (Dijon 1982, p.7). Between 1928 and 1982 approximately 5000 wells were drilled in Kenya, primarily for urban use.

Based on per capita consumption rates of 25-30 liters/day, Dijon (1982) estimates that rural water needs could quantitatively be met through groundwater extraction. This is not technically or economically feasible for all of Kenya, however, because groundwater is not evenly distributed at readily accessible depths. But for areas where easily reached shallow aquifers (down to 80 meters) do exist, their use has been increasingly encouraged by donor groups such as the World Bank, the United Nations Development Programme (UNDP) and the United Nations Children's Fund (UNICEF).

Natural springs provide an additional source of

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1) An unconfined aquifer occurs where underground water completely fills an aquifer and is overlain by a confining bed. In an unconfined aquifer, water only partly fills the aquifer and the surface of the saturated zone is free to rise and fall (Environmental Protection Agency 1985, p.6).

groundwater supplies. Spring protection projects have been established in order to guard against surface source pollution. In some areas of Kenya, groundwater quality of both dug wells and springs is subject to excessive levels of chloride, fluoride and nitrate (Dijon 1982, p.8). Because of their questionable quality and limited geographic distribution, groundwater supplies do not represent the single solution to Kenya's rural water needs. In many cases, though, groundwater handpump systems have proven to be a relatively inexpensive alternative and/or supplementary water supply system (World Bank 1986a, p.9).

3.3 Populations Affected by Water Supply Improvements

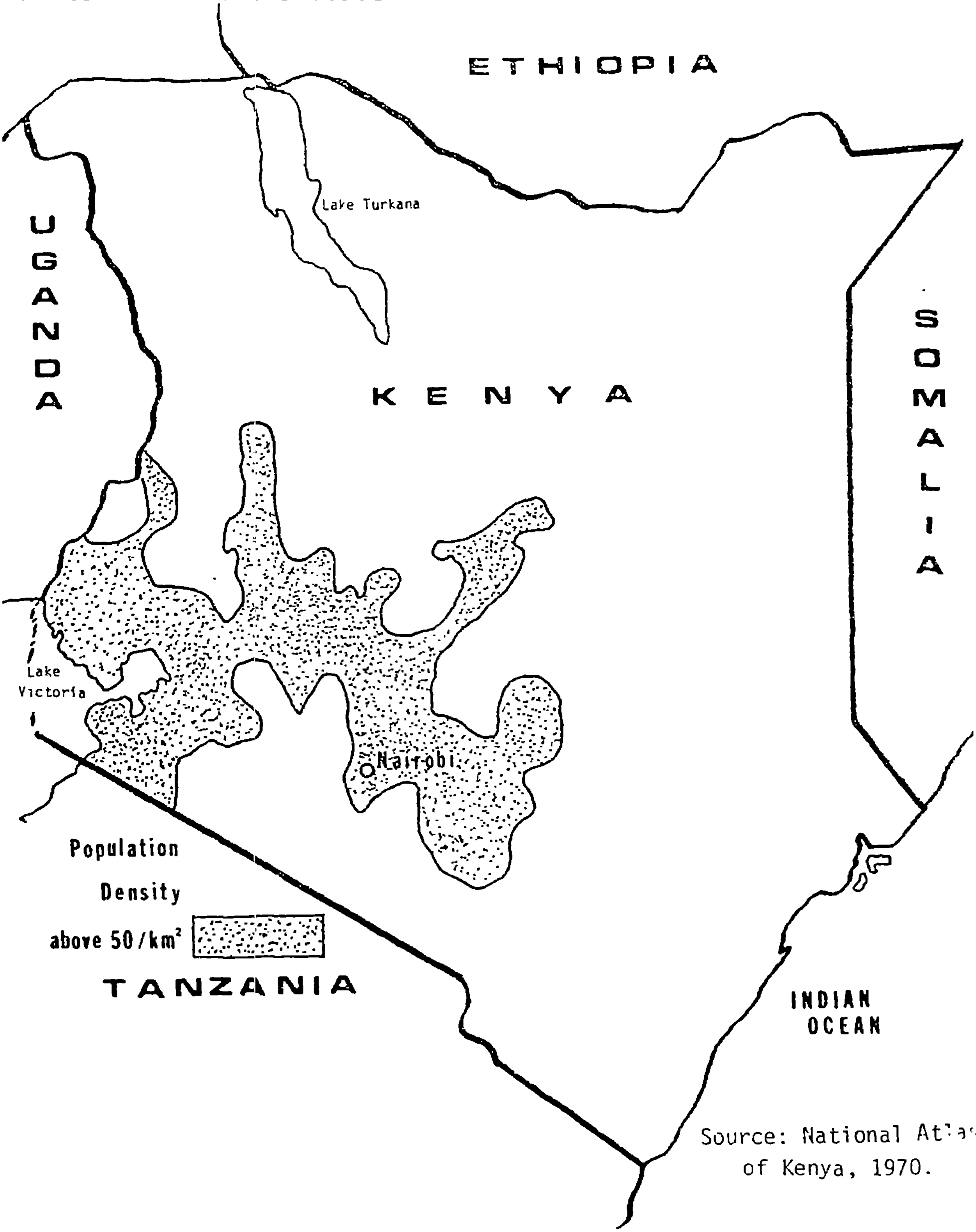
In alliance with the United Nations Water Decade, the Government of Kenya set a goal of supplying everyone in the country with adequate water supplies by the year 2000. This is an ambitious goal considering that population growth rates have usually exceeded the rate of water supply improvements (Dworkin 1980, p.1). Kenya has one of the highest population growth rates in the world, close to 4 percent per annum. Even using a more conservative annual population growth rate of 3.5 percent, Kenya will have an estimated 29 million inhabitants by the end of this century. In order to provide water for all by that time, over 1.3 million more Kenyans must have access to improved water supplies every year between 1980 and 2000. This annual increase is equivalent to the total increase which occurred from 1972 to 1980 (Awori 1982). In 1985 the population was estimated to be 18.9 million, of which 15.9

