VILLAGE WATER SUPPLY

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CONTENTS

SUMMARY AND CONCLUSIONS

This paper deals with the supply of water for domestic use—not for irrigation—in the rural areas of the developing world.

Probably over 1,000 million people in rural areas do not have an adequate water supply, and the rate at which access to safer water is being provided is too slow to keep pace with population growth. The majority of people without safe water live in developing countries of Asia, which also contain the largest numbers of the rural poor.

In these countries, waterborne or water-related diseases are among the three major causes of sickness and death. The strongly held opinion of public health experts is that the provision of safe water is of prime importance to public health. The World Health Organization (WHO), in particular, considers that provision of a safe and convenient water supply is the single most important activity that could be undertaken to improve the health of people living in rural areas.

Governments of developing countries are becoming increasingly concerned with improving living conditions in rural areas. The World Bank,[1] too, has been shifting the emphasis of its lending program so as to have a greater impact on the rural population through projects in agriculture and integrated rural development. Rural water supply and sanitation should be a significant component of these projects. In addition, the Bank's fourteen-year involvement in the financing of the water supply and sanitation sector, which so far has been predominantly for urban projects, will be progressively extended to the rural subsector. Because rural water supply has hitherto been largely neglected, experience and knowledge are lacking to set specific targets for action in the next few years. As a first step, therefore, this paper concentrates on the problems peculiar to this subsector and suggests ways to begin to overcome the current state of neglect.

Background

There are no internationally accepted definitions of "urban" or "rural" communities. The paper is concerned with communities of 300 to 10,000 inhabitants, and with water systems ranging from

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[1]*All references to the World Bank in this paper are to be deemed to refer also to the International Development Association (IDA), unless the context requires otherwise. The fiscal year (FY) of the two institutions runs from July 1 to June 30.*

simple, protected springs to surface water systems with piped distribution of treated water. It considers the needs of all the people in these communities, including, but not limited to, the poor—who form the vast majority.

This study is based on the experience of the World Bank and also the Inter-American Development Bank (IDB). It takes account of a survey of water supply and sewage disposal in developing countries carried out in December 1970 by the World Health Organization (WHO), referred to in the remainder of this paper as "the WHO survey."[2] In addition, the Bank is participating in an Ad Hoc Working Group on rural water supply and sanitation, established in 1974 by a number of international agencies. Most of the statistical information obtained from the WHO survey should be regarded only as indicative, due to inadequacy of data, a lack of common definitions, and wide variations between countries.

In 1970, only about 15 percent of the rural population in developing countries had reasonable access to safe water. In these areas, over 1,000 million people or nearly one-third of the world population, had no proper water supply. In urban areas, the situation in 1970 appeared far better: about 70 percent of the inhabitants had access to a piped water supply. Even so, about 150 million people, usually those in the lower-income brackets, were not served, and in many areas with nominal service, its quality was extremely low.

To improve this situation, the United Nations set goals for the global improvement of water supply in the Second Development Decade (1971-80). These UNDD goals are to supply safe water to all of the urban population and one-quarter of the rural population. To achieve these goals would mean, in round terms, increasing the numbers served in urban areas by 390 million—from 320 million to 710 million, or by 120 percent. In rural areas, even this modest goal means extending service to a further 273 million people—increasing coverage from 140 million to 413 million, or nearly 200 percent. It should be noted that, even if the UNDD goals were achieved, there would still be *more* rural inhabitants without proper water supply in 1980 than there are today.[3] Impressive as they are, these facts do not reveal the dimensions of the problem as fully as one example: One rural water program in India covers 65,000 square kilometers,

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[2]*World Health Organization, "Community Water Supply and Sewage Disposal in Developing Countries,"* World Health Statistics, *Vol. 26, No. 11, 1973.*

[3]*For the 91 countries included in the WHO survey, 1,076 million rural inhabitants were without proper water supply out of a total of 1,259 million in 1970. By 1980, even with the UNDD goals reached, the corresponding figures are 1,134 million out of 1,547 million.*

with a population of 6.4 million in 16,000 villages. Providing water to 2,000 of these villages, to serve 800,000 people, will involve constructing 1,000 new water systems.

The investments required to meet the UNDD goals are estimated in the WHO survey to be about $11,000 million for urban water supplies and $3,000 million for rural water supplies (at 1970 prices). The World Bank's experience suggests that these estimates may be low, but the estimated costs of extending water service vary so widely—from a low of $1 per capita to a high of $300 per capita, depending on local conditions—that no firm estimate can be made. In current dollars the investments will, of course, be very substantially higher than in 1970 terms.

The likelihood of achieving the UNDD goals differs greatly from country to country. In some, a continuation of existing progress will probably be sufficient. In others, particularly the larger and poorer countries, expenditure on water supply would have to be expanded tenfold or even one-hundredfold, and would require a disproportionate share of future investment. In these countries, the goals are almost certainly unattainable. In any case, it is evident that the poorer countries can afford only very simple systems in rural areas—typically, shallow wells with handpumps—if they are ever to achieve a significant increase in coverage. In general, countries are more likely to achieve the urban targets than the rural ones, since past investment has been concentrated heavily in the urban sector,[4] and reasonably competent institutions have been built. In contrast, investment in rural water supply has been relatively small,[5] and the record of success is poor, with many systems breaking down soon after commissioning.

In common with most programs in developing countries, the major problems in rural water supply programs are those of financing, securing suitable personnel, and developing adequate institutions. The most important of these problems are—

- Lack of government rural water policies
- Undefined or overlapping responsibilities of numerous agencies
- Institutional weakness at all levels
- Lack of trained manpower at all levels
- Low village incomes

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[4]*For example, 77 percent of total water supply investment in 1970 was urban, according to the WHO survey.*

[5]*WHO estimates that rural water supply coverage increased only from 10 percent to 12 percent of the rural population in the decade 1961-71. Only in Latin America, where the corresponding percentages are 7 percent and 24 percent, was there any significant improvement.*

- Failure to collect adequate charges from water users, due either to lack of financial policies or to ineffective means for collection
- Lack of public health education, resulting in inadequate appreciation of the advantages of safe water supply
- Frequent failures in water supply systems due to poor operation and maintenance procedures or lack of spare parts
- Difficulties in communication between widely dispersed rural systems and their support agencies

Technical Aspects and Costs

Various factors affect the type of village water system to be constructed—level of service, water quality and quantity, and nature and location of sources. Each of these also has an effect on costs.

The level of service provided may range from a simple protected spring or a well with a handpump to a fairly elaborate distribution system serving most consumers through private house connections. Both capital and operating costs increase with the level of service, and increased complexity makes mechanical failure more likely. Nevertheless, since higher levels of service result in greater health benefits, they should be encouraged whenever villages feel the need and are able to pay for them.

Standards should be set for quality to ensure that the water supply does not contain any chemical or biological constituents that could affect its safety or acceptability. A number of chemical characteristics and substances which affect the design of urban systems (e.g., hardness, chlorides, iron and manganese content) can be disregarded in village water system design unless they affect acceptability, or could cause technical problems through corrosion or encrustation. (Throughout this paper it is assumed that all new systems are designed to provide safe water.)

The quantity of water required depends largely on the level of service to be provided. It also varies widely from country to country, depending on climatic and cultural factors. Daily consumption reported in the WHO survey ranged from 3 liters to 340 liters per capita per day (lcd.). However, about half the countries reported consumption of 40 lcd. or less, and as a rough guide 20 lcd. might be adequate for simple systems which employ public hydrants. Where a high proportion of house connections is proposed, 100 lcd. would be more realistic. More will be required in the rare cases where waterborne sewage disposal is to be provided. Because of these wide variations, sampling and demonstration projects are an important means for determining likely demands on new water systems.

The source of water has a major effect on system design and hence on costs. Properly constructed and operated groundwater systems will, in almost every case, yield water which is safe to drink without any form of treatment. Surface water sources will normally require disinfection (usually by chlorination and storage) and, depending on the degree of turbidity or contamination, may also require filtration, possibly preceded by sedimentation for very turbid waters. To reduce costs and operating and maintenance problems, surface water systems should usually be based on simple processes, such as sedimentation lagoons, slow sand filters, or infiltration galleries making use of the natural filtration capacity of alluvial material. Four general principles can be applied to most village water programs:

- Groundwater, which requires little or no treatment to make it safe, is preferable to surface water; in particular, in the poorest countries shallow wells with handpumps should be used whenever possible.
- Systems must be rugged, designed for simple, trouble-free operation and maintenance by local technicians.
- Replacement parts must be readily available.
- Standard designs, which can be slightly modified to meet local conditions, should be developed and used for cost estimation, procurement, and construction. These designs should employ, as far as possible, local materials and technology.

System costs vary widely. Estimated costs for rural services shown in the WHO survey vary from $1 per capita to $150 per capita for individual countries. Averages for the WHO regions were from $6 per capita to $24 per capita (at 1970 prices). Because of this variation, cost estimates have to be prepared separately for each project; generalizing from "typical" figures can lead to substantial errors.

The following general conclusions may be drawn concerning the effects of scale, levels of service, and water source on costs (see Annex 2):

- In areas where groundwater is readily available, shallow wells with handpumps are by far the cheapest means of providing a good water supply.
- Use of surface water which requires full treatment may be several times more expensive than using groundwater.

