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Rural Water Supply and Sanitation

Time for a Change

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PREFACE

The International Drinking Water Supply and Sanitation Decade is now more than half over. Although the Decade has had some notable achievements, its original quantitative goals are unlikely to be met. This is particularly true of coverage in rural areas. The number of people in rural areas without adequate water and sanitation services continues to grow and will be larger at the end of the Decade than it was at the beginning. It is not simply a question of inadequate amounts being invested. Past investments have often fallen short of their objectives. In many cases, because of lack of community input and proper maintenance, systems are going out of operation faster than new ones are being built.

This paper examines the sources of past disappointments and outlines an approach for developing more effective solutions. Its conclusions suggest that changes are needed in the way that resources in this sector are allocated and utilized. Too many untested assumptions have been made about both the benefits and costs of these investments. In many countries these assumptions in turn have led to investment programs that are not replicable at the required scale and furthermore are unworkable even at present inadequate levels.

The recommendations and analytic framework set forth here are directed at aiding countries and donor institutions in dealing with these issues. Their task will not be easy. Many constituencies will have to be convinced to alter firmly entrenched viewpoints. Yet the first steps have been taken already. Elements of the approach proposed here are being used now in the design and selection of policies and projects. This paper seeks to carry the process one step further, to help countries and donor agencies work toward their objective of delivering convenient water supply and adequate sanitation to rural populations.

Many people have contributed to the development of this paper. They include Joseph Friedman, A. Saravanapavan, Albert Wright, James Listorti, Constance Paige, Fred Wright, and Edward Quicke. The staff of the World Bank/UNDP Handpumps Project provided invaluable assistance throughout.

Finally, a deep debt of gratitude is owed to the many reviewers and commentators of the earlier drafts. Their suggestions have greatly improved the paper.

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EXECUTIVE SUMMARY

Improvements in rural water supply and sanitation services are priority investments in most developing countries. Few public services have had as much popular appeal among both aid donors and national leaders as has had rural water supply. All parties involved in the International Drinking Water Supply and Sanitation Decade have placed special emphasis on reaching rural populations with improved services. Yet a review of the experience shows that few countries have programs that are replicable on the scale required to reach any significant fraction of the rural population within any reasonable time frame and that many of the services provided to date have been underutilized or abandoned.

This disappointing record, coming after many years of effort and investment, has been discouraging but has led to a renewed interest in, and a greater acceptance of, the need for developing alternative delivery mechanisms. The purpose of this paper is to contribute to this reexamination of the issues and problems.

ISSUES AND PROBLEMS

Can the rural poor pay for services? It has generally been assumed that much of the rural population is too poor to pay for adequate water supply and sanitation services. The available evidence suggests otherwise. Although there are undoubtedly some rural areas in some countries where poverty is so extreme that resources are not available for improving services, this is far from being the general case. A review of the global situation reveals that most rural areas can afford to pay for improved services, provided appropriate technologies and delivery mechanisms are used. People in rural areas already are spending large amounts of time and energy in collecting water; the issue is whether it can be done at a lower cost.

Are there significant health benefits? Most rural water supply and sanitation projects have been justified on the basis of assumed improvements in health. The available evidence suggests that there is a very tenuous link between improvements in health and investments in water supply and sanitation services. The best that can be said is that these services may be necessary, but not sufficient, to achieve any tangible effects on morbidity and mortality. The complex chain through which disease is transmitted does not lend itself to simple interventions. Human behavior and its interaction with the environment are just as important in determining overall health status as availability of clean water. Improvements in health are highly correlated with literacy, level of female education, and income, rather than the level of water and sanitation services. Thus, in practice, human behavior, particularly in low-income rural areas, has overwhelmed any theoretical links between improved services and improved health. Clearly, more analysis is required to determine the cost effectiveness of health-related investments from the point of view purely of health. Fortunately, however, most investments in rural water supply can be justified on grounds other than achieving improvements in health.

To what extent can strengthening of institutions help project performance? The weakness of institutions in this sector is usually singled out as a reason for the difficulty of expanding services. Undoubtedly, institutional weakness is a major issue, but it is not easy to separate this problem from the weakness of virtually all institutions in developing countries. Many of the changes required in this sector will only come as part of the general process of development. But it is important to focus on those steps that can be taken within the limits imposed by existing institutional constraints. A reexamination of this issue is required to see if the institutional constraints can be overcome by changing the way in which business is being done.

To what extent can more appropriate technologies help? There are many examples of overly capital-intensive and complicated technologies being used in situations where their maintenance and operation is beyond the capacity of the state and the local community. The Bank, the United Nations Development Programme (UNDP), and other bilateral donors have conducted extensive research into this issue. Appropriate technologies do exist and are available to be used in developing countries. But countries will not use them unless appropriate incentives are adopted. Extensive subsidies, in particular, have discouraged the development of more efficient and lower-cost options.

TOWARD BETTER SOLUTIONS

To overcome the problems of past efforts and to lay the foundation for accelerated progress in the future, countries and donors need to thoroughly reassess their policies and investment strategies. In doing this, they must take into account many factors, including: what consumers want and what they are prepared to pay for; what the costs are for providing water and sanitation services, given the technology alternatives and site-specific conditions; what the benefits are that accrue to either individuals or society from consumption of these services; and how the options available to decisionmakers compare with one another in terms of their net benefits (benefits minus costs).

Benefits. Determining what consumers are willing to pay for and what the benefits are have generally been the most difficult aspects of developing a benefit-cost analysis. An approach is outlined here that makes it possible to deal much more effectively with these issues than has traditionally been the case. The approach recognizes that the benefits of rural water supply and sanitation projects include, besides the possible health effects, some significant non-health-related effects. In particular, rural water projects lead to a savings for villagers in the time and effort required to get a given quantity of water to their home or workplace.

This time savings is often substantial. For the vast majority of rural dwellers, getting water is still time-consuming and heavy work, taking up 15 percent or more of women's time in some areas. Improvement projects reduce that burden, frequently drastically, by introducing a central well where formerly there was only a water hole outside the village center, or by providing neighborhood standpipes or perhaps even a yard tap outside each house where formerly there was only a single central well. In certain cases, the time savings can be an hour or more per household per day.

If this time-savings effect is adequately allowed for in assessments of the benefits and costs of policy and investment options, it is usually possible to design and prioritize strategies effectively without having to try to estimate the health effect. In the rare instances where information on the health effects is vital to deciding which of several options is best, it still helps to start by examining the time-savings effect and then modify that result only to the extent justified by the health evidence.

A key step in estimating the time-savings effect is the determination of the value to households of the time saved. Saving time has greater or lesser value to a household, depending on what its members can do with the extra time. Regardless of what the members actually would do with the time, a valid measure of its value to them can be inferred from how much they could earn if they used it in income-producing work. This measure should reflect a number of crucial factors:

- It is the time of the women in the household that matters most, since the work of getting water usually falls to them.

- Women in rural areas do not always have access to wage employment. Thus, one cannot simply assume that prevailing wage rates provide a good indicator of the value of the freed-up time.

- Nevertheless, rural women generally do have other ways of adding to their own or the household's income, either through activities that may be characterized as petty trading (for example, making and selling street foods, clothing, or baskets) or through increased labor in agriculture (for example, growing more food in the household's own plots). The increment in income need not be in cash; for instance, it may be in extra food grown and consumed at home.

- In some instances, households currently pay someone to get their water. The amounts they pay can offer additional insights on the value of water-hauling time to rural populations.

A procedure is proposed in the text that can be used to develop appropriate estimates of the value of the time saved for a given project in a given setting, drawing only on information that can be readily obtained on the spot.

It is clear from the available evidence that this time does have a value greater than zero in rural settings. Although the value varies with the circumstances, it probably reflects the rates of women's earnings in petty trading and agricultural work and is less than average wage levels for males.

Costs. The costs of supplying water and sanitation services in rural areas can differ considerably, depending on the technology selected, the environment, maintenance regimens, and other factors. Nevertheless, adequate cost estimates for a particular project can be compiled using a procedure outlined in the text. The procedure requires only a modest degree of on-site data collection and allows one to explore the sensitivity of the results to alternative assumptions about uncertain quantities.

One crucial cost often overlooked in the past is the value of the time that households expend to get water from its source to where it is used. This cost of transporting water manually, literally head-loading, is expensive relative to other cost factors and, even in low-wage economies, can result in high total costs per unit of water consumed.

Comparing Benefits with Costs. When benefits are compared with costs, piped systems demonstrate substantial economies of scale at a surprisingly low level of population size and density. Most of the economies of scale are reached at village sizes of 800 people and above and at densities as low as 80 persons per hectare. The combination of piped water systems with some hauling of water--the standpipe--rarely proves to be the lowest cost alternative.

All of this suggests that there have been considerable underinvestments in water systems in many countries. Governments in many cases have selected low capital cost, point-source systems, the capital costs of which are about one-fourth that of piped systems but which in fact turn out to deliver high-cost water. This would appear to be an important reason for consumers rejecting many systems.

POLICY IMPLICATIONS AND INVESTMENT STRATEGIES

The Policy Framework. The design and implementation of replicable programs for rural water and sanitation require four essential policy elements:

1) Cost Recovery. Without a high level of cost recovery it is unlikely that programs will be either financially or administratively replicable on the scale required to get the job done. The evidence suggests there is both a willingness and ability to pay for improved services in most rural areas.

2) Consumer Participation. Assessing consumer preferences is one of the most neglected aspects of rural water systems and features prominently in the reasons for project failure. Unless consumers participate actively in the selection of service levels and in decisions associated with the how and why of cost recovery, they will not accept ownership.

3) Involvement of Women. As primary providers of water supply, women are also the primary beneficiaries of any improvements. Their role has been all but ignored in the past, but recent attempts at including women in project development, maintenance, and oversight have proven promising and should be extended.

4) Public and Private Supply of Services. In most countries rural water supply is considered a public service and largely the prerogative of a central government monopoly or department. Given the difficulty the central governments of most countries have in providing these services, increasing attention must be focused on alternative supply mechanisms that rely more on community authorities and on the private sector.

Finance and Pricing. Few communities have the capital required for investments in water improvements without recourse to borrowing. Improving this access to funds is an obvious first step toward appropriate financing. One alternative is the creation of a revolving fund at the local or national level. Another is the use of financial intermediaries. Credit institutions exist in various forms in many countries, although with little if any experience in financing these services. The development of such intermediaries does have a number of advantages, including the community ownership of the assets and the encouragement of small private firms providing investment and maintenance services.

An acceptable level of cost recovery will require decisions on what prices to charge to whom and for what services. Although the ultimate decision rests with the local or community decisionmakers, there are a number of helpful guidelines. In order to maximize the economic benefits, it makes sense to charge marginal costs. This may be inadequate in the case of handpumps, where no rationing exists and where placing a charge on incremental use sufficient to cover the financial costs may cause people to return to traditional sources. To avoid this situation, the solution is to charge villagers throughout the village a lump-sum fee not related to consumption that is agreed upon in advance of the project. Communities must be encouraged to explore and develop systems that are acceptable to the local population.

Non-Household Use of Water. Improving access to water in rural areas can be expected to lead to its greater use in other productive activities, agriculture being an obvious example. In such cases, the benefits may be understated by not taking into account possible increases in agricultural output. This has implications on the cost side as well; if a significant amount of the water is to be used for agricultural purposes, then the design of the system will have to provide for these circumstances, and increases in capacity may be justified. Estimating these effects on demand and supply will require observation and quantification of the effects of improved water on agricultural production in those villages with existing projects. Increased use for nonhousehold purposes may introduce increased costs as well, such as, for example, the keeping of larger cattle herds that cannot be sustained because of insufficient grazing lands.

Institutional Development. Most institutions working in this sector are weak because of the weakness of the policy framework--that is, an overreliance on the central government to the virtual exclusion of local government and the private sector. Given a more supportive policy framework, what would be the role and structure of the institutions within it? It is doubtful that a case can be made for a specialized institution, given the scattered nature of the rural population. Rather, using existing private and public institutions with established rural networks is probably the best route. The issue is the extent to which such institutions require specialized expertise to evaluate the technical and economic feasibility of proposals they receive. There is, however, no one answer to this question.

Promoting a vigorous private sector to complement the work of public agencies is one of the more important institutional objectives. In the past, private companies have not had the incentive to develop water supply and sanitation services because central governments for the most part have been entrusted with providing them. Reversing this trend will be difficult, but not impossible. Financial assistance to small firms, either through equity or loan capital, may be required, together with training and technical assistance. If communities choose the alternative of utilizing some kind of cooperative structure, that, too, will require considerable financial, training, and technical support. Institutions providing information and governance need considerable strengthening as well. Information on hydrology, geology, rainfall, and so on is seriously lacking in all countries. Record keeping is poor or nonexistent.

Sanitation. Investments in sanitation services do not appear to be of high priority to most rural dwellers. The public sector through education and other means can have some limited effect on this demand but should limit its direct investment to high-priority urban areas where there is likely to be a higher payoff in terms of improvements in the environment.

Training and Technical Assistance. It is important that training and technical assistance programs be designed within a framework that requires the maximum use of incentives and a minimum of administrative rules. The spreading of the knowledge of appropriate technologies, workable policy frameworks, and streamlined regulatory systems should have high priority. The World Bank, the UNDP, and bilateral donors are providing such assistance through an international training network.

Research and Development. Further research is required to expand the knowledge of economic, social, institutional, and technological issues related to improving the delivery of water and sanitation services in rural areas. In particular, better estimates of the factors determining the demand for services would be of great assistance in designing better projects. A better understanding of the complex interrelationships between water, sanitation, and health services could improve the cost effectiveness of delivering these services.

A ROLE FOR THE BANK

Limited resources and competing priorities preclude the Bank from coming close to the level of investment required to deliver water and sanitation services to the rural population. The Bank can still play, however, an important role in assisting countries to use available resources more efficiently by redefining objectives and by developing acceptable and workable strategies.

The Bank should be active only in those countries that are prepared to work toward the development of replicable programs. This is likely to be a difficult process, requiring staff-intensive effort over a prolonged period of time. One-shot projects that provide for a few handpumps per village cannot realistically be expected to achieve the type of institutional and policy adjustments needed to operate more efficiently in the sector.

In addition to working with the borrowing countries, the Bank will have to engage in an intensive dialogue with other investors, particularly the bilateral agencies. As long as these institutions are prepared to provide funds without requiring an appropriate policy framework, it will be difficult for the Bank to provide any support in this sector.

The following recommendations should guide Bank policy:

1) The Bank should move away from the direct financing of rural water supply systems constructed by central

government departments and instead focus on the use of financial intermediaries. Commercial banks, for example, could provide loan funds to communities, and small, local investment firms could perform activities such as brokering the loans, operating and maintaining the services, and collecting the fees.

2) Consideration needs to be given to the financing of small and medium-size, locally based enterprises that would be able to construct and maintain rural water systems.

3) The cornerstone of any Bank involvement in this sector should be a goal of full cost recovery in its rural water and sanitation projects. In order to achieve this goal, the Bank should be prepared to accept some continuing level of subsidy in the short run in order to introduce the structural and policy reforms that would achieve higher levels of cost recovery over the longer term.

4) The benefit-cost framework developed in this paper should be tested and developed further.

5) Efforts should be made to estimate the time and labor savings from the investment, and only when these are sufficient should projects be undertaken.

6) Benefits from improved health should be noted where possible, but they should not be relied on as the primary means of justifying projects.

7) Bank financing of rural water and sanitation services in the form of subcomponents of rural development projects should be continued only in those cases where there exists an adequate policy framework of the sort suggested in this paper or when the project can assist in the development of such a framework.

8) Encouragement should be given to efforts that attempt to shift the demand for sanitation services through general educational programs and those directed at specific behavioral practices affecting health and hygiene.

9) High priority needs to be given to research on demand estimation and improved methods for benefit-cost analysis of water supply and sanitation projects.

10) To complement the Bank's considerable investment in research in engineering and technological issues, additional work should be done on low-cost distribution systems, the development of lower-cost drilling techniques, and the use of alternative energy resources.

I. THE SCOPE OF THE PROBLEM

Rural populations throughout the developing world continue to be without adequate access to safe, convenient water and appropriate sanitation facilities. In an effort to improve conditions, governments and international agencies have invested billions of dollars in recent years, with particular emphasis during the current International Drinking Water Supply and Sanitation Decade (1981-1990). Although considerable advances have been made, the results overall have met the expectations neither of rural dwellers nor of investors. More and more countries and aid institutions are concluding that something must be done to accelerate progress in the future.

To achieve that goal, this paper argues that a fundamental reorientation of policies and investment strategies is needed. It proposes an approach aimed at helping rural dwellers, governments, and donor agencies attain their water supply and sanitation objectives sooner and more effectively and efficiently than would be possible if past approaches were continued.

The findings and conclusions are based on an extensive review of investment project reports, the published literature, and discussions with water and sanitation experts at the World Bank and elsewhere. The investment projects examined cover a range of water supply systems, excreta disposal facilities, and some related health education programs. Financing for these projects came from the World Bank, the U.S. Agency for International Development, the Inter-American Development Bank, other multilateral and bilateral agencies, and the developing countries themselves.

This chapter first describes the context within which the concern about present strategies has emerged. It then points out--and challenges--some common assumptions underlying current approaches.

FALTERING PROGRESS

In 1985, an estimated 65 percent of the rural population in the developing world was without access to a safe and convenient source of water. An estimated 75 percent had no satisfactory means of excreta waste disposal. This was true despite the fact that over US$10 billion have been invested in rural water supply and sanitation projects in recent decades.

Much of that sum has been contributed by the governments of developing countries themselves. World Health Organization figures show that during 1971-75 alone, the developing countries, excluding China, invested an estimated US$3 billion per year (in 1973 dollars) in water supply and sanitation. By 1979, that amount was over US$6 billion per year (in 1979 dollars), of which external assistance amounted to a little less than 10 percent.[1]

The World Bank began lending in the water sector in 1961 but did not begin activities in rural areas until the early 1970s. Until 1974, Bank lending amounted to less than US$1 million a year, mostly in small components in agriculture, rural development, and water supply projects. By 1979, the cumulative figure had reached nearly US$180 million. Through 1984, the Bank's first ten years of rural water supply and sanitation lending had totalled nearly US$530 million.[2] (See Table 4.1)

Although representing an impressive effort, these substantial investments had little effect on the millions of people needing assistance. In the late 1970s, as governments, bilateral and multilateral institutions, and the non-government organizations tallied the results of two decades of investment, they began to recognize that most programs had fallen far short of their intended objectives. In-depth studies in Latin America revealed that the problems encountered there some fifty years ago--typical today throughout the Third World--had not been overcome, despite a considerably longer involvement in rural water supply and sanitation investments in Latin America than in the other regions. In all regions, rural water supply and sanitation investments have often failed to provide affordable, acceptable services or to deliver all of the expected health benefits to a population that remains by and large poor and in fragile health.

The problems in producing results were stubborn and varied. In one country, only three-quarters of the 29.3 million cubic meter production capacity of a rural water system were recently being used, with only two-thirds of the population that had been scheduled for service getting it and half of them receiving water only three or fewer days per week. In another country, where the central authorities decided to serve a particular area with a communal diesel-pumped system, the villagers would not use the system or pay for the fuel to operate the pumps. They preferred the taste of the water from their usual source at a more convenient location. In yet another country, as many as 80 percent of the handpumps were not functioning at any one time, since no provision had been made for maintenance or repair. When the pumps broke down, the villagers returned to their traditional--and unhealthy--water sources. In still another country, authorities

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1/ United Nations General Assembly, "Development and International Economic Cooperation; International Drinking Water Supply and Sanitation Decade: Present Situation and Prospects" (New York, September 18, 1980).

2/ U.S. General Accounting Office, "U.S. Strategy Needed for Water Supply Assistance to Developing Countries" (Washington, D.C., August 25, 1981).

installed some 2000 latrines in rural villages at no cost to the users. Two years later, project personnel discovered that most of the households were using the latrines as storage closets.

India is a good example of how heroic efforts still could not meet the need. In 1981 the government adopted a master plan for the Decade, with the target of delivering safe water to 75 percent and sanitation facilities to 25 percent of the population in rural areas. At the end of the first four years of the Decade the coverage of the rural population for water nearly doubled from 31 to 56 percent but still fell far short of the goal, and the coverage for sanitation remained at less than one percent.[3/]

In country after country systems are going out of operation almost as fast as they are being built. Such failures make the international aid community understandably wary about continuing to lend money for programs that not only have little to recommend them in terms of returns for the dollar, but also simply do not work.

Even projects deemed successful have not been replicable on the scale required to reach any significant part of the rural population. The rural poor throughout the developing world are still spending large amounts of their labor to obtain inadequate supplies of water. In regions such as rural Africa, where increases in agricultural productivity are key to economic development targets, the consequences of a continued erosion of the productive potential of the people are especially severe.

Meanwhile, continued rapid population growth exacerbates the challenges. Despite high rates of rural-to-urban migration throughout the developing world, its rural population is estimated conservatively to be increasing at an average 1.3 percent per annum, adding some 30 to 35 million new rural inhabitants each year who require arable land and supporting services--including water and sanitation facilities. In the case of Africa, even more rapid rates of population growth make the task ahead all the more difficult. In Nigeria, which currently accounts for approximately 22 percent of the sub-Saharan population, the rural population is expected to increase at about 2.6 percent per annum, which could add 35 to 40 million more people by the year 2000. Today, an estimated 55 million rural dwellers in Nigeria lack a safe water supply and adequate excreta disposal facilities, and that figure could rise to 81 million and 91 million respectively unless a major breakthrough is

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3/ Government of India Ministry of Urban Development, Proceedings of Mid Term Review of Water Decade Programme: Conference of Secretaries, Chief Engineers and Heads of Implementing Agencies in Charge of Water Supply and Sanitation (New Delhi, October 16-17, 1985), p. 18.

made in project coverage. In Kenya, in 1980, about 95 percent of its 14 million rural dwellers were without access to safe water supplies; growing at an estimated high rate of 3 to 4 percent per annum, this number could nearly double by the year 2000. By the end of the International Drinking Water and Sanitation Decade (1990), it is estimated that some two billion or more people will lack adequate water supply and sanitation services--this including the backlog of the millions slated for improvement but as yet to be served as of this date midway into the Decade. (See Table 1.1)

Table 1.1

RURAL WATER SUPPLY AND SANITATION AT A GLANCE

Just exactly how many people are receiving what services in the rural areas is difficult to estimate. There are no common definitions, for example, of what constitutes "adequate" services or what is meant by "access" to services. Few countries keep up-to-date information on what is happening in their rural areas. The figures in Table 1.1, drawn from a sample of fifteen countries representing about 50 percent of the rural populations of the world, should be seen more as illustrative of the situation than as "hard" facts. Several trends should be noted. With the exception of a few African economies, average rural incomes are or will be in the near future at levels above US$250 per capita per year—an income level where piped water systems tend to become affordable. Also with the exception of Africa, rural population growth rates are beginning to take a downturn. Access to electricity that dramatically lowers water costs, again with the exception of Africa, is increasing rapidly in most of the world (for example, in India it is estimated that nearly 80 percent of the rural population will have access to electricity by the year 2000). There are no reasonable figures on "access" to "adequate" sanitary services.

TABLE 1.1

RURAL WATER SUPPLY AND SANITATION AT A GLANCE

Region / Country	Rural/Population 1980 (millions) a/	Rural/Population 2000 (millions) a/	Net Rural Growth Rate b/ %	1980 Access to Elec. *c/ %	1980 Access to Safe Water %	Est. Per capita Rural GNP 1980 US$	Est. Per capita Rural GNP 2000e/ US$
East Africa							
Kenya	14.4	28.4	+3.4	6*	4	400	700
Malawi	5.4	9.2	+2.7	-	29	200	200
Ethiopia	27.4	41.9	+2.0	9*	2	100	100
West Africa							
Nigeria	64.1	107.9	+2.6	7*	25	300	600
Burkina Faso	5.7	9.2	+2.3	3	23	200	200
Mediterranean							
Egypt	22.8	29.5	+1.7	23	50	600	1,100
Tunisia	3.0	3.1	+0.2	31	25	1,300	2,300
Latin America							
Brazil	39.4	31.1	-1.3	43	57	2,000	3,800
Mexico	23.1	24.7	+0.4	3.4	51	2,000	3,600
East Asia & Pacific							
Philippines	30.3	38.1	+1.1	-	33	500	1,000
China	799.1	922.0	+0.7	50	NA	200	300
Indonesia	117.4	129.9	+0.5	8	18	400	600
South Asia							
India	527.5	632.4	+0.9	14*	20	200	400
Bangladesh	79.0	119.2	+1.8	-	55	100	300
Pakistan	62.7	88.6	+1.8	33	17	300	600

* indicates estimate for both urban and rural areas

Sources:

a/ UN Estimates and Projections of Urban, Rural and City Populations, 1982 assessment, UN Population Division.
b/ Ibid.
c/ IBRD, Energy Department, July 1984.
d/ IBRD, Social Indicators Data sheet, June 1984
e/ IBRD, Water Supply and Urban Development Department, July 1984; GNP estimates are based on best available data and are designed primarily to give an order of magnitude for comparisons among regions.

ASSUMPTIONS OUT OF STEP WITH REALITY

Water supply and sanitation strategies typically have been based in the past on several conventional assumptions that relate to:

- the ability and willingness of rural households to pay for services;
- the health effects of service improvements;
- the appropriate roles for the public and private sectors and for community groups in relation to higher-level governmental agencies;
- the extent to which institutional strengthening can solve the problems observed in past projects; and
- the extent to which better technology choices can avert such problems.

The conventional assumptions on these points have proven in many cases to be faulty. As a result, the conceptual basis for current strategies has often been unrealistic, a fact that has contributed to faltering progress. These assumptions and their effects are examined next.

Are the rural poor able and willing to pay for water supply and sanitation improvements? Although data on rural incomes and, hence, ability to pay are scarce, few disagree that rural populations are much poorer than their urban counterparts and that rural incomes are denominated often not in cash but in kind. On these grounds, along with assertions about health benefits, it has commonly been argued that water supply or sanitation services should be made available to rural populations at little or no charge. Often little consideration is given to collecting data on the subject. As Saunders and Warford note, "the general lack of any hard evidence on ability (and willingness) to pay has resulted in the politically expedient assumption, which has been made in most developing countries, that the rural population cannot pay the full cost of water".4/

In fact, though, rural households have much more demonstrated ability to pay than is generally recognized. Two considerations must be addressed on this question of ability to pay: (i) Do rural households have enough income (or resources) overall to be able to contribute toward covering the costs of water supply and sanitation services, and (ii) Is a large enough fraction of their income (or resources) available

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4/ Robert J. Saunders and Jeremy J. Warford, Village Water Supply: Economics and Policy in the Developing World, (Baltimore and New York: The Johns Hopkins University Press, 1976), p. 190.

in a form that can be accepted in payment (for example, cash, or labor and materials for constructing and maintaining service improvements)?

Even very poor households--at, say, US$150 per capita annually--have some resources, in particular, their own time. And a small portion of those resources can almost always be devoted to water supply and sanitation services without forcing the household below subsistence minimums in its consumption of other essentials, such as food. If a household's only contribution is labor, that can still cover a significant share of the costs of construction and maintenance.

Self-help construction is the preferred method in many countries to reduce costs and fees and in some cases justify a higher level of service than would otherwise be possible, as this study concluded:

> "The main value of this type of participation [the contribution of voluntary labor] is that, when well-organized, it has sometimes led to considerable savings in capital cost, particularly in gravity schemes. In areas with communal facilities, these cost savings have reverted to the agency or led to the provision of an extra tap or facility for the users. In areas with house connections, contributions in kind have reduced the connection cost so that at the time of installation more households could participate in the project."[5/]

On the issue of how much of total household income is in cash or some other form acceptable for payment, recent data suggest that cash is far more prevalent in rural villages than is often recognized. A household survey conducted in one of the least-developed and most remote areas of Mali provided evidence that rural dwellers have considerable sources of cash income from nonagricultural activities; the percentage of total income from cash-earning activities ranged from 43 percent to as high as 50 percent. Furthermore, high expenditures absolutely and proportionately on social activities (community projects, celebrations, gifts) and durables and loans to others provided a strong indicator of ability to pay at least some amount toward water supply improvements; these expenditures ranged from 28 percent to 45 percent of total

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5/ Christine van Wijk-Sijbesma, Participation of Women in Water Supply and Sanitation: roles and realities, Technical Paper 22 (The Hague: International Reference Center for Community Water Supply and Sanitation, 1985), p.4.

household income in the areas surveyed.[6/] In other countries, too, cash or a barter equivalent is frequently available. The village producing only for subsistence has become virtually a vanishing breed. Valued consumer items such as radios and motorbikes are no longer rare sights even in remote areas.