million (approximately 84 percent) lived in rural areas (FINNIDA 1985, p.1). Of these rural inhabitants, those with access to potable water supplies varied from 4 to 25 percent within different provinces (FINNIDA 1985, p.4).

Rural population densities in Kenya vary depending upon the agricultural potential of the land (Dworkin 1980, p.4). Appropriate maps indicate that there is also a close relationship between rainfall patterns and population densities (Dijon 1977, p.3). (See Figure 3.2 for Most Densely Populated Regions in Kenya and compare with Figure 3.1.) Population distribution information suggests that the surface water sources and arable land are already heavily utilized. Even in the most densely settled rural regions, people live in dispersed communities. The Kenyan government has stressed the use of private metered connections in both rural and urban settings without regard to population density considerations. The emphasis on private connections for dispersed rural communities has required extensive and complex piping systems resulting in high per household costs. Communities which are especially remote, with low agricultural potential, are frequently bypassed or improperly served by water development projects (Dworkin 1980, pp.4,5).

In contrast to rural regions, estimates for Kenya's urban populations served by adequate supply systems are generally high, especially when urban fringe groups are excluded from water service calculations (FINNIDA 1985, p.3).[2] It is evident that the rural populations experience the greatest need for water supply improvements in Kenya. The fact that

Figure 3.2 Most Densely Populated Regions in Kenya



Source: National Atlas of Kenya, 1970.

population growth rates tend to be highest in rural regions (Gillis et al. 1983, p.156) exacerbates current water supply problems. In realizing the predicament faced by most rural inhabitants, the Kenyan Government, along with various international donors, has established programs aimed specifically at improving the water supply situation in the rural sector.

3.4 Institutions Related to Water Supply Improvements

Within the Kenyan Government, the Ministry of Water Development (MWD) is responsible for overall water development, catchment protection and pollution control. The MWD is also the government agency in charge of the operation and maintenance of water supply systems (FINNIDA 1985, p.2). The current activities of the MWD were conducted within the Ministry of Agriculture until 1974, when the MWD was officially designated as a separate agency. Water development planning and operations decisions are made centrally in the MWD's Nairobi headquarters and delegated to its branch offices in each of Kenya's eight provinces (Dworkin 1980, p.2).