- Providing a high level of house connections may more than double the per capita cost of the system, because of the additional system capacity required.
- Distribution costs are a high proportion of total system costs; to reduce costs, it may be desirable to provide only a few central water points.
- Very considerable economies of scale exist in village water systems.

Additional public health benefits to rural areas may be achieved by other sanitation measures which should usually be taken at the same time that water is provided. Pit latrines, which can be constructed at very low cost on a self-help basis, would be the usual means of excreta disposal; septic tanks may be required where houses have individual water connections and use water-flushed toilets. Piped sewerage systems are expensive and unlikely to function effectively where only a few houses have inside toilets; they should not be installed except in the rare cases where no cheaper alternative can be found.

Financial Aspects

At present, it is most uncommon for the full costs of village water systems to be recovered from the villages served. This is due to a number of reasons: government attitudes that water is a social service and should not be charged for at full cost; unwillingness of villagers to pay, either because they regard water supply as a natural right, or because they do not appreciate the benefits of improved water systems; or inability of villagers to pay because of poverty. It is important that these attitudes be changed, since a considerable increase in resources will be required in many countries in order to maintain, let alone improve, access to service in rural areas. Especially in the poorest developing countries, where the problems are greatest, the increases will be beyond the means of government budgets. Realism and consistent social policies require that the more privileged consumers, particularly those in urban areas, no longer be subsidized, and that all consumers contribute toward the cost of service to the extent that their circumstances permit. Villages should, therefore, be required to pay as much as they can of the costs of constructing and operating their systems. Nevertheless, in most cases governments will have to provide funds to cover a large part of initial construction costs and also some of the recurrent costs, and will have to recognize this implied commitment when they first embark on village water programs.

Five potential sources of funds for village water programs may be discerned: central or local government budgets; foreign assistance; institutional lenders within the country; cross-subsidies from urban systems; and the villages themselves. The first two sources are generally determined on the basis of perceived national priorities. Local lending institutions—the third source—are frequently undeveloped, or may be unwilling to lend to the noncreditworthy agencies responsible for rural water. The fourth source—cross-subsidies from urban water systems—is unlikely to have any major impact, since in many developing countries the urban systems themselves are having difficulties in meeting demand. The fifth source—the villages—can, therefore, have an important effect on the size of program to be undertaken, but is frequently not fully exploited at present.

A number of strong reasons exist for requiring payment by villages toward construction and recurrent costs:

- It is desirable that beneficiaries should contribute toward the cost of services received.
- It makes more funds available to the program and, by reducing the use of government funds to meet recurrent costs, allows more to be spent on extending new systems to other rural areas.
- It will help ensure that funds are available to meet operating expenses and the cost of minor repairs.
- It instills a sense of responsibility on the part of the villagers for the new systems.
- It will help to ensure that the level of service to be provided is appropriate to the needs and desires of the village.

The WHO survey showed that 20 percent of the countries required villages to make a contribution to capital costs, and 70 percent of the countries required them to pay all or part of operating and maintenance expenses. However, in the Bank's experience, these policies are not enforced consistently.

Determining the ability and willingness of villages to pay is a problem, due to a lack of data on rural incomes and because many villages have essentially a barter economy in which little cash changes hands. As a general rule, it appears realistic that water charges to villages should recover at least all operating and maintenance costs, and that villagers should be required to contribute at least 10 percent of initial construction costs (either in cash, or in kind by providing labor or materials).[6] These charges would be for a basic system, supplying water through public hydrants. Where villages desire a higher level of service, with a number of private house connections, they should normally meet the full additional costs.

Payment should be set at as high a level as possible, and should be reviewed from time to time. For example, in a number of development projects villagers' cash incomes may rise substantially as the project matures, and in such cases water charges might be increased over time so as to provide for depreciation. However, decisions on targets and the way in which they are to be applied have to be tailored to suit the individual circumstances of each case, depending on such factors as ability to pay, system costs, and the social objectives of the program.

The collection of water charges from villages usually presents difficulties. Larger domestic consumers with individual house connections, and any commercial or industrial customers, can be metered and charged accordingly; supplies would be disconnected if payment were not made. Most supplies, however, will come from public hydrants or through house connections where consumption would be small and, therefore, uneconomical to meter. For these, flat-rate charges, unrelated to consumption, can generally be used, raised through head taxes, individual or family fees, water tax or property assessments, or other methods. In some countries, water is sold from public hydrants; this may ensure better operation and maintenance of the system, but raises the price to the consumer and so may discourage proper use of the supply. The most important thing is that the method chosen should be simple and effective.

Organization and Management

Institutional weakness is probably the most important single problem in rural water supply. Many countries do not have a national policy. No coordinated objectives are set for the various agencies responsible, and no clear government financial commitment exists to meet the overall needs of the subsector.

Numerous agencies are normally responsible for rural water supply. They include various national and state ministries, national and regional water authorities, and rural development agencies. This leads to uncoordinated or inefficient planning and execution of projects, and unnecessary duplication of demands on the limited pool of available trained manpower. It also results in an extremely complex

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[6] *Payment at this level would, in many cases, result in water charges not exceeding about 5 percent of total annual income, a level frequently adopted as a guideline for setting charges to poorer urban consumers.*

legislative framework, which needs review and improvement when any change is made in the organization of the sector; this work demands specialist knowledge and is very time-consuming.

Most agencies suffer from inadequate staffing, usually because the conditions of service are unattractive compared with those in the private sector or in organizations working in metropolitan areas. To attract better staff in sufficient numbers, salaries and other benefits should be improved where possible. The government should make clear the priority it attaches to this subsector, giving it more prestige than at present. In addition, training is required at all levels, from village operators and technicians to professional staff. In the early stages of a program, this training can be provided on the job, using demonstration projects. Later, a more formal training program will be required, preferably combined with that for urban water supply personnel.

The need for proper operation and maintenance is frequently ignored. Schemes are constructed without any clear assessment of the funds and manpower needed to keep them running, or of the logistical problems involved. As a result, a high percentage of water supply systems break down soon after having been brought into service. To operate successfully, stores, technical assistance, etc., must be available locally; operation and maintenance cannot be done by a centralized unit.

A village water program may be undertaken in various ways, with varying institutional implications:

- As part of a national or regional water supply program, including both urban and rural elements
- As an independent rural water supply program
- As part of a multisectoral project, such as a regional integrated rural development project

The first approach—a rural water supply program as part of a national water program—will probably be the responsibility of an existing central body such as a national water agency, and will benefit from the available manpower and consistent application of the sector policies of the national agency.

The second approach—pure rural water projects—has been employed for a number of years in many countries, and a competent executing agency exists. In others, the rural water agency may be so weak that extensive institution building would be necessary to strengthen the agency before it could successfully undertake the program; in these countries, it may be preferable to amalgamate the urban and rural agencies.

The third approach—a rural water supply program as a part of integrated rural projects—may be administered either by the rural water agency or by a water unit within the rural development project agency. The rural water agency is preferable, mainly because it makes the best use of available expertise in the sector, avoids proliferation of sector agencies, and provides a long-term institutional framework. But the project may not have sufficient leverage to strengthen or reorganize a weak rural water agency. In this case, the only alternative is to administer the project through a water unit in the rural development agency. Liaison should be maintained between the water unit of the rural development agency and the rural water organization, particularly on sector issues such as pricing policy. Care should also be taken to reconcile as far as possible any conflicts between the objectives of the rural development project agency and the rural water agency, which often do not coincide. For example, in a rural development project one agency may aim at rapid development of a whole geographic area, while the other attempts to extend service to selected villages, keeping pace with institution building.

Justification for Investment

Ideally, decisions to invest in village water supply should be based on cost/benefit analyses in which both costs and benefits are quantified. However, despite considerable research, no satisfactory method has yet been developed for quantifying all the benefits of improved water supply. Nevertheless, experts in the field, particularly WHO, have little doubt that safe water is essential for good health, and is a prerequisite to the control of those diseases most common to the rural areas of developing countries.

In urban areas, good water supply is essential to the existence of a city and to protect public health. There is usually no alternative to a public water system. Projects in urban areas can normally be supported by consumers' willingness to pay for the service provided. In rural areas, the justification becomes far more tenuous: The threat of epidemic due to waterborne diseases lessens as population density decreases, but the number of diseases is greater. Alternative sources frequently exist but are polluted, inconvenient, or unreliable. Willingness to pay declines, due to poverty or to a lack of appreciation of the benefits of improved supply. Direct benefits which are readily quantifiable—for example, the development of agro-industries, fish freezing, and the like, which had been inhibited by the lack of safe water—may accrue in some cases but are unlikely to be sufficient, on their own, to justify the investment.

In most cases, therefore, it is impossible to present a rigorous economic justification for village water projects. Instead, the justification must rest on a qualitative assessment of the benefits anticipated from the investment. The most important direct benefits from improving the quality and quantity of water available are better public health, greater convenience, and some fire protection. The first two of these may also increase productivity. The indirect benefits commonly cited are a slowing down of rural-urban migration; redistribution of real income in favor of the rural poor; a better standard of living; and the development of village institutions.