Thus, there is generally ability to pay, but is there also willingness to pay? On this point, the situation for water supply appears to be different from that for sanitation. Although villages in a few rural areas are so poor that they cannot contribute to improvements, rural populations in a wide range of circumstances clearly are willing to contribute substantially toward covering the costs of water service improvements. In several projects in Kenya, the labor, materials, and monthly fees that villagers have contributed have helped finance construction, operation and maintenance.[7/] In Bangladesh, communities now finance the sinking cost of their manually-constructed tubewells, which amounts to about 10 to 15 percent of the total cost of the project; despite their being very poor, rural dwellers find the money, employ the contractor, get the work done, finance it, pay the operating costs, and guard their investment jealously.[8/] In Thailand, planners discovered the hard way what can happen if they underestimate willingness to pay:

> "The Thai piped water project, with 250 systems serving 600 communities, had been a failure when it supplied water only through communal taps. By 1972, three years after the completion of the project, only one-quarter of the systems were working. In 1979, at the time of the evaluation over 80 percent of these systems were operating and self-sufficient. The change resulted from the conversion from communal facilities to individual metered connections. The private connections provided

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6/ Nancy Birdsall, Francoise Orivel (Consultant), Martha Ainsworth, and Punham Chuhan, "Three studies on Cost Recovery in Social Sector Projects," CPD (Country Policy Department) Discussion Paper No. 1983-88 (Washington, D.C.: World Bank)

7/ U.S. Agency for International Development, Kenya Rural Water Supply: Programs, Progress, Prospects, AID Project Impact Evaluation Report No. 5, (Washington, D.C., June 1980).

8/ Gabriel Roth, "The Role of the Private Sector in Providing Water in Developing Countries," Natural Resources Forum, Vol. 9, no. 3 (1985), p. 172.

> more convenient sources of supply than had the water from existing community shallow wells."[9]

Willingness to contribute resources also is demonstrated in many other countries, including China, Paraguay, Nepal, Zimbabwe, Mali, Tanzania, and Sudan.[10]

Moreover, even in areas where there is no organized mobilization of local resources currently, rural dwellers are "paying" for water in another way. The time and effort it takes them to get water from waterholes or wells to where they want to use it is a cost to them. As elaborated in the next chapter, this cost can be relatively large, even in rural areas where opportunities for using extra time in income-producing activities are limited. For example, the time cost can easily exceed the equivalent of, say, $0.30 per cubic meter--which is the cost that residents of Washington, D.C., pay for water. The fact is that rural populations would not devote as much time as they do to getting water, when for subsistence they could get by with less water, if they were unwilling or only marginally willing to commit resources to the task.

Rural populations appear to be much less willing to pay for sanitation improvements than they are for water. The importance that people attach to safe waste disposal derives in part from a desire for (i) privacy when defecating and urinating, (ii) convenience (not having to travel far), and (iii) a more pleasant home environment (by eliminating disagreeable smells and unsightly areas). In sparsely populated rural locales, individuals can often satisfy these objectives without investing in new facilities; traditional solutions--for example, use of a nearby field--suffice. Thus, where population density is low, one would not expect to find a high degree of willingness to pay for sanitation improvements. Where density is higher, new systems can be introduced with good results, as in the case of improved latrines in rural Zimbabwe and pour-flush toilets in peri-urban and urban areas of India and Pakistan. Yet there are few documented instances in any rural or semi-rural areas where households have been willing to pay a major share of the costs of sanitation improvements on a sustained basis.

9/ U.S. Agency for International Development, Community Water Supply in Developing Countries: Lessons from Experience, AID Program Impact Evaluation Report No. 7 (Washington, D.C., September 1982), p. 17.

10/ Eleanor Hewitt, "Cost Recovery: Water Supply and Sanitation," in draft (Washington, D.C.: World Bank).

Do rural water supply and sanitation projects have significant health benefits? The declaration of the International Drinking Water Supply and Sanitation Decade and the formulation of current rural water supply and sanitation strategies are predicated on the assumption that use of improved facilities will lead to substantial improvements in health. However, efforts to demonstrate that projects and policies indeed do have health benefits have not always succeeded, for several reasons.

Part of the problem is that the diseases in question are transmitted in a variety of different ways. Some diseases affected by water supply and excreta disposal, such as typhoid and cholera, are often "water-borne," a term used to refer to the fact that they depend primarily on the bacteriological quality of the drinking water supply. Other diseases, such as schigellosis and trachoma, are usually "water-washed," meaning that they depend mainly on the quantity of water used for personal hygiene. Still other diseases, such as schistosomiasis, are "water-based," meaning that they require direct contact between people and the infected water source. Another category of diseases, such as sleeping sickness and river blindness, depends on vectors that breed in or near water sources. Also, in some places, the presence of minerals or other natural contaminants may cause health problems. In parts of India and China, for example, high levels of fluorides in the water result in serious physical deformities.11/

A second difficulty in evaluating the effects of water supply and sanitation on health is that it is difficult to separate these effects from those of the numerous other factors that contribute to the spread of diseases, such as poor personal hygiene or contamination during transportation of water or preparation of food.

This perspective on disease transmission suggests that intervening at only one part of the transmission cycle will have relatively little effect on health. It comes as no surprise, then, that introducing clean water--without taking any other steps to alter the environment within which it is used--has often had little effect on health, as this conclusion from a study in Lesotho indicates:

> "...no measurable reduction in water-related disease has resulted so far from [improving] village water supplies. It is possible that benefits might result were other health measures to be implemented together with water supply improvements. But we suspect that they would in that case result in the first instance from

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11/ G.F. White, D.J. Bradley, and A.U. White, Drawers of Water (Chicago: University of Chicago Press, 1972); also Staff Appraisal Reports (Washington, D.C.: World Bank, 1984).

those other measures, rather than any improvements to the water supply."[12]

Indeed, health projects have yielded better results when they included more than just a single intervention. A study comparing the decrease in mortality in Sri Lanka and Guatemala, for example, shows that health improvements were related to the combined effects of general advances in the standard of living, greater literacy, and a mix of health services rather than to just a specific health-related intervention, in this case malaria control.[13]

This complexity notwithstanding, a recently completed, careful literature review by the Diarrheal Diseases Control Program of the World Health Organization shows that there are some demonstrable reductions in morbidity and mortality due to diarrhea as a result of the use of improved water supply and sanitation facilities.[14] But these effects are substantially lower than the predictions that are used to justify investments in such facilities.

Ten years ago the World Bank convened an Expert Panel to advise the Bank of whether it was possible to assess the health effects of water and sanitation projects. The Panel concluded that "long-term longitudinal studies of large size and expense are probably the only means through which there is any chance of isolating a specific quantitative relationship between water supply and health"[15] and advised the Bank not to undertake such studies.

12/ Overseas Development Administration, Manual for the Appraisal of Rural Water Supplies (1985), p. 89.

13/ S.A. Meegama, "Malaria Eradication and its Effects on Mortality Levels," Population Studies, vol. 21, no. 3, (November 1967), p. 237.

14/ S.A. Esrev, R.G. Feachem, and J.M. Hughes, "Interventions for the control of diarrhoeal diseases among young children: Improving water supplies and excreta disposal facilities," Bulletin of the World Health Organization, 63 (4), (1985), pp. 757-772.

15/ World Bank, "Measurement of the health benefits of investments in water supply," Report of an expert panel, Report PUN 20 (Washington, D.C., 1976).

Recent developments suggest that, alternatively, the case-control method offers some promise as a rapid, inexpensive, yet valid method for assessing the effect of water supply and sanitation improvements on diarrheal disease. This method proceeds not from cause to effect but from effect to cause. For example, in a community with unimproved and improved water sources, individuals who report to the clinic with a given water-related disease (the cases) may be compared with other clinic patients (the controls) with respect to use of unimproved or improved water. From that comparison a ratio can be developed to estimate the relative risk of contracting the water-related disease for a user of the unimproved water. The advantages of this method over others are that the sample sizes are smaller, the sensitivity of the disease measures are likely to be greater, and the procedure requires data collection only once.[16/]

As pointed out by the proponents of this approach, however, it would be only under a special set of circumstances that it would be appropriate to undertake an evaluation of the likely health effect of improvements in water supply and sanitation facilities.[17/] Specifically, such evaluations would be appropriate only when, after an assessment of the direct economic benefits (see Chapter II), there was uncertainty as to whether a project should be undertaken or what level of service should be provided and when the setting was such that it was considered likely that the improvements would result in a substantial health improvement.

The difficulties in disentangling the effect of water and sanitation projects on health from everything else that is happening suggests that benefits from these projects may not be as large or as obvious as many have thought. If the benefits were large, they would stand out and not require complicated and difficult studies even to discern their existence. This is not to say that health benefits do not exist or in some circumstances might not be substantial, but that considerable caution should be applied in using them as the sole criteria in justifying investments.

16/ J. Briscoe, R.G. Feachem, and M.M. Rahaman, Measuring the Impact of Water Supply and Sanitation Facilities on Diarrhoea Morbidity: Prospects for Case-Control Methods, WHO/CWS/85.3 CDD/OPR/85.1 (Geneva: World Health Organization, 1985).

17/ J. Briscoe, R.G. Feachem, and M.M. Rahaman, Evaluating Health Impacts: Water Supply, Sanitation and Hygiene Education (Ottawa: International Development Research Centre, 1986).

Can the public sector provide adequate rural water supply and sanitation service? Central governments in the developing world traditionally have played a major role among the providers of rural water supply and sanitation services. The private sector has not had the opportunity to develop and market these services, and local authorities and village groups have not been encouraged to undertake the responsibility. With the exception of only a few countries, central governments have thus functioned as monopoly providers. This appeared to be the best way to reach the largest number of people, and international aid institutions for the most part have not interfered.

The conventional wisdom has been that only a large provider like a central government has the capacity to realize the economies of scale inherent in water systems. But this presumption is based on experience with urban water systems, and most rural systems do not exhibit the same economies of scale. Moreover, in those places where central governments do function as monopoly providers, they can be high-cost suppliers responsible for considerable diseconomies of scale.

Public monopolies, in fact, have often been inefficient. Many programs rooted in high levels of public subsidy tend to breed excessive administrative costs and overstaffing. Moreover, where public employees are paid at less than the market wage, there is the temptation for them to work less diligently than those in the private sector, and it is more difficult to prevent graft and other forms of corruption. Although this certainly does not affect every country, it is a problem for some.

Another problem associated with the dominance of the central government is an ignorance of, or lack of exposure to, consumer preferences--leading to little or no community participation in a project. When rural communities contribute little or nothing of their funds, time, or other resources to a project, it is not theirs. Their sense of ownership in the whole undertaking and interest in maintaining the system in operational condition are likely to be limited. Inadequate provision for community involvement frequently leads to systems poorly matched to users' desires and ultimately to underused or abandoned facilities, as this U.S. Agency for International Development (AID) report states:

> "The evidence shows that when communities value a system, the system tends to be successful. Systems that were

built to fulfill AID's perceived need to provide only better quality water were not valued and did not survive."[18/]

A study of water supply improvements in Mexico, for example, evaluating 94 projects with, and 43 projects without, community participation found that 71 percent of the systems with participation were still functioning at the time of the survey as compared to only 51 percent without participation.[19/]

Neglecting community needs has also meant ignoring the traditional role of women in water supply and the importance of involving them in improvements. In most developing countries women have far more responsibility than men for water and sanitation. In Africa, Asia, and Latin America women traditionally decide where to collect water, how much, and how to use it, and many women, particularly the poor, spend a substantial part of their day in the tedious task of hauling water. They typically receive help from children--girls more than boys--whose long hours at these chores often limit their attendance at school. Women also generally maintain, or supervise maintenance of, sanitation facilities. Because women will be the primary beneficiaries of most improvements in water and sanitation, they should be recognized as potentially valuable partners in water and sanitation projects, but this has not customarily been the case, and services have suffered accordingly.[20/]

The implicit costs of underutilized or abandoned services can be substantial. Suppose, for example, that a country has 20,000 rural water supply systems, representing an average investment of US$25,000 each. If only 60 percent of systems are functioning, then 8,000 are out of operation at any given time. If an improved maintenance system were to result in the proper and continuous functioning of 4,000 of these, this would be equivalent to a capital investment of US$100 million.

In addition to all these problems, the central governments of some countries, notably the poorest, are simply not able at present--given their severely limited budgets and managerial weaknesses--to

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18/ U. S. Agency for International Development, Community Water Supply in Developing Countries: Lessons from Experience, AID Program Evaluation Report No. 7, (Washington, D.C., September 1982), p. 25.

19/ Van Wijk-Sijbesma, op. cit., p.71.

20/ Van Wijk-Sijbesma, op.cit.

assume the responsibility of bringing water supply and sanitation services to widely scattered rural populations. As a result, large numbers of rural dwellers simply get no service at all.

The alternative is to encourage central governments to share with local governments and the private sector the responsibility for water supply and sanitation. In some countries, the new providers might be community owned, or rural cooperatives. Obviously, any change of this sort would have to occur gradually and systematically, and in some places the central government would have to maintain its involvement for some time to come until local governments were prepared to take on some responsibilities and the appropriate firms could be found, financed, and promoted. But the ultimate goal would be for the central government to serve in the role mainly of educator, promoter, and regulator, and communities in league with the private sector, in that of provider.

<u>To what extent can strengthening institutions help project performance?</u> In the search for answers to the problems of past projects, it is often argued that stepped-up "institutional development" is needed. But institutional development is not likely to resolve the many and varied problems in rural water supply and sanitation. One of the problems is that institutional development alone cannot overcome difficulties in all the other areas of water supply and sanitation (financial constraints, technical weaknesses, and so on). But of far more importance, in the absence of a more fundamental change--that is, a shift from exclusive reliance on the central government to a partnership between the public and private sectors--institutional development will accomplish little of note.

Water supply and sanitation institutions presently suffer from the same broad spectrum of structural and policy weaknesses that plague most other institutions in developing countries: inadequate financial and human resources, poor management, too much or too little staff of a particular category, overcentralization or too much decentralization, inadequate incentives for good performance, lack of sensitivity to consumer needs, and so on.

The major challenge is to develop institutions that are highly responsive to localized needs yet at the same time capable of effectively using scarce and usually centralized resources. Many countries have experimented with a variety of institutional forms, from large centralized institutions or government ministries to private voluntary agencies. More often than not, diverse institutions exist side by side, sometimes under the sponsorship of different external donors.

Modest reforms will seldom be enough. A more far-reaching examination of the issues is usually required; this should focus on what services are delivered, how they are delivered, to whom, and who ultimately pays. But even projects that have hoped for fundamental change have met with obstacles. For example, where overcentralization has been identified as a weakness, efforts to decentralize have proven difficult in practice because the services traditionally require large amounts of public resources and the allocation of resources is inevitably made in a centralized and usually political way--precisely the way in which rural populations have the least influence and representation. Likewise, where maintenance has been a problem, attempts to design better systems have not always worked. In theory, maintenance that is more dependent on local efforts appears to be a step in the right direction. In practice, local communities have been reluctant to accept responsibility for infrastructure over which they have had little say in its design and construction.

Although improvements in institutional performance are always possible and desirable, the institutions responsible for rural water supply and sanitation services cannot be expected to achieve levels of efficiency much beyond those found in the central government in general. Thus, institutional development is unlikely to be sufficient by itself to resolve all of the problems of past investments. Institutional improvements are vitally needed, but other steps are essential too. This is the heart of the issue. All too often problems have been approached by choosing the institutional structure that will work for a particular delivery system rather than by selecting the delivery system that will work given the limitations of the existing institutional framework.

To what extent can more appropriate technologies help project performance? When water supply improvements were first undertaken, not enough emphasis was given to simple systems, such as gravity ones fed by springs, that required little in the way of operation and maintenance. Pumping systems were too sophisticated and complicated; early handpumps designed for single-family use broke down when subjected to heavy, intense village use. In some countries, workers from the centralized depot handling maintenance often reached villages requiring assistance only when fuel was available for transport. Latrines and other low-cost sanitation techniques were not coupled with adequate village education, fell into disrepair, or were simply abandoned. By the late 1970s, donor agencies were reporting that even handpumps, widely hailed as one of the simplest means of supplying drinking water to rural and urban fringe areas where groundwater was reasonably available, had failure rates of over 70 percent in some projects.

Although the poor choice of technologies has undoubtedly contributed significantly to the failure of many projects, it is not the sole cause. The poor performance and short working life of the handpumps, for example, can be traced to problems with their design, their selection for particular environments, the availability of replacement parts, the quality of their manufacture, and their misuse, overuse, and care. But the more fundamental questions are, why were the wrong technologies chosen and what were the incentives that led to the wrong choices? Is the issue that the appropriate technologies do not exist, or is it that they have not been used or adapted properly to meet local needs?

There is little doubt that appropriate technologies do, indeed, exist. Techniques of water delivery and the sanitary disposal of human wastes are centuries old. What has changed is the introduction of modern materials and methods (for example, plastic pipes and remote-sensing devices and improved geophysical techniques for groundwater location and development) that have lowered the per capita costs of providing services. But these improvements have not been employed on a scale wide enough to filter down to low-income, rural-area groups. Part of the reason is that in low-income rural areas the virtual monopoly power of the public sector discourages private enterprise, and limited and fragmented markets give entrepreneurs little incentive to promote the modern, more efficient techniques. Furthermore, although local governments and consumers, properly informed about the options, presumably know a good deal about what would or would not work best in their environment, they rarely participate in decisions about appropriate technology. Instead, external donors far removed from the site often make these decisions.[21]

In response to these difficulties, the World Bank and the United Nations Development Programme (UNDP), with the support of a number of bilateral aid agencies, have undertaken a large-scale research and demonstration effort (over $30 million to date) to develop, test, and introduce more workable handpump and sanitation technologies in the developing world. Handpumps that can be operated and maintained at the village level are an example, as are improved dry-pit and pour-flush latrines. Perhaps more important than the technologies themselves has been the careful evaluation of how they are used and under what circumstances they can be introduced successfully on a large scale with financially sustainable strategies. (See Box 1.1.)

Although continuing research and demonstration work involving appropriate technologies is desirable, that alone will not resolve the problem of how (or if) these technologies will be applied on a global scale. Improving handpumps, for example, will do little to lower the cost of delivering water supplies to rural communities if boreholes continue to be drilled in costly and inefficient ways and are not

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21/ Richard G. Feachem, David J. Bradley, Hemda Garelick, and D. Duncan Mara, Sanitation and Disease: Health Aspects of Excreta and Wastewater Management, (New York: John Wiley and Sons, 1983).

properly developed and protected; a better latrine will be of little use if the consumer does not see the need for this investment and make use of the facility. Unless appropriate incentives are provided for the implementation and use of improved technologies, their application will be limited.

BOX 1.1

THE WORLD BANK/UNDP WATER DECADE PROGRAM: RESEARCH AND DEVELOPMENT OF LOW-COST TECHNOLOGIES

During the past six years the World Bank and United Nations Development Programme (UNDP) have cooperated in a special global program to develop, field test, and demonstrate the effectiveness of low-cost technologies for providing safe drinking water and basic sanitation to low-income groups in urban and rural areas of developing countries. The program presently includes four major components: testing and development of rural water supply handpumps, development of low-cost sanitation investment projects, research and development on integrated resource recovery, and an information and training network for water and waste management. In FY85 the program was conducting activities in thirty-eight countries with a budget of about $6.0 million, with financial support provided by the UNDP, one multilateral and seven bilateral agencies, and the Bank itself.

Testing and Development of Rural Water Supply Handpumps

Through extensive laboratory and field testing of different handpumps, this project is attempting to identify those that are most efficient, reliable, and cost-effective for the varying requirements of rural water supply systems throughout the world. Laboratory tests have been conducted on twenty-three pump types, and field trials, on seventy different types in seventeen countries. The project is also supporting research and development on handpumps that can be maintained and repaired at the community level or by a low-cost, decentralized mobile maintenance system. Recently, the findings of the handpump testing were published as guidelines for selection of handpumps for rural water supply projects and local manufacturing. Hereafter, project activities will give greater emphasis to the promotion of, and assistance to, local manufacture and to the application of the findings to, and promotion of, large-scale rural water supply investment projects.

Development of Low-Cost Sanitation Investment Projects

The project has been highly successful in disseminating knowledge and gaining increased acceptance of on-site sanitation options as technical alternatives to costly conventional sewerage. The project is presently conducting activities in sixteen countries and financial support through a network of country sanitation projects and advisory posts, with a headquarters team providing the overall management, intellectual leadership, and technical backstopping. The project has assisted governments in designing and implementing pilot demonstration projects both urban and rural; preparing large-scale feasibility studies; formulating sector policies and programs; and training sector staff. The project has also sponsored and supervised research to refine low-cost sanitation technologies and human waste management systems. Recently, the project has been placing greater emphasis on the development of large-scale investment projects and on the vital institutional and delivery systems to implement large-scale, on-site sanitation schemes.

Research and Development in Integrated Resource Recovery

The resource recovery project has been analyzing and demonstrating basic technological, environmental, and institutional practices and potentials of waste recycling in developing countries. The project has produced a series of reports on resource recovery practices and is preparing studies of waste management and recycling in metropolitan areas of nine countries. Among the most important topics are: solid waste recycling, biogas production, remanufacturing of durable products from discarded materials, the use of effluents in aquaculture, and the health aspects of effluent irrigation. In the future, the project will deal with the economic and institutional feasibility of the most promising waste recycling technologies and prepare case studies in a number of metropolitan areas, such as Colombo, Mexico City, Dakar, and Jakarta, to evaluate the potential for recycling and large-scale recycling investment projects.

Information and Training Network for Water and Waste Management

The World Bank has recently completed the production of a comprehensive set of information and training materials on the full range of appropriate technologies and is now launching a training network of developing country institutions to disseminate knowledge of these technologies and promote their use. The network is more fully described in Chapter III.

CONCLUSIONS

Current strategies for meeting rural water supply and sanitation needs are not living up to expectations. Despite the considerable advances of recent years, progress remains slow compared to the growing challenge posed by rapid population increases and disappointing outcomes from past investments.

Although the reasons are complex, there is an urgent need to reexamine the basic assumptions that have shaped current policies and programs. Commonly held views about subsidy requirements, health benefits, the proper role of the public sector (particularly government authorities above the local level), and the potential of institutional strengthening and appropriate technologies have led to incomplete and inadequate assessments of present conditions and appropriate responses.

Continued reliance on present strategies and the assumptions underlying them will only exacerbate the failure to come to grips effectively with constraints in resources, particularly resources available through the public sector and external assistance. A fundamental reorientation of approach is required.

Clues to where to start were already beginning to surface as the evaluations of past investments emerged in the late 1970s. Experiments in the Sahel, for instance, showed that communities could and would help decide on the location of their wells, help build them, and contribute to their recurrent costs. Niger, Burkina Faso, Mali, Senegal, and the Ivory Coast financed similar pilot operations, with the assistance of the multilateral and bilateral donors and private and public voluntary agencies. Those experiences, though isolated, reflected a turning away from a sector development philosophy that once appeared irrevocably linked to the notion that rural populations are incapable of taking a more central role themselves in improvement initiatives and are too poor to contribute to covering the costs.

Although the precise form that this reorientation should take will depend, of course, on each country's circumstances, it is possible to consider the general principles that should govern in most cases and the questions that should be asked. It is to that end that the next three chapters are directed.

II. A FRAMEWORK FOR DEVELOPING IMPROVED STRATEGIES

INTRODUCTION

To address the problems identified in the preceding chapter, countries will need to reassess their current strategies thoroughly. This chapter outlines a conceptual framework to aid in that process.

In water supply and sanitation, no less than in other sectors, resources are limited, and choices have to be made. Questions must be resolved concerning what services are to be provided, to whom, and how -- and who will pay the cost. It is as important for these sectors as for others that such choices be based on (i) considering the benefits and costs of all relevant options and (ii) choosing the option that appears to yield the highest benefits, net of the costs.[22/]

In a sense, all decisions always are based on some form of benefit-cost assessment. Even staunch opponents of formal analyses implicitly are making their own assessment when they decide that certain benefits "obviously" outweigh the costs. What can be debated is not whether to think about benefits in relation to costs, but how. Many institutions active in the past in designing and financing improvements in the water supply and sanitation sectors have assumed that the assessment of benefits and costs is too difficult for purposes of using such information for decision making. The argument developed in this chapter outlines an approach aimed at helping make the task easier.

The main challenge is how to assess the benefits, since estimating the costs of water supply and sanitation investments, although not easy, is conceptually much more straightforward. The principal benefit has usually been assumed to be improved health. However, given the uncertainties noted in the preceding chapter about the health benefits of water supply projects, it is important not to forget that investments in these sectors have other benefits as well, not dependent on the health link.

In the case of water projects, the most obvious of these other benefits is that water is made available closer to where rural households need it for domestic or work-related purposes. Thus, households no longer need to spend as much time and effort traveling to

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22/On the general arguments why societies are best off basing resource allocation choices on benefit-cost criteria, see I.M.D. Little and J.A. Mirrlees, Project Appraisal and Planning for Developing Countries, (New York: Basic Books, 1974); also L. Squire and H.G. van der Tak, Economic Analysis of Projects, (Baltimore and New York: The Johns Hopkins University Press, 1975).

and from water sources and waiting in queues. In addition, water projects also may provide better access in terms of hours of service and reliability of supply, and better quality in terms of taste, clarity, and odor. For sanitation improvements, there can be benefits related to greater convenience (a nearby latrine in place of a farther away field) and privacy. These can involve time savings, better access, and better quality--the same as for water.

Some of these non-health-related benefits can be substantial--especially the savings in time. For the vast majority of rural dwellers, hauling water is still time-consuming and heavy work. It is not uncommon to find that up to 15 percent--or even up to 25 percent in some cases--of the women's time in rural areas is spent in getting water. Improvements reduce that burden significantly, whether through introducing a central well where formerly there was only a water hole outside the village center, or multiple neighborhood standpipes where formerly there was only a single central well, or a yard tap outside each house where formerly there were only standpipes serving a group of houses. In parts of Mozambique women used to spend three to four hours per day getting water, until an improved system was installed. The time savings resulting from the new wells averaged 1.75 hours per day, or approximately half the former water-hauling time.[23/]

By contrast, if there are health benefits, they are less obvious and immediate. It is not clear that rural populations think much about the relationships between water and health--which must often seem remote possibilities, difficult to believe, and of uncertain worth relative to more tangible concerns. Even for trained evaluators in the best of circumstances, health effects are frequently impossible to identify and quantify with any accuracy.

Given all this, it appears that the best way to examine investment and policy options is to start by assessing the non-health-related benefits and then deal with the difficult problem of identifying and quantifying the health benefits only if and when necessary to resolve an ambiguity. That is the approach developed here. In many situations, the appropriate option to choose can be determined without bringing in health effects.

The first part of this chapter elucidates a way of estimating the non-health-related benefits. Then costs are discussed. The primary challenge in estimating costs for water supply and sanitation projects is to squeeze the most useful information from the limited data typically available in each new specific situation. The last part of the chapter brings together benefits and costs. The conclusions there shed additional light on the deficiencies of existing policies and provide further grounds for questioning the presently widespread low cost recovery and high subsidies. Because of its reliance on consumer demand and

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23/ S. Cairncross and J. Cliff, "Water Use and Health in Mueda, Mozambique," Transactions of the Royal Society of Tropical Medicine and Hygiene, in press.

expected use of services, the methodology described here implies a stronger case for (i) changing tariffs, (ii) redefining public and private sector roles and, within the public sector, local and higher-level responsibilities, and (iii) shifting more control than in the past to local residents. These and related themes are pursued further in Chapter III.

The methodology described here can be applied to both water supply and sanitation. However, the exposition below focuses mainly on water supply, for reasons discussed in a section on sanitation services in Chapter III.

ASSESSING THE BENEFITS

The benefits of rural water supply and sanitation projects usually cannot be inferred directly. For example, one cannot simply observe how much people presently pay for service and use that evidence as a basis for estimating how much they would be willing to pay for improvements. In most rural areas households currently either pay no cash fee related to their amount of use or only a very small sum that bears no connection to how much they would be willing to pay.

One is thus forced to turn to less direct evidence. To avoid excessively complex techniques that would be impossible to implement in field applications, one might try the following:

-First, determine the amount of time that users would save as a result of whatever service improvement is being considered.

-Then, estimate the value of this time to users, in light of evidence on the behavior for these households.