There are several other government agencies which work in conjunction with the MWD. The Ministry of Local Government

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2) An urban area is understood here to represent a population growth center with a population of over 50,000 people such as in Nairobi or Mombasa. Estimates for urban water service coverage in Kenya are as high as 100 per cent. While coverage is high, this is an overestimate as there are occasional shortages due to urban population growth and subsequent increases in water demand (FINNIDA 1985, p.3).

works with the MWD in developing sewage and sanitation facilities to improve community health. The Ministry of Local Government also assists in providing financial support for water development and sanitation projects in some of the more major towns. The Ministry of Health is the primary overseer of rural sanitation and health education. In addition, the Ministry of Health plays a supervisory and policing role in the areas of water quality and sewage disposal. Finally, the Ministry of Culture and Social Services supports self-help water projects in rural areas (FINNIDA 1985, p.2).

In addition to governmental agencies, there are numerous international agencies which have been actively involved in Kenya's rural water supply improvement campaign. A list of the more significant internationl donors includes: the World Bank, the United Nations Development Programme (UNDP), the United Nations Children's Fund (UNICEF), the United States Agency for International Development (USAID), the Finnish International Development Agency (FINNIDA), The Norwegian Agency of International Development (NORAD), the Danish International Development Agency (DANIDA), and the Canadian International Development Agency (CIDA).

3.5 Water Development Policies and Programs

3.5.1 Introduction

Since the early 1970's the Kenyan government has actively sought to improve the water supply situation in its rural sector. Initial development efforts were based on the premise

that improved water supplies would provide consumers with a higher cash income, a more reliable subsistence, improved health and increased leisure. Kenya's water development progressed successfully in the urban centers while the rural areas generally have not experienced a marked improvement (Agarwal et al. 1981, p.117). The problems related to inadequate water supplies in the rural sector are not necessarily due to a lack of investment. From 1970 to 1980 over $70 million of Kenya's development funds were invested in rural water supplies alone (Dworkin 1980, p.1). Although increased funding may result in more successful programs, it is also important to examine other aspects of Kenya's water development efforts.

3.5.2 Rural Water Development Policy

At this point in the Decade, it appears that the goal of reaching every household in Kenya with an adequate water supply by the year 2000 will not be met. In spite of the probable delay of this goal, many of the Decade's original questions are still relevant. For instance, if everyone's needs cannot be met at the same time, who should receive first priority?

As originally established, priorities of community water supply improvement were based on need, such that the most needy communities were supposedly most eligible for supply improvements. In practice, however, the poorer communities in Kenya have not been the recipients of water development activities. The reason for this apparent incongruency between

policy and practice has been largely political. In most cases, communities with the most articulate and influential government representatives have received the greatest development attention. Because these communities are often wealthier and better educated, poorer communities generally have been neglected in terms of government support and assistance (Dworkin 1980, p.2).

Even within the self-help projects initiated and financed by the local community, the community depends on the MWD for technical advice on design, construction and operation (Dworkin 1980, p.3). Such assistance is also subject to political influence and therefore biased toward communities best able to gain government attention.

In 1982 water development policy was restated so as to focus on communities demonstrating the greatest need for improved water supplies. This approach is intended to better integrate the community self-help and standard MWD programs and thereby better promote water supply improvements within rural communities (Dworkin 1980, p.4). Whether or not this actually leads to improved water supplies for Kenya's poorest populations is yet to be determined.

3.5.3 Rural Water Development Programs

There are basically two types of water supply improvement programs in Kenya: 1) programs supported by agencies (MWD or otherwise) from outside of the community; and 2) programs primarily supported and financed from within the community (Pineo 1977, p.12). The Rural Water Supply Program (RWSP) is

the major rural investment effort undertaken by the MWD. The RWSP began in 1970 and is broken down into four separate consecutive programs. The first three programs are mutually funded by the governments of Kenya and Sweden. The fourth and most recent program is funded in agreement with the World Bank. All of these programs have been subject to delays, cost overruns, and overstatements of the population served by the improved water systems (Dworkin 1980, p.3).

Each of the four RWSP was scheduled to take only two years. None of the programs met their deadlines, usually with only half of the scheduled systems completed by the deadline date. The most recent program was completed four years behind schedule. In the initial RWS program, actual total costs exceeded planned costs by 95 percent. Cost overruns decreased in subsequent programs but remain problematic (Dworkin 1980, p.5).