Numerous epidemiological studies have clearly identified contaminated water as the principal agent in transmitting typhoid, cholera, and shigellosis (bacillary dysentery). Lack of safe water for drinking and washing is also an important factor in the spread of other diarrheal diseases, the most common cause of death in infants in the developing world. A number of additional diseases, especially the debilitating parasitic diseases, are linked to inadequate and contaminated water supply and poor sanitary conditions (see Chapter 5).[7] It is nevertheless difficult to predict exactly to what extent an improved water supply will reduce the number of diseases or their incidence, partly because alternative vectors exist and partly because some of the diseases are epidemic in nature and may be temporarily absent in project areas.

The effect of water on health will depend on many factors, especially the prevalence of various diseases, and the extent to which villages use the water. To break the chain of transmission of certain diseases, improved excreta disposal methods must be provided together with improved water supply; the combination of these two measures will frequently be found to be the most effective means of control. Public health education will almost always be necessary to achieve full health benefits.

Provision of a safe and convenient water supply should help raise productivity as health improves and as less time and effort are spent on fetching water. In addition, the new water supply could help directly such agro-industrial activities as fruit and vegetable processing or fish freezing. But whether potential benefits to productivity are realized or not depends on individual cases. In some villages, the ill health of the labor force seriously affects agricultural development, whereas in others there is underemployment, and benefits may not be realized unless the water supply project forms part of an

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[7]*See also World Bank,* Health—Sector Policy Paper, *March 1975.*

integrated rural development or similar project providing increased employment opportunities.

It is often argued that better rural water supply should reduce migration to urban areas, relieving their severe housing and other social problems. Even if a slowing of migration were desirable, there is little evidence that better water supply affects the rate of migration. It is possible that improved rural health and lower infant mortality could actually increase migration, unless efforts to secure these benefits are coupled with rural development to encourage people to remain in their villages.

Rural water projects, which usually require subsidies from central government revenues or possibly from more prosperous urban consumers, often lead to income redistribution. Care must be taken that richer farmers do not benefit at the expense of the urban poor.

Although no supporting data are available, it seems likely that community involvement in the construction, operation, and funding of a water system would strengthen village institutions, and help villagers in dealing with other development decisions.

Priorities: Selection of Subprojects

As the benefits described above are for the most part unquantifiable, they do not provide a clear guide for setting priorities in a rural program covering a number of years. This must be done after considering the merits of various sector objectives and the characteristics of particular villages. Financial criteria alone are not adequate, as they ignore too many important social benefits.

In many countries, a sector survey is necessary, because basic information about the sector is lacking. This survey should identify the principal problems and constraints in the sector, analyze the strategy for development (or by examining alternatives, help develop such a strategy), estimate the investments needed, and recommend policies, institutional improvements, and other measures necessary to assure a program's success. This important and difficult work must be carried out by competent staff. It can be done entirely by local experts, but often some external assistance may be required.

Typical sector objectives are:

- To provide safe water to as many people as possible
- To reduce waterborne or water-related diseases
- To encourage rural development
- To improve living conditions for the rural poor

Any selected program will have to compromise to some degree between these various interrelated objectives, which cannot normally be achieved fully at the same time.

Village characteristics which affect the choice of the villages to be served first include:

Village need and demand—

- Village involvement and interest, including a willingness to contribute labor and money for the improved supply
- Adequacy of existing supply and distance from village
- Prevalence of water-related diseases

Village potential—

- Growth potential
- Village institutions

System costs—

- Nature of sources
- Population density
- Level of service
- Accessibility

Of these characteristics, village participation is the most important. Systems in villages having a real interest in improved water supply are far more likely to remain in working order than systems installed regardless of village opinion. Systems may also be tailored to meet the needs and desires of the village, and in such cases prompt collection of water charges is more likely. Sufficient lead time should be allowed in project preparation to obtain this kind of village participation.

Whatever ranking is adopted, projects will require review as they are implemented, to determine whether the weights given to the various objectives and characteristics are appropriate. Careful monitoring, especially of the initial stages of programs, is therefore essential.

Implications for the World Bank

Lending for village water supplies would not involve a major departure from World Bank policy, but rather constitutes an increased emphasis upon one aspect of a sector with which the Bank has been associated for many years. The Sector Working Paper, *Water Supply and Sewerage,* published in October 1971, which was primarily concerned with urban water supply and waste disposal, stated that the World Bank would be prepared to finance well-justified rural water supply projects, despite the considerable institutional and financial difficulties involved. More recently, several

World Bank projects have included the provision of potable water in rural areas, but the involvement remains minor.

Helping extend potable water (and sanitation) to people in rural areas clearly proceeds from the World Bank's policy to help spread the benefits of development to the poor, and from the rising concern for health conditions in the poorest countries. The enormous needs involved, the particular state of neglect of rural water supplies in most parts of the developing world, and the complexity of the problem, all indicate that a particular focus needs to be maintained on this subsector within the Bank, as well as in individual countries and the international community. The work of the international panel on rural water supply, which the Bank helped sponsor, is part of this effort.

Further steps need to be taken to translate principles into a practical program. Problems have been researched and identified, and may be broadly categorized as being mostly of an institutional and organizational nature. It is in these areas that World Bank assistance will be most significant, acting to build local capability for project planning, execution, and operation. In view of the diverse conditions in developing countries, the problems can best be tackled by actual lending experience, stemming from the preparation, appraisal, and monitoring of rural water supply projects. Monitoring is particularly important, both to signal actions required to ensure that the intended benefits are achieved and to identify those experiences that may be useful to projects in other areas. Health benefits are an essential but very difficult aspect to monitor. Steps are being taken to develop a methodology for monitoring the health impact of water supply which can then be tested in accordance with the recommendations of an international panel of experts convened by the Bank.

Because of the problems and uncertainties inherent in World Bank lending for village water supply, it is not possible to make recommendations on the amount of future Bank lending for this subsector. In the short run, lending will develop largely in response to the needs of operations in the sectors concerned with rural development, particularly integrated rural development projects, where water supply forms one component of the project infrastructure. Several projects are currently being developed in which village water supply will be included, either as an independent program or as part of a national program with both rural and urban elements. Their number is expected to increase only gradually, because most governments continue to view the needs of the water supply sector largely in terms of urban systems, whose requirements are great—and more visible.

To develop balanced programs and successful projects of either type requires a long lead time, which may be reduced if expert attention is paid at an early stage to the many and diverse issues involved. In many countries, one of the Bank's important functions will be in improving sector knowledge, formulating sector policies, and developing investment programs designed to serve rural areas.

INTRODUCTION

Sanitary or public health conditions in many developing countries are extremely bad. Probably over 1,000 million people living in rural areas do not have an adequate water supply, and waterborne or water-related diseases are usually among the three major causes of sickness and death. The rate of extending water supplies to these areas is slow, and does not keep pace with population growth. Even when new systems are provided, they frequently become inoperable in a short time due to the lack of proper operation and maintenance.

Governments of developing countries are becoming increasingly concerned with improving the life of the people in rural areas. Many health experts and, in particular, the World Health Organization (WHO) believe that the provision of a safe and convenient water supply is the single most important and cost-effective activity that could be undertaken to improve the health of rural populations. As the World Bank responds to governments' needs and shifts the emphasis of its lending program to have a greater impact on rural areas (through agriculture and integrated rural development as well as through infrastructure projects such as water supply), it will have to face the problems that have hitherto prevented successful development of rural water supply.

A major problem is that in many developing countries rural water supply has received little attention from the central government and has been developed piecemeal. These countries lack centralized policies and adequate information on the subsector. The World Bank as an institution has little experience so far in rural water projects, since past Bank lending for water supply has concentrated heavily on urban schemes (although many have also served adjacent villages and some, forming part of national or regional programs, have included quite large rural components). The purpose of this paper is, therefore, to describe the characteristics and problems of village water supply, to suggest ways of improving the present situation, and to propose guidelines for future World Bank lending for village water supply projects.

There is no generally accepted distinction between an "urban" and a "rural" community. Each country selects the division most appropriate to its needs, and compiles statistics on this basis. As a rough guide, this paper is concerned with communities in the range of 300 to 10,000 inhabitants. It considers the needs of everyone in these communities including, but not limited to, the rural poor.

The water supply systems considered in this paper may range from wells or protected springs, from which villagers fetch water, to quite elaborate systems with piped distribution of treated water. One common characteristic assumed for each of these systems is that they provide safe water, that is, water free from disease-carrying organisms and toxic substances, and are protected against accidental contamination.

Sources of Data

The principal source of the statistics in this paper is a special survey carried out by the World Health Organization (WHO) in December 1970 to obtain data on water supply and sewage disposal in developing countries. Ninety-one countries, with an estimated 1970 population of 1,700 million, responded to part or all of the survey. So far only the statistical results[1] of the survey have been published; an analysis of these results is expected shortly.

Because the WHO survey used the definitions employed by each individual country, its consolidated statistics on the division between urban and rural population, reasonable access to safe water, and other data may be somewhat misleading. Apparent large differences between countries may be due partially to the use of different definitions, and WHO cautions that the survey figures are only indicative. Spot checks of data for countries in which the Bank has been involved in water supply operations have shown a number of inconsistencies. However, the WHO survey contains the best global data presently available.