Suppose, for instance, that a proposed project would introduce a new, centrally located well in a village where hitherto there was only a traditional water source, remotely located. Suppose, too, that the new well would save residents an average of, say, 70 minutes per household per day and that the value of that time (a concept about which a good deal more will be said presently) would be $0.15 per hour. Then the benefit of the project would be estimated by this approach at ($0.15 x 70 ÷ 60), or $0.18, per household per day. The project is justified only if its cost per household is less than that amount.[24/]

A well-known concept underlies this procedure: namely, the benefit that an individual derives from something can be inferred from

24/ In practice, of course, the benefit may vary over the stream of years that the project will last, as will the costs. Ideally, a standard calculation of net present value (NPV) with an appropriate discount rate should then be done. Skeptics of NPV calculations will prefer the simpler comparison, as in the example above.

how much he or she would be willing to give up in order not to be without it. In this case, an estimate of how much the individual would be willing to give up is derived from evidence on what is given up before the new well is introduced. If what is given up is $0.18 worth of time per day, then the individual will ascribe at least that amount of benefit to having the new well, perhaps more, but certainly no less. So this measure of observed time savings, suitably valued, will serve as a minimum measure of the benefits he--or she--derives from the project.

The primary advantage of this particular approach to assessing the benefits of water supply and sanitation projects is that it expressly stresses what appears from the observable evidence to be an important benefit (time savings)--probably the most important benefit, at least for the sorts of water supply projects that have been and will remain for some time the foremost priority for the majority of rural areas in developing countries.

The approach is mercifully simple--but not too simple to be truly useful. Although benefits other than time savings seem to be overlooked entirely (for example, benefits from changes in hours of service, reliability, and water quality), there is a way--discussed below--to take them into account indirectly. The example above assumes that users pay no fee for water (they face a time cost but not a cash or in-kind price), but a simple refinement to calculate net benefits can be added to provide for cases where fees exist.

The details of the approach are discussed next and then common misconceptions about it.

Estimating the Time Savings

If, when a water supply or sanitation improvement was introduced, its users were to continue consuming the same amount of the service as before, then the steps required to estimate the time savings would be obvious. In the case of water, for instance, one would need to know only the reduction in the distance that the village residents would have to travel to get water and any concomitant changes in queue time at the source or in their mode of travel. For a given community, these will obviously vary from one household to another. Nevertheless, an approximate average savings can be calculated that is adequate for policy-planning purposes.

In reality, users may not continue consuming the same amount of a service after it is improved. When the time required to get water is sharply reduced, it is likely that households will increase their consumption -- just as when the price for any other commodity falls, people typically seek to buy more of it. To allow for that possibility, one must consider how sensitive consumers are to marginal changes in the time needed to get water or use sanitation services.

It is possible to use an estimating procedure (for example, a demand equation) that accounts for the tradeoffs that households make between the quantity they consume and the time it takes them. Ideally, this procedure (for example, a demand equation) would incorporate other variables, such as income level, and be based on data pertinent to the communities being studied. An example of a method along these lines is described in Annex B. The data collection and analysis needed to arrive at a demand equation of the sort indicated there will normally entail no more than a week or two of effort on site and probably can be done locally by government staff.

Once the change in consumption is determined, there is still a further issue to resolve, relating to how the additional amount of water consumed should be accounted for. Consider, for example, a village where a typical household currently consumes 100 liters a day, each liter of which takes one minute to collect on average from the traditional source. Suppose that if a new central well were installed, the average time per liter would fall to 6 seconds, a 90% decline; also the amount of water taken per household would rise to 150 liters, because the easier access induces increased consumption.

What is the time savings in this case? Clearly, there is a savings of 90 minutes for the original 100 liters. But what about the additional 50 liters? There is an implicit time savings for them too, but it is incorrect to assume the same 90%. Since the people in the household obviously are not consuming the extra 50 liters of water initially, they must think it is not "worth" spending one minute per liter to get it. But since they would consume the 50 liters if the new well were installed, they must feel it would be worth at least 6 seconds per liter. The implicit time savings must lie somewhere between these two extremes of one minute and six seconds. A convenient, albeit arbitrary, compromise is to take the midpoint between 60 and 6 seconds, or 27.5 seconds per liter for 50 liters. The total time savings is thus 90 + 27.5, or 117.5 minutes.

Estimating the Value of the Time Saved

Time savings have greater or lesser value to a household depending on what its members can do with the time saved. If the household would use the time in an income-producing activity, then the value of that time could be inferred from the income earned. If the household would not engage in an income-producing activity, the value of the time could still be adduced from an income measure; but in this case, it is the income that would have been earned if the household had opted for an income-producing activity.

The reasoning behind this latter point is simple. As long as the household has the option of producing more income, the fact that it instead chooses some non-income-producing activity reveals something. Namely, it reveals that the value to the household of spending the time in that non-income-producing activity must be at least as great as the value of spending that time in generating more income. Otherwise, the household would have chosen differently. Suppose, for example, that the choice is between spending the time on making bricks or caring for children. From information on the earnings possible from selling bricks, the value of an extra hour in brick making can be estimated. Say it is $0.50. The rewards from devoting additional time to caring for children are not as precisely quantifiable. Nevertheless, if a household chooses childcare in lieu of brick making, then the value to the household of using the freed-up time in childcare in this instance must be at least $0.50 per hour, and possibly more.

Thus, regardless of what the household actually does with the time, the key issue is how much it could earn if it chose to. That figure will reflect a number of critical considerations:

-It is the time of the women in the household that matters most, since the work of getting water usually falls to them.

-Women in rural areas do not always have access to wage employment. Thus, one cannot simply assume that prevailing wage rates provide a good indicator of the value of the freed-up time.

-Nevertheless, rural women generally do have other ways of adding to their own or the household's income, either through activities that might be characterized as petty trading (for example, making and selling street foods, clothing, or baskets) or through increased labor in agriculture (for example, growing more food in the household's own plots). The increment in income need not be in cash; for instance, it may be in extra food grown and consumed at home.

-In some instances, households currently pay someone to get their water. The amounts they pay can offer additional insights on the value of water-hauling time to rural populations.

A rough estimate of how much the women of a given rural area could earn from an extra half hour or more of time can generally be obtained from a quick, informal survey of petty trading activities in selected villages within the area. Where possible, information on payments to water carriers and on the returns to women's labor in agriculture can be collected at the same time. There is no necessity in such a survey to resort to elaborate procedures or strive for precision. For most planning purposes, approximations will suffice.

Given this sort of information, one can reason as follows. Where water vendors exist, all households have the option of paying someone else to get their water. Even in communities where there are no commercial water vendors, households generally have other possibilities -- for example, a neighboring child or a household servant can be induced to get water, perhaps with payment in kind (for instance, a meal) rather than cash. Where such practices are not customary now, there is no reason in principle why they would not come into being if the demand were strong enough.

Where households choose not to pay someone else to get their water, that fact is evidence that they value their own time at something less than the amount they would pay a hired water carrier. Where they do use someone else, that must mean they value their own time at more than the wage cost of the water carrier; but the carrier's wage is then the appropriate value to use in assessing a money value for time savings. Thus, the greater the fraction of water carried by hired water carriers, the closer the approximation of the value of the time savings to the prevailing average wage of water carriers. In practical applications, the following formula can be used:

(value of one hour of time saved) = (K) x (hourly wage of water carriers) + (1-K) x (hourly earnings of women in "marginal" time)

where (K) is the fraction of the total village water that is brought to households by hired carriers and (1-K) is the fraction brought by household members themselves.

Note that where no hired carriers are used, the value of one hour saved reduces in this formula to the hourly earnings of women in "marginal time," where the word "marginal" is included simply to underscore that these earnings might be lower than what women could earn for their primary income-producing work during the day, whatever that work might be. The following formula can be used to estimate the earnings from "marginal" time:

(hourly earnings of women in "marginal" time) = (a) x (hourly earnings of women in petty trading) + (1-a) x (hourly earnings of women in other work -- e.g., growing more food)

where (a) is the fraction of the freed-up time that the women of the village would spend in petty trading and (1-a) is the fraction they would spend in other work. Obviously, one can make only a rough guess of (a) and (1-a) in practice, but that is better than nothing.

Even with very rudimentary assumptions representing stylized facts for a hypothetical village, one can learn something from this method about the probable range of the value of the time saved by water supply projects. For example, consider a case where women can earn the equivalent of $1.25 a day in marginal time. This would not be among the poorest of rural communities today, but it would not be a high-income village either. By way of comparison, studies in Botswana (1977), Lesotho (1980), Niger (1981), and the Philippines (1982) found an estimated average daily agricultural wage of $8.78, $3.60, $2.17, and $2.35 respectively.[25]

25/ Unpublished World Bank country economic reports.

One possible set of circumstances that may lead to this $1.25 figure is as follows. Suppose that in a country with an income per capita similar to that of Nigeria (about $700), 60 percent of income accrues to labor. Thus, labor income is $420 per capita. If 50 percent of the population is "active" (measured in full-time equivalents), then this implies a labor income of $840 per full-time equivalent capita. Assuming a 250-day year, the average daily wage would then be almost $3.50. That figure, however, would be the average daily labor income over the whole economy. The wage in rural areas would be below this average, depending in part on the relative size of the rural and urban work force. If the rural work force were much larger than its urban counterpart, which would not be atypical, then the average rural wage could be, say, 75 percent of the $3.50 overall average, or $2.63. Women's earnings may be less than men's in rural areas. For that reason, rural women's average wage might be, say, $2.00. In petty-trading activities, women might earn more or less than in agricultural work, depending on a large number of factors. Suppose in this case petty trading yields, say, $1.00 per day. Applying the second formula above, one can estimate the value of time for rural women in this example at:

(hourly earnings of
women in "marginal time") = (0.25) ($2.00) +
(0.75) ($1.00) dollars per day
= $1.25 per day, or, say, $0.125
per hour

where it is assumed that 25 percent of income-producing activities in marginal time would be in agriculture and the remaining 75 percent would be in petty trading.

If, in addition, 20 percent of the water used in this district is carried by hired carriers (presumably for the better-off households in the community), and if hired carriers earn $0.25 per hour in this work, then by the first formula above:

(value of one hour of time saved) = (0.2) ($0.25) + (0.8) (0.125)
= $0.15 per hour

One certainly should <u>not</u> conclude from these illustrative calculations that the value of the time saved in water supply projects is about $0.15 per hour. Nevertheless, the calculations do demonstrate one possible way to arrive through simple procedures at a figure that can serve as a basis for estimating the benefits of projects. What is most important in the end is not whether the final figure is, say, $0.15 or $0.14, but whether it is in that general range or much higher or lower. As will be evident below after the cost side has been discussed, a lot can be learned about the relative merits of a set of investment options with only rough figures.

More on the Value of Time

Because misconceptions about the value of rural women's time have had a major influence on past water supply and investment strategies, there are a few further points worth stressing here.

The conventional wisdom used to assume that time spent getting water is not really a cost to those who do it or to society, since that time would not otherwise be productively employed, in the sense of wage-earning work. But that assumption cannot be valid. If time getting water were truly not a cost, then one would expect to find villages located at considerable distances from water sources, since other determinants of locational patterns would dominate the "costless" time to get water. Deserts would be dotted with settlements where households would travel miles to water sources. Absurd, of course, but that is the logical consequence of the "time is costless" assumption. Indeed, the evidence against that assumption is powerful; in his classic study of English medieval villages, Hoskins showed that one of the main determinants of location was a gravel deposit and associated proximity to a ready supply of water.[26]

Also, if water-hauling time had no value, one would expect to find that people get the same amount of water regardless of whether the source is nearby or farther away. That, too, is unrealistic. Although the quantity of water consumed may be relatively insensitive to the time factor over a narrow range, people who must travel more than, say, an hour to get water are observed to consume significantly less water than those who have a tap a few meters from their home.[27]

The conventional wisdom also once held that rural women rarely had ways of engaging in income-producing activities. This belief ignored activities like petty trading and handicraft. For decades, the statistics on economic development omitted petty trading as though it did not exist or was without value, but recent reassessments of the informal sector, which consists predominantly of petty traders, have shown that petty trading is an important economic activity contributing much to GNP and welfare. Nevertheless, there is still a residual temptation to assume that the value of rural women's time is close to zero.

Doubts have been expressed in the past, too, about whether time spent in caring for children, maintaining the home, or just plain

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26/ William G. Hoskins, The Making of the English Landscape (London: Hodder and Stoughton, 1955); and Hoskins, Local History in England (London: Longmans, 1959).

27/ G.F. White, D.J. Bradley, and A.U. White, Drawers of Water, (Chicago: University of Chicago Press, 1972).

leisure really has value. Obviously, many rural women, if freed from spending as much time as they do now on getting water, would use substantial portions of the extra time in those non-income-producing activities. The Mozambique study mentioned earlier found that:

> "... the time saved for the women of Namaua, an average of 106 minutes per day or almost two hours, permits an increase in their free time of 48 minutes per day--almost half of the time saved. It should be noted that a considerable part of the time spent resting by the women is passed in the company of their children ... the majority of the remaining time is spent on other household chores ... [principally] ... those of cleaning and of preparing food." 28/

It must be remembered, though, that income-producing activities generally are available or can be initiated. The fact that households choose in some cases to use their time on other pursuits instead is evidence that they value those pursuits more highly.

Other doubters have argued that time spent getting water is not a cost because women enjoy the social interaction at water sources. One study found otherwise:

> "We found no evidence in Lesotho for the common supposition that the opportunity for gossip, while waiting for water at the tap, has a positive social value. For example, when one village tap flowed only very slowly due to blockage of the pipes, the women preferred to make an arduous uphill walk of several hundred meters to another tap, rather than wait ... for their buckets to fill." 29/

In another setting, Bangladesh, it was found that social interactions at water sources were generally unpleasant and were a major reason for avoiding certain water sources.30/ But even if the social interaction were an attraction, what is important is that rural women are making a

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28/ Cairncross and Cliff, op. cit..

29/ Overseas Development Administration, Manual for the Appraisal of Rural Water Supplies (1985), p.93.

30/ J. Briscoe, M. Chakraborty, and S. Ahmed, "How Bengal villages choose sources of domestic water," Water Supply Management, (5), (1981), pp. 165-181.

choice, weighing that attraction against the cost to them of the time expended.[31]

Finally, the most compelling evidence of all that time spent getting water does have value is that households do often choose to pay others to get their water. Studies of vendor use find the expected inverse relationship between price and the amount of water consumed. Antoniou, for instance, examined vendor sales in poor urban fringe areas in the Sudan where vendors compete with kiosks (supervised stand-pipes). At the kiosks, water is dispensed for little or no charge, but there is often a queue and, hence, a wait. Vendors were able to charge four times as much as kiosks, or more. Vendor prices increased with distance from the kiosk, showing that households will pay more as the alternative of fetching water themselves becomes more burdensome.[32]

Both Antoniou [33] and Zaroff and Okun [34] found vendor earnings in the $2 to $3 per day range. This compares favorably to rural wages in the areas they studied. Antoniou reports that in some areas where periodic dry seasons create a temporary demand for vendors, these vendors are drawn from rural areas to work in the urban fringe. Close links like this between rural and urban labor markets, which have been extensively documented, [35] could be useful in estimating the value of water-hauling time.

Quality of Service

On a separate point, it was noted earlier that although the approach here seems to focus exclusively on time savings, in fact other benefits, such as reliability, hours of service, and water quality, are taken into account indirectly. The estimate of the amount of time saved should in principle allow for these factors. The time saved depends on the choices that households make among alternative sources, and their

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31/ Note that this does not presume a high degree of access to cash money. If most income-producing activities reflect in-kind transactions -- food produced from field labor, bartered commodities from petty trading, or a meal, perhaps, as payment to a water carrier -- then benefit is calculated from the monetary equivalent of these in-kind transfers.

32/ James Antoniou, "Sudan: Khartoum-El Obeid Water Supply Project Urban Poverty Review" (Washington, D.C.: World Bank, October 1979).

33/ Antoniou, op. cit.

34/ Barbara Zaroff and Daniel A. Okun, "Water Vending in Developing Countries", Aqua, No. 5 (1984), pp. 289-295.

35/ Friedrich Kahnert, "Improving Urban Employment and Labor Productivity" (Washington, D.C.: World Bank, February 1985).

choices are the result of their weighing of all the attributes of the sources, not just the distance to each.

Suppose, for example, that in a village where a new well was being considered, there would be qualitative differences between the new supply and the old source, and that because of those differences, half of the village residents would continue to use the old source. Then, as an approximation, one might estimate the amount of time saved at half of what it would be if everyone switched to the new source. In the illustrative example above, this would lower the benefit from $0.15 to $0.075 per "average" household.

Obviously, a key requirement here is to be able to predict, at least roughly, the fraction of the population that would use each source. But that would be a requirement of any method that allowed for other attributes of water sources besides distance. A simple informal survey from a brief visit to the project site, together, if possible, with information on similar experiences elsewhere, might suffice to provide a basis for proceeding. Of course, more elaborate modeling techniques that try to identify each attribute explicitly are conceivable.[36] Yet in the overwhelming majority of cases the simpler approach is likely to be sufficient.

Social Benefits -- Health

Thus far, the discussion has focused on benefits from the perspective of the beneficiaries. For benefit-cost analysis, benefits should be calculated from the perspective of society as a whole. The two perspectives yield different results only if there are some additional benefits beyond those that accrue to the beneficiaries directly. In practice, for the rural water supply sector, there would be significant additional benefits of this sort only if there were appreciable health-related "externalities" -- that is, if, when some people got better water, others benefited through reduced disease transmission. However, it has been argued above that the existence of substantial, health-related externalities is in doubt, given the evidence. Thus, the approach proposed here, which excludes any consideration of externalities, is likely to give at least a reasonably good approximation of the total benefits of a water supply investment. In rare cases where additional benefits such as externalities do need to be incorporated, it is still best to proceed this way as a first step; amendments can then be made later to reflect any further information available.

36/ For a review of possible techniques, see John Briscoe et al., "Developing a Methodology for Assessing Willingness to Pay for Water in Rural Areas," unpublished draft (Washington, D.C.: World Bank, March 1986).

What is being suggested here is not to ignore health benefits, but rather to rely on them only to the modest extent the evidence justifies. In most instances, it will probably be possible to design investments without recourse to guessing the health benefits. In those instances where the benefits are suspected as being substantial or where additional benefits are required to justify the investment, case-control studies of the type suggested by Briscoe, Feacham, and Rahaman 37/ should be considered. It may be possible in such cases to use historical evidence of lower mortality or incidence of water-related diseases from villages with similar characteristics where similar improvement projects have been in use. Another alternative is to use the relatively sophisticated techniques of Clark, Goodrich, and Ireland, which evaluate on a "cost-per-life-saved" basis the value of water treatment in order to predict expected reductions in disease as a result of the project. 38/ In other cases, it may be sufficient to show that the benefits, in relation to the costs, are of such order of magnitude that there is little risk in undertaking the project.

ESTIMATING THE COSTS

The costs of supplying water and sanitation services in rural areas can vary considerably, depending on the technology selected, operation and maintenance regimens, and other factors. In addition to the usual costs of capital and labor, the costs of rural water supply depend on four other variables: the cost of the source (well, river, and so on), the size of the village (the number of inhabitants), the density of population (persons per hectare), and the value of time of those hauling water. With information on these six variables, it is possible to draw some interesting conclusions about the behavior of the cost functions under a variety of circumstances. (As an example, a variety of situations are simulated in Annex A on the basis of generally used parameters, and the behavior of the different components of costs is examined with respect to those parameters.) The results are sufficiently robust to permit some important generalizations.

One of the most significant observations that comes out of a study of the cost functions is how large a part of total costs are haul costs whenever water has to be carried any distance. In a typical situation where a handpump is used, for example, the haul costs can account for over two-thirds of total costs when certain assumptions

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37/ John Briscoe, Richard G. Feacham, and Mujibur M. Rahaman, Evaluating Health Impacts: Water Supply, Sanitation, and Hygiene Education, (Ottawa: International Development Research Centre Press, 1986).

38/ Robert M. Clark, James A. Goodrich, and John C. Ireland, "Cost and Benefits of Drinking Water Treatment," Journal of Environmental Systems, Vol. 14(1), (1984-85), pp. 1-30.

about value of time are followed, with capital and maintenance costs the remainder (see Annex A, Table A-2). This holds true even for very low costs of labor or values of time and suggests that whenever per capita incomes of rural populations are much over US$250, it will seldom pay to invest in systems that involve headloading of water.

Closely related to the haul costs are the high per liter costs of water from low-volume point systems where headloading is required. Water from low capital cost systems is in fact very expensive. Costs per liter may be five times the costs of water delivered through piped systems.

Piped systems demonstrate substantial economies of scale at a surprisingly low level of population size and density. Most of the economies of scale are reached at village sizes of 800 people and above and at densities as low as 80 persons per hectare. The combination of piped water systems with some hauling of water--the standpipe--rarely proves to be the lowest cost alternative.

All of this suggests there have been considerable underinvestments in water systems in many countries. Governments in many cases have selected low capital cost, point-source systems, the capital costs of which are about one-fourth that of piped systems but which in fact turn out to deliver high-cost water. This would appear to be an important reason for consumers rejecting many of these systems.

As has been noted above, operations and maintenance problems are the main reasons for the failure of many systems. Operations and maintenance, however, seldom account for a major portion of total costs. (An exception to this is when diesel fuel is used.) For handpump systems, operation and maintenance costs are typically less than ten percent of total costs and for piped systems, on the order of twenty percent. The failure to adequately maintain and operate systems appears to result from institutional and organizational inadequacies rather than from the number of resources required.

The availability of electricity can significantly affect maintenance performance, not so much because of its significance in the cost structure but because of the greater ease of maintenance of electric pumps. Operation and maintenance costs for electricity are generally less than ten percent of total costs, but in some parts of the world, particularly in Africa, it will be a long time before extensive networks exist in rural areas. Diesel fuel systems are usually more expensive to operate and maintain than electricity from a network but seldom more than fifteen percent of total costs. Other forms of motive power--windmills, solar, and so on--are all more expensive than diesel and can be justified only under exceptional circumstances.

In the case of ground water sources an important cost parameter is the depth from which water has to be pumped. The more costly (and usually, deeper) the bore hole, the more sense it makes to extract the maximum volume of water from each hole if the community can afford the additional costs. In most circumstances this means that some form of mechanical pumping will be required where the water table is deep. If the use of electric or diesel pumps can be justified, then the economies of distribution systems are such that it usually pays to install a piped distribution system.

These analyses underscore the observation that man--or, more accurately, woman--is an inefficient carrier of water. The carrying of water is an expensive process and, even in very low-wage economies, can result in a high implicit price for water. When the correct value of time is taken into account, the rural poor of Africa and Asia may be paying prices for water that are many times higher than what is being paid by their urban counterparts in both the developing and developed world. This is not to say that all carrying of water can be eliminated; it will continue to be necessary in many parts of the world where incomes and population densities are too low to justify piped distribution systems. It does suggest, however, that there is much scope for reducing costs by concentrating on minimizing haul distances and wait times. Whether this is to be done through investments in piped distribution systems or improvements in the spacing and the number of point sources will depend on the specifics of each situation.

COMPARING BENEFITS WITH COSTS

Once the value of people's time and effort in hauling water has been calculated, the estimating of the maximum net benefits for any particular investment follows the normal practices of benefit-cost analysis. An investment in improving village water supply and distribution will result in either a lower cost (in terms of time and effort) or a greater quantity of water compared with what existed prior to the investment, or both. Alternative technologies can be examined within this framework and the most appropriate one--that is, the one that maximizes net benefits--selected. Annex A contains a number of examples illustrating how the benefit-cost framework can assist in making appropriate investment decisions.

The analytical framework can also be used to take into account such factors as scarcity of foreign exchange or particular equipment, political considerations regarding distribution of investments by income groups or geographical regions, and a variety of economic and social factors. The information requirements are fairly modest, and in many regions large numbers of villages would tend to have similar characteristics. The choice outcome, once known for one village, would hold for many.

The preferred technology choice and project design in each setting is likely to depend critically on a number of key variables.

This is particularly true when the choice is between handpumps and piped distribution systems. Handpumps are likely to be the better choice in areas where incomes are very low and distances to existing water sources are long. Many of the poorer countries in sub-Saharan Africa probably are in that category. However, yard taps are likely to be better where income levels have reached the per capita average of, say, Nigeria, much of East Asia, and most of Latin America.

CONCLUSIONS

Investment and policy choices in water supply and sanitation should ideally be based on (i) considering the benefits and costs of all relevant options and (ii) choosing the option that appears to yield the highest benefits, net of the costs.

The benefits depend significantly on the amount of time that users are saved and on the value of that time, which is a function of the opportunities available to people to use the time in some other way. Although estimating these effects is not easy, an approach has been outlined that can provide reasonably good approximations to help in the weighing of options against one another. Where there is a clear case for allowing for other considerations, such as health benefits, the approach offers a good starting place from which to add these modifications.

The costs of options can vary, of course, from place to place. Nevertheless, in any given setting, the sort of analysis described here, with calculations of the sensitivity of the results to alternative scenarios of cost assumptions, requires only modest on-site data collection and can produce estimates adequate for most practical purposes.

In the past, governments have often chosen systems with low capital costs in an effort to keep total costs down, but use of the framework described here suggests that larger investments might be more appropriate in many cases. Although handpumps might be the best choice of technology for the poorer countries of sub-Saharan Africa, piped systems probably would better serve the higher-income countries of East Asia and Latin America.

This method of comparing benefits and costs has already proved successful. The Inter-American Development Bank has employed it in programs for several Latin American countries in recent years, for example, using time and labor savings as the measure of benefits. (See Box 2.1.) Evaluation of these and other programs using the benefit-cost framework described here can aid in developing the kinds of policy mechanisms discussed in the next chapter.

Box 2.1

BENEFIT-COST ANALYSIS USED IN
WATER SUPPLY AND SANITATION IN FOUR COUNTRIES

The Inter-American Development Bank (IDB) is using benefit-cost analysis similar to that proposed in this report in water supply and sanitation programs in rural areas of Haiti, El Salvador, Honduras, and Chile. All these programs have been underway for many years. The IDB uses standard benefit-cost analysis to assess whether the rural water supply components of the programs are viable. The benefits are measured for the most part in terms of the saving of time and trouble of water hauling and are reflected in the market through the users' willingness to pay. The programs have substantial health education components—indeed, eventual eradication of water-borne diseases contributing to high rates of infant mortality and morbidity is mentioned prominently among project objectives—but health benefits are not included in the benefit-cost analysis and are considered only "qualitatively."

These rural water supply components have several salient features. One is that the IDB requires some user contributions. In the second stage of a program in Haiti, for example, where the government is trying to reach 126,000 rural dwellers with water supply, an estimated 92.3 percent of the beneficiary population is low income, and yet users are still expected to pay some amount toward the service.

Another notable aspect of the IDB programs is strong emphasis on community participation, which is thought to be one of the keys to the continuation of projects. In El Salvador, for example, where the third stage of a program seeks to extend coverage to 230,000 people, villagers are enlisted for all phases of the project. To ensure community participation, the executing agency promotes a campaign informing the beneficiaries about the obligation they must undertake to provide labor, material, grants of land, water rights, rights of way for construction, administration, operation and maintenance, payment of charges, and so on.

Care is taken to try to remedy past deficiencies. The third phase of the Honduras program, for example, aiming to increase water supply for 132,000 people, specifically addresses the past problems of lack of manpower; poor training of middle-level personnel; inadequacy of equipment, tools, materials, and spare parts; limitations with respect to office space, workshops, and storehouses; a lack of up-to-date manuals, procedures, and regulations; and an ambiguous definition of various responsibilities.

Despite endemic problems like this, all the programs have enjoyed some success. Chile is the best example, with its present program 10 percent ahead of its goal. In line with IDB policy, the projects in Chile have been planned to be self-sufficient, covering costs of operation and maintenance, administration, and, to the extent possible, depreciation. In force since 1961 and about to enter its fourth stage, with the object of reaching 114,300 people, the project to date can boast a high rate of cost recovery, with approximately 71 percent of all services and operations in 1983 and 1984 covering the cost as contracted.

Sources: Inter-American Development Bank, Project Report on Rural Water Supply Programs, for Haiti (second stage), El Salvador (third stage), Honduras (third stage), and Chile (fourth stage) (Washington, D.C., 1985).

III. POLICY IMPLICATIONS

The preceding chapters' conclusions have important implications for country policies and investment strategies in this sector, particularly regarding cost recovery, consumer participation, the involvement of women, and the roles of the public and private sector. In formulating approaches, it will also be important to consider nonhousehold use of water, requirements for training and technical assistance, and areas for further research and development.

Throughout, a key issue is replicability. To be replicable, a program must be financially sustainable, not just at the demonstration site but also on a large scale. Programs fail to be replicable when they are too costly (for example, if overly expensive technologies have been employed), when insufficient funding is available to cover the costs (for example, from user payments or subsidies), or when the design is not flexible enough (for example, unable to adapt to different or changing consumer needs). Investments in programs that are replicable are more likely to result in service for significant numbers of the rural poor in a reasonable period of time. Replicability therefore should be a primary goal in any policy change.