The most significant problem involves the limited number of people served by the rural supply programs. In all of its water supply programs, the MWD has emphasized the use of metered private connections. Metered systems allow water pricing to be based on a measurable volume of flow per connection. This is a useful but expensive method of determining water charges. As a means of promoting individual connections, the MWD has restricted the use of communal water points in a number of ways: limiting the number of hours of water availability at these points; not repairing public systems which have broken down; or closing off the water flow to communal points altogether. As a result, the number of

people served by communal systems has been significantly reduced and rural water programs are little more than "highly subsidized methods of bringing water to an elite minority" (Dworkin 1980, p.9). Such results run directly counter to the goal of providing water to all.

At one particular project site, Tetu Thegenge, 125 communal water points had been installed to serve 67,500 people. All of the communal taps were eventually closed. There were, however, 839 private connections which remained open. The total cost of the original project was $1,300,000, which by the end of the project amounted to a cost of about $1,500 per operating connection. The Tetu example is only one of many such cases where water consumers without access to private connections were discriminated against (Dworkin 1980, p.10).

As a result of investments such as the Tetu project, the Kenyan government became more concerned with the cost-effectiveness of its water development projects. The reasons for this concern included: 1) water projects are in competition for funding with other types of development projects; 2) the costs of water projects are increasing faster than project funding; 3) skilled labor is scarce; and 4) increased amounts of funding is required for the operation and maintenance of existing projects (Development Plan 1978, p.193).

A major part of Kenya's water development reorientation has involved an alternative type of program, referred to as self-help projects. The concept of self-help is based on the

Swahili word "harambee" popularized by Kenya's first president Jomo Kenyatta. Translated literally, harambee means "pull together" and is one of the unique features of Kenya's more recent rural water supply programs (Pineo 1977, p.34).

By 1980, 18 percent of all people served by rural water programs were served by harambee projects. These projects range in size from systems serving less than 100 consumers to larger more complex systems providing water to over 100,000 individuals (Pineo 1977, p.35). Self-help programs are planned, financed, constructed, operated and maintained by the local community, and therefore relieve the government of equivalent expenditure of development funds, professional staff effort and ministerial responsibility. As a result, self-help programs have an obvious appeal to the governmental authorities (Pineo 1977, p.12). The apparent autonomy of community based programs is still kept in check, however. Communities must first ask permission from the proper government authorities to construct new supply systems and to receive any technical advice. The possibility of bureaucratic obstacles therefore continue to exist but usually to a lesser extent than with projects under the full jurisdiction of the MWD.

System reliability[3] is a key issue in determining the success of water development projects. In Dworkin's survey (1980, p.12) 80 percent of the respondents served by reliable systems indicated that the system improved health, increased income, beneficially impacted women and children, and "made the community feel progressive". Of the communities with

unreliable systems, only 22 percent of the respondents reported benefits related to their water systems. These are self-evaluations and should therefore be regarded with caution, because these findings are not supported with direct measures of economic activity or health improvement. The survey is useful to the extent there appears to be a significantly different perception of benefits between users of reliable and unreliable systems.

The importance of system reliability and perceived benefits relates back to the two different water development programs available in Kenya. Projects sponsored solely by MWD funding have tended to be overly complex and subject to funding and skilled labor constraints. Water systems are in disrepair due to problems in design, construction, operation and maintenance (Dworkin 1980, p.14), and government projects have typically not matched system technology with the capacity of the MWD to keep the system functioning (Dworkin 1980, p.18). A system's reliability is crucial to the potential benefits it promotes and to its overall level of performance. The MWD projects appear to fall short of desirable levels of reliability.

Self-help projects are not without problems of their own. Dworkin (1980, p.19) found that harambee projects were often poorly designed and installed. But self-help projects do tend to mobilize local funding, labor, support and participation

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3) "The MWD has defined reliable systems as those which do not have repetitive interruptions in service which continue for two days" (Dworkin 1980, p.8).

more effectively than MWD projects. Given sufficient technical advice from government institutions, the self-help projects may prove to be a viable alternative for Kenya's rural water development campaign.