In addition to the WHO survey, the paper draws on—

- A research project carried out by the World Bank in 1972-74[2]
- Sector studies executed under the WHO/World Bank Cooperative Program
- Experience gained by the World Bank in its lending operations for water supply, agriculture, and rural development
- The experience of the Inter-American Development Bank (IDB), which has made some 20 loans for rural water supply in Latin America (see Annex 4)

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[1] *World Health Organization, "Community Water Supply and Sewage Disposal in Developing Countries,"* World Health Statistics, *Vol. 26, No. 11, 1973.*

[2] *Robert J. Saunders and Jeremy J. Warford,* Village Water Supply: Economics and Policy in the Developing World *(forthcoming).*

- The findings of the Technical and Organizational Panels of the Ad Hoc Group on Rural Potable Water Supply and Sanitation established in April 1974 by a number of international organizations—United Nations Children's Fund (UNICEF), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), World Bank, World Health Organization (WHO), International Development Research Centre (IDRC), and Organisation for Economic Co-operation and Development (OECD)

Chapter 1: BACKGROUND

The first part of this chapter is based on the statistical material in the WHO survey and reviews the worldwide water supply situation in 1970; the United Nations Development Decade (UNDD) targets for 1980; the investments needed to meet those targets; a comparison with past achievements and with past total investment; and the level of past financial assistance. The chapter then describes recent moves by the international community to coordinate its efforts in rural water supply, and closes with a list of the principal problems usually encountered in village water supply projects.

The Situation in 1970

The WHO survey obtained information on the water supply situation in 91 developing countries at the end of 1970. WHO engineers and consultants checked the data to the extent possible, in particular those concerning the 25 largest countries which contain 75 percent of the total population surveyed. Nevertheless, WHO cautions that the statistics are figures in the order of magnitude rather than precise data. The population of the countries surveyed was 1,700 million, of whom over 70 percent lived in rural areas (a breakdown by WHO regions is given in Annex 1, Table 1:1).

The percentage of this population with reasonable access[1] to safe water[2] varied widely between countries and regions; a summary is shown in Annex 1, Table 1:2. In every region, service in rural areas was very much worse than in urban areas—overall, only 14 percent of the rural population had reasonable access to safe water, compared with 68 percent of the urban population.[3]

Expressed in numbers, the results are even more disturbing. In urban areas, 144 million people had no service, but in rural areas 1,076 million people—about one-third of the total world population—were without reasonable access to safe water (see Annex 1, Table

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[1] *"Reasonable access" is defined as follows: in urban areas, within 200 meters of a public hydrant; in rural areas, sufficiently close so that family members do not spend a disproportionate part of the day in fetching water.*

[2] *"Safe water" includes treated surface water or untreated but uncontaminated water such as that from springs, protected boreholes, or sanitary wells. Other waters of doubtful quality are classified as unsafe.*

[3] *This latter value is probably too high, since in many cities the population is technically "served," but the quality of the service (a few hours a day) and the quality of the water badly need improvement. This is particularly true of fringe slum areas, the usual destinations of poor rural migrants.*

1:3). Two-thirds of these were in Southeast Asia and the Western Pacific, which also contain the largest numbers of the rural poor.[4]

Targets for 1980

The UNDD goals call for the extension of water supplies to serve 100 percent of the urban population (60 percent through house connections and 40 percent through public hydrants) and 25 percent of the rural population. For Latin America and the Caribbean region, slightly different goals were adopted by a conference of public health ministers in Santiago (Chile) in 1972: to reduce the percentages of population not served in 1970 by at least 50 percent in urban areas and 30 percent in rural areas. These are useful as broad goals, but are necessarily arbitrary with respect to individual countries, which will need to determine their own priorities and their own urban-rural mix.

By combining these goals with a forecast of the population growth during the period 1971-80 (Annex 1, Table 1:4), the WHO survey estimates the additional numbers of people to be served by 1980 (Annex 1, Table 1:5). On the basis of these figures, several conclusions may be drawn:

- The urban population growth rate (averaging 4.5 percent per annum) is substantially higher than the rural population growth rate (2.2 percent).[5] This is particularly marked in Africa, where it is 5.6 percent, 2.5 times higher than the rural rate.

- Because of this high urban growth rate, urban supplies would need to be expanded even more than rural supplies in order to meet the UNDD goals. Worldwide, about 400 million new consumers would have to be served in urban areas, compared with about 250 million in rural areas.[6]

- To meet the goals would involve at least a doubling, and in some cases a tripling or quadrupling, of the number of persons served, taking 1970 as the base year.

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[4]*See World Bank,* Rural Development—Sector Policy Paper, *February 1975, particularly Annexes 1, 2, 3, and 13.*

[5]*In Latin America, several countries (Argentina, Chile, Uruguay) anticipate a decrease in rural population in this period.*

[6]*The lower rural figure is, of course, due to the lower rural goals: If 100 percent of the rural population were to be supplied, service would have to be extended to about 1,400 million people by 1980, instead of 250 million.*

Investments Needed

The WHO survey presents estimates of the investments needed to meet the UNDD goals by combining estimates of the number of additional people to be served (Annex 1, Table 1:5) and of per capita costs (Annex 1, Table 1:6). The results are summarized in Annex 1, Table 1:7, which shows that a total of $14,000 million may be required: $11,000 million for urban and $3,000 million for rural water programs. Spot checks using data from World Bank projects in individual countries suggest that these estimates are low; but in view of the wide country variations described below, it would be unwise to increase the estimates across the board on the basis of a few samples. Actual expenditures to meet the goals in current dollars will, of course, need to be very much higher than the WHO figures, which are in 1970 dollars, but are probably based on data from 1969 or earlier.

Annex 1, Table 1:6, shows the assumed per capita costs for extending water service. These costs, averaged by WHO region, vary widely: $12 to $53 for urban supplies through house connections, $9 to $28 for urban public hydrant supplies, and $6 to $24 for rural supplies. Even wider variations occur between countries, ranging from $1 to $300 per capita.

Comparison with the Past

The WHO survey is a rather more extensive version of an earlier survey in 1962, in which urban supplies in 77 countries were covered. This permits a comparison of past achievements in urban water (summarized in Annex 1, Table 1:8) with the UNDD targets. From Annex 1, Tables 1:5 and 1:8, it will be seen that, whereas the *rate* of growth of urban population served in 1962-70 was comparable with that needed to meet the UNDD goals, the *numbers* of new urban consumers to be served in 1971-80 are about three times those served in 1962-70 (390 million compared with 134 million).

Unfortunately, no comparable detailed study was made of the achievements in rural water supply. One informed estimate is that rural water supply coverage increased only from 10 percent of the rural population to 12 percent between 1961-71.[7] Only in Latin America did coverage increase dramatically from 7 percent to 24 percent in the same decade.[8] In most countries, past investments

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[7] *World Health Organization,* Community Water Programme—Progress Report by the Director General to the 25th World Health Assembly, *April 1972 (Document A25/29).*

[8] *Pan American Health Organization,* Annual Report of the Director, *August 1972 (Official Document No. 116).*

have been predominantly for urban systems, and meeting the rural goals will call for a greatly expanded effort.

The amount of the global needs—a $3,000 million investment (in 1970 dollars) to serve 250 million people—makes a misleadingly simple impression. For the difficulty of the task to be fully comprehended, the needs should be expressed in terms of the enormous number of villages to be served and of small subprojects to be developed. The rural water supply program in Uttar Pradesh (India), illustrates the scale of the problem. One particular project area has a surface of 65,000 square kilometers, with 16,000 villages and a population of about 6.4 million. At present, only 25 percent of the villages (17 percent of the inhabitants) have adequate water. The project, estimated to cost $30 million, will involve the construction of over 1,000 water systems, grouped into 300 subprojects, to serve an additional 2,000 villages with a population of 800,000, so that 40 percent of the villages and 35 percent of the population will have service by 1981.

Accurate figures for investment in water supply are difficult to obtain because of the many sources of funds and, particularly in the rural subsector, because of the many agencies responsible. The WHO survey estimates that in one year, 1970, a total of $982 million was spent, of which $765 million (77 percent) in urban areas and $217 million (23 percent) in rural areas. A regional breakdown is given in Annex 1, Table 1:9. An examination of these figures for some countries where the Bank made loans for water supply in that year suggests that actual expenditures were probably considerably higher.

The WHO estimates of expenditures required to meet the UNDD goals average $1,100 million per annum for urban water supplies and $300 million for supplies in rural areas. Worldwide, a substantial increase in real terms over the reported 1970 investment levels will, therefore, be needed to meet the UNDD goals. Regionally, by far the greatest increases will be needed in Africa and Southeast Asia (in each case, approximately a threefold increase). However, it is not advisable to make generalizations, and individual assessments must be made for each country. In some developing countries, for example, Ethiopia, Mali, Pakistan, and Zaire, the calculated increases are so great (approximately 145-, 140-, 25- and 70-fold, respectively) that, even allowing for underreporting of 1970 investment levels, the UNDD goals appear unattainable. In other countries, the 1970 investment level, if sustained throughout the decade, appears adequate to meet the goals.