Within the framework set out in this paper, replicability is not simply a financial concept; the administrative and political feasibility of proposed interventions must also be considered. A program requiring substantial administrative inputs or managerial talents, for example, is not likely to be replicable in most developing countries. Similarly, a program calling for substantial resource transfers from those in political power also is not likely to be successful.

COST RECOVERY, PRICING, AND FINANCING

Cost Recovery. One of the most critical implications of what has been said thus far is that country policies and investment strategies should aim for a higher level of cost recovery than has been sought in the past. Unless users--the ultimate beneficiaries--of water investments bear a larger share of the costs, expanded coverage and adequate service are unlikely to be financially sustainable on a large scale. Higher cost recovery, by helping to generate more revenue, increases the likelihood that a program will be replicable. Relying mostly on government subsidies is simply unrealistic in the majority of cases. The amounts required are too large, and competing needs for these scarce resources are too great, to permit other than token programs--which result in little more than token improvements.

Higher levels of cost recovery will require changing the basis on which communities are charged for water supply and sanitation improvements. At present many countries, as a stated policy objective, charge only for operations and maintenance costs. But setting the subsidy this way can harmfully affect both the choice and use of the system. If users are selecting a system and expect to pay only operations and maintenance, they may opt for one in which those charges are low. They may end up with a system, like piped water, with low operations and maintenance costs but high capital costs and thus high subsidies, when one with lower overall costs but higher operation and maintenance, like handpumps, will suffice. If the basic decisions are made by governments or donors, the preference may be to minimize their expenditures and transfer more of the costs to villagers with a system that may be less expensive initially but costly over the long haul. In this case, the poor community, which will get the lower capital-cost technology, may end up paying a higher proportion of total costs than those that are richer and use more capital-intensive technologies. Charges instead should be based on total costs. In poor areas in Asia and Africa the amount villagers actually pay may have to be subsidized until they can pay the full costs themselves.

Pricing. How should increased cost recovery be accomplished? What charges should be levied, and how should they be collected? In urban areas, where incomes are higher and consumption levels greater, the most effective means of cost recovery has been through metered connections, where the user is charged on the basis of volume used. This mechanism is not likely to be feasible in most rural areas, first, because the costs of metering will be excessive in relation to the benefits received and, second, because many services will not have individual connections.

One obvious option is a periodic per-family or per-capita payment applied to the entire community. This approach, however, has the potentially serious drawback of charging all residents the same, regardless of how much water they use. Consequently, conservation of water would not be encouraged. In villages where supplies are limited, unrestrained use by one family may be at the expense of the rest. These occurrences are by no means uncommon and can cause much tension in small communities.

In cases where water has to be rationed, the form of rationing can provide an opportunity for levying appropriate charges; sufficient social pressures may exist to discourage the antisocial use of water. In some cases, it is possible to institute explicit rationing measures, such as allowing each family to fill only a limited number of containers of a certain size, even from yard taps. In other cases, people can be charged as they draw water from the taps.

Another traditional rationing device is to limit the number of water points, that is, to raise the price by requiring people to walk further. However, this approach can be self-defeating because the major benefits from most projects arise from reducing these distances.

Ultimately, the decision on how water is to be priced and how financial charges are to be recovered from within the community must be a local or community decision. Communities should be encouraged to explore and develop systems that they find acceptable. The role of the financial intermediary -- discussed in the following section -- or supplying agency should be to ensure that a workable scheme is in place and to insist that it be adequate to meet the financial obligations of the community.

Certain guidelines can assist in the process. In order to maximize the economic benefits, it makes sense to charge marginal costs. But in the case of a handpump system where no rationing exists (that is, no queues), such charges may be insufficient to cover total costs. Placing a charge on incremental use sufficient to cover the financial costs may cause people to return to traditional sources. If eliminating use of these traditional sources is desired, then the solution is to charge villagers throughout the village a lump sum fee not related to consumption; this charge could vary with income or persons per household and should be agreed upon in advance of the project. A similar problem may exist in the case of yard taps. Again, an "all or nothing" pricing decision may be appropriate. The village must agree to this form of lump-sum payment before a financial commitment is made to lend to the village in question.

Opportunities also exist for some degree of cross-subsidization in all programs. In Tunisia, for example, water is supplied by one public monopoly that is responsible for both rural and urban areas. Charges levied in urban areas are sufficient to provide large subsidies to the rural areas. The degree to which this can be done depends, of course, on the relative sizes of the urban and rural populations and the ability of the monopoly to extract funds from the urban populations. In most countries, the charges in urban areas are insufficient to cover their own costs, let alone subsidize rural areas. High charges in urban areas can create problems with respect to economic incentives. Commercial and industrial users, who usually account for a large portion of total revenues, can change their production patterns or resort to less economically efficient sources. In the Tunisian example the availability of funds for rural areas has meant a lessening of discipline on costs, with water being supplied to some villages almost regardless of costs. Cross-subsidization thus is desirable only in those situations where the amounts to be transferred are relatively small and are sufficient to cover those considered eligible for subsidies without major distortions in either supply or demand in those markets being taxed.

Financing. For the relatively large capital costs of constructing improved water supply and sanitation services, few communities have sufficient resources readily available locally. Massive subsidies from domestic public funds or external assistance have generally been used in the past to meet these costs. However, in some situations a preferable alternative, more in keeping with the user-bear-the-cost principle, is for the community to borrow the funds.

At present, borrowing funds is difficult in rural areas. Capital markets tend to be relatively underdeveloped and subject to many distortions and controls (although the wide prevalence of informal markets operated by moneylenders would attest to the ineffectiveness of many of these controls). Improving the access of rural communities to loan sources should therefore be undertaken first before water investments can be accomplished mainly through borrowing.

One possibility is to establish a revolving fund at the local or national level. Loans are made to communities for the financing of water services and, as repayments come in from the communities, they are used to finance projects elsewhere. One of the disadvantages of this type of fund is its special status. When established at the national level, it falls within and under the control of the Ministry of Finance. Funding usually comes from special, earmarked sources and, in a budget crunch, more often than not is diverted to cover central treasury shortfalls. Nonetheless, establishing a revolving fund with its attendant cost-recovery practices and consumer participation can be an important first step in developing replicable water supply programs, the inherent weaknesses notwithstanding.

The use of financial intermediaries can avoid such pitfalls. Commercial banks and private and public credit institutions, including credit unions and cooperatives, exist in various forms in nearly every country. Few, however, have had much, if any, experience with the financing of rural water services, and most would require strengthening of their appraisal and loan management capacity. Despite the lead time involved in such strengthening, this route may well be the most promising for many countries, particularly given a number of attractive features. Instead of being "given" services, rural communities, furnished the access to financing and technical assistance to make correct decisions, would be actively involved in the process of deciding what they want, and what they are willing to pay. As stated elsewhere, this ownership of assets is critical to assuring maintenance of the system and the recovery of the costs.

The use of financial intermediaries has the added advantage of encouraging the development of small, local private firms capable of providing rural communities with investment, operation and maintenance, fee collection, and possibly other services. Once a village has obtained financing, it should have some discretion in selecting a supplier; a number already exist in many countries, and with adequate incentives, including access to capital from the local investment firm, more could be created. It is estimated that between US$50,000 and US$100,000 would be adequate capitalization for most local investment firms of this nature, even in the high-cost regions of the world. The existence of a large number of small investment firms--probably a rare occurrence in many countries, but, again, a realistic objective within a longer-term time horizon--should lower costs. Furthermore, smaller investment firms are likely to be available to provide regular and reliable maintenance services. They are also likely to have a greater degree of success in collecting fees for such services, when compared to the remoteness of centralized collection mechanisms.

It will not be easy to promote effective small investment firms. Throughout rural areas, there are a variety of similar institutions, official credit bureaux that are frequently only channels for subsidized public funds; their repayment records are poor, and the credibility of the cost recovery effort is minimal. One way of preventing some of these problems is to avoid any pre-allocation of credits and to keep repayment periods relatively short. In Bolivia, for example, where funds were made available only to communities that had made a commitment to meet certain initial conditions, including cost-recovery plans, the competition for the available funds encouraged improved performances on the part of the institution and the communities. The initial capitalization of small investment firms will vary considerably from country to country, but it is unlikely that the sums required would be any greater than the amounts already being spent on rural water services. More careful use of existing funds, combined with a vigorous program of cost recovery from those who are first in line, will go a long way toward breaking the present bottlenecks in providing services to the bulk of the rural population.

COMMUNITY PARTICIPATION

Active community participation means that communities and individuals take a central role in the selection of service levels and in decisions about the how and why of cost recovery. Participation generally is more successful when the community takes over much of the responsibility than when higher-level public agencies attempt to assess consumer preferences through surveys or meetings. In theory, such efforts to establish intensive interactions between the public supplier and the community should work, and there are in fact examples of this having been done on a small scale, with the involvement of voluntary organizations. In practice, however, these types of programs are difficult to maintain over any but a short time frame and at any scale. They are expensive in terms of human skills and require considerable organizational efforts.

Mismatches between what users want and what planners supply have other ill effects besides user dissatisfaction: they waste a nation's resources--materials, labor, time, and foreign exchange vitally needed for other purposes. Over- or under-designed systems and poorly maintained or mismanaged services consume excessive resources, relative to the benefits they produce. If more appropriate solutions were found, more resources could be freed up to devote either to extending services into underserved areas or to accelerating development through other sectors.

In order for community participation to work, projects must include special components addressing it. Villagers can be recruited to help in all phases of designing, implementing, maintaining, supervising, and evaluating new water supply and sanitation systems, but only if the time, effort, and money is spent to do it right. Special attention must be paid to the development of local committees and governance structures that can adequately oversee local participation. The cost of organizing community participation should be included in the basic cost assessment of a project. (See Box 3.1)

BOX 3.1

PROMOTING COMMUNITY PARTICIPATION IN RURAL WATER SUPPLY IN GUINEA-BISSAU

As a means to better project planning, socioeconomic studies have been carried out in the preparatory phase of large and long-term projects. These studies serve to identify the interest, willingness, and capacity of community members to participate in water supply projects. In the course of the project, if it is discovered that some components are not serving community interests, projects may be redesigned, as indicated in the observation of a program in Guinea-Bissau:

"To prepare its community participation component, a socio-economic study was carried out on water use patterns and perceived problems.... The study showed that women applied different criteria to water use for different purposes, and that considerable differences existed in perceived problems and priorities, social organization, and water culture. Experience with non-use of handpumps in [one] area also showed the importance of involving the community, especially the women, in the project period. A team of one male and one female promoter consulted the villagers before site survey and construction took place. After construction, visits were continued to organize local maintenance and health education... For maintenance, the community selected a team consisting of a man responsible for the technical tasks and a woman for upkeep of hygiene.

"Evaluation of the first projects resulted in adaptation of procedures, including fewer but longer visits by the promotional team, contact with women at their places of work, and an earlier initial evaluation visit. Factors related to a lack of interest of the women in health education were a lack of time, and a too theoretical instructional approach. As a result, the promoters were considered to be arrogant. Thus health education was replaced by joint activities such as making laundry facilities and vegetable gardens at the well and preparing more nutritious meals. The promoters also sold soap and vegetable seeds. The new approach resulted in better support for the project...

"Role playing and field visits were the most effective message in training women promoters. Extra time and effort were needed to give them sufficient confidence to participate on equal terms. The cost of social activation work including expatriates and development work amounted to 17 percent of the cost per well."

Source: Jan Teun Visscher, "Rural water supply development: The Buba Tombali water project, 1978-81" (The Hague: International Reference Center, 1982), abstract quoted from Christine van Wijk-Sijbesma, Participation of Women in Water Supply and Sanitation: roles and realities, Technical Paper 22 (The Hague: International Reference Center for Community Water Supply and Sanitation, 1985), pp. 182-3.

INVOLVEMENT OF WOMEN

Women have participated in many phases of rural water supply and sanitation programs, sometimes because of their own initiative and sometimes because of systematic efforts at bringing them into the process of project development. (See Box 3.2) Involving women in water supply projects requires a recognition of their traditional roles and cultural status. In many societies women may haul the water supply, but men are more likely to be represented in community political and social institutions, to have access to expendable incomes, and to speak publicly for the community, particularly in front of outsiders. In some societies, women, even with their responsibility for water supply, are not allowed by custom to take part in public affairs.

These factors should influence the design of water projects, particularly with respect to preliminary efforts to ensure community participation. Strategies must be developed so that project field workers include local women when consulting the community on needs, preferences, and expectations. If a project utilizes local community institutions that traditionally exclude women, mechanisms must be developed to reach women in other ways. Sometimes this might mean developing house-to-house surveys, sometimes conducting meetings exclusively for women, sometimes including special training to encourage women's participation in community-wide assemblies. To ensure full representation of women, projects must also take into account existing household financial arrangements. Otherwise, fees for water use might fall inequitably on women, who usually pay for household expenses but have less money than men to contribute.

BOX 3.2

INVOLVEMENT OF WOMEN IN RURAL WATER SUPPLY: SITE MANAGEMENT

As the primary beneficiaries of water supply improvement, women have contributed greatly to all phases of many water supply projects in the developing world. Sometimes this has occurred as a result of community participation components in projects, and sometimes spontaneously, as shown in this description of site maintenance taken from an overview report on women's involvement in this sector:

"Participation for adequate operation of new facilities begins in the planning phase. Damage and vandalism may be the delayed result of lack of involvement in design and testing for easy and adequate use, and lack of consensus on use and control of use by various user categories, such as women, children, cattlemen, vendors, and neighbouring settlements. In some cases, traditional norms and social control of the use of communal sources and the sense of communal ownership of new facilities are strong enough to guarantee proper use and maintenance of the sites. Often, the manner of use is a form of management as it protects the durability or quality of the source. In rural communities in Botswana, 'no one fetching water from a well or hafir surrounded by a thorn fence would think of leaving without replacing the thorn bush which serves as a gate.'...

"In other cases, satisfactory site maintenance has been achieved through the organization of women users. Sometimes this is a spontaneous initiative of the women themselves, presumably based on traditional arrangements. For example, in a village in Zimbabwe, the women themselves organized the use and upkeep of the communal water point comprising bathing and washing facilities. In an urban slum in Zambia the women's branch of the political party organized the women on an ad-hoc basis to approve the drainage of public taps. In other cases, water, health or community development staff have made arrangements with the users concerned. In Malawi, tap committees composed mainly of women have been established. Women have also been encouraged to use the pipeline routes as paths and to report leakages to the village caretaker. Committees have also been formed to supervise the use of protected wells. In Samoa, members of the women's subcommittees used to sit in the open walled watch-house near village bathing and drinking sources to weave their mats and at the same time to ensure proper use of these facilities. In Tanzania, women have chosen a site attendant from a nearby household or established rosters for site upkeep and preventive maintenance."

Source:Christine van Wijk-Sijbesma, Participation of Women in Water Supply and Sanitation: roles and realities, Technical Paper 22 (The Hague: International Reference Center for Community Water Supply and Sanitation, 1985), pp. 66-7; Botswana quote is from Louise Fortmann, "Managing seasonal man-made water sources: lessons from Botswana," Waterlines, 1985, 1, 4, pp.22-5.

PUBLIC AND PRIVATE SECTOR ROLES

Toward a New Partnership. In many developing countries, rural water supply is considered largely the prerogative of a central government monopoly or department. Alternative strategies need to be developed that foster expansion of local-level and private sector involvement in the planning, construction, maintenance, and oversight of operations. A substantial role for formal central government agencies will still be required -- to help initiate community participation, educate users, and provide services where private suppliers will not or where supplier markets are not yet well-developed. Central governments also will have to formulate and enforce regulations concerning financing, construction, pricing, and quality of water services. But central governments should move away from trying to maintain a public monopoly on all aspects of water supply. Policy development will be a question seldom of public versus private but rather of identifying the most appropriate partnerships.

Experience has indicated that the public-private partnership can serve developing countries well. In the Ivory Coast, for example, the central government builds the system and a private company operates it. (See Box 3.3) In Kenya, the private sector has even more control. (See Box 3.4) By contrast, China has community-owned systems. (See Box 3.5) Another route toward private sector provision of water are water cooperatives, which are common in some Latin American countries, the Philippines, and parts of the Middle East. (See Box 3.6) Cooperatives, according to a recent study, "can be particularly helpful at the village level where informed consumers, sharing common interests within small communities, can take the place of the professional management that can only be afforded by large systems."39/

39/Gabriel Roth, "The Role of the Private Sector in Providing Water in Developing Countries," Natural Resources Forum, vol. 9, no. 3, (1985), p. 172.

BOX 3.3

PUBLIC-PRIVATE COOPERATION IN THE IVORY COAST

One example of public-private cooperation is the network of water systems in the Ivory Coast, which are built and run according to the French affermage model. Under affermage, the public authority handles the construction of the system and contracts out its operation and maintenance, collection of charges, and relations with consumers to the fermier, or private operator. The fermier is compensated only by means of the sale of water, and the contract sets the sale price. To enable the public authority to amortize initial investments, the water price customarily includes a surcharge collected by the fermier for the authority's account and paid over to it. Abidjan has used this system since 1960 through a fermier called the Societe des Eaux de Cote d'Ivoire (SODECI). In 1973, a new contract gave SODECI responsibility for the rest of the country — including 122 towns and several hundred villages. The technology utilized is sophisticated in urban areas, but less so in the countryside. The system has served communities well, as this description indicates:

"Despite rapid expansion, water supply in the Ivory Coast offers one of the highest standards in West Africa. The systems are well designed, equipped, maintained and operated. Water quality and pressure are uniformly good. Consumption is metered and water losses are low."

Water tariffs reflect total costs, with consumers, rather than taxpayers, paying for the service they receive. Rates for small quantities are low, which helps the poor to afford water.

Source:Gabriel Roth, "The Role of the Private Sector in Providing Water in Developing Countries," Natural Resources Forum, vol. 9, no. 3, (1985), p. 170.

BOX 3.4

PRIVATE WATER SYSTEMS IN KENYA

"...The water systems in Kenya, built and run by private associations that were completely independent of the national ministry, were among the most reliable systems in the country. These were often designed and built without adequate professional and technical assistance. Although poor design often resulted in inadequate supply, members persisted in improving both the reliability and quantity of water furnished to users.... The systems were built either without any government support or under the formal Harambee or self-help rules. All were built with the substantial involvement of the community which had specific intended uses for water from the system, often for dairy cattle or other agricultural activities. Systems were operated independently of the Kenya Ministry of Water Development. Private entrepreneurs repaired and replaced faulty components and redesigned parts of the system that were inadequate. Funds for operating the systems were assessed directly to members."

Source: U.S. Agency for International Development, AID Program Impact Evaluation Report no. 7, September 1982, pp. 16-20.

BOX 3.5

COMMUNITY-OWNED WATER SYSTEMS IN CHINA

Community-owned water systems in China offer another alternative to large central government monopolies for the provision of water supply. There, the community is required to deposit in advance 80 percent of the cost of the system and gets assistance from county engineering units in design and construction and financial support of about 20 percent of project cost. The community plays the leadership role in initiating the project and in selecting the water source, system technologies, and service levels; it also pays the full cost of operation and maintenance. The result is a strong sense of pride and ownership. The systems are usually well-operated and maintained because they are wanted and needed by the community, as demonstrated by their willingness to pay the bulk of the cost in advance.

BOX 3.6

A WATER COOPERATIVE IN BOLIVIA

Cooperatives are one form of institution for delivering water. The following description is of an urban system, but many of the same organizational principles would hold for rural areas:

"The organization and operation of water co-operatives, of which there are many, can be illustrated by the Saguapac Co-operative in Santa Cruz, Bolivia. Until 1979, Santa Cruz was served by a municipal company, but in that year it was converted into a co-operative to overcome inefficiencies that were blamed on government control. Since the establishment of the co-operative, water services are reported to have improved significantly and are currently (1984) provided without interruption. The co-operative provides drinkable water to a population of 350,000 in the District of Santa Cruz. Neighboring areas are served by other, smaller co-operatives. Saguapac has a staff of 250. Some services—e.g. pipe installations and meter readings—are sub-contracted to private firms in order to minimize overhead costs. Under the co-operative scheme, each household head has one share which provided [sic] voting power. There are currently 43,000 connections and the same number of shareholders. Saguapac provides a comprehensive water service. Water is extracted from subterranean sources with 13 pumps. The raw water is considered to be safe to drink, but it is chlorinated as a precautionary measure. After extraction, it is transported to large storage tanks, from which it is finally distributed to the urban area through a network of pipes owned by the co-operative. Tariffs are proposed by Saguapac but have to be approved by a government agency... In 1983 the co-operative was hit by a trebling of energy costs, and the government did not allow it to increase its tariff sufficiently to meet this increase. As a result, the co-operative is running a deficit; it has no public subsidy. It is trying to deal with the situation by negotiating for reduced energy costs and for tariff adjustment."

Source: Gabriel Roth, "The Role of the Private Sector in Providing Water in Developing Countries," Natural Resources Forum, vol.9, no.3, (1985), pp. 171-2.

Institutional Development. Achieving the policy reforms recommended in preceding sections will require changes in the roles, structure, and capacities of many institutions, public and private. Chapter I noted that institutional development is no panacea. Still, given an improved policy framework, there is much that can and should be done to help institutions evolve so as to support policy objectives. Some combination of both private and public initiatives will be required.

Perhaps the most important institutional development that can take place is the promotion of a private sector able to provide a wide range of services, from construction to operation and maintenance. The objective is to encourage development of a large number of small firms that would tend to disperse geographically and thus establish a local base for the provision of operation and maintenance services, as well as, of course, promoting a more competitive environment for controlling costs.

In the past, small private firms in this sector have not flourished because of the dominant role of the central government. This has meant covering whole areas or regions and awarding large contracts to foreign suppliers, as is the case in Africa, which tend to use large-scale, capital-intensive techniques that may not be appropriate where capital is scarce and economies of scale are limited.

Changing the way in which business is done will assist in the development of small firms, but it may not be enough in some countries. Private capital may be reluctant to commit itself to the necessary investments because of the perception of high risks, with regard to both the instability of public policy and the poor record of financial intermediaries. Thus, countries may have to undertake programs of active promotion. Financial assistance to small firms, either through equity or loan capital, may be required, along with training and technical assistance. In some cases, foreign suppliers of materials and equipment may be interested in participating in equity or franchising arrangements with local capital. There are a large number of possibilities, including the use of private firms to undertake under contract some of the operation and maintenance functions for public institutions.

A set of central government institutions that needs considerable strengthening is that engaged in providing information. General information on hydrology, geology, rainfall, and so on, is seriously lacking in all countries. Records are poorly kept or not kept and are seldom available to those who require them. This lack of information can result in dramatic increases in the cost of water supplies. Where groundwater is the basic source, for example, the cost is almost directly proportional to the ratio of successful to unsuccessful boreholes and the rate of success is related to information about what is underground. Few central governments have or enforce regulations regarding the keeping and filing of drill logs. For those that do, there is often a multiplicity of central government agencies involved, with little coordination among them. Putting some order into this institutional chaos, along with more adequate levels of funding, would have a high payoff in terms of lowering water costs.

In addition to promotion and the provision of information, there are the pure governance functions of public institutions, that is, the establishment and enforcement of the rules and regulations for those working in this sector. Again, it is typical to find some institutional chaos. Centralized ministries of Health, Rural Development, Public Works, Local Government, and so on, all promulgate rules and regulations, often conflicting and often unenforceable. Efforts to build a more supportive regulatory framework must be an important part of any institutional development effort in the sector.

In some instances, a case could be made for a separate institute (or part of a central government ministry) to promote projects and provide technical assistance to both borrowers and lenders. The same institution, however, would not be the one to provide financing, since the combination of promotion, together with financial intermediation, runs the risk of loss of financial discipline and independence of judgment.

In many cases, the best approach is to utilize existing private and public institutions with established networks in the rural areas. But the long-term goal is for the central government to diminish its role as supplier and move into that of promoter, provider of information, and regulator.

Private Voluntary Organizations (PVOs). Private voluntary organizations have long been active in both rural water supply and sanitation. With a few exceptions these organizations have had as their focus the health of the rural populations, with improved water supply and sanitation seen as a means of achieving this end. The general approach used by these organizations has created a set of expectations that will be difficult to fulfill. Although some of these organizations have tried to collect limited funds to pay for operation and maintenance, for the most part these schemes have been highly subsidized. This has encouraged the view, both at the village level and at the level of national decision making, that these services are properly treated as welfare or charitable good.

These organizations do have an important advantage in having close ties at the local level. Their assistance in promoting and developing both rural water and sanitation programs could be of great value--provided there is an appropriate framework for their participation. At the moment, when most countries lack a carefully thought out pricing and cost-recovery policy, the danger is that the involvement of both domestic and international PVOs will continue to encourage consumers to expect that they need not pay most of the costs of water supply improvements.

NONHOUSEHOLD USE OF WATER

As water becomes more plentiful and available, it may be diverted for nonhousehold use in agriculture, industry, or commerce. Project design must take this into account, correcting for both demand (the increase in agricultural, commercial, or industrial use) and for costs (the increase in system capacity).

Experience has shown that rural villagers have often diverted water intended for drinking, cooking, and washing to irrigating crops for domestic use and sale. This is particularly true where water is made available in large quantities through the use of piped distribution systems. Villagers in Senegal and Nigeria, for example, were found to be tapping a large percentage of their piped water for agriculture. In a United Nations Development Programme (UNDP) project, villages of 100 to 250 people actually paid for water enough for two and three times as many people; they used the excess water to grow tobacco and cash crops, the proceeds of which helped pay for the excess water.

Increases in the amount of water available may also lead to its use for other commercial and industrial purposes. It is not unusual in many areas of the world to find as much as 30 to 40 percent of rural incomes coming from off-farm activity. The introduction of yard taps, for example, may encourage development of industries ranging from beverage to noodle factories and other forms of food processing.

Increased use for nonhousehold purposes may introduce costs other than installation and maintenance fees and recurrent charges. Higher levels of consumption for commercial and industrial purposes in some cases, for example, have increased the problem of waste water disposal and added considerably to the investments required. In other cases, the increased availability of water has encouraged the keeping of larger cattle herds, for which villagers have not been able to find sufficient grazing lands. In situations like this, problems will arise because of the difficulty in either defining property rights over water or in pricing (rationing) supplies in such a way as to reflect their real costs; this can cause a high level of social tension.

In order to estimate the possible effects of these nonhousehold uses on demand and supply, it will be necessary to observe and quantify the effect of existing water supply projects. Assumptions will have to be made on whether new projects will have a similar effect in order to assess the correct level of investment and avoid social tension. The often dramatic decrease in prices or real costs of water that can result from these investments means that the increases in demand may be considerable. These nonmarginal increases are difficult to analyze because they require information about production functions and markets that is not readily available. Fortunately, the pace of implementation of most programs is sufficiently slow to permit adjustments to take place gradually in response to changing market requirements. But this does suggest that monitoring and evaluating the results of investments should be an ongoing part of any rural water supply program.

SANITATION SERVICES

As noted earlier, demand for sanitation services may often not be strong in sparsely populated areas. In such settings, the best route to improving sanitation may be by education and other means of persuasion, rather than by investing in new facilities.

In contrast to urban areas, where economies of scale require collective decisions, decisions in most rural areas about what is to be invested and how it is to be used are inevitably made at the household level. Investments are made on plot and usually for exclusive household use. Public or collective influence over these decisions is marginal at best. Even large subsidies for investment costs do not provide sufficient incentives if the use cost (in terms of time and effort) is high.

All of this suggests a more limited role for the public sector in improving rural sanitation services than has traditionally been proposed by prospective donors. If a demand for improved services can be generated, low-cost technologies are within the capacity of the household's resources. The problem is on the demand rather than the supply side.

This also suggests, given the enormous size of the problem, that initial efforts should be concentrated in those areas where there is potentially a high payoff, both in terms of consumer willingness and possible health benefits. More densely populated rural villages and urban fringe areas deserve priority, since that is where the potential for disease transmission and desire for convenience and privacy are most pronounced. Here, the information on both the benefits of improved waste disposal and the methods for doing so are likely to receive a favorable response.

As in the case of water service, the replicability will depend greatly on the willingness to limit public subsidies, particularly for direct investments. The most effective use of scarce public funds is likely to be found in providing information that would improve household investment decisions.

Since the investments to be made by households are in small discrete units, the most efficient providers to construct the physical infrastructure are likely to be small contracting firms or craftsmen. In many instances, these could be the same firms providing water supply services. This is a common practice in both developed and developing countries. Many of the recommendations made above concerning the financing and other promotional efforts for water supply firms would apply to sanitation as well.