Chapter Four

SUMMARY AND CONCLUDING REMARKS

This study has addressed several issues concerning rural water supply improvements, but perhaps the most important issues have been left for this last chapter. At this stage in Kenya's water development efforts, it is important to consider the next step to take in evaluating rural water supply projects. For example, where would research efforts be best applied at this time for water projects in Kenya and in other less developed countries in general? However, before discussing these additional considerations, it is helpful to briefly review the major points presented in the previous chapters.

4.1 Summary of Major Points

1) In order to reach rural populations with water supply improvements in the near future, investments must specifically target the rural sector and possibly run counter to economically efficient investment criteria. The United Nations Water Decade goal of providing water for all is a socially motivated objective, as contrasted to economically based investment strategies. In order to attain complete population coverage, even within the next several decades, a basic needs or worst first investment approach must take precedence over traditional or growth point investment

strategies. Because the population growth rate in Kenya is greater than the rate of water supply improvements, unless investment priorities are reoriented toward the rural poor, the number of Kenyans not served by adequate water supplies will continue to increase over time.

2) Several of the benefits often associated with improved water supplies are inconclusively linked to water supply improvements alone. In past studies, researchers have assumed that water supply improvements provide both direct and indirect benefits over time. While there is evidence that direct benefits such as time and energy savings do result from improved supplies, indirect benefits such as improved health and increased per capita income are more difficult to demonstrate. Recent findings indicate that water supply improvements are necessary but not sufficient in achieving economic development and health improvement in rural regions.

3) Many of the potential benefits of water development are not readily quantified or converted into monetary values. Once the potential benefits due to water supply improvements are identified, project evaluations often require the benefits to be quantified and assigned a monetary value. The extent to which these measurements can be quantified will determine which evaluation methods are most useful for purposes of economic analysis. Even when water project benefits such as health improvement, a potentially more productive labor force,

and time and energy savings can be identified, these variables are not easily quantified and even less amenable to monetary valuation.

4) Several of the cost variables associated with rural water project analysis must be adjusted relative to their market prices in order to evaluate projects based on the true scarcity values of the resources they utilize. The true scarcity value of resources such as capital and labor are reflected in their opportunity costs. The opportunity cost of a resource is related to its marginal revenue product and may vary between different sectors of the economy. Because of distortions or imperfections in the market, the market price of a resource is adjusted and assigned a shadow price which corresponds more closely to its opportunity cost. Rural development projects often require cost adjustments for items such as foreign exchange rates, interest rates and wage rates.

5) Depending on available information, certain methods of project evaluation are more appropriate than others. Benefit-cost analysis is best suited to situations where project costs and benefits can be identified, quantified and converted to monetary values. Such situations are relatively rare in the rural regions of Kenya, despite numerous studies of its rural water supply projects. Project efficiency and effectiveness can be evaluated using alternative methods such as multiobjective cost-effectiveness analysis which examines

measurable and verifiable project achievements relative to project cost.

6) Kenya faces physical and economic constraints in its rural water development plans. Kenya's physical environment is primarily dry with limited available water resources. The population growth rate in Kenya is one of the highest in the world, making it difficult for water supply improvements to keep pace with population growth. The constraints of limited water resources and a rapidly growing population combined with limited financial resources and skilled labor, provide significant obstacles to Kenya's goal of providing water for all by the year 2000.

7) The results of Kenya's rural water development programs have in many cases been inconsistent with the government's stated policies. The Ministry of Water Development's emphasis on individual water connections has excluded large portions of Kenya's rural communities and resulted in water systems with high per capita costs. Self-help or "harambee" schemes have become increasingly popular with rural communities and the Kenyan government. This favorable reception is due to improved rural water service and a reduced financial burden for the government.

4.2 Implications for Rural Water Development in Kenya

Recent water development records in Kenya indicate that

in order to better meet the water needs of the rural poor, water supply investments must focus more directly on the the rural sector. Nevertheless, even if investment targets are significantly redirected in the near future, the goal of providing potable water for all by the end of the century remains unrealistic. Given the unlikely nature of attaining this original goal, Kenya must reevaluate its water development agenda and determine the most appropriate next step in moving toward the eventual achievement of water for all.