Nearly two-thirds of the additional rural population to be served by 1980 will live in the developing countries of Asia, where per capita incomes are generally low. It seems doubtful that the economies of these countries can sustain the investments necessary to meet the UNDD goals. Annex 1, Table 1:10, compares the public expenditure component of gross domestic fixed investment (GDFI) in selected countries in 1970 with the annual average rural water supply investments derived from the WHO survey: It will be seen that even with per capita water supply investments under $10, 2.5 percent to 3 percent of public GDFI would have to be devoted to rural water supply in India, Indonesia, and Pakistan. In Sri Lanka (per capita cost $21), the percentage rises to 9.4. In practice, these percentages would probably have to be even higher, because of low investments in the first half of the development decade.

Remembering that the UNDD goals are modest, in that they only aim at serving 25 percent of the rural population, it is evident that every effort must be made in these countries to keep down the per capita cost of water supply, if an appreciable proportion of their populations are ever to have adequate water. Details of various alternative forms of water systems and of their comparative costs are given in the next chapter and in Annex 2. From these, it is clear that for the rural supplies in the poorest countries, groundwater sources should be used wherever possible, either by using handpumps for shallow wells or, where the water is at greater depth, by motorized pumps supplying a central water point, with no distribution system. Selection of more elaborate systems providing a better service would increase costs to a level where the villages could not be expected to meet running costs and where their capital contribution could be only a small proportion of project costs. The burden on the central economy of extending rural water supplies would then increase, and the pace of extensions would necessarily be slowed.

Actions by the International Community

Assistance provided by multilateral and bilateral agencies to governments for rural water supplies over the past two decades has been widespread and has taken many forms, ranging from short-term technical advice to projects which have provided supplies, equipment, and technical assistance extending over several years. Among the agencies which have been associated with rural water supplies are the European Development Fund (FED), Food and Agriculture Organization (FAO), Inter-American Development Bank

(IDB), Organisation for Economic Co-operation and Development (OECD), Pan American Health Organization (PAHO), United Nations Children's Fund (UNICEF), United Nations Development Programme (UNDP), World Health Organization (WHO), and numerous bilateral agencies such as the Canadian International Development Agency (CIDA), Cooperative for American Relief Everywhere (CARE), Kreditanstalt fuer Wiederaufbau (KfW) (Federal Republic of Germany), Overseas Development Ministry (ODM) (United Kingdom), Rockefeller Foundation, Swedish International Development Agency (SIDA), and United States Agency for International Development (USAID).

Apart from data obtained from IDB, statistical information on the amounts and the extent of assistance provided for rural water and sanitation has often not been in a form which could be evaluated, either because water supply has been mixed with other activities, or because records have been retired or never collected from the field.[9] Only very rarely have evaluations been undertaken after the project was finished.

In view of the increasing attention given to the plight of the poorer segments of society in the developing countries, the multilateral and many bilateral agencies are becoming concerned that the poor, both in rural and fringe urban areas, are currently deprived of a fundamental need—access to a safe and reasonably convenient source of water. Some of the questions being raised are: Why, after a rather lengthy experience, has so little been accomplished? What are the ways in which the international community can best assist in overcoming problems? How should the community proceed?

To find answers to these questions and to explore ways by which a coordinated international effort might be launched to stimulate action, an Ad Hoc Working Group was established in 1974 at the initiative of UNDP and the International Development Research Centre (IDRC). The Working Group consists of representatives from UNDP, UNEP, UNICEF, WHO, World Bank, IDRC, and OECD. A series of meetings have been held by the Group, which is now drawing up proposals for expanded activity in rural water supply for discussion with potential donor agencies.

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[9] *External financial assistance for water supply projects reported in the WHO survey totaled $711 million in 1966-70, averaging $140 million annually. Some World Bank loans were not reported in the survey, so the true total should be higher.*

Common Problems

Sector characteristics change markedly as one progresses from large urban centers, through medium-sized cities, small towns and villages, to the dispersed population. The administrative structure becomes more diffuse, income levels decline, and per capita costs for equivalent levels of service tend to increase. Inherent in these changing characteristics are many of the typical problems encountered in rural water programs (and regarding most other facets of rural development). These problems may be grouped into the following broad categories, although they naturally overlap:

Institutional—

- Lack of a rural water supply policy forming part of a national water supply policy
- Existence of several government agencies whose lines of responsibility overlap or are ill defined
- Lack of institutions capable of project development
- Lack of water organizations at the local level
- Lack of trained manpower at every level
- Lack of criteria for project evaluation and priority selection

Financial—

- Per capita costs which, for a given level of service, increase as village size decreases
- Relatively low income of villagers and limited village financial resources
- Lack of a policy to obtain maximum financial support from areas to be served
- Lack of local government infrastructure, inability to collect and retain locally collected taxes for local use, and difficulty in collecting fees from water users
- Lack of village motivation and of public health education, so that villagers are unaware of the potential benefits of improved water systems and are not willing to pay for them
- Seasonal availability of water from ponds, streams, shallow wells, and other sources of questionable quality to which the rural population may return if high charges for piped water are imposed

Technological—

- A record of short operating life for equipment, poor maintenance, and many project failures

- Lack of local capacity to fabricate simple, reliable equipment for which spare parts and service would be available locally
- Use of a wide variety of types and makes of equipment by the various national agencies, compounding the problem of operation and maintenance
- Severe communications problems between remote rural systems and their support organizations in areas with poor or nonexistent telephone service, so that system breakdowns are not reported promptly
- Difficulty in obtaining spares due to lack of money, scarcity of foreign exchange, cumbersome procurement procedures, problems of logistics, and absence of a support agency which maintains an inventory of needed parts
- Difficulty in providing sufficient repair staff and transport to attend promptly to breakdowns in widely dispersed rural systems with very poor road links

By far the most crucial problems are the institutional and financial ones; if these could be resolved, the technological problems would largely disappear.

Chapter 2: TECHNICAL ASPECTS AND COSTS

Factors affecting the type of water supply system to be constructed in a village include the level of service, water quality and quantity, and the nature and location of water sources. Certain general principles may be applied to most village water programs. These are:

- Groundwater from springs, wells and boreholes, which requires little or no treatment to make it safe, is preferable to surface water; particularly, in the poorest countries shallow wells with handpumps should be used wherever possible.
- Systems must be designed for simple, trouble-free operation, and be capable of being operated and maintained by local technicians.
- Equipment must be able to withstand hard usage, and replacement parts must be readily available.
- Standard designs, which can be slightly modified to meet local conditions, should be developed and used for cost estimation, procurement, and construction.

Wide variations between systems and between countries make it difficult to apply generalizations to all countries on quantities of water to be provided or on system types or costs. However, in many cases consumption is likely to be from 20 liters to 100 liters per capita per day (lcd.), and per capita construction costs between $1 and $3 for shallow wells, and $10 and $50 for piped systems.

Levels of Service

Various levels of service can be provided in village water systems:

- One or more water points, such as a protected spring or a well with a pump, but no distribution system
- A simple distribution system with a few public hydrants, supplied with water from a single source
- A more elaborate distribution system serving a substantial number of public hydrants and some house connections
- Systems with a substantial number of house connections and few public hydrants

Both capital costs of the facilities and the operating costs associated with the volume of water produced will rise with the level of service. For example, the first two levels are likely to be very simple systems, using a handpump or a gravity supply, whereas the latter two, which require larger quantities of water, will require motorized pumps and some treated water storage facilities to meet peak demands and guard against breakdown. Selection of a higher level of service may also necessitate changing to a more expensive source—for example, to poor quality surface water requiring treatment—because groundwater of sufficient good quality is not available. Higher levels of service will probably not be affordable for the majority of the rural population presently without water, because they cannot themselves meet the additional costs, and for their governments to do so would place an excessive burden on the national economy. Nevertheless, systems with house connections should be encouraged whenever income levels permit, since the full health benefits are not achieved until a plentiful supply of water, free of the risk of contamination, is available in the house.

Quality

Quality standards for village water supply are principally concerned with ensuring that the water does not contain any matter, either chemical or biological, which could affect its safety or acceptability. Standards which have little bearing on health (such as hardness of the water, or the presence of iron, manganese, or chlorides), can usually be relaxed unless this could cause technical problems such as encrustation or corrosion, and so long as the villagers find the water acceptable. Acceptability can be an important factor: for example, groundwater with a high iron or manganese content, which will have a distinctive taste and will discolor laundry and foods such as rice, may be rejected in favor of water from a contaminated river or pond.