TRAINING AND TECHNICAL ASSISTANCE

Training and technical assistance are essential to the success of new rural water supply systems, but they must be closely linked to the way in which business is done. The amount of training and technical assistance required, particularly from external sources, is likely to be inversely proportional to the effective use of incentives within the system for supplying services. A system that relies heavily on the community to elucidate its demands and to obtain its own financing is less likely to need large numbers of trained social workers and other community motivators than a system that relies primarily on government initiatives. Small firms providing drilling and other services will have sufficient motivation to train their own workers. But large public "campaigns" will require substantial training of both managerial and technical staff. In countries where trained manpower is scarce, greater reliance will have to be placed on setting in place the appropriate incentives, and less reliance will have to be placed on the use of trained public service personnel.

There are, however, a number of critical areas where even when appropriate incentives are used, technical assistance and training can be an important input. One is the dissemination of information about low-cost technologies. Few people in the developing countries have this knowledge, and training in its application is critical. The Bank, UNDP, and other bilateral donors have indicated their strong support for this type of training and technical assistance through their contributions to the International Training Network for Water and Waste Management that has been established. This Network, of which the Bank is the coordinator, will provide training institutions in developing countries with materials and technical assistance designed to promote the use of lower-cost and more appropriate technologies. (See Box 3.7)

BOX 3.7

THE TRAINING NETWORK

The International Training Network for Water and Waste Management was established at a meeting of bilateral and multilateral agencies convened by the World Bank in Bonn in October 1984. The principal aim of the Network is to disseminate knowledge and promote the use of low-cost water supply and sanitation technologies, where appropriate, in the planning and design of sector development strategies and projects.

The Training Network consists of fifteen developing country institutions; full expansion is expected to be reached in about five years. The training and information-dissemination programs of Network Centres is supported by bilateral agencies. Development-oriented institutions in industrialized countries also participate in the Network as "associated institutions" to provide technical support to Network Centres as needed in building up their training and research capacity. In 1985/86 Network Centres have been established in East and West Africa, South Asia, and East Asia.

The World Bank has developed a comprehensive set of audiovisual information and training materials necessary to teach the purpose and application of low-cost technologies to selected audiences of the Network. The Network's audiences include policymakers, practicing engineers, engineering students and their educators, project field staff and trainers of community development health, and other field workers. The materials cover not only technical aspects but, equally important, concepts of community participation and health education — all components of successful low-cost technology projects. The World Bank's Publications Department is reproducing and distributing these materials, which have been prepared in English but will be translated into French, Spanish, and other languages.

The Coordination Unit for the Network is located in the Water Supply and Urban Development Department of the World Bank. The Bank and the United Nations Development Programme have provided initial financial support for the Unit. The Unit's Coordinator and staff are assisting developing country training institutions and bilateral and multilateral agencies in developing and expanding the Network. The Coordination Unit is also providing technical support and guidance to Network Centres as needed to formulate, implement, and monitor their activities. The Unit also serves as liaison with World Bank Project staff and the Economic Development Institute in the planning and execution of Network activities.

Another area in which training and technical assistance are important is in the establishment of appropriate country policy frameworks. Most governments have seen their role in this sector as financiers, builders, and maintainers. Few are equipped to step back and take on the more demanding responsibilities of being promoters and regulators. To do so will require the development of new skills. The collection, analysis, and dissemination of information on water resources, for example, are poorly understood and badly done in most developing countries. Yet this information is vital in any type of program to develop rural water supplies. If financial intermediaries and local investment firms are to be used effectively, their establishment and regulation will require some assistance in most countries. If large numbers of community organizations or small firms are to be service providers, their promotion and regulation will require the establishment of new skills and new ways of doing business on the part of the central government.

RESEARCH AND DEVELOPMENT

Although it is always desirable to have more reliable data and information, the framework set out in this paper can be implemented without a major research effort. Research on some of the economic, social, institutional, and technological issues could provide useful insights that would persuade policy makers to act more expeditiously and could lower the risks of mistakes in specific situations.

Economic Issues. The most obvious area for research is in developing a better understanding of the factors that determine demand for both water and sanitation services. The estimates of Chapter II and Annex A are the best that can be done under existing circumstances but leave a great deal to be desired. Better studies on the relationship between distance hauled and the amounts of water consumed, for example, would greatly strengthen the credibility of the numbers used. Better information on who in the family hauls what quantities of water for what purposes, including nonhousehold use, would help predict the outcome (benefits) of investments designed to reduce haul costs. More data on water markets in rural areas would increase the confidence with which income and wage data can be used. In the case of sanitation, almost nothing is known about the demand or the factors that determine that demand. It has been hypothesized that convenience and privacy are the major factors. But what is meant by convenience and privacy? How much convenience? Under what circumstances?

Social Issues. One of the most controversial and puzzling issues surrounds the links between water and sanitation investments and health. This paper has pointed out that the assumption of large health improvements is not necessary to justify water projects. But the existence of better water supplies can enhance and may even be necessary to achieve any health benefits from investments in public health and education services. The links between water supply improvements and public health benefits need to be clarified, from the point of view not so much of justifying these improvements but rather of determining the role of water supply improvements in health programs. Given the existence of some level of water service, how and in what form can hygiene education programs contribute to improvements in health? What are the circumstances under which benefits are achieved?

If adequate sanitation is to reach most rural areas, it will require a well-considered marketing strategy. Research needs to be done on the most effective ways of modifying human behavior in this regard. Waiting for general improvements in educational levels and rising incomes implies that such services will be a long time in coming to most rural areas.

Furthermore, mechanisms need to be developed to help involve communities--and especially women--in water supply improvements. Much of the research to date on participation has been anecdotal. More information is needed on the traditional role of women, the extent to which involving women can benefit projects, and the ways in which this may enhance the overall productivity of a community. Of particular interest would be data on whether involving women in all aspects of a project leads to a higher than present level of cost recovery.

Institutional Issues. There are a number of issues to be addressed under this heading. There are, for example, a large number of alternatives for cost recovery at the village level. Some villages have used head taxes in one form or other; some have used direct user charges; still others have used property or similar wealth taxes. In order to offer a range of possibilities, together with their strengths and weaknesses, it will be necessary to survey what has been done, how it has been done, and what has worked under what conditions. Access to this type of information would greatly assist institutions in giving guidance to villages and would improve the chances for a reasonable degree of cost recovery.

A key recommendation of this paper has been the use of community organizations and small firms to supply water and sanitation services to rural communities. The promotion and development of these firms will be a relatively new activity in most countries. The experience of existing practices in both developed and developing countries needs to be documented and guidance provided to those countries seeking to emulate this approach. Financial institutions providing support need to have access to these data in order to develop their own guidelines.

If countries are to step back from the direct provision of services, they will need to develop a more appropriate regulatory framework, as well as to improve informational and technical assistance services. Today, few countries have anything like a supportive framework for these types of activities, and much will need to be done to develop them. Here, the experience of the developed countries could provide some guidance.

Technological Issues. Although a great deal of effort has gone into research on the technological issues, there is still much to be done. The development of better handpumps needs to be supplemented by improved technologies for locating and drilling boreholes. In many countries, it would appear that drilling technology is excessively capital intensive. A return to simpler, more labor-intensive technologies, where feasible, is a more efficient direction in which to move. Equipment of this nature is available, but its use and the necessary adaptations required for use in developing countries need to be explored.

From the analysis of Chapter II and the supplementary material in Annex A, it is clear that the gains from improved water supplies come from decreasing haul distances. The cost figures used in the calculations for yard taps have assumed a fairly sophisticated system based on "standard" design specifications for raised storage and buried pipe. It is possible to reduce these costs by installing storage tanks that are raised only enough to provide adequate, but not necessarily ideal, flows to each residence and by burying pipe in shallow trenches, particularly along village pathways that are not subject to vehicular traffic. In many developing countries, it is possible to observe a great variety of "homemade" systems in place. These systems often minimize installation costs by using such things as above-ground plastic hose; although this is not generally recommended, such practices do show that unconventional designs can significantly improve access to water.

Costs can also be reduced by eliminating the central government's role in preparing detailed drawings of proposed systems in small villages where an experienced contractor is fully capable of installing a working system with minimal design drawings. The extent to which services are provided more efficiently by the private sector should be documented.

It will be increasingly important to monitor and evaluate the performance of alternative energy sources related to water supply in remote places. In the example in Chapter II of an analysis of the costs and benefits of yard tap systems, it was assumed that power from an electric grid would be available, but in many countries electricity is either unavailable or unreliable. To evaluate the increased cost of water due to either of these conditions, the source costs of pumping water by means of diesel, solar, and wind-powered pumps must be examined.

Whichever method of pumping proves to be most suitable in a given location, it is clear that locally based, private installation and maintenance contractors working closely with local communities in many ways offer the key to widespread coverage of community water supply systems.

CONCLUSIONS

The suggestions made here--particularly those addressing the ability of the rural poor to pay for water supply, the changing role of the central government, and the necessity of refocusing programs in sanitation and public health--are admittedly controversial and will require careful and thorough implementation. A strong case can be made that a new approach to country strategy and investment policy is likely to provide more water for more people at less cost, and it is imperative to convey the reasoning behind these initiatives and their likely result, as well as to move toward implementing them.

IV. A ROLE FOR THE BANK

GENERAL OBJECTIVES

Limited resources and competing priorities preclude the World Bank from coming close to financing the level of investment required to deliver water and sanitation services to the rural population. The Bank can, however, play an important role in assisting countries in using available resources more efficiently by redefining objectives and by developing acceptable and workable strategies. In addition, the Bank can be catalytic in mobilizing other sources of financing. The previous chapters have developed an analytical framework that can serve as a starting point for this process.

World Bank assistance must be contingent on the recognition that whatever is done has to be replicable on the scale required to address the problem within a reasonable time frame. The Bank should be active only in those countries that are seriously prepared to work toward this objective. The definition of replicability and an understanding of what is meant by a reasonable time frame are clearly matters of judgment and will probably vary from country to country.

The development of country policy will be a slow and difficult process. Although there are "pockets" of potentially replicable operations in a handful of countries, no country has what could be termed an appropriate policy framework with replicability as a goal. Thus, the first and critical step will be the establishment of country dialogues with a view toward creating such a framework. This inevitably means a long-term and staff-intensive commitment on the part of the Bank to program development in specific countries. One-shot projects that provide for a few handpumps per village cannot realistically be expected to achieve the type of institutional and policy adjustments needed to operate more efficiently in the sector.

The choice of countries will, therefore, have to be judicious. Countries willing to make a political commitment to change policy are obvious candidates. Beyond that, priorities can be set on the basis of needs. These can be broadly defined in terms of income levels and the scale of the problem. Poor countries with large rural populations are an obvious first priority; Africa and southeast Asia fall within this category. In the other regions, the Bank's efforts should be selectively targeted to projects where participation can yield substantial and demonstrable policy improvements relative to the resources transferred.

It is not possible to predict the effect of these new directions on the demand for Bank financing. At the present moment, the volume of Bank lending for rural water supply and sanitation projects is small and sporadic. (See Table 4.1) In the short run (the next three to five years), it is unlikely that there will be any significant shift.

TABLE 4.1

WORLD BANK LENDING IN RURAL WATER SUPPLY AND SANITATION: TOTAL LENDING AND PERCENTAGE OF PROJECT LENDING, 1974-85
(in millions of dollars)

Year	RURAL WATER SUPPLY: Free-standing projects	RURAL WATER SUPPLY: Project Component: Water and sanit.	RURAL WATER SUPPLY: Project Component: Agri-culture	Total lending to rural water supply	Total lending to urban water and sewerage	Total lending to water and sewerage sector	Total lending of IBRD and IDA
1974	0.0	0.5	7.2	7.7	173.2	180.9	4,423.6
1975	0.0	1.5	22.7	24.2	143.6	167.8	5,945.9
1976	0.0	12.1	11.1	23.2	322.5	345.7	6,702.4
1977	0.0	3.6	28.9	32.5	297.1	329.6	7,086.8
1978	9.0	0.0	29.8	38.8	366.2	405.0	8,410.7
1979	20.0	19.6	11.9	51.5	979.2	1,030.7	10,010.5
1980	0.0	23.6	12.0	35.6	607.5	643.1	11,481.7
1981	11.8	27.3	34.7	73.8	495.4	569.2	12,291.0
1982	30.5	2.5	33.5	66.5	408.2	474.7	13,015.9
1983	46.1	8.6	28.4	83.1	747.5	830.6	14,447.0
1984	60.9	11.9	17.6	90.4	620.1	609.7	15,524.0
1985*	80.0	2.4	25.5	107.9	772.3	880.2	14,386.3
Total	258.3	113.6	263.3	635.2	5,832.4	6,467.2	123,725.8
Cumulative percentage of total Bank lending				0.5%	4.7%	5.2%	100.0%
Cumulative percentage of rural water supply investments as part of water sector and agriculture components				9.8%	90.2%	100.0%	

* Figures for 1985 were calculated on a basis different from that used for previous years.

During the critical phase of country dialogue, however, an important consideration will undoubtedly be the amount of staff and other resources the Bank is prepared to devote to both the dialogue and project development. At a minimum, it is estimated that the development of suitable projects will require three times the average resources presently going into preparation of rural water supply and sanitation projects.

A further constraint on project and program development will be other lenders' support for these new initiatives. At present, relatively few of the bilateral and multilateral agencies, including national and international volunteer agencies, finance rural water and sanitation projects with cost recovery as a project objective. As long as a commitment to cost recovery in rural water supply and sanitation projects is the exception rather than the rule, it will be difficult for the Bank to engage in a constructive dialogue with its borrowers.

It will therefore be critical for the Bank to engage in a major effort to coordinate its rural water supply and sanitation strategy work with other funding agencies. The growing and collective frustration of both borrowers and lenders over the poor results of past efforts should aid in the willingness of all concerned to reexamine the issues. Here the Bank can be instrumental in explaining and testing the framework set out in this paper and in taking the lead in bringing the donors together to coordinate overall sector objectives. The Bank's role as executing agency for the United Nations Development Programme and bilaterally financed research projects in low-cost water and sanitation has placed it at the center of a network of agencies in both developed and developing countries. This strategic position can serve as the springboard for a programmed series of discussions with all concerned.

POLICY RECOMMENDATIONS

Financing. As discussed above, the key to the successful implementation of any strategy is the transfer, over time, of the responsibility of service provision to local or community entities. A prime instrument for reaching this goal will be the support of financial intermediaries as a means to overcoming financing constraints. Most of the agencies promoting water and sanitation services have little experience in working with financial intermediaries of the type envisioned. The Bank, with its experience, is in a unique position to provide the support needed.

The promotion of appropriate financial intermediaries for project financing will require the Bank to scale down and, over the long run, to withdraw from financing these services through investments directed toward ministries of public works or rural development. In place of this, the Bank must be prepared to lend only if financial intermediaries play a role. Clearly, this change will have to be introduced gradually. In most countries, well-entrenched interests encourage the present way of doing business, and considerable resistance will be encountered in efforts to change. Also, existing financial intermediaries are often ill-equipped to undertake a new line of financing. This suggests a cautious, experimental approach, with the Bank continuing to finance some limited public works programs, but only on the condition that part of the loan be used to develop and strengthen intermediaries and to finance their programs of lending for rural water supply. Certain regions or villages with an agreed level of population, income, or existing cooperative financing activity, for example, could be identified to receive financing through the mechanisms suggested above.

In addition to providing financing to communities to invest in rural water supply and, when appropriate, sanitation services, the Bank should consider providing financial support to firms engaged in constructing or maintaining these services. One way would be for the Bank, by providing for a credit line component, to encourage existing financial institutions such as the commercial banks to become more active in this area. Supporting national guarantee funds to underwrite some of the risks or directing some portion of loan proceeds to existing financial intermediaries working in rural areas is another option. But perhaps more important than making loan funds available will be the development of programs to encourage the mobilization of both local and foreign private capital. The International Finance Corporation, for example, could be encouraged to provide equity or loan capital to programs designed to support the development of large numbers of small firms, using franchise-like arrangements with foreign suppliers of equipment. In this way, foreign firms can be encouraged to provide the necessary technical assistance and training as well as some capital.

<u>Cost Recovery</u>. The cornerstone of any Bank involvement in this sector is a markedly improved record on cost recovery; without it, few countries will be able to afford other than token programs. Most countries will commit themselves to recover operation and maintenance costs, but few will go beyond this to recover total costs. Even when the commitment has been only to operation and maintenance, however, the performance has not been satisfactory. Attitudes and beliefs in this area will be difficult to change. Nonetheless, the Bank will have to take a firm stand in principle and be prepared to be flexible in practice.

As a first step, it is recommended that the Bank articulate its goal of full cost recovery in its rural water and sanitation projects. In order to achieve this goal, the Bank should be prepared to accept some continuing level of subsidy in the short run in order to introduce the structural and policy reforms that would achieve higher levels of cost recovery over the longer term. Where high levels of subsidy exist, the amount of the subsidy--both implicit and explicit--should be quantified and a justification given. This justification should show what income groups are receiving the subsidy, the relationship between their income and the subsidy, the percentage of the unit cost of water represented by the subsidy, the total amount of the subsidy relative to public expenditures, the level of the subsidy relative to the needs of the populations not being serviced, and so on. The objective is to encourage countries to move toward a more complete accounting of actual subsidies in the sector and then to formulate an explicit subsidy policy that can then be discussed in terms of need and effectiveness. The Bank should not be against subsidies per se but should insist that within a reasonable period of time they meet the replicability criterion and be efficient in terms of distribution and administration.

The framework of analysis discussed in Chapter II can be useful in determining the efficiency of the subsidies. Suppose, for example, that government policy is to allocate a major share of investment funds to rural water supply projects in region B; application of the decision rules, however, does not justify this politically motivated decision. Nonetheless, the projects in region B could be ranked according to their net benefits and then compared with a similar ranking of investment alternatives in region A, where it was clear that government could maximize benefits relative to costs. The project planner could then approach the decisionmaker with a concrete choice. By allocating investment to region A, the government would lose net benefits but, nonetheless, could choose from among the best alternatives in terms of the net benefits produced. The planner could further demonstrate that, by making this decision, the government would be foregoing X amount of benefits in region B and that this would represent the cost of the political decision.

Project Design and Preparation. The failure to reach more of the rural population at existing levels of investments is due largely to the absence of a suitable approach to project design. The framework presented in Chapter II and the supplementary material in the Annexes sets out the minimum requirements to assess the benefits and costs of a proposed intervention, together with the steps needed to ensure that costs are minimized and services are affordable to both the beneficiaries and the country. As seen above, a minimal amount of information is required both to design interventions and to measure their benefits. Where information is not available or where it is subject to a wide range of interpretation (for example, the value of rural labor), some estimate is still required to make explicit the underlying assumptions and judgments used.

One issue that is likely to cause controversy is the evaluation of health benefits. The evidence suggests that water supply interventions by themselves are likely to yield minimal health benefits--even if it were possible to quantify them. There are many, however, who will continue to insist on the importance of these benefits. The Bank should encourage project designers to be more explicit in linking specific investments to improvements in health and to recognize that these links are more likely to occur when health and hygiene education components and programs are included in projects. In addition, there will be some cases where there are explicit links between the quality of the water and specific diseases, such as with excess fluorides in the water. While recognizing these possibilities, the Bank should maintain the position that most high-priority projects will be amply justified in terms of the real economic benefits from time savings rather than the illusory "benefits" of health improvements.

Water and Sanitation Projects as Components of Rural Development Projects. Most of the Bank's financing of rural water and sanitation services has taken place in the form of subcomponents of rural development projects. (See Table 4.1) As parts of these larger projects, water and sanitation receive relatively low priority in terms of their design and institutional objectives. To improve project performance, the Bank should exercise caution about continuing to finance these services as subcomponents unless there is an adequate policy and institutional framework in place. Without such a framework, there is little chance of achieving a substantial rate of return on the component.

Some projects may permit substantial improvements in the policy and institutional framework. This would require more staff resources being devoted to these components than was generally the case in the past. There also may be opportunities for experimenting with new ways of doing business within the context of the larger project.

Investments in Rural Sanitation Services. As indicated earlier, there appears to be limited demand for this type of service in low-density, small rural settlements. In any case, it is not clear that there are measurable benefits that justify priority financing. This suggests that the Bank should limit its funding to a few experimental programs that would test different approaches, technologies, or combinations of services and evaluate and compare their performance. In the peri-urban areas and in the larger rural settlements, there is both sufficient demand and greater likelihood of having some effect on health; under such circumstances packages of such services are warranted and should be considered for Bank financing.

In the less dense, more remote rural areas, the Bank could target limited financing to programs that aim to shift demand, that is, to encourage the use of improved waste disposal systems. Both general educational programs and those directed at specific behavioral practices affecting health and hygiene are examples. In addition, financial aid and technical assistance could be used to encourage private suppliers to meet the limited demand for such services. Higher-income families and those living at the center of higher-density villages would be prepared to purchase greater convenience and privacy, provided acceptable techniques were available at a low enough price. The firms contracted to build water systems could be encouraged to provide sanitary services as well. Although the limited use of these facilities would not greatly affect health in the short term, increased familiarity with their construction and use could have a cumulative effect as incomes and densities increased.

Research and Development. At present the Bank is engaged in a highly productive program of research and development with the support of the United Nations Development Programme (UNDP) and most of the bilateral donors. (See Box 1.1) This program has concentrated on developing technically feasible, low-cost water supply and waste disposal systems. Most of the basic research is now coming to an end, and increasingly the effort is focused on marketing and dissemination. The setting up of the training network is an important step in the active dissemination of the research findings. (See Box 3.7) Even though this work is moving out of the basic research stage, it would be cost-effective to use the capacity that has been developed to continue to do some limited research into the engineering and technological issues. In particular, some of the suggestions for further research discussed in Chapter III could be followed up on at relatively low costs. High priority should be given to further work on very low-cost distribution systems, the development of lower-cost drilling techniques, and the use of alternative energy resources. More study is also needed on the development of local governance structures, community participation, and the involvement of women in rural water supply.

The Bank is in a unique position to follow up on some of the economic issues raised throughout this paper. No other agency or research institution has the capacity to do so. In particular, high priority needs to be given to research on demand estimation and improved methods for benefit-cost analysis of both water supply and sanitation projects. The UNDP-funded program has made a modest start. Research is under way in rural Kenya to quantify more precisely the relationship between quantities of water consumed and the distance hauled. Additional information will be obtained on prices paid for water, who is doing the hauling, under what circumstances, and the relationship between income levels and water consumption. This work needs to be expanded to cover a greater variety of situations.

In addition, the Bank can assist countries in developing appropriate country strategies. Through its financing of innovative projects using the type of institutions and financing methods suggested in this paper, the Bank would be in a good position to monitor and disseminate the results. By making sure, through its knowledge of overall investment priorities and constraints, that these programs are replicable, the Bank could provide an important service to both borrowers and lenders in this field.

One area where the Bank does not have any particular comparative advantage is in the research that will be required to better link water and sanitation investments with investments in public health. Other organizations such as the World Health Organization, the United Nations Educational, Scientific and Cultural Organization, and national health agencies should be encouraged to become more active in providing these links.

The recommendations set forth here are directed at aiding countries and donor agencies in correcting past problems in rural water supply and sanitation services. The task will not be easy. Many constituencies will have to be convinced to alter firmly entrenched viewpoints. Yet the first steps have been taken already. Elements of the approach proposed here are being used now in the design and selection of policies and projects. This paper seeks to carry the process one step further to help countries and donor agencies to work toward their objectives of delivering safe, convenient water supply and adequate sanitation to rural populations.

ANNEX A[40]

COST/BENEFIT CALCULATIONS

This annex, expanding on the material in Chapter II, includes an illustration of how to calculate costs and how to use the benefit-cost rules. Also presented is a discussion of source and conveyance costs, more on water demand, and more on water cost, with a fuller description of various possible technology choices.

ESTIMATING THE COSTS: AN EXAMPLE

The costs of supplying water and sanitation services in rural areas can vary considerably, depending on the technology selected, the environment, operation and maintenance regimens, and other factors. The available evidence on typical costs is limited, making generalization difficult. Nevertheless, with a modest degree of data collection, reasonable estimates can usually be compiled for a specific investment decision in a particular locality.

Because some cost items, even when on-site data have been collected, cannot be predicted perfectly, alternative scenarios of assumptions about cost factors generally need to be considered. Sensitivity analyses also are required to gauge how sensitive the results are to variations in the assumptions. With the aid now of portable computers, procedures for carrying out these steps are easy to develop and apply, even in remote field locations.

The following example illustrates the sort of analysis and inferences possible by this means. Suppose that two alternative options are being considered for a prototype village with the characteristics listed in Table A.1. The two options are a system of handpumps only, representative of typical point sources from which water must be carried to the point of use; or a yard tap system, from which water is available with little or no haul and queue time. There are obviously many other alternatives conceivable--an electric pump, for example, can be substituted for a handpump, or standpipes serving entire neighborhoods can replace yard taps serving houses individually. But the analytic approach remains the same, regardless of the types or number of alternatives examined.

The data in the table describe an initial (or "base case") set of assumptions from which variations will be considered. The base case

40/ Contributors to this Annex were R. Roche, F. Wright, and E. Quicke.

TABLE A.1

AN ILLUSTRATIVE EXAMPLE:
STANDARD VALUES FOR COMPONENTS OF WATER SUPPLY SYSTEM

Demographic Characteristics	Standard Value		
Total population	400		
Persons per household	8		
Total households	50		
Persons per hectare	200		
Households per hectare	25		
Economic Conditions			
Average wage rate ($/hr)	0.125		
Income ($/capita/year)	?		
Discount rate (%)	10		
Electric power cost ($/Kw Ht)	0.10		
Village Water Use and Collection	**Handpumps**	**Standpipes**	**Yard Taps**
Meters to alternative water source	500	500	500
Liters of water carried per trip	20	20	-
Walking rate (km/hr)	4	4	-
Collection time			
Travel time (min/trip)	1.5	1.5	-
Queue time (min/trip)	2.5	1.0	-
Fill time (min/trip)	1.3	1.3	-
Daily water use (liters/cap)	20	30	60
Water Supply System			
Number of wells	2	1	1
Number of water points	2	3	50
Cost per well ($)	2,000	2,000	2,740
Pumping lift (meters)	20	20	20
Storage volume (stor vol/total daily flow)	-	0.30	0.30
Useful life mechanical equip. (yrs)	10	10	10
Useful life non-mech. equip. (yrs)	20	20	20
Water delivery rate (liters/min)	15	15	10
Maximum daily output (m^3)	14	15	30
Annual O&M, mech. equip. (% cap cost)	10	10	10
Annual O&M, non-mech. equip. (% cap cost)	1	1	1

values are based on engineering estimates and actual cost experience.41/ In general, they assume "best practice." The estimates for the source cost of water from a well system are based, for example, on the assumption that appropriate well-drilling equipment is available and is used. Obviously, it is possible (and is borne out by experience in many parts of the world) for poor construction management or inappropriate technology, or both, to lead to substantial increases in costs.

Total costs are estimated as the sum of annual capital charges, operating costs, and maintenance costs, taking into account the useful life of equipment, the opportunity cost of capital, and other factors. Costs are figured on the basis of unit of volume delivered to the point of consumption, which, in the case of the handpumps option, for example, includes the value of time that users spend getting water to wherever they use it.

Starting with these initial assumptions, Figure A.1 compares the total costs of the two options, as reflected in cost curves relating consumption in liters per capita per day (lpcd) to cost in dollars per cubic meter ($\$/m^3$). Not surprisingly, cost per cubic meter declines as consumption increases, due to economies of scale. For handpumps, the decline is relatively modest and levels off above about 30 lpcd. For yard taps, it is larger and levels off only at much higher consumption amounts, above 60 lpcd.

When the value of time is varied from zero to as high as $0.50 per hour, the cost of the handpump system increases (Figure A.2), whereas the cost of the yard tap system remains unchanged because there is no travel and waiting time for yard taps. The effect of successively higher figures for the value of time is substantial. In this case, the cost per cubic meter is more than ten times as much when the value of time is $0.50 per hour as when it is zero. Water from a handpump system can cost up to US$2.50 per cubic meter compared to a range of between US$1.00 (at 20 lcpd) and US$0.25 (at 75 lpcd) for a yard tap system. (As a point of comparison, the cost of water in Washington, D.C., as mentioned earlier, is approximately US$0.30 per cubic meter.)

The figure shows that when the value of time is above about $0.20 per hour, the yard tap system is the least-cost option, assuming that consumption is in the 20 to 75 lpcd range. When the value of time is below about $0.05, the handpump system is the least cost. Between $0.20 and $0.05, the choice depends on the level of consumption.

41/ Anthony M.J. Yezer, "An Economic Analysis of Alternative Water Distribution Systems: Public Standpipes vs. House Connections" (Washington, D.C.: World Bank, 1984); also, D.T. Lauria, "Design of Low-Cost Water Distribution Systems," Research Working Paper 11 (Washington, D.C.: World Bank, 1979).