Assuming Kenya continues to pursue the goal of providing improved water supplies for its entire population, water development planning agencies must address the questions related to how this will be carried out. That is, which water supply systems will most effectively and efficiently provide improved water service to the needy rural communities throughout Kenya? There are several water sources and systems from which to choose; however, water sources are geographically limited and not every system is suitable to all rural situations. Each system provides a certain level of improvement and has a corresponding cost associated with it. For instance, project analysts may determine that in order to maximize water related benefits, every hut and household should be equipped with its own piped system; but from a cost perspective, this is not a feasible solution. The question remains as to which system is most economically and technologically appropriate for the various rural communities

in Kenya.

Before improvements can be considered, there is need for baseline data regarding the pre-improvement water situations existing in rural communities. This involves an assessment of existing measures of water quantity, quality, availability and reliability from which necessary improvements can be determined. From an economic perspective, it is also useful to evaluate the demand for water supply improvements in specific rural communities. Currently, empirical measures of consumer demand for water development are extremely limited, and it is difficult to derive demand data for improvements which have not yet reached the communities in question.

While community demand for water supply improvements is difficult to determine, rough estimations or indicators of demand can be generated for rural Kenya by using available information. Self-help water projects have become increasingly popular in Kenya. Other self-help initiatives such as community school and health clinic projects have preceded water development efforts in most rural areas. To the extent that each of these self-help efforts indicate a community's desire to develop and progress, aggregate household contributions toward educational and health facilities could be used to determine a general range of water supply investments which would be technologically appropriate and economically feasible for a given community.

Demand estimation offers an imprecise yet useful tool for evaluating a community's capacity for water development based

on its prior level of development. This assumes that community investment in self-help water projects is positively correlated to these other self-help investments. Communities which have previously invested in other economic development projects would be expected to be willing to support a more costly and technologically advanced system than a community with relatively less exposure to economic development. This approach does not exclude lesser developed communities; it simply offers poorer communities an option of a less expensive and less sophisticated system design.

The result of demand estimation derived from previous self-help projects is not intended to be an actual measure of demand for water supply improvements. It does provide an indication of a project's likelihood of success within a variety of rural communities. Demand estimation offers an increased potential for matching community water needs with an economically and technologically appropriate water supply system. As demand and supply are more closely equated, investments in water supplies will be more effective and funds will be more judiciously allocated toward the provision of sufficient water supplies throughout Kenya.

Determining community water demand for rural water supply improvements is one of many research areas yet unsolved by water development analysts. Further investigation of rural water supplies and more complete information is required in Kenya and most other developing countries before the benefits, costs, demand for and performance of rural water supply

projects are more fully understood.

4.3 Research Needs for Rural Water Development

Information related to improved rural water supplies is generally scarce and costly to acquire in all developing countries. In Kenya, estimating demand for improvements using other self-help project data is one example of utilizing available information to enhance investment decisions. There are other methods of evaluating water supply projects which also may be useful in other developing countries.

Given sufficient information, benefit-cost analysis is a useful means of evaluating development projects. However, at the present time, information required for benefit-cost analysis of rural water supply projects is incomplete, especially regarding the assessment of project benefits. Continued research is needed in order to generate more accurate information concerning the value of the non-market benefits pertaining to water projects. This research will most likely require an extensive period of time in order to conduct meaningful time series analyses for individual projects. For the rural consumer currently without potable water, the time involved in more comprehensive research may mean further delays in receiving safe and adequate water supplies. During the interim period of research on traditional project evaluation methodology, alternative approaches should be investigated and implemented. One possible alternative involves examining cross sectional as

opposed to time series data.

By substituting cross sectional studies for time series analyses, researchers can determine the relationships between water supply variables such as water quantity, quality, availability and reliability and the goals of improved community health and economic development as they currently exist at different project sites. The multiobjective method of cost-effectiveness analysis discussed in Chapter 3 lends itself to this cross sectional approach.

These alternative methods of project evaluation are not meant to displace more traditional methods of evaluation, but rather to add to the otherwise limited supply of knowledge regarding rural water supply improvements. Appropriate investments occur only along with appropriate information. Improved water development information permits better project planning and sharpens the decision making process; but researchers must remember that water development investments, water projects and their appraisals are only intermediate objectives. The ultimate goal remains in meeting the increasing needs of a thirsty world.

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