Quantity

In most villages, water is primarily for personal use. The quantity consumed depends on several factors, of which the most important is convenience. If there is a supply in the house or courtyard, consumption may be five or more times greater than if water has to be fetched from a public water point. If water has to be carried a considerable distance—say more than one mile—consumption may fall to as low as 5 lcd., which approaches the minimum necessary to sustain life. The climate and cultural patterns of bathing, laundering, and food preparation are also important factors. The provision of public bathing and laundry facilities may increase demand considerably. Waste may be a major problem unless public hydrants are properly designed to prevent faucets from being left to run continuously, or measures are taken to control and supervise their use.[1]

The WHO survey gives the following data[2] for average daily consumption in rural areas:

Region	Liters per capita per day (lcd.) Minimum	Maximum
Africa	15	35
Southeast Asia	30	70
Western Pacific	30	95
Eastern Mediterranean	40	85
Europe (Algeria, Morocco, Turkey)	20	65
Latin America and the Caribbean	70	190
World average	35	90

The individual data for 91 countries, from which WHO's regional figures were consolidated, show a minimum-use figure of about 5 lcd. for seven countries; 20 lcd. or less for 24 countries; 40 lcd. or less for 45 countries; and more than 40 lcd. for 15 countries. Because of the wide variations between regions and countries, no single consumption figure can be adopted for a worldwide design of rural systems. In some villages with only public hydrants, 20 lcd. would be adequate, while in cases where a number of houses are supplied through private connections, more than 100 lcd. might be required. To obtain design data, samples should be taken either in villages within the proposed project area which already have water supply or in other villages with similar cultural, economic, and climatic conditions. Allowances should be made for the growth of demand for water for productive purposes, such as livestock watering, irrigation of small gardens, preparation of produce for market, and, in some instances, the establishment of small industries and food-processing plants. Demonstration projects or initial programs will give reliable design data for planning subsequent stages.

[1] *The Bank is now undertaking research into possible improvements in public hydrant design and other methods for reducing waste. See* World Bank Research Program—Abstracts of Current Studies, *October 1975, Category VI—Public Utilities: "Reduction in Waste Water from Public Hydrants" (Ref. No. 671-12).*

[2] *Judging from Bank experience, certain figures appear to be overestimated. Possible reasons for this include the use of design criteria or production data rather than true consumption figures, and not weighting consumption figures according to population when calculating regional and world averages.*

Water Sources

The requirement that the water supplied be safe to drink has an important bearing on design and costs, since different sources of water require different degrees of treatment. Where groundwater is available, springs and wells which are properly located, constructed, and maintained, will normally yield water which, without any treatment, will meet the most stringent standards for biological purity. Exceptions are areas of fissured limestone, where groundwater may be contaminated by surface water.

Because of the possibility of contamination by humans or animals, some treatment will be required where surface water has to be used or when groundwater is polluted. Introducing treatment will increase the likelihood of a breakdown and may increase the cost of the system, so wherever possible safe groundwater sources should be used. The degree of treatment will be determined by the nature and degree of possible contamination and by the raw-water characteristics. Where the water has little turbidity and is unlikely to be contaminated by parasitic cysts and ova, simple chlorination and storage will usually be sufficient. Some storage will normally be required in the system in any case, so the additional cost of treatment is that of a chlorinator and of hypochlorite powder. Solution-feed chlorinators, which are comparatively trouble free and easy to operate, can be fabricated locally. Careful organization will be necessary to ensure that the villages receive a reliable supply of fresh hypochlorite powder.

For water with moderate turbidity, chlorination alone is not effective, and some type of filtration will be required. This may be done at the source, using well points or simple sand and gravel infiltration galleries, constructed mainly with local materials and labor. Slow sand filters may also be used; they are labor intensive both in construction (especially in obtaining suitable sand) and in operation, and are ideally suited for self-help schemes. Costs are mainly determined by the extent of structures needed to connect the river, lake, or irrigation canal to the infiltration gallery or filters; the topography; the availability of sand and gravel; and required output.

Where high turbidities occur regularly, adaptations of standard water treatment plants will be required. Although most installations can be fabricated from local materials, they are still expensive. Since these plants show considerable economies of scale, and since they also require fairly skilled operation, the possibility should always be considered of constructing one large plant to serve a group of villages. Where sufficient sand is available, settling basins followed by slow sand filters should always be considered, since their use could reduce costs significantly even for turbid raw waters. They have the further advantage of providing comparatively safe water even if the chlorination system fails.[3]

Transmission costs vary significantly with the source of water. Costs are zero for a well within a village with no distribution system, small for a gravity supply from a neighboring protected spring, but may be thousands of dollars for a river source at some distance and where both raw and treated water have to be pumped. Annex 2, Table 2:5, contains an example of transmission costs for typical surface water systems, which range from $1 to $11 per capita, depending on village size, distance to the source, and height through which the water has to be lifted.

Typical Costs

Annex 2 illustrates the effects on system costs of various levels of service, sizes of community, and types of source. The following conclusions may be drawn:

- In areas where groundwater is readily available at moderate depth, constructing a number of wells fitted with handpumps is by far the cheapest means of providing a good water supply.
- Use of surface water which requires full treatment may be several times as expensive as using groundwater.
- Providing a high level of house connections may at least double the per capita cost of the system, since the capacities of the source works, treatment, transmission, storage and distribution facilities have all to be greatly increased.
- Distribution system costs are a high proportion of total system costs. For systems serving poor regions, considerable savings may be made by omitting the distribution network and delivering the water through overhead storage tanks to a few central public hydrants.
- There are considerable economies of scale in piped village water systems. For similar systems, per capita costs for a project in Tanzania fell from $27 to $16 as the population served increased from 1,750 to 5,000. For a project in Peru, the per capita cost for a village of 1,500 inhabitants was

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[3] *The most-quoted example of this is the 1892 Hamburg cholera outbreak. Both Hamburg and neighboring Altona drew water from the Elbe river, the former treating it by settlement only, the latter by settlement and slow sand filtration. When the river became infected from an upstream immigrant camp, Hamburg suffered an epidemic which affected one person in 30 and killed 7,500; Altona was almost unaffected.*

estimated at $27, one-third of the cost ($86) for a village of 150. In another illustrative example, the per capita cost of a system for a village of 10,000 is only about 40 percent of that for a village of 1,000.

As will be seen from the wide variation in the per capita costs quoted in Annex 2, these values, while based on actual projects, are illustrative only and should not be used as estimates. The WHO survey shows capital costs ranging from $6 to $24 per capita (at 1970 prices), taking the average for the WHO regions (Annex 1, Table 1:6). Individual country costs varied much more widely, extending from $1 to $150 per capita. For Inter-American Development Bank (IDB) projects, where over 60 percent of houses are supplied through private connections, per capita construction costs on projects financed up to 1974 averaged about $40 (Annex 4). These variations emphasize the need for a careful review of project estimates.

Standard Designs

To reduce both project preparation time and engineering costs, sets of standard designs should be developed with corresponding standard costs. These standard designs must be carefully considered initially, and should be modified as necessary in the light of field experience. It is essential that they are tailored to suit local conditions. For example, voltage fluctuations or supply outages in the electricity system may mean that electric pumps can only be used satisfactorily if extra pumping capacity and treated water storage are provided to compensate for reduced hours of pumping, and if extra protective measures are incorporated. Pumps ordered "off the shelf" to take care of nominal requirements will not meet the full demand and will suffer early motor failure. Alternative sources of power (diesel, gasoline, local hydro) may, therefore, be more economical even in areas which have been electrified.

The technology involved should be kept as simple as possible, so that local operators will be able to operate and maintain the system for long periods of time without the assistance of a trained operator from a central agency or of a qualified engineer. Each individual system will then comprise a number of standard design units, amended as necessary to suit the particular conditions. Careful engineering review will be necessary to ensure that the standard designs and cost estimates have been correctly adjusted to reflect conditions in the project area.

Sufficient attention must be given to the cost effectiveness of the designs and materials selected. Too often cheap materials are used to minimize initial costs, leading to early failure in service and a loss of supply for protracted periods while replacements are obtained and installed. These failures are not confined to the more complex systems with motorized pumps: Throughout the developing world, thousands of handpumps are unserviceable and research is being carried out to discover the reason and improve designs.[4]

To the greatest extent possible, the standard designs should use local materials and technology, and be suitable for construction with unskilled village labor. Block work and masonry can be substituted for concrete, locally fabricated asbestos cement or polyvinyl chloride pipes for imported cast iron or steel. Simple components such as handpumps may be made locally, although difficulties with quality control in foundries may lead to early failure in service. Local improvisation may also lead to import substitution (e.g., basic handpumps and simple well-jetting rigs developed in Thailand). However, in many developing countries the specialized technology does not exist to fabricate equipment for deep wells (such as drilling rigs, well casing, submersible pumps, and prime movers), and the small local market would often not justify setting up factories to produce such equipment.

Excreta Disposal

As will be discussed in Chapter 5, provision of safe water is the most important contribution to improving public health, but proper excreta disposal facilities also play a significant part. However, if waterborne sewerage is required, its per capita cost may be more than double that of the water system. It is clear that lack of finance will limit the rate of expansion of village water supplies, and if these additional facilities are to be included, the financial problem will become even more serious. Many villages see little need for sewage disposal and are much less willing to pay for it than for water supply. There is also the technical problem that, unless a sufficient number of houses can afford water-flushed toilets and connect to the sewer system, the flow in the sewers will not be enough to prevent them from becoming clogged. Fortunately, the population density of many villages is low enough to accommodate traditional excreta disposal methods such as pit latrines, which can be constructed at low cost and with a large self-help component. Typical installations are discussed in Annex 3.