FIGURE A.1

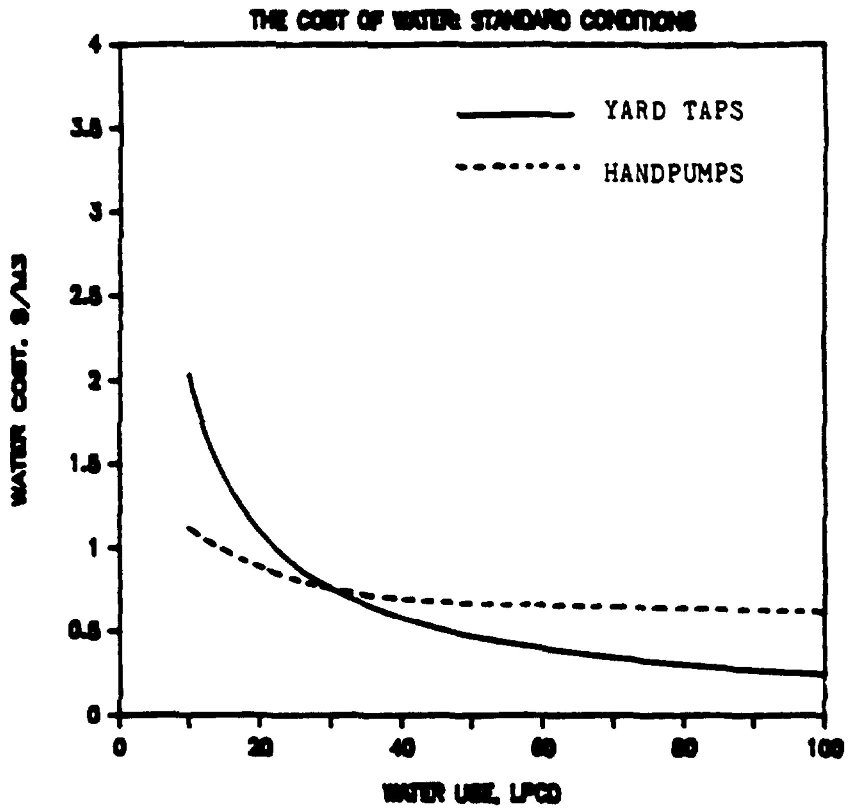
THE COST OF WATER: STANDARD CONDITIONS
YARD TAPS
HANDPUMPS
WATER COST, $/M3
WATER USE, LPCD
0
0.5
1
1.5
2
2.5
3
3.5
4
20
40
60
80
100

FIGURE A.2

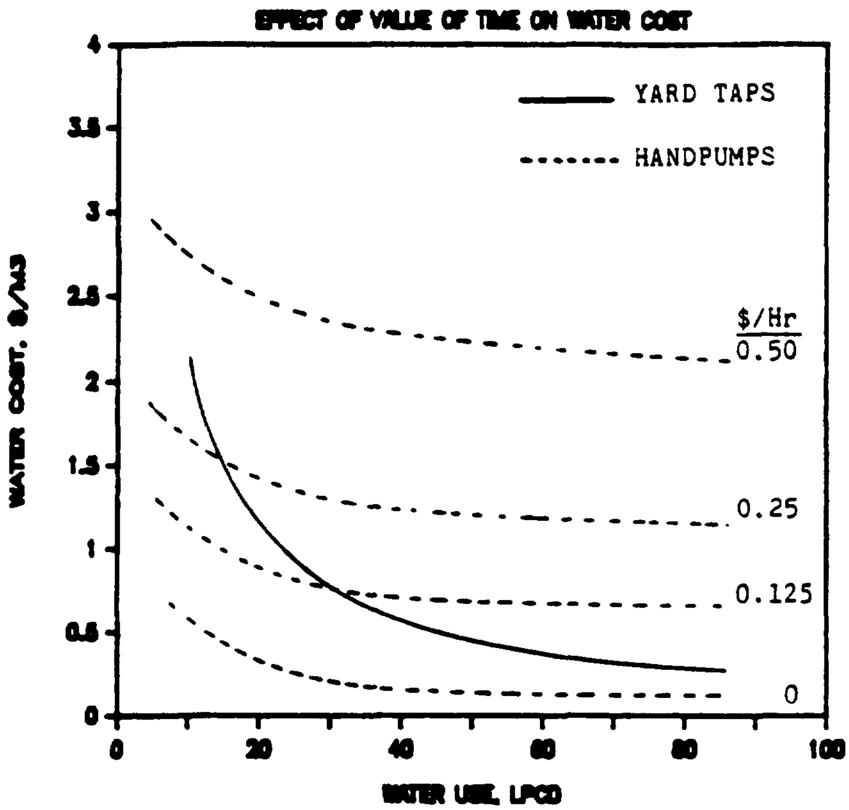
EFFECT OF VALUE OF TIME ON WATER COST
YARD TAPS
HANDPUMPS
$/Hr
0.50
0.25
0.125
0
WATER COST, $/M3
0
0.5
1
1.5
2
2.5
3
3.5
4
WATER USE, LPCD
0
20
40
60
80
100

Figure A.3 shows the effect of varying population size. In these comparisons, density is held constant in all cases. Thus, the comparison is between a small village occupying a certain area and a larger village occupying a correspondingly larger area. The data show that the cost per cubic meter declines as population increases, starting from a very small community (100 people). However, this effect disappears quickly as higher population levels are reached. For handpumps, there are no further economies after population exceeds 200. For yard taps, there is little effect after 400.

In Figure A.4, population is held constant (at 400), but now density is varied. Density affects both the piped distribution costs of the yard tap system and the haul distances of the handpump system. For both systems, costs fall as density increases. But there is little additional effect on costs once density reaches about 10 households per hectare. (Ten households per hectare is a comparatively low-density community for many countries.)

Varying the assumption about the cost per well has relatively little effect on the total cost of the two systems, contrary to what some of the literature on the subject has implied in the past. In this context, "well cost" includes all costs incurred to drill and prepare a well. For handpumps, an increase in well cost from $1,000 to $8,000 per well raises the cost of water by only $0.50--from about $1.00 to $1.50 per cubic meter. This is because the value of the time people spend hauling water accounts for a large share of total costs. For instance, when the well cost is $8,000 and the value of time is $0.125, the collection and consumption each account for about 50 percent of the total. In the case of yard taps, an eightfold increase in the well cost leads to less than a one-third increase in total costs, when water consumption is 75 lpcd.

In the above results, assumptions have been varied one at a time. In order to get a better idea of how these parameters interact with each other, various combinations of the more important parameters can also be compared.

In Figure A.5, the effect of jointly varying village size, density, and value of time is shown. The curve represents the points at which handpumps and yard taps are equal in cost at a consumption level of 75 lpcd. Anywhere to the left of the curve, the handpump system yields the lowest cost; to the right, yard taps cost less. For example, yard taps cost less where (i) density is 60 persons per hectare, (ii) population exceeds 400, and (iii) the value of time exceeds $0.125.

These analyses underscore the observation that man--or more accurately, woman--is an inefficient carrier of water. The carrying of water is an expensive process and, even in very low-wage economies, can result in a high implicit price for water. When the value of time is taken into account, the rural poor of Africa and Asia are paying prices for water that are many times higher than what is being paid by their urban counterparts in both the developing and developed world. This is not to say that all carrying of water can be eliminated; some will continue to be necessary in many parts of the world where incomes and population densities are too low to justify piped distribution systems. It does suggest, however, that there is much scope for reducing costs by concentrating on minimizing haul distances and wait times. Whether this is to be done through investments in piped distribution systems or improvements in the spacing of point sources will depend on the specifics of each situation.

COMPARING BENEFITS WITH COSTS

Once the benefits and costs of the options being considered for a particular investment or policy choice have been assessed by the steps outlined above, the rest of the analysis is simple. The comparison between handpumps and yard taps can continue to serve as an example. Suppose that the number of handpumps for the village in question ranges from one to ten or more. A choice must be made not only between handpumps and yard taps but also, if handpumps are selected, about the number of pumps. (There is no corresponding set of suboptions for yard taps in this example because it is assumed that a yard tap system means a tap in every yard. Again, additional or more complex options could be included, but the nature of the analysis would remain the same.)

In general in a problem of this sort one can first focus on the issue of how many pumps there should be if a handpump system were selected, and then compare the resulting "optimally sized" handpump system with the yard tap system. Similarly, if other options are being considered as well, the leading variant of each generic type can be determined separately and then compared with the others. As long as net benefit (benefits minus costs) is the criterion of choice, one will arrive at the same final selection in the end, regardless of the order in which options and variants are taken up.

Deciding on the Number of Pumps in the Handpump System. Calculating the benefits and costs for each different number of pumps produces graphs like Figure A.6.[42/] These are based on the methodology used earlier in this chapter for assessing benefits. From the net benefit curve (which is simply the difference between the two other curves), it can be concluded that a three-pump system is best in this case. The sensitivity of this result to variations in the assumptions can be explored in several ways. As an example, Figure A.7 shows the effect of varying the well cost. As the well cost increases, one would expect systems with multiple wells to become less attractive relative to systems with a smaller number of wells, holding other things constant. Figure A.7 confirms that this indeed is so and shows the extent to which

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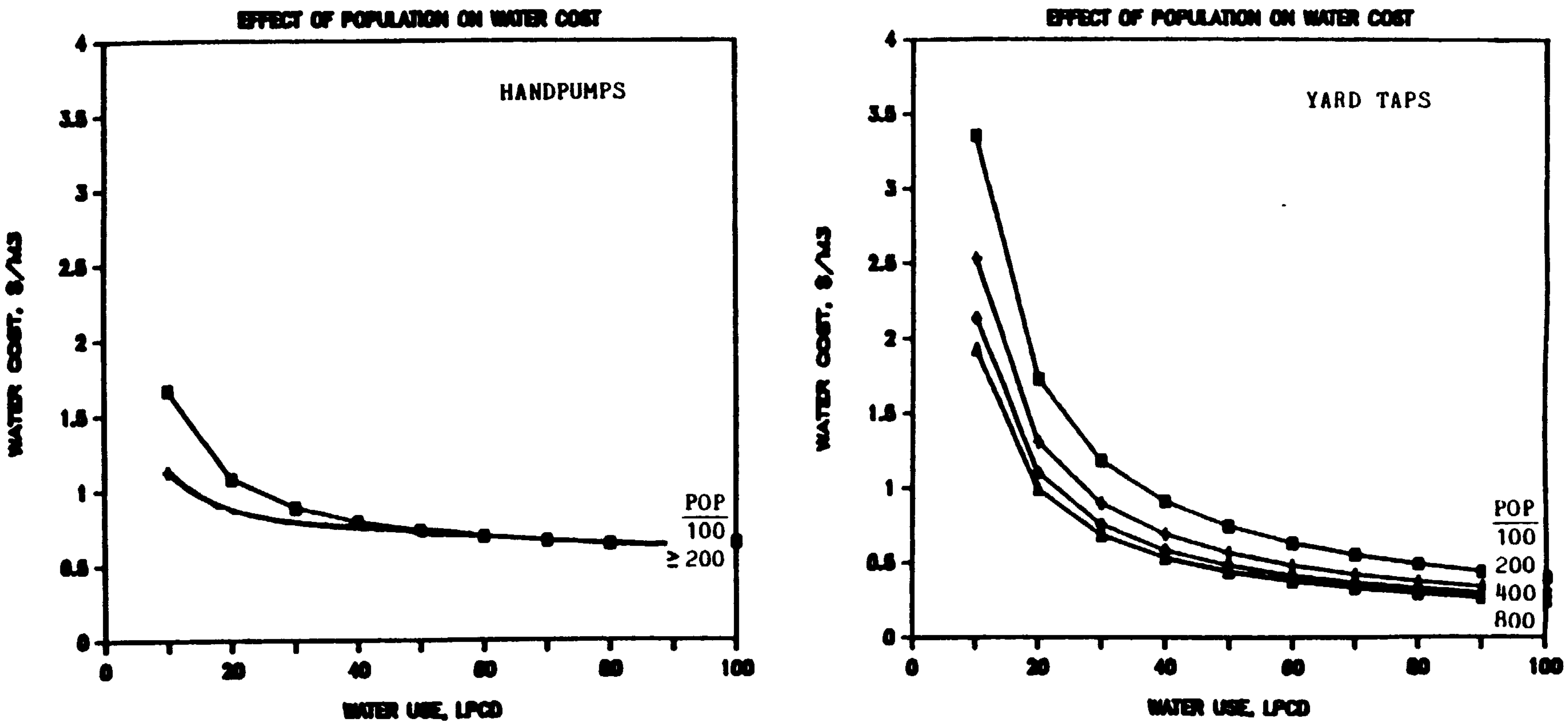
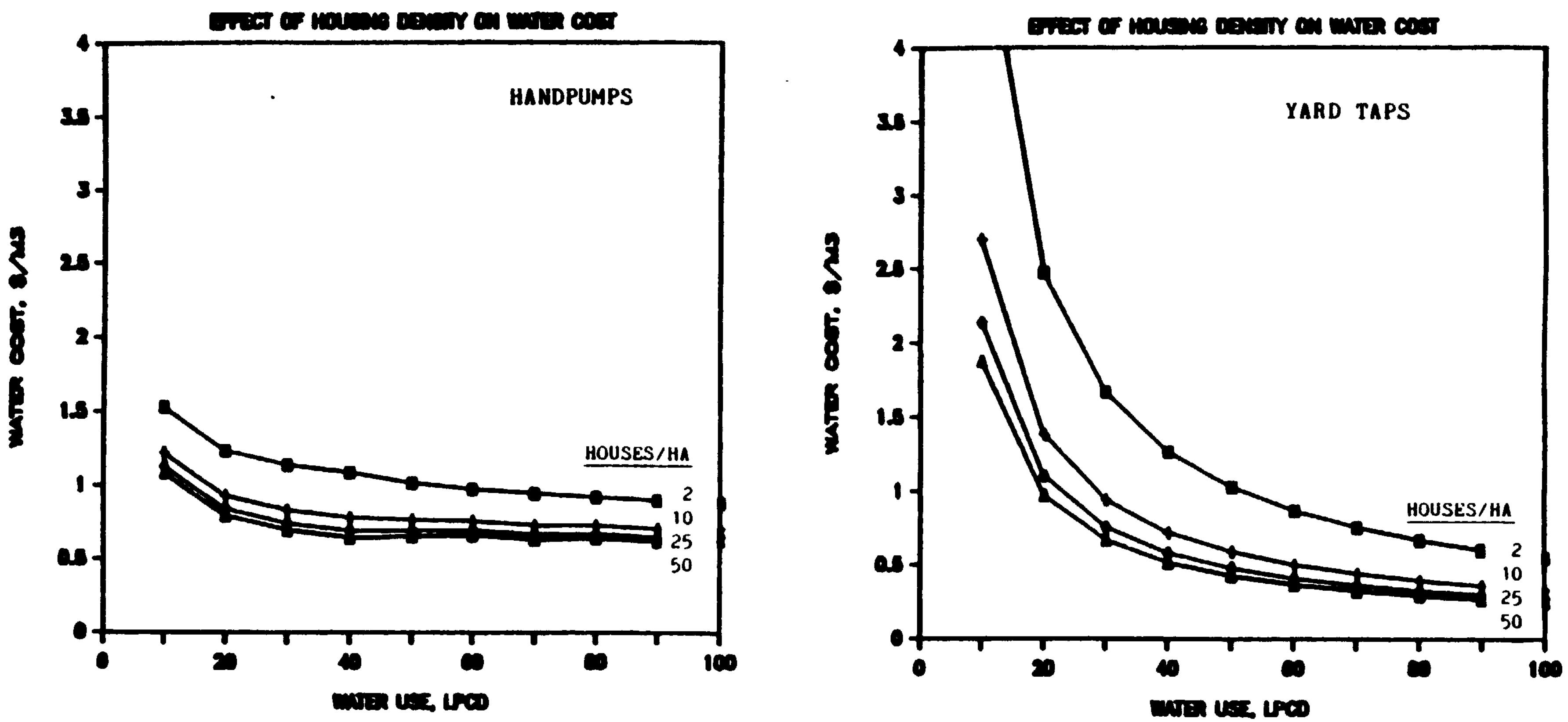
42/ For easier interpretation, Figures A.6 and A.7 have been drawn with the horizontal axis expressed in terms of persons per pump, with the number of pumps appearing as a second measure. The two are easily convertible one to another in this case because population size is fixed (for example, in the base case, it is 400).

FIGURE A.3



EFFECT OF POPULATION ON WATER COST
HANDPUMPS
WATER COST, $/M3
WATER USE, LPCD
POP
100
≥ 200
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20
40
60
80
100
EFFECT OF POPULATION ON WATER COST
YARD TAPS
WATER COST, $/M3
WATER USE, LPCD
POP
100
200
400
800

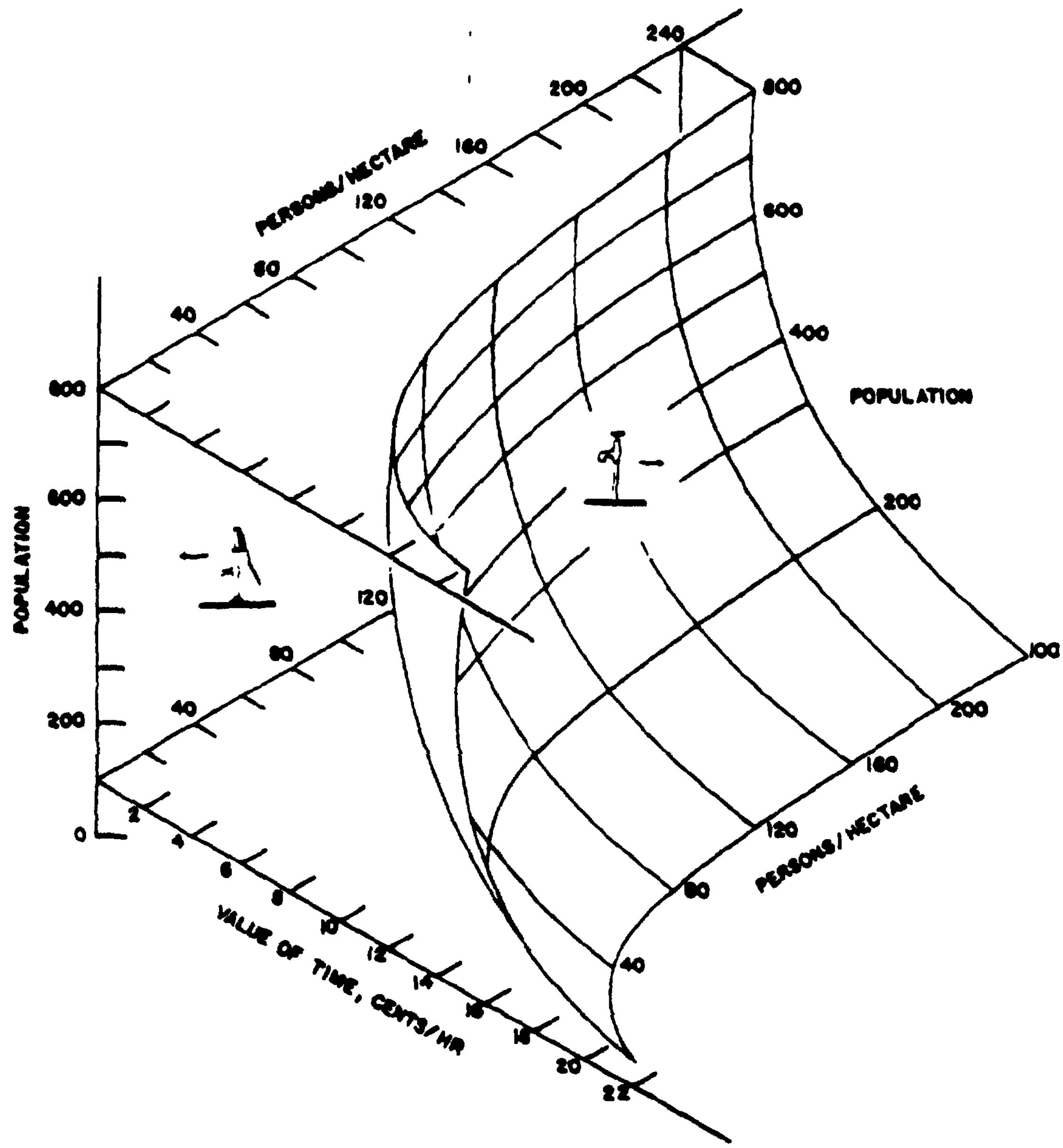
FIGURE A.4



EFFECT OF HOUSING DENSITY ON WATER COST
HANDPUMPS
WATER COST, $/M3
WATER USE, LPCD
HOUSES/HA
2
10
25
50
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20
40
60
80
100
EFFECT OF HOUSING DENSITY ON WATER COST
YARD TAPS
WATER COST, $/M3
WATER USE, LPCD
HOUSES/HA
2
10
25
50
0
0.5
1
1.5
2
2.5
3
3.5
4
0
20
40
60
80
100

FIGURE A.5

COMBINATIONS OF VILLAGE POPULATION, HOUSING DENSITY, AND VALUE OF TIME AT WHICH HANDPUMP AND YARD TAP WATER COSTS ARE EQUAL



The curved surface corresponds to the combinations of population, housing density, and value of time at which the cost of water ($\$/m^3$) from handpumps and yard taps are equal. Points inside the curved surface indicate that handpumps provide water at a lower cost than yard taps, and, conversely, points outside the curved surface indicate that yard taps provide water at a lower cost than handpumps.

the optimal number of wells is sensitive to incremental changes in well costs. At the initially assumed value of $2,000 for well cost, net benefit is highest at 3 wells for the entire village, or 133 persons per well. At $4,000, net benefit is highest at nearly 200 persons per pump, or 2 wells. At $8,000, the best option is one well; and at well costs above $12,000, net benefit is always negative, and no project can be justified.

Similar calculations can be done to examine the effect of varying other assumptions, or two assumptions simultaneously. In general, the effects of varying any two variables at once are, in this example at least, what one would expect from adding together the one-variable results. For example, if both the value of time and the well cost are increased above their standard values, the effects of both variables on net benefit and best number of handpumps tend to cancel. If, however, the value of time is reduced while well cost is increased, there is a dramatic fall in net benefit and in the best number of handpumps.

Deciding between handpumps and yard taps. Once the best number of pumps for the handpumps option has been determined, the comparison of that alternative with the yard tap choice is simple. For the base case assumptions, the conclusion is that the handpump option has the highest net benefit. Sensitivity analyses on this result are described in the annex.

As an example, Figure A.8 demonstrates the effect of jointly varying the assumptions about the value of time and the discount rate. The lines shown correspond to different ratios of the net benefits of yard taps to the net benefits of the handpumps system. If that ratio is greater than one, the yard tap system has the highest net benefit. If it is less than one, the handpump system is the better choice. For example, for the conditions in the prototype village where the value of time is $0.125 per hour, the net benefit provided by handpumps is $6.00 per capita per year. However, if the value of time increases to $0.21 per hour, net benefits provided by handpumps and yard taps are both $12.00 per capita per year.

Given that raising the value of time tends to increase the benefits of yard taps faster than those of handpumps, and that raising the discount rate tends to increase costs of yard taps faster, the constant net benefit ratio curves should have a positive slope--as indeed they do. The base case values generate net benefits for yard taps that are only 80 percent as large as those for handpumps. However, small increases in the value of time, from $0.125 to $0.21, raise the net benefit ratio to 1.0. Because technology selection is so sensitive to the value of time, an important element of water project planning should be the determination of income levels and time values for water collection in the villages in the proposed project area.

FIGURE A.6

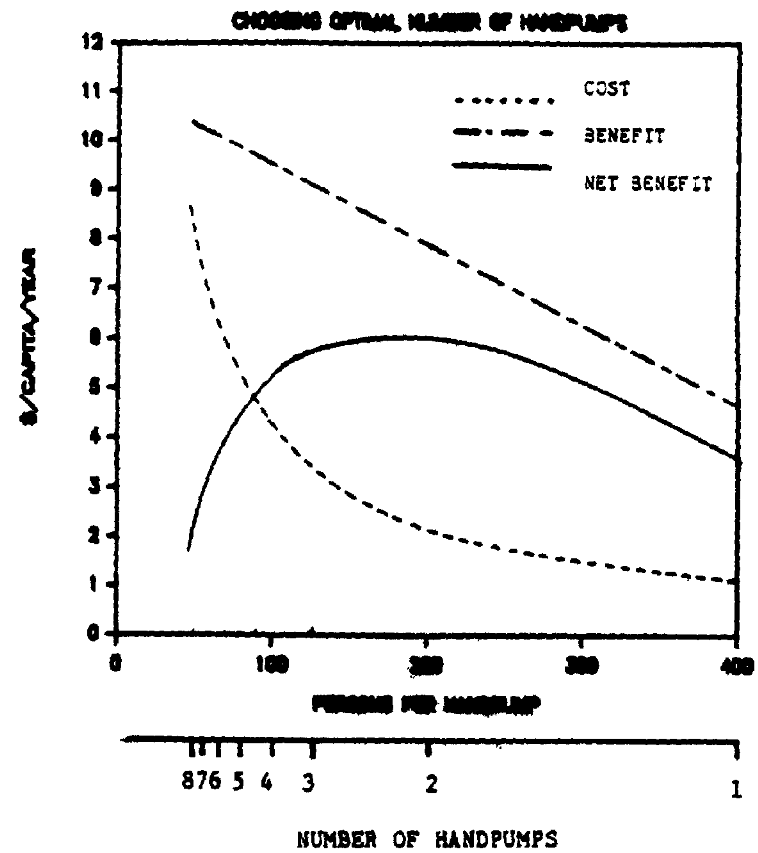
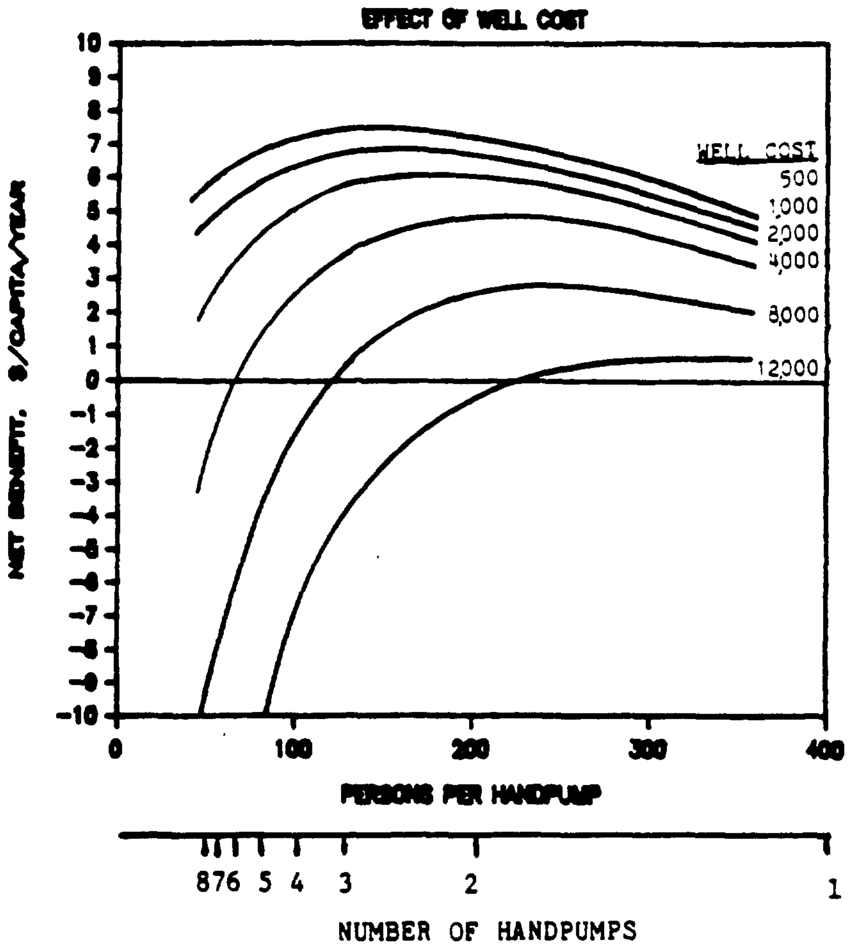

COST
BENEFIT
NET BENEFIT
$/CAPITA/YEAR
12
11
10
9
8
7
6
5
4
3
2
1
0
0
8
7
6
5
4
3
2
1
NUMBER OF HANDPUMPS

FIGURE A.7


EFFECT OF WELL COST
NET BENEFIT, $/CAPITA/YEAR
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
0
100
200
300
400
PERSONS PER HANDPUMP
WELL COST
500
1,000
2,000
4,000
8,000
12,000
8
7
6
5
4
3
2
1
NUMBER OF HANDPUMPS

The effects of varying well cost and value of time jointly are shown in Figure A.9. While increasing the well cost raises costs for both yard taps and handpumps, the cost increase is relatively larger for handpumps, so that the constant cost lines have a negative slope.