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[4] *This research is carried out, for example, by the USAID – Battelle Columbus Laboratories program, and by the Water Resource Center of the Accelerated Rural Development Organization, Thailand.*

Chapter 3: FINANCIAL ASPECTS

Increasingly, national or urban water supply utilities aim to achieve and maintain financial viability. This policy has four objectives:

- To encourage the development of financially responsible management resulting in better investment decisions at the utility level, better financial planning, and more cost-effective operations
- To ensure the availability of adequate funds for operation and maintenance
- To mobilize resources for the development of the sector by generating an internal cash flow which will enable the utility to service borrowings and help finance part of its expansion program
- To make consumers aware of the financial consequences of their use of the service

In a number of countries, however, both governments and consumers have the attitude that good water supply is a social service, for which charges should be kept to a minimum. This attitude must be changed, at least insofar as it applies to higher-income areas, if resources are to be freed for extending service to the poorer and rural areas; consistent social policies require that, as a first step, anyone able to pay should be charged at least the full cost of service.

In villages, relatively high unit costs and relatively low consumer incomes make the inability to pay a further problem in recovering a reasonable proportion of total costs. Moreover, the existence of some alternative source of water—however inconvenient and unsafe—and a general lack of appreciation of the benefits of using a safe water supply makes the imposition of higher user charges undesirable. The problem is, therefore, how to achieve these objectives—which remain applicable even at low levels of financial performance[1]—in those circumstances.

Changing government and public attitudes toward water charges takes time and education. As a general principle, user charges should

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[1]*Where a water undertaking is heavily dependent on government funding to meet debt service and serve recurrent costs, the mobilization of resources clearly cannot be achieved by generating an internal cash flow. However, the underlying concept behind this objective can still be realized if the undertaking makes proper financing plans and obtains clearly defined government contributions toward these plans, rather than proceeding on the basis of an ad hoc annual budget.*

be set at as high a level as possible because the size of the program, and to some extent its continuing operation, depend on this source of funds as well as on general public revenues. But the level of these charges must take account of village income levels, and the method of assessing them—by region, by individual village, or on some other basis—will need careful adjustment to the characteristics of each particular program. Whatever pricing policies are adopted, village water supply programs in many countries are likely to require the continuing support from national revenues. Government funds will be necessary to cover not only the initial costs of construction, but also the costs of establishing and running the administrative unit, and of initial and continuing training. It would be prudent to include part of the operating and maintenance expenses, at least in the early stages of a program. Governments should recognize this implied commitment when they undertake such programs; failure to look beyond first costs has been the cause of severe problems of the operating stages in many cases.

Sources of Funds

Five potential sources of funds for village water programs may be perceived: the government budget, foreign loans, institutional lenders within a country, subsidies from urban water systems, and the villages themselves. The amount of funds allocated to village water supply from the first two sources is usually determined by the government on the basis of national priorities and the needs of other sectors of the economy.

The third source of funds—the institutional lenders of a country (insurance companies, banks, etc.)—has been largely untapped so far, either because the lending institutions are relatively undeveloped or because the institutions responsible for rural water are not acceptable as borrowers. One of the objectives of improving rural water institutions should be to enable them to attract funds from these sources.

The fourth potential source of funds—subsidies from urban water systems—is a natural extension of internal cross-subsidization already occurring within the urban systems: typically, industrial and commercial consumers pay a relatively high tariff, while only a nominal charge, if any, is made for water distributed through public hydrants. However, many urban systems, particularly those where migration has greatly increased the numbers of the urban poor, are already having difficulty in maintaining an adequate service. Urban dwellers naturally strongly resist any large increase in their tariffs in order to subsidize supplies to other areas. The extent to which urban systems will be able to make any sizable contribution to the needs of smaller communities is, therefore, questionable.

In these circumstances, the total amount available to meet initial and recurrent costs is dependent to a large degree on the contribution from villages. It seems clear that, if the needs for village water supply are to be met in a reasonable time, the targets for collecting capital and operating costs from the villages must be as high as possible. The more government funds have to be used to cover operating costs, as is now usually the case, the fewer new systems will be built.

Level of Villages' Payment

It is widely held that villages in general are so poor that they are unable to pay anything toward the costs of a water supply system. While this view may be correct in the case of the smallest and poorest villages, the prospects for collecting a reasonable proportion of the costs are probably better than is generally thought if the following conditions are fulfilled: The standard of service should be carefully tailored to the needs of the individual village; villagers should be given basic health education so that they appreciate the benefits of improved water supply; and a policy of maximizing user charges should be vigorously enforced.

Several good reasons exist for asking villages to pay part of the costs, both of construction and of operation and maintenance, of their water supplies:

- It is desirable that beneficiaries contribute toward the cost of the services they receive.
- As discussed above, this will enable the program to be larger.
- It will help to ensure that funds are available to meet operating expenses and the costs of minor repairs.
- It will increase the villagers' sense of responsibility for the system, and so encourage good maintenance and careful use of facilities.
- Since villagers should participate in the decision on the level of service to be provided, the requirement that they make a capital contribution (whether in money, materials, or labor) will ensure that this decision is carefully considered.
- It will establish the principle of payment for services received; this will become more important if, at a later stage of development, a higher level of service is desired.

The WHO survey shows that of the 84 countries giving details of charges for rural water supplies, 24 countries (29 percent) required villages to make some payment toward capital costs, and 61 (73 percent) insisted on some payment toward operating expenses. Many countries showed various degrees of cost recovery; only 23 (27 percent) indicated that they made no charge at all for rural water. The Bank's experience is that many countries do not consistently enforce charging policies, and arrears may be extremely high.

Even with a decision in principle that villages should meet part of the costs, determining their ability and willingness to pay remains a serious problem, because of a lack of reliable data on rural incomes, and because many villages have essentially a barter economy and little cash changes hands. IDB, whose projects provide a fairly high level of service and correspondingly have a relatively high per capita cost, has found that communities may be expected to pay between 3 percent and 20 percent of the capital costs of their systems, averaging about 10 percent. Water charges, set at about 3 percent to 5 percent of the income of the head of the family, cover at least operating and maintenance costs and possibly also some depreciation. Very rarely can families pay more than 5 percent of their income for water charges.[2]

Similar levels of payment could probably be required as a minimum elsewhere, provided that the level of service is carefully tailored to village needs and resources. For example, in the poorest areas each family might be required to contribute one man-day of labor in helping to dig a simple well to be fitted with a handpump, and this labor contribution might be equivalent to 10 percent to 20 percent of the cost of this simple system. Operating and maintenance costs for handpump systems are a few cents per person per year, and should be affordable even in poor villages with a noncash economy.

Both capital and operating costs are naturally higher for more elaborate systems, but attempts to establish guidelines on the proportion of these costs to be paid by the beneficiaries have not been successful. The Bank does not have sufficient data to take a position. In many countries of Asia, per capita rural incomes are $50 per annum or lower, but only a small proportion of this is in cash. In these cases, if a village is unable to make a cash contribution to the capital costs of a scheme, labor or materials should be accepted instead. Using village labor can be desirable because it generates additional

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[2]Guidelines being developed for the PIDER rural development program in Mexico suggest that the monthly water tariff should not exceed the equivalent of one day's pay at the prevailing minimum wage.

employment. However, the availability of labor may fluctuate with the agricultural cycle, and project work may be curtailed during planting and harvesting seasons. On a number of projects an unreliable work force has led to a wasteful use of material and to delays and difficulties in project execution.

Nevertheless, with system costs in the range of $20 to $40 per capita, it should not be difficult to identify a suitable local contribution in kind (e.g., digging pipe trenches, collecting sand for filters or concrete) equivalent to at least 10 percent of project costs.[3] A greater problem may be deciding how villagers can best contribute to operating and maintenance costs. Since they may have some difficulty in making cash payments for chemicals or energy, villagers should be given the opportunity to contribute labor (e.g., for cleaning filters or sedimentation basins, or for regular operation of the scheme).

As a first approximation, levels of payments on many projects might be set to cover at least 10 percent of construction costs and all operating and maintenance costs. These levels would be applied to the "basic system" costs, with a supply through public hydrants. Where individual householders require private connections, they should normally meet the full additional costs, probably with the assistance of some form of revolving loan fund. While contributions to capital costs and to operating and maintenance expenses are both important, more stress would be laid on the village covering operating expenses than on its contribution to construction costs. It is relatively easy to ensure that the construction costs are provided for in a well-defined program, but experience shows that many rural systems break down shortly after completion due to lack of funds for operation and minor repairs.

To increase the funds available to the program, the minimum levels of payment suggested above should be reviewed in every project, during project preparation as well as periodically thereafter, and raised when possible. This may be done by establishing payment levels according to village size or potential income, provided that the villagers accept the rates as equitable. It may even be done on a village-by-village basis, as is done in some Latin American countries, where villages vie with one another to make the maximum contribution and so receive higher priority in the program.

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[3]*For example, villages in the Republic of Korea are now contributing, through the* saemaeul *(village renewal) movement, over half the construction costs of simple piped water supplies.*

Complicating Factors

Application of the minimum levels to each individual village enables a village to understand clearly the financial implications of installing a water system. But some complicating factors may make it more desirable to establish levels for groups of villages or by some other category:

1. Other things being equal, systems for smaller (usually poorer) villages are more expensive per capita than those for larger (usually more prosperous) villages. If the systems to be provided have already been reduced to the cheapest possible level, the requirement that each individual village make payments at a predetermined level may have the result that only the larger villages qualify for new systems. This may be advisable from the standpoint of economic growth but is less desirable on social grounds.
2. Since systems using groundwater are generally much cheaper than those using surface water, more villages will qualify in areas where groundwater is available, even though the need in these areas may be less.
3. The relationship between per capita costs of installing and operating a system and per capita income will vary from village to village and from country to country. The most expensive systems may be required in the villages least able to afford them.

Some circumstances may also make it unreasonable to expect villages to provide a substantial capital contribution, such as—

- Resettlement schemes, in which people are to be attracted to new villages by the services available
- Rural development projects, in which the cash incomes of villagers will not increase markedly until crops mature, perhaps after a number of years, and where it may be prudent to allow, at the design stage, for a high proportion of house connections, even though villages may not desire them initially and may not be able to afford them

In these cases, the initial capital contribution may be kept low and may be largely replaced by higher water charges, covering not only operation and maintenance but also depreciation. (This, however, increases the strain on government finances during the early years of the program.) Alternatively, fairly large contributions, financed from a short-term revolving fund, may be required later in the program as villagers request house connections.

The decision on the levels of payment and the way in which they are to be applied has to be taken by the government, since the government will be responsible for funding the program. It is extremely difficult to draw up general pricing rules when the ability to pay and the system costs may vary widely from village to village, and when "social" objectives such as improved health or income redistribution are an integral part of the concept of the program; each decision will have to fit the specific case. Whatever decision is taken, it should be reviewed periodically and the targets altered if necessary, to reflect changes in village economic conditions and consumption patterns. Frequently, the basic data on which to base such a decision—for example, sector needs, estimates of capital and operating expenses, villagers' ability to pay—are not available (the use of sector surveys to supplement sector information is discussed in Chapters 6 and 7).

Collection

The financial performance of village water supply programs will almost invariably be well below that normally required in urban projects. The reasons for accepting lower standards are pragmatic, based on experience. The typically low incomes of villagers, and the existence of some alternative source of water—however inconvenient and unsafe—simply make it impossible in most cases to charge the full cost of the service. The real problem will be to collect any charges.[4]

Metering of individual supplies, the usual and most equitable basis for charging in urban systems, will not generally be justified in villages where consumption is small and where only a few houses may have individual connections. As a rule, revenue meters should only be used in villages for commercial or industrial consumers (if any) and possibly for a few large house connections; other house connections would be charged at a flat rate, with a flow-limiter in the supply line to reduce wastage.

Inhabitants dependent on public hydrants for their supplies will normally pay a flat rate, for example, through individual or family fees, head taxes, a water tax, or an assessment on property. Part of the state revenues received by the village may be used to meet the charges for hydrant supplies. In some countries (e.g., Kenya), water from public standpipes is sold by a subcontractor, who purchases it

[4]*Experience on IDB projects shows that charges for water are more readily collected where house connections are provided. This may be a factor in deciding whether to incur the higher costs of installing a system with a high proportion of such connections.*

from the water undertaking. However, the cost of the standpipe attendant may double the cost of water to the consumer.

The situation is further complicated by the use of the smallest coin for each container: Even if only one cent is charged for a 20-liter container (the typical size in many countries), the effective rate is $0.50 per cubic meter, which is much higher than the normal domestic tariff. On the other hand, because quantities used are small, the total monthly bill per family is not excessive—about $2.30 for a family of six using 25 liters per capita per day—and the consumers receive a reliable service because the subcontractor has an interest in maintaining the hydrant in good order. (Since the selling price of water cannot be reduced, this raises the possibility of the water undertaking increasing its price to the subcontractor in cases where he would make excessive profits, and returning the profit thus made to general village revenues.) In some countries, this system may greatly reduce consumption: In Ethiopia, when charges for standpipe water were waived during a cholera outbreak in order to encourage greater use, consumption increased several times. The strict control over the dispensing of water from sales points means that users are unlikely to wash out the containers adequately, or to wash themselves, so contamination of the containers from soiled hands becomes a health problem.

The choice between various charging methods is largely dictated by local conditions, and should normally be made on the basis of administrative simplicity, acceptability, and the likelihood of effectiveness. The Bank research project referred to in footnote 1 of Chapter 2 is concerned with, inter alia, methods of charging for public hydrant supplies.

Where one system serves a group of villages, the individual village consumption may be assessed from bulk meters on supply pipelines, records of the number of operating hours of pumps, etc., which will usually be necessary for operational control of the system. On this basis, system operating and maintenance costs can be fairly allocated.

In conclusion, the village payment should be as high as circumstances allow in each case, normally with water charges covering at least all operating and maintenance costs, and including a substantial contribution toward the scheme's construction cost. For this to be possible, the system's capital and operating costs must be reduced to a level compatible with villages' willingness and ability to pay; factors affecting costs have already been described in

Chapter 2, and consultation with villages on the system to be provided is discussed in Chapter 6. Moreover, the levels of service to be provided in many of the poorer countries will have to be minimal if water supply is to be extended to a reasonable proportion of the rural population without placing an intolerable strain on the national economy.

Chapter 4: ORGANIZATION AND MANAGEMENT

Institutional weakness is probably the most important single problem in rural water supply. This weakness manifests itself in various ways, particularly in a lack of any central policy for rural water supply, and a multiplicity of ineffective and understaffed ministries and agencies which each have some responsibility in the subsector. Much of the efforts of development agencies in urban water projects over the past 10 to 15 years have been directed at creating strong, competent, and financially viable institutions. In general, much less effort has been made to bring any order in the rural subsector, which is more dispersed and heterogenous, and has far greater problems.

Institutional Problems

National policy. Most countries do not have a national policy for rural water supply. Although overall national objectives, such as the UNDD goals, may nominally have been adopted, these have usually not been translated into actual objectives for the responsible agencies, and their financial and other implications, both for the government and the agencies, have not been assessed. As a result, it is unlikely that objectives will be achieved.

Proliferation of agencies. A major factor contributing to this situation is the existence of numerous agencies responsible for rural water. Typically, the ministries of health and agriculture may be responsible for supplies to small villages or the dispersed population, and the ministry of works for larger villages and small towns. Where they exist, national or regional water authorities or rural development agencies are also involved. Approval for the development program for new projects may have to be obtained from the ministry of planning, and funds for construction and, in many instances, operation and maintenance, may have to be released through budgets agreed with the ministry of finance. In larger countries, the situation may be complicated further by the existence of both national and state governments. In most countries, an effort should be made to improve coordination between the agencies involved in the sector, to reduce their number, and to establish small interagency, policy-setting units. Sector surveys may be needed to identify areas of inefficiency and duplication in the sector organization and to propose improvements.

Staffing. In almost every country, the agencies responsible for rural water are inadequately staffed. In most countries, this is a reflection of a general lack of suitably qualified personnel in government service. The condition is accentuated by a number of factors which make work in rural water supply particularly unattractive, such as low prestige, low salaries, poor living conditions in outback areas, low technological standards affording little stimulus to engineers and other professionals, and little scope for career development. If a government wishes to achieve its rural water objectives, it must itself have adequate staff in its own institutions to perform the task; consultants or other organizations in the private sector should normally be used only for specialist investigations such as groundwater surveys. Obviously, benefits for rural water supply personnel should be brought into line with the benefits in other sectors of the government civil service, but it is impractical and inequitable to increase them beyond this point. Perhaps the most effective step to attract better staff into rural water supply would be for the government to declare it to be a key development sector, and pay greater attention to personal motivation.

Training. Few countries make adequate provision for the training of rural water supply personnel. A substantial training element should be included in most village water programs. Ideally, and whenever possible, the program should be integrated into a national training effort for the sector as a whole; few countries can afford separate training facilities for urban and rural water supply personnel. In assessing training needs, the whole range of skills must be considered: local staff such as plumbers, operators, and mechanics; tradesmen such as bricklayers, pipe layers, and well drillers; supervisory staff such as foremen and sanitary inspectors; technical professionals such as engineers, chemists, and bacteriologists; administrative personnel, such as accountants and their support staff, administrators, and community organizers. A careful inventory should be made of the extent to which the required skills are already available in the country; often, civil or sanitary engineers are found working in other fields because of better salaries, conditions, or career opportunities. An attempt should be made to attract these qualified staff to the sector. The preparation of training programs is a specialized skill, and, since the programs will need to fit local circumstances, local experts should be used as much as possible.

In the early stages of rural water projects, large training centers may not be needed, since facilities may not be constructed at a rate sufficient to absorb newly trained personnel. In these circumstances, demonstration projects providing on-the-job training in fundamentals are probably the most useful and flexible means of training, so long as they are carefully designed to provide adequate instruction. In integrated rural development projects, advantage may be taken of training and education facilities established for other components of the project, which, in many cases, also give instruction in the operation and maintenance of simple mechanical systems.

Operation and maintenance. These are among the most neglected responsibilities of rural water agencies. Often funds are allocated for construction without any assessment