Further Observations. Calculations such as these help identify which variables should be the focus of further data collection and research. In addition, estimates for many different sets of circumstances can be compiled into tables showing which option is best under alternative assumptions about the values of key variables. A planner equipped with such tables and a modest data collection budget could easily look up the appropriate project design that is likely to be best suited for a particular village. In many regions, large numbers of villages would tend to have similar characteristics, and the choice outcome, once known for one village, would hold for many.

Still, there will generally be several further considerations that must be dealt with, including the following:

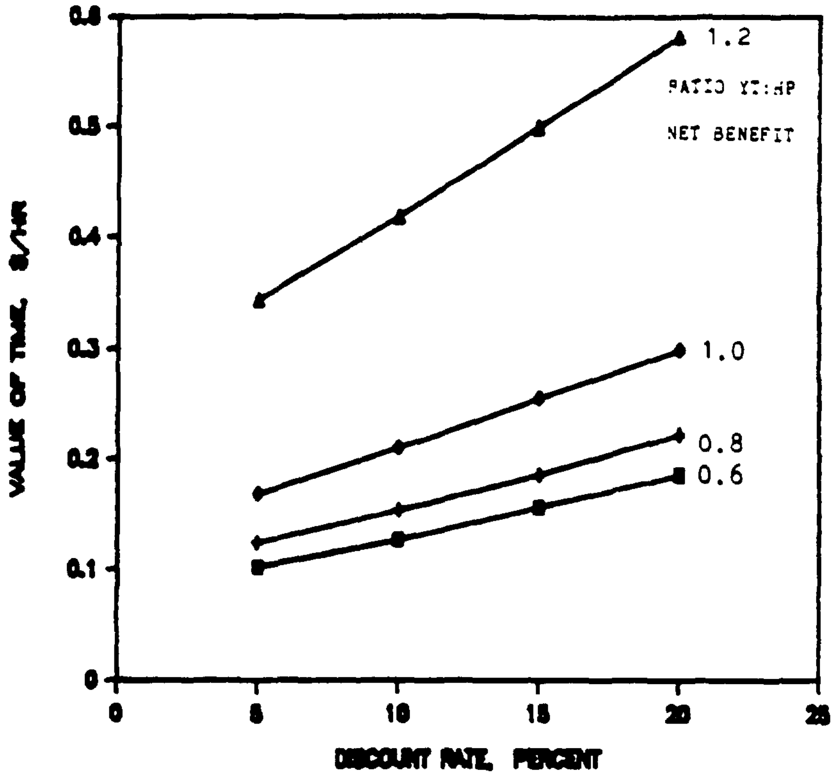
1) Any of the parameters used to characterize a project site may be changing over the twenty-year economic life of the water service project. This is particularly true of the population size and income or wage variables. In many villages being evaluated for water service projects, important variables such as population or income may be changing rapidly. To the extent that such changes are taking place, the water service project should be evaluated based on both the current and the expected future characteristics of the village.

2) It may not be possible for the agency responsible for financing water service projects to borrow funds at an official interest rate. In case of such a "capital shortage" problem, there may be large numbers of projects that cannot be undertaken promptly that will eventually generate positive net benefits. Indeed, it may be many years before all projects with significant net benefits can be undertaken. In such circumstances, the net benefit calculation should be performed with a higher cost of capital or discount rate because of the extra limits on capital availability facing the agency. Alternatively, the analysis may be performed for several years' worth of projects at once to determine optimal project design and then a scheduling routine adopted to maximize the present discounted value of net benefits. A similar analysis will hold for foreign currency limitations on agency projects. In such cases, costs of inputs that must be imported should be increased to reflect the limitations imposed on the use of foreign currency for water projects.

3) There may be limitations on the availablity of certain essential equipment, particularly well-drilling rigs. The approach taken to resolving this problem is in the general spirit of that proposed for the "capital shortage" case

FIGURE A.8

EFFECT OF CHANGING VALUE OF TIME AND DISCOUNT RATE ON RATIO OF NET BENEFITS OF YARD TAPS TO HANDPUMPS



above. The cost of well-drilling should be increased in order to reflect the scarcity of equipment for producing wells. In addition, the time period covered by the analysis could be increased to cover several years.

4) There may be special concerns that must be addressed concerning transfering income or improving services to the lowest-income groups. In principle, extra weight could be given to net benefits generated in lower-income villages, but it might be difficult to achieve agreement on appropriate weights. Also, the amount of income redistribution involved in water service projects is determined by the method of finance. Clearly, if there is public provision with no charge to the village, the redistribution may be large. However, the use of the willingness-to-pay criterion implies that villages can be charged for the improved water services. If such charges are implemented, the redistribution associated with the project will be small.

5) There may be political considerations that must be accommodated. Suppose, for example, that practical politics requires that 40 percent of the water project funds be allocated to projects in region X. This can be treated as a constraint in implementing the benefit-cost criterion. Projects in region X and those in the rest of the country are ranked separately in terms of net benefit and funded in each area, beginning with the highest net benefit case. At least 40 percent of the funding is used in region X. The difference between the net benefit of the last project undertaken in region X and that in the rest of the country can be cited by the planner as a measure of the marginal cost of the political constraint. Thus political and social constraints can be imposed on the benefit-cost analysis, and the net benefit approach makes apparent the social cost of those limitations.

6) There may be significant transportation costs for drilling equipment if the projects where net benefits are highest are located at opposite ends of the country. In such instances some tradeoffs may be required between ordering projects according to net benefit and minimizing transportation costs between villages; these can be achieved by comparing net benefits differences with transportation costs.

Finally, it is worth stressing the speciousness of the argument in favor of spreading water projects around so that there is one handpump in every village before second handpumps are added. There are four problems with this approach. First, projects would undoubtedly be constructed even when net benefit was negative. Second, this approach would make it very difficult to achieve significant cost recovery, because in some areas net benefit would be small and in others only a fraction of demand would be met and villagers would resent being charged for a handpump with a long queue. Third, the operating life of these handpumps might be very short because some villages would be unwilling to pay and in others, the system would be vandalized by frustrated users who found a single pump inadequate to meet demand. (Such fighting in the queue and damage are well-documented in discussions of project problems.) Fourth, it is very expensive to return year after year to the same village to add increments to the water supply system, particularly when the design of the first system is not consistent with that of a higher level of water services.

SOURCE COSTS

A water supply system can be considered in terms of its source works plus conveyance to the point of use. The source works include the well, a pump, and a storage tank if water is not pumped by hand. In the body of the report, the cost of pumping water is based either on handpumps or electric submersible pumps run off an electric grid. Since electric power is not available in most rural areas, the cost of diesel, wind, and solar-powered pumps will also be evaluated. In addition, if handpumps are used, the height that water must be lifted and the power a person can input to a pump have major effects on the cost of lifting water. Accordingly, special attention will be given to the effect of pumping lift on the cost of water and choice of pumping technologies.

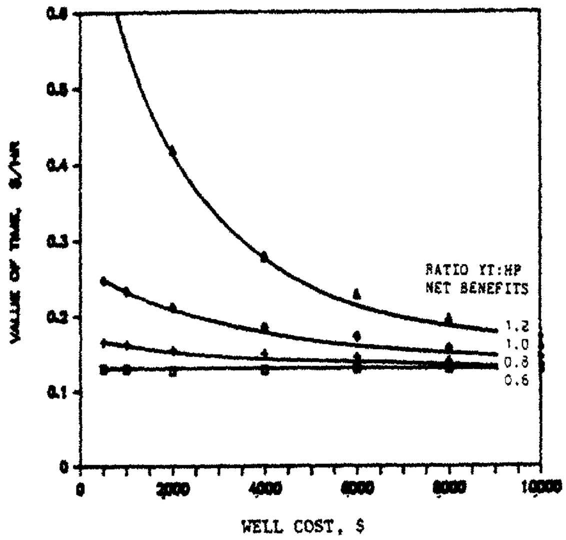
Wells. Because the cost of well drilling is highly dependent on the type of drilling equipment, the amount of expatriate labor, construction efficiency, and borehole success rate, well construction costs are specified on a lump-sum basis rather than by first specifying a well depth and geologic conditions and then estimating the cost of the well. For example, in some drilling projects, the construction cost per well has been more than $10,000, while other drilling projects using more suitable drilling equipment, minimum expatriate labor, and an efficient drilling program have constructed wells to equal depths in similar geologic strata for less than $2,000.

In order to allow for a wide range of well yields, the lump-sum cost is applied to a well that provides up to 15 m^3 per day, and the cost of wells with larger capacities is assumed to increase above this base cost in proportion to the square root of the daily capacity. The cost of wells with capacities greater than 15m^3 per day is given by the equation (cost/well = base cost $(Q/4)^{1/2}$), where Q is the well capacity in m^3/day.

A single well is used for standpipe and yard tap systems. Handpump systems, however, are limited by the amount of power a person can exert. Consequently, the capacity of a well fitted with a handpump is inversely proportional to the pumping lift. Water delivery rates are given by the equation ($Q_{l}pm = 6W_{p}E/H$), where Q_d is the water delivery rate in liters per minute, W_p is the power input in watts, is the mechanical efficiency of the handpump, and H is the pumping lift in meters. Well capacity assumes 8 hours of pumping each day at this water delivery rate.

FIGURE A.9

EFFECT OF CHANGING WELL COST AND VALUE OF TIME
ON RATIO OF NET BENEFIT OF YARD TAPS TO HANDPUMPS



It is observed that a typical adult women will input about 100 watts of power when the pumping lift is greater than 15 meters and somewhat lower power inputs at lower pumping lifts. Consequently, power inputs are assumed to be 100 watts for lifts above 15 meters and the following empirical equation is used for pumping lifts below 15 meters: ($W_p = 4H + 40$). The mechanical effecency is a function of the pumping lift; the following empirical equation reflects typical efficiencies: ($E = 0.4 + 0.0067H$).

Handpumps. The cost of handpumps can vary from less than $100 for simple direct action, low-lift pumps to more than $2000 dollars for imported, heavy-duty pumps. In this analysis, the installed cost of low-lift handpumps (pumping lifts less than 12 meters) is set at $200, and the cost of community handpumps for pumping lifts greater than 12 meters is given by the equation ($/handpump = 500 + 8H). Accordingly, the installed cost of a handpump with a 20 meter pumping lift is $660.

Diesel Pumps. The cost of low-lift diesel pumps is assumed to be the same as electric pumps ($500/pump). However, for greater depths, the cost of either a direct-drive turbine pump or a diesel-powered generator and submersible electric pump is significantly higher. For estimation purposes, it is assumed that the cost of a diesel-powered pump (lift > 7m) is double the cost of an electric submersible pump operating under the same conditions. Also, the useful life of a diesel pump is assumed to be 5 years, half that of an electric pump. The annual energy cost for a diesel pump is given by ($1.15\ Q\ HP_d$), where P_d is the cost of diesel in $/liter, and it is assigned that the fuel-to-water output efficiency is 7.5 percent and the energy content of diesel fuel is 150,000 Btu/liter.

Electric Pumps. The cost of electric, surface-mounted pumps (suction lift less than 7 meters) is assumed to be $500. For higher pumping lifts, in the capacity range needed for community water supplies, the cost of electric submersible pumps is dependent on both the pumping lift and required water delivery rate. The installed pump cost used here (including discharge pipe, electric panel, and wiring) is given by the equation [$/pump = 275 + 25(H + 10) + 75Q/t], where the required delivery rate is a function of the daily water demand of the community (Q) and the number of hours (t) that electric power is available each day. For the conditions found in the prototype village ($H = 20$ meters, $Q = 30\ m^3$/day, $t = 5$ hours/day) the pump cost is $1475/pump. Annual energy costs are given by the equation ($/year = $2.5QHEP_e$), where the mechanical efficiency of the pump is 40 percent and P_e is the price of electricity in $/KWHr.

Wind pumps. The cost of a wind pump is proportional to the cross-sectional area of wind intercepted by its blades, and the required blade diameter (D_w) is given by the equation ($D_w = 1.2QH/Vw^3$) where V_w is the average daily wind speed in meters per second. Costs vary roughly between $250/m^2 for locally made, light-weight wind pumps to $750/m^2 for heavy-duty pumps made in Australia and the United States. A cost of $500/m^2 is used in this analysis.

Storage tanks. Storage tanks are sized to meet a daily peaking factor of 3, where the peaking factor is given by the maximum divided by the average hourly flow. It is also assumed that electricity is available during peak morning-use hours and that it remains on for a minimum of 5 hours each day. Accordingly, the required storage volume is 1/3 of the total daily flow.

A major factor in the cost of storage tanks, particularly large ones, is whether they must be raised or whether the terrain is such that sufficient head can be obtained with the tank placed on the ground. Here it is assumed that tanks are raised to provide a maximum of 10 meters of head in the distribution system. The cost of storage tanks is given by the equation ($\$/\text{tank} = V_s^{1/2}$) where V_s is the useful storage volume in m.

Two alternatives to community storage were considered: (i) individual household storage and (ii) minimal community storage, consisting simply of a constant head tank where electricity is available throughout the day so that pumps and wells can be sized to meet a daily peak demand of 3 times the average hourly flow. Household storage at $100 per household results in storage costs that are somewhat higher than community storage; and when storage is offset by increasing well capacity to meet the daily peak demand, the cost is essentially the same as community storage.

Yard taps and standpipe outlets. When water is pumped by hand, water use is typically between 15 and 25 liters per capita per day (lpcd), and when it is piped to individual yards, consumption increases to between 50 and 125 lpcd. Because the water use generated by yard taps often results in ponded water and muddy village pathways, proper design requires the provision of either surface drainage or a seepage pit at each outlet. The $100 per outlet cost used for yard taps includes the installed cost of both a tap and drainage pit. Similarly, drainage is needed for public handpumps and standpipes. Five hundred dollars is used as the installed cost of an outlet, splashpad, and drain field for standpipes, and these costs are included in the above costs of handpumps.

CONVEYANCE COSTS

As discussed previously, the costs and benefits of water supply projects should be compared at the point of use. To do this, piping and haul costs must be assessed.

Piping cost. The required length of piping depends on the number of outlets and size of a community. The length of distribution piping is approximated by the equation ($L_d = 90\ (AN)^{0.4}$), and the length of individual house laterals by the equation ($L_l = 40\ (A/N)^{0.6}$), where N is the number of water points in the community and A is the size of the community in hectares. The optimal average diameter of distribution piping (D_d) is given by the following equation:

$$D_d = 2.7N^{-0.20} A^{0.10} (Q_{lpcd} P_k)^{0.38} H_p^{-0.23}$$

where P is the population of the community, Q_{lpcd} is water use in liters per capita per day, P_k is the daily peaking factor, and H_p is the available head less (meters) in the piping network. For the range of conditions typical of small community water supplies, 1.5 to 2 inch average diameter pipe is suitable for distribution piping and 3.4 to 1 inch diameter pipe is suitable for house laterals. An installed cost of $10 per meter is used for distribution piping and $8 per meter is used for house laterals.

Haul cost. The cost of collecting water depends on the distance to the source, queue time, the water delivery rate at the water point, and the quantity of water carried per trip. The cost of water collection is then determined by multiplying the collection time by the price at which people value their time. It should be noted, however, that no assumption has been made about how people value their time; rather, throughout this analysis the value of people's time is approached in terms of a sensitivity analysis, that is, by evaluating the effect of a range of time values on the cost of water collection.

The collection time T (hrs/m^3) is given by the equation

$$T = (2D/1000\ S + q/60 + V/60Q_d)1000/V$$

where D is the one-way travel distance (meters), Q_t is the queue time (minutes/ trip), S is the walking speed (km/hr), V is the volume carried (liters/trip), and Q_d is the water delivery rate at the source (liters/minute). The collection cost of water, in dollars per cubic meter is then given by the equation ($\$/m^3 = TW$), where W is the value of time (dollars/hour).

Just as the required length of distribution piping is a function of housing density, so, too, is the distance a person must walk to collect water. If the assumption is made that paths in a community are laid out in a rectangular grid and outlets are evenly distributed throughout the community, then the average round-trip travel distance is proportional to the square root of the area per outlet. Thus the round-trip travel distance is given by the following equation where A is the size of the community in hectares and N is the number of outlets:

$$(D = A^* \ 10{,}000/N)^{1/2}.$$

In order to put collection time in perspective, the following example is offered. If the distance to the water source is one kilometer, a family of 6 using 15 liters per capita per day (lpcd) will spend about 3 hours each day collecting water. If the water source is brought into the village, the distance to the well will typically be between 50 and 100 meters, and if there is a 2 minute queue each time a family member goes to the well, about 40 minutes per day will be needed to collect water.

MORE ON WATER DEMAND

When calculating the costs and benefits of a project, the procedure used is: 1) determine the amount of time required to collect water (hours/m^3) at both the existing and new sources, 2) estimate water consumption using the demand curve, and 3) calculate component costs based on the required capacity of the system.

The method used to assess the benefits of a water supply project are presented in detail in Chapter II. The demand curve is shown in Figure A.10 and is given by the following equations:

Inelastic region

$$Q_{lpcd} = q_o + 1/F\ (1000\ h/T)^{\frac{1}{2}}$$

Elastic region

$$Q_{lpcd} + K/F * 1000h/T$$

Where Q_{lpcd} = water use (liters/capita/day)
q_o = Minimum water use (lpcd)
F = Family size
h = Income generating work (hours/family/day)
K = Fraction of income spent on water
T = Collection time (hrs/m^3)

MORE ON THE COST OF WATER

The purpose of this section of the annex is to expand on the discussion of the important factors that affect the price of water and choice of technologies, and to show an example of how the proposed framework of analysis can be applied. Examples discussed earlier in this annex are based on either manual or electric pumps, and comparisons are made between handpump and yard tap systems. In this section, the cost of pumping water with electric, diesel, solar, wind, and manual pumps are compared; and a fuller comparison of handpump, standpipe, and yard tap systems is made, based on the method of analysis presented in the report.

Source costs. Pumping technologies are assessed here by comparing source costs, where source costs for mechanized pumping include a well, pump, and storage tank, and source costs for handpumps include one or more wells and pumps plus the value of time ($0.125 per hour unless otherwise specified) that must be spent pumping water. In the case of mechanized pumping, it is assumed that a single pump can meet the water demand of the village, whereas the amount of water that can be manually pumped is limited by the power a person can input to a handpump, so a sufficient number of handpumps is provided to meet the water demand.

In the upper pair of graphs in Figure A.11 the cost of water ($/m3) is presented as a function of water consumption (lpcd) for 20 and 45 meter pumping lifts. These graphs demonstrate that water can be pumped for substantially less cost if an electric grid is available than if a pump must be powered by diesel, wind, or solar power. In fact, only handpumps are competitive with electric pumps and then only if pumping lifts are low. It should be borne in mind, however, that 30 to 50 percent of hand-pumped water at a $0.125 time value is attributable to labor and that the value people place on their time will have a significant effect on the cost of hand-pumped water.

If a village is not connected to an electric grid, alternatives to electric pumps include diesel, solar, and wind-powered pumps. Of particular note are the relatively large economies of scale of diesel pumps relative to solar and wind-powered pumps. This has an interesting implication, since it suggests that solar pumps can provide water at a lower cost than diesel pumps if small volumes of water are required. When the cost of photovoltaic panels drops and long-term field experience is gained, solar pumping may well become a practical alternative to diesel pumps for such applications. However it appears that solar pumps will become a viable alternative to handpumps only where the value that people place on their time to collect water is reasonably high.

The results for wind pumps also suggest that they are best suited to low consumption. As will be shown, however, the cost of water from wind pumps is so highly sensitive to average wind speeds that comparisons on a general basis can not be made, other than to conclude that for typical wind regimes, wind pumps are not competitive with other pumping technologies.

Because economies of scale are important, the effect of pumping lift on the cost of water is shown for water consumption levels of 20 lpcd and 75 lpcd in lower pair of graphs in Figure A-11. Of particular importance is the effect that pumping lift has on the cost of hand-pumped water. At low pumping lifts, handpumps provide water at a lower cost than any other pumping technology, regardless of the level of water consumption. However, as the pumping lift increases, hand-pumped water becomes more expensive. Consequently, at higher pumping lifts, mechanized pumps can provide water at lower costs than handpumps. Electric pumps become competetive at a pumping lift of 20 to 25 meters even at low consumption levels, whereas diesel pumps can provide water at lower cost only if water consumption is high (for example, the 75 to 100 lpcd consumption level typical of yard tap systems) and pumping lifts exceed about 40 meters.

Before looking at total system costs, a sensitivity analysis of the effect of energy costs (electric and diesel) and power inputs (human energy and wind speed) on the cost of water is presented in Figure A-12. Because power costs are a small portion of the source costs, the cost of water is not particularly sensitive to the price of electricity or diesel fuel. For example, an order of magnitude increase in the price of electricity ($0.10 to $1.00 per KWHr) or a four-fold increase in diesel fuel ($0.50 to $2.00 per liter) increases the cost of pumping water only by about 50 percent. Power inputs to handpumps, however, have an important impact on the cost of water, suggesting the importance of designing handpumps that can conveniently be used by more than one person (for example, putting a T-bar on the end of the handle). Wind speed also has a dramatic effect of the cost of lifting water. When the average wind speed drops below 3 meters per second, costs escalate rapidly; however, in the few places where average wind speeds exceed 4 meters per second, wind pumps become an attractive alternative.

System costs (source plus conveyance). Background information about the prototype village is listed in Table A.1, and a breakdown of the component costs for manual, electic, and diesel-based systems are summarized in the illustrative example in Table A.2. It should be noted that the number of water points for the handpump system (2) and standpipe systems (3 for electric and 2 for diesel pumping) provide the greatest net benefit in each case and, accordingly, are optimal handpump and standpipe water supply systems for the prototype village.

The installed costs of handpump, standpipe and yard tap systems are roughly $5,000, $10,000 and $20,000 respectively, while the annual per capita costs for capital plus operation and maintenance are about $2.00, $4.00, and $8.00. Investment and repayment requirements for handpump, standpipe, and yardtap systems increase by ratios of about 1:2:4. Thus for a given investment, handpumps can be provided to twice as many people as standpipes and four times as many people as yard taps. This suggests that the financial constraints on governments and donors make widespread coverage of improved water supplies possible only if handpumps are installed. However, if the "improved" system does not sufficiently improve access to water or the safety of it to outweigh its cost, users probably will not value the new system enough to see to it that it is maintained in operating condition. As a result, such an approach to water supply planning may result in major investment loses.

The price of water, as used above for source costs, is typically expressed in terms of cost per unit volume. While this is an important measure, it is also useful to consider pumping costs in terms of annualized expenditures on water (dollars per capita per year). This is particularly true for small community water supplies, where water consumption can vary from less than 20 lpcd to more than 100 lpcd, and where financial constraints require people to choose between low water consumption at relatively high unit costs and high consumption at lower unit costs.

Accordingly, in Figure A.13 the costs of optimal handpump, standpipe, and yard tap systems are expressed in terms of both $/m3 and $/capita/year. The upper pair of graphs show system costs if mechanized pumps are powered by electricity, and the lower pair show the costs for diesel pumps. When expressed in terms of $/m3, pumping lift is shown to

FIGURE A-10

Water Demand Curve

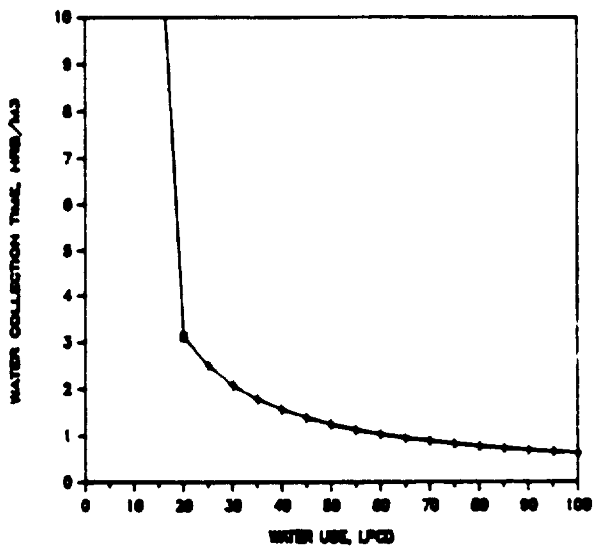


FIGURE A-11

The Cost of Pumping Water

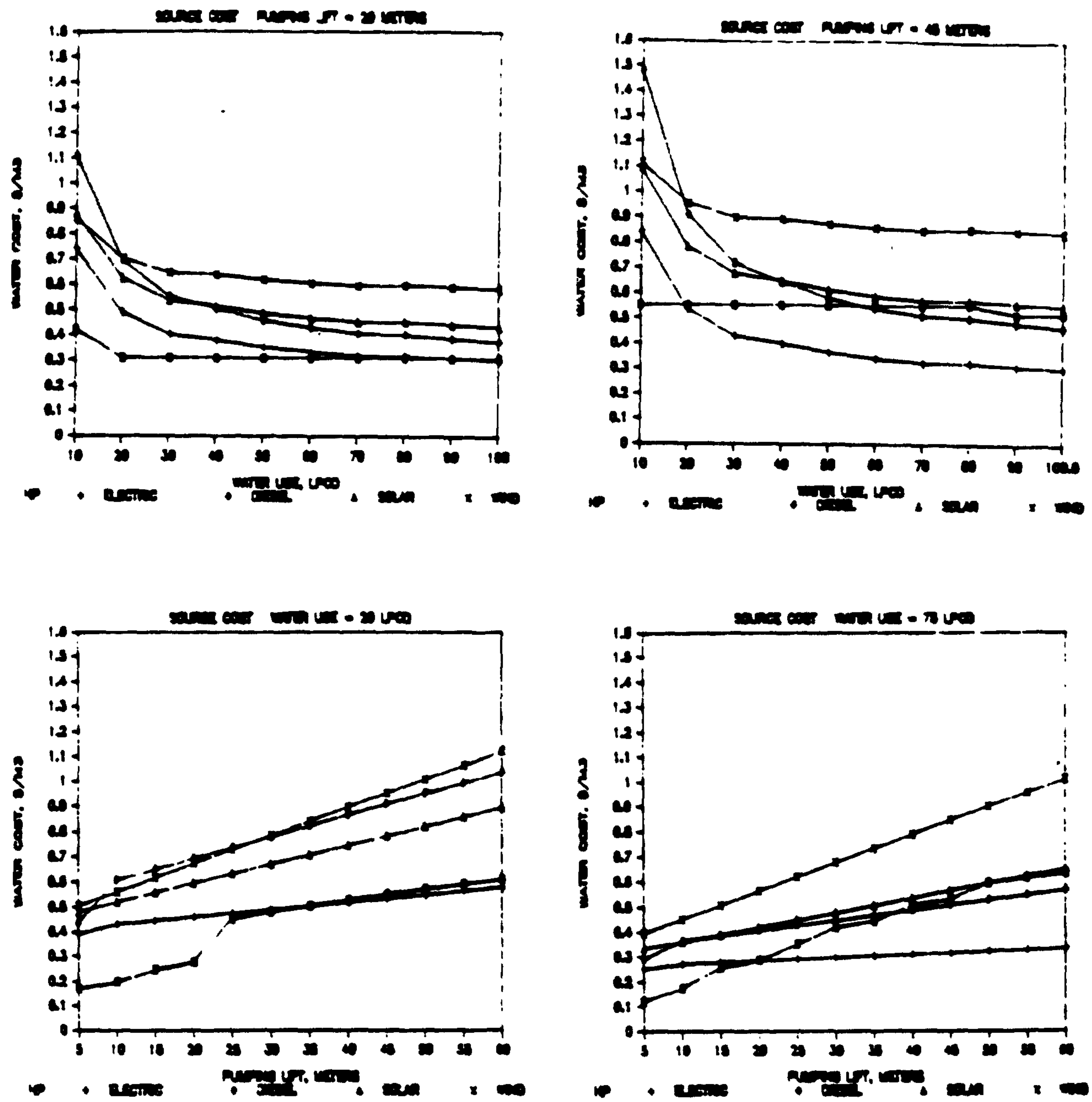


TABLE A.2

COST OF OPTIMAL WATER SUPPLY SYSTEMS FOR PROTOTYPE VILLAGE

System Components	Handpumps and Electric Pumps			Diesel Pumps		
	Unit Cost ($)	Total Capital Cost ($)	Annual Per Capita Cost ($)	Unit Cost ($)	Total Capital Cost ($)	Annual Per Capita Cost ($)
HANDPUMPS						
Wells	2,000	4,000	1.17			
Handpumps	660	1,320	0.53			
O&M			0.43			
Capital + O&M		5,320	2.13			
Haul Cost			3.90			
Total Cost			6.03			
STANDPIPES						
Wells	2,000	2,000	0.59	2,000	2,000	0.59
Electric pumps	1,200	1,200	0.49	2,350	2,350	1.53
Storage	1,900	1,900	0.56	1,730	1,730	0.51
Distribution pipe	10	2,100	0.62	1,800	1,800	0.52
Standpipes	500	1,500	0.61	500	1,000	0.41
O&M			0.83			0.98
Electricity/diesel			0.23			0.64
Capital + O&M		8,700	3.93		8,880	5.18
Haul Cost			3.82			3.82
Total Cost			7.75			9.00
YARD TAPS						
Wells	2,500	2,500	0.73	2,500	2,500	0.73
Electric pumps	1,400	1,400	0.57	2,800	2,800	1.85
Storage	2,750	2,750	0.81	2,740	2,740	0.80
Distribution pipe	10	6,500	1.91	10	6,520	1.91
Lateral pipe	8	2,100	0.62	8	2,100	0.62
Yard taps	100	5,000	2.03	100	5,000	2.03
O&M			1.94			2.30
Electricity/Diesel			0.47			1.62
Capital + O&M		20,250	9.08		21,660	11.86
Haul Cost			0			0
Total Costs			9.08			11.86

FIGURE A-12

Effect of Energy Costs and Power Inputs on the Cost of Water

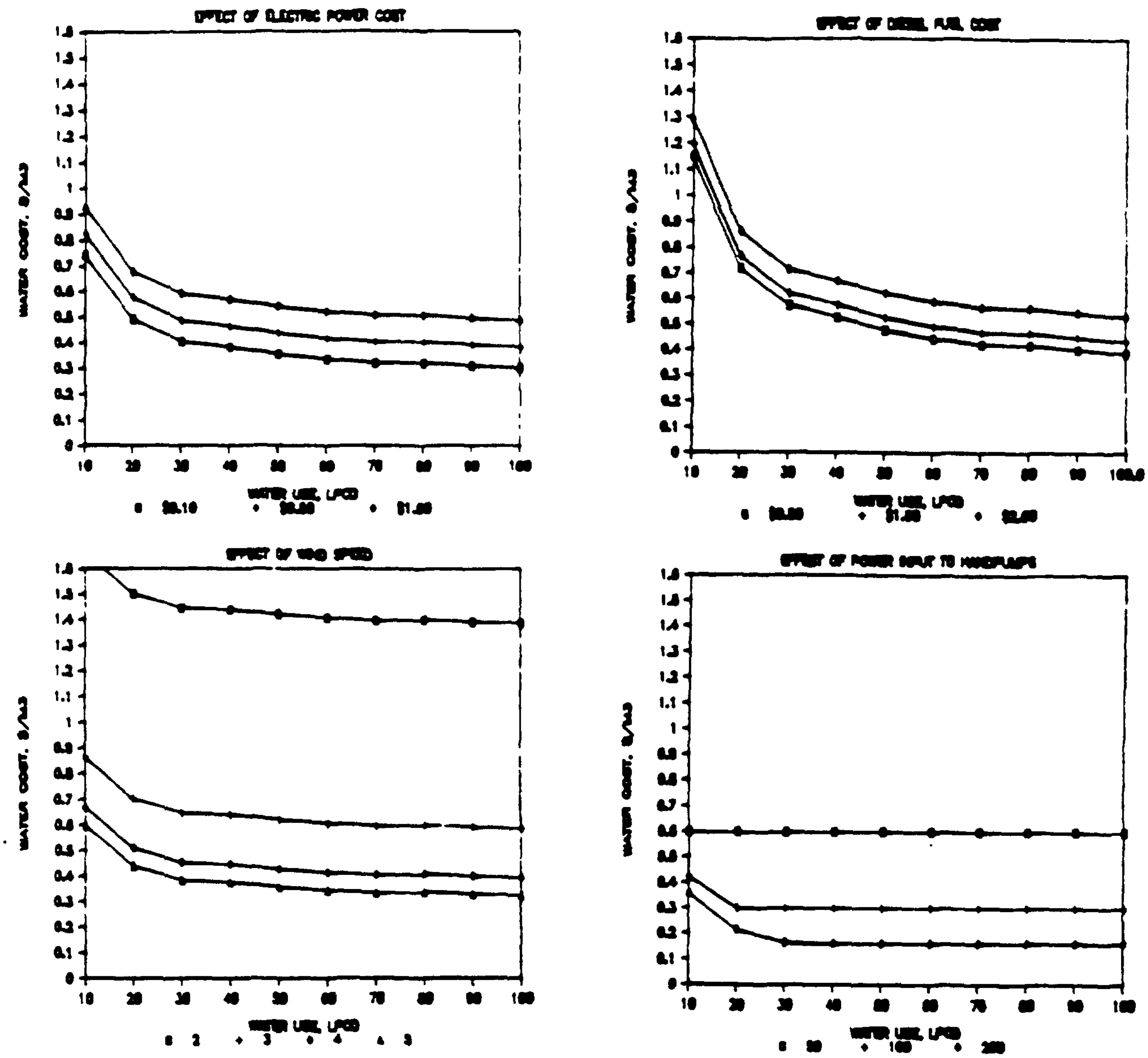


FIGURE A.13

The Cost of Handpump, Standpipe, and Yard tap Systems, Depending on Pumping Lift

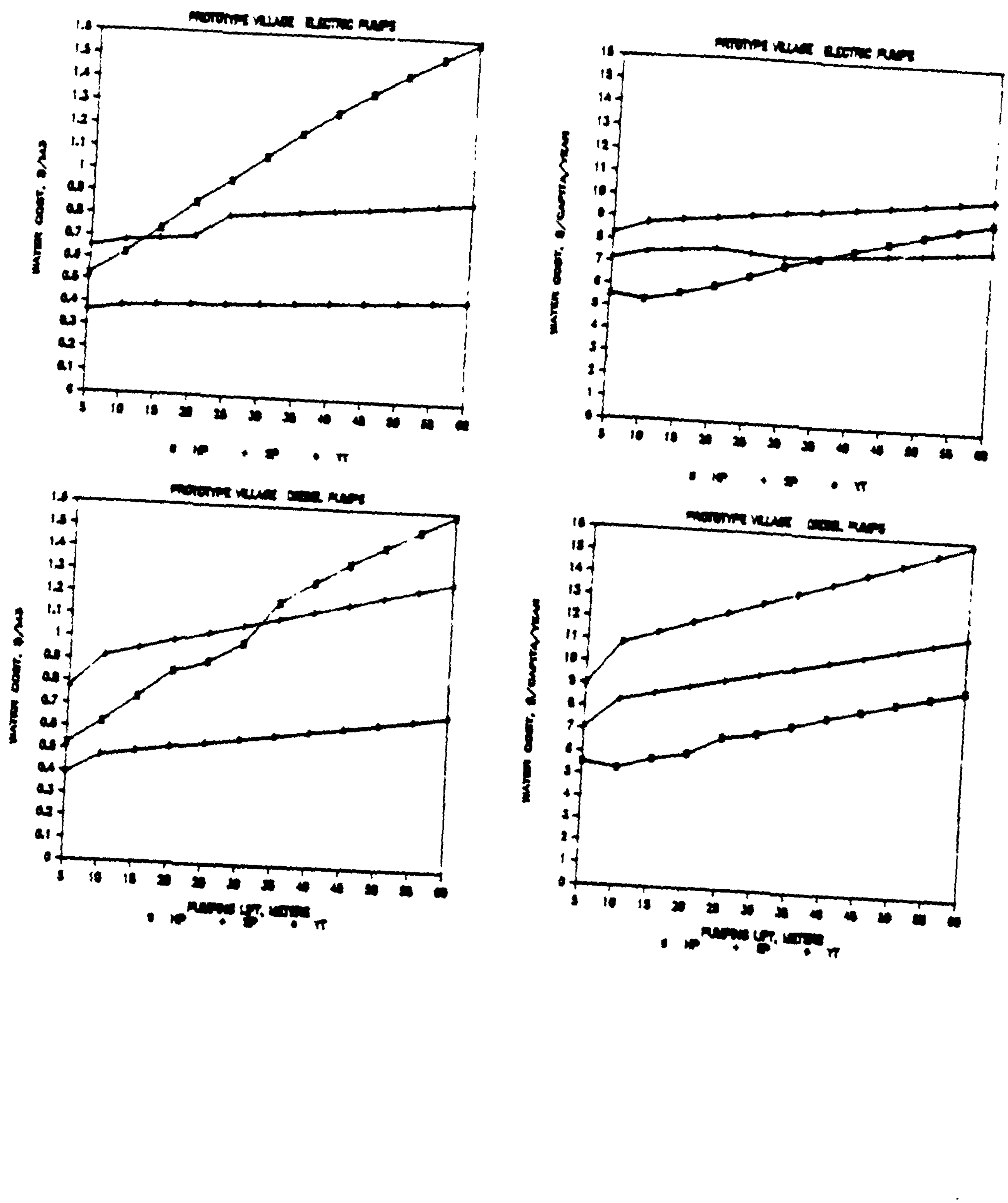


FIGURE A.14

The Effect of the Distance to the Existing Source On Net Benefits

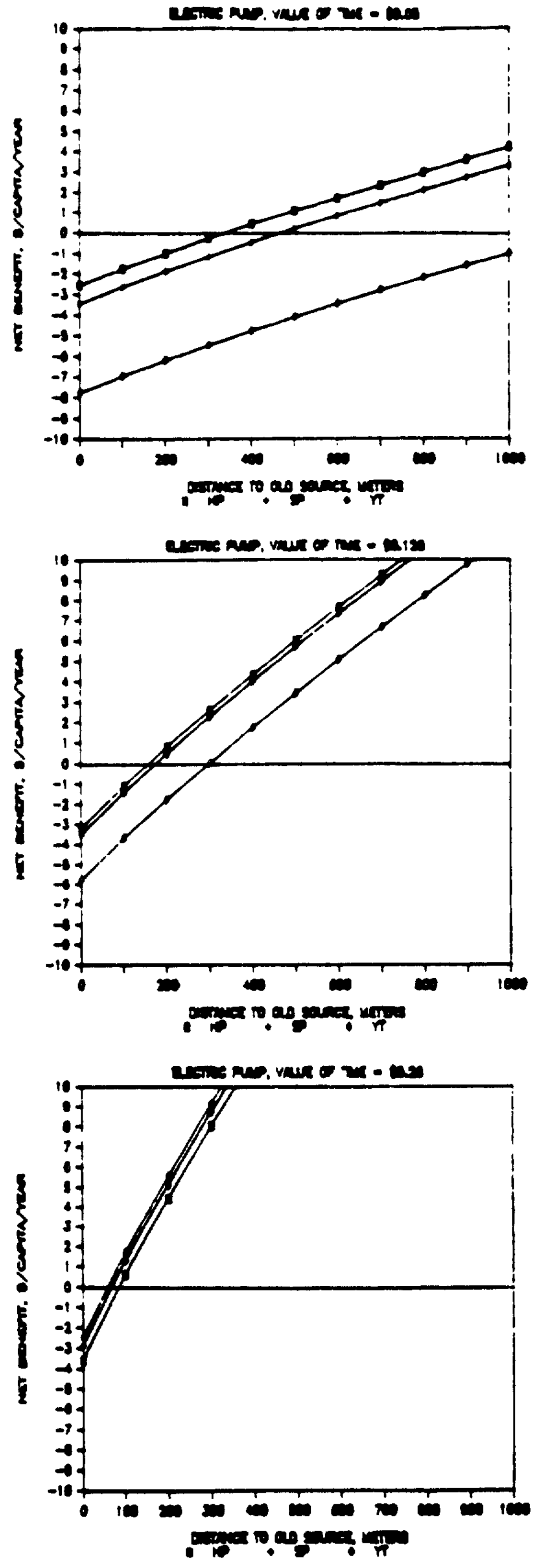
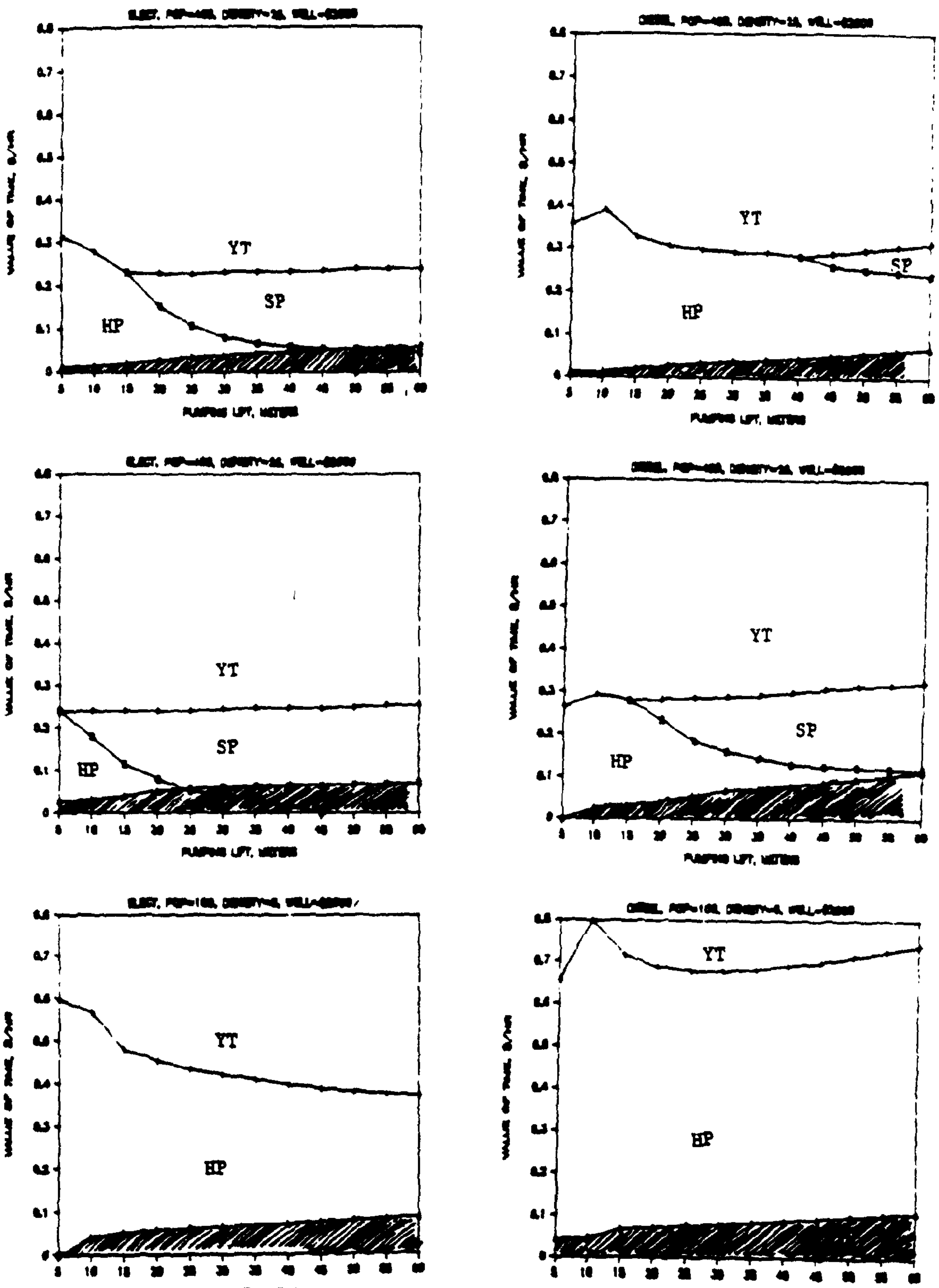


FIGURE A.15

Choice of Technologies



have a major effect on the cost of hand-pumped water, however, because water consumption from handpump-based systems is limited by the time required to collect it (refer to the discussion about the demand curve for water), the actual cost of a handpump-based water supply system will usually be lower than a yard tap system. Accordingly, while yard tap systems provide water at the lowest unit cost, least-cost systems in terms of $/capita/year are provided by either handpumps or standpipes. Whether handpumps or standpipes are best largely depends on the pumping lift and the availability of electric power.

As suggested often in this report, the value of time is the fundamental factor that guides the economic choice of technologies. In addition, because the benefits of an improved water supply are based on the time savings provided by an improved supply, the distance to the existing source is very important, for it largely determines not which alternative (handpumps, standpipes, or yard taps) is best but rather if a project should be undertaken at all.

The three graphs in Figure A.14 demonstrate this by plotting net benefits against the distance to the existing water source for time values of $0.05, $0.125, and $0.25 per hour. For the standard value of time ($0.125/hr), handpumps provide the greatest net benefit of any of the three technologies, but there is a positive benefit only if people must walk more than 150 meters to the existing water source. Similarly, if the value of time is $0.05/hr, the distance to the existing source must be at least 350 meters to obtain a postive net benefit. It should be noted, however, that when the value of time reaches $0.25/hr, yard taps give the greatest net benefit, and therefore are the technology of choice. At such a high value of time the distance to the existing source may be as little as 50 meters while positive net benefits are still obtained.

As a point of comparison, once water is available within a village, one-way travel distances are typically less than 100 meters. Thus if values of time are under 15 to 20 cents per hour and water is available within a village, it is not likely that the community will value an improved supply. As a word of caution, however, it should be noted that the cost calculations do not include the cost of maintaining the existing system (for example, replacing ropes and buckets), nor do the results presented here reflect possible long queuing times at the existing source or seasonal availability of water in the village. The important point is that, if water is currently available in the village, it should not be assumed that the community will value the improved supply.

To obtain a better overview of the conditions in which handpumps, standpipes, and yard taps are best suited, the graphs in Figure A-15 are useful. They show the combinations of pumping lift and the value of time where handpumps, standpipes, and yard taps provide the greatest not benefit and time values (shaded areas) below which net benefits are negative. These selection diagrams compare electric and diesel pumping, well costs of $2000 and $5000, and small, low-density villages versus the prototype village, a medium-size village with a farily high housing density.

For villages with populations greater than 300 to 400 and housing densities more than 10 to 15 households per hectare--which would be typical of rural areas in many countries--the proposed analysis procedure leads to the conclusion that yard taps are the technology of choice if the value of time exceeds about $0.25/hr. However, if the value of time is under this, the choice is between handpumps and standpipes, that is, manual versus mechanized pumping. If electricity is available, handpumps are suitable for pumping lifts up to 15 to 25 meters, whereas if diesel pumps are required, handpumps become limited by the cost of the well and the amount of effort a person can expend pumping water. In practice, when pumping lifts exceed about 45 meters there are no good solutions since diesel-based systems are likely to be too expensive and handpumps require too much effort to pump. Fortunately, such conditions exist in very few locals.

Finally, the lower pair of graphs in Figure A.15 indicate that in small villages with low housing densities, standpipes are not a viable technology. This is because the value of time at which yard taps become the technology of choice is lower than the value of time at which handpumps give way to standpipes.

LIST OF SYMBOLS

A = Size of village, hectares
D = round trip travel distance to water point, meters
D_d = optimal average diameter of distribution piping
D_w = blade diameter of windmill, meters
E = mechanical efficiency
F = family size, number of persons
h = Income generating work, hours/family/day
H = pumping lift, meters
H_p = available headloss in piping network, meters
K^p = Fraction of income spent on water
L_d = Length of distribution piping, meters
L_l = length of individual household laterals, meters
N = number of water points in village
P = village population
P_e = Price of electricity, \$/KWHr
P_k = daily water demand peaking factor
P_d = Proce of diesel fuel, \$/liter
q = queue time at water point, minutes/trip
q_o = minimum water use, lpcd
Q = well capacity, m^3/day
Q_{lpcd} = water use, liters per capita per day
Q_{lpm} = water delivery rate, liters/minute
Q_t = Queue time at water point, minutes/trip
S = walking speed, Km/hours
t = pumping time, hours/day
T = water collection time, hours/m^3
V = water volume carried, liters/trip
V_w = wind celocity, meters/second
V_s = storage tank volume, m^3
W_p = power input, watts
W^p = value of time to collect water, \$/hr

ANNEX B

ESTIMATING THE DEMAND

The traditional method for estimating how much a family should pay for water involves using somewhat arbitrary rule-of-thumb implying that the amount should be no more than 5 percent of income. This is a larger percentage of income than most urban dwellers pay for water. (See Box B-1 and Table B-1.) In this Annex an alternative method of figuring demand is described, elaborating on points made in Chapter II.

In water projects, most of the benefits are to be found in the reduction of the costs of the existing water consumption. In the example used in Chapter II, the typical household whose water consumption is 100 liters per day, which customarily takes 100 minutes to haul, has a reduction in water-hauling time of 90 percent after a central well is installed. But since it is likely that there will be some response, in the form of greater water consumption, to the reductions in cost, this 90 minutes per household will underestimate the benefits of the project. And the larger the increase of water consumption in response to the cost reduction, the greater will be the extent of the underestimation. If, for instance, the reduction in cost from 100 minutes to 10 caused households to increase consumption to 1,000 liters per day, then the lion's share of the benefits [900 x 0.05 (100-10)], or 405 minutes per day of benefits, would be ignored if the benefits were calculated merely as the reduction in cost of the existing 100 liters. It is thus important to know the reactions of consumers to changes in the cost of water.

BOX B.1

PERCENT OF INCOME SPENT ON WATER

Saunders and Warford note that according to "a frequently used rule-of-thumb," a rural near-subsistence family "should never have to spend more than about 5 percent of its income for water. This 5 percent of income figure is usually more than most urban dwellers pay for the water they consume from the public system."

Table B.1 presents tentative estimates of the percent of household income spent for water in eleven selected cities in developing countries. According to these estimates, the lowest-income group pays about 5 percent of household income in Sao Paulo and Lima and more than 5 percent in Addis Ababa, Manila, and Nairobi. In the remaining seven cities the figure is less than 5 percent.

Source: Robert J. Saunders and Jeremy J. Warford, Willage Water Supply: Economics and Policy in the Developing World, (Baltimore and New York: The John Hopkins University Press, 1976), pp. 187-188.

TABLE B.1

ESTIMATED MONTHLY WATER CHARGES AS A PERCENTAGE OF ESTIMATED MONTHLY INCOME, BY INCOME GROUP, ELEVEN SELECTED CITIES

City	Income Group (and consumption category by liters)				
	Lowest 20% (7,000)	Second 20% (15,000)	Third 20% (27,000)	Fourth 20% (36,000)	Upper 20% (40,000)
Addis Ababa (1972)	8.70	7.89	7.70	6.17	2.46
Bogota (1971)	0.67	0.70	1.04	0.83	1.51
Bangkok (1972)	0.49	1.12	2.19	2.02	0.86
Cartagena (1971)	0.97	0.84	1.23	1.25	0.62
Kingston (1971)	1.76	3.04	6.05	3.75	0.81
Lima (1971)	4.96	2.34	1.25	1.41	0.56
Manila (1970)	9.27	1.67	1.65	1.50	0.72
Mexico City (1970)	0.41	0.33	0.38	0.29	0.17
Nairobi (1970)	6.80	5.51	6.00	3.93	1.88
Sao Paulo (1970)	4.71	2.28	3.35	2.85	0.90
Seoul (1972)	0.36	0.32	0.55	0.61	0.49

Note: Water charges are estimated from tariff schedules and estimated water consumption figures for households in the individual cities. Income is the estimated monthly income of households.

Source: Computed by Kenneth Hubbell from survey data.

In the traditional economic analysis of demand, the emphasis is on explaining the behavior of consumers in terms of the price of water, relative to those of other goods, and the level of real income of the consuming household. In the case of most other investigations of demand, the effects of changes in the prices of substitutes or complements are explored; in the case of water, it seems safe to assume there are no substitutes close enough to matter, and complements are ubiquitous rather than specific. Thus, they will be ignored in what follows. Similarly, the analysis will not take into account the random variations in demand that are occasioned by changes in the climate or the seasonal variations in cost of water collection, such as the increase in wage rates and the value of labor during harvest or planting time. In project analysis, the concern is with the "permanent" demand and, although the project must be planned to take account of variations about that "permanent" demand, these can be ignored in the analysis of project viability. And it is hoped that any long-run changes in the demand for water, such as those induced by a gradual increase in standards of hygiene, can be captured by a time trend.

In short, the quantity of water "bought" by the household will be higher if the price is lower and the level of real income higher. But by how much? Research can offer at least some limits to these reactions. The simplest form of the demand reaction suggests the following rule:

0000000000 a 10 percent reduction in cost (that is, price) will increase consumption by 5 percent, and

0000000000 a 10 percent increase in real income will increase consumption by 5 percent.

If this rule is true for <u>all</u> consumption levels, prices, and real incomes, then it can be expressed in simple math as:

$$q = a.p^{-0.5}.x^{0.5}$$

where (q) is the quantity of water consumed by the household per day, (p) is the relative price (cost) of water per liter, and (x) is the real income per day of the household; (a) is a constant, which depends on the units used to measure other variables.[43/]

This equation is broadly consistent with the data collected in studies of water demand. It implies that, if the relative price of water remains constant, as income increases households spend a smaller and smaller fraction of their income on water. Water is, therefore, a "necessity" of life rather than a luxury. Again, the data from surveys both in developing and developed countries suggest that this is the case. Table 2.1, shows only the money expenditure on water for different income groups in particular cities. These figures exclude the expenditure in the form of time spent in carrying water--which, one might reasonably expect, is characteristic of the lower- rather than the upper-income groups. Nevertheless, there is a clear downward trend in the fraction of income spent on water tariffs in most cities. If time costs were included, the result would be even more marked and ubiquitous.

The response of water consumption to price, as to income, is modest--or, in technical terms, the price elasticity of demand is inelastic. As the price falls for a given income, expenditure on water declines. This implies that there are few good substitutes for water and that water cannot readily take the place of other goods. One of the objectives of projects that reduce the price (cost) of water is to enable people to spend less of their time, plus money, on water--although, in practice, one would expect a big reduction in time and a small reduction, or even an increase, in money expenditure.

This formulation of demand supposes that the response of the consumer to a given percentage change in the price (cost) is the same whatever the level of price or income. Many would argue that this cannot be true. Some quantity of water -- albeit a very small quantity (say, 10 liters per household per day) -- is a necessity of life, and at almost any price and even with very low incomes, households will always acquire this quantity. If this minimum quantity is denoted as (q_{min}), the equation can be written as follows:

$$q - q_{min} = a.p^{-0.5}.x^{0.5}$$

which says that the household will always, come what may, consume at least the specified minimum quantity of water. The discretionary

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43/ See Barbara Zaroff and Daniel A. Okun, "Water Vending in Developing Countries," Aqua, No. 5 (1984), pp. 289-95; there, the coefficients, instead of being 0.5 plus for income and minus for price, are about 0.64 plus for income and minus for price.

consumption of water over and above this minimum depends, as before, on real income and the relative price of water.[44/] This formulation of the demand for water then allows that at high prices and low income the response of demand is less elastic than at the higher levels.

The simpler formulation of the demand relationship shown above permits even more simplification. Suppose that the household's disposable income was derived only from labor, that is to say the household enjoys no income from property, and with less verisimilitude, that the household supplies homogeneous labor services on the market amount to (h) hours at a real wage of (w) per hour. Thus, the real income of the household, (x), is (hw) (and this includes the time spent in carrying water). Thus, the simple formulation becomes:

$$q = a.p^{-0.5} (hw)^{0.5}$$

by substituting (hw) for (x). But if, as assumed, the household wage rate is the appropriate measure for the cost (price) of water, and assuming that an hour's labour gives (t) liters (where t is a variable, not a constant), then (pt = w), so:

$$q = a.p^{-0.5} (hpt)^{0.5}, \text{ which reduces to}$$

$$q = a.(ht)^{0.5}$$

The quantity of water demanded is independent of the real wage rate per hour. The demand varies directly with the geometric mean of the total labor hours of the household and the productivity of the water carriers.

It is natural that the real wage rate per hour should disappear from these calculations, provided that the proportionate effect on quantity of both real income and price (but with the opposite sign) is the same. An increase in the real wage increases income, for a given number of hours, but correspondingly it makes water carrying proportionately more expensive; the one offsets the other. But real income still appears in the equation in the form of (h), that is, the income measured in hourly labor units rather than the goods and services that labor units buy. Similarly the price of water still appears in its surrogate form of the productivity of water carriers.

44/ Strictly, one should extract from real income the amount that is spent on this minimum amount of water; only the remainder is discretionary income that can be spent on additional water as well as other goods and services. Thus, on the right hand side of the equation, (x) should be reduced by ($p.q_{min}$), but in this exposition such niceties have been ignored.

ANNEX C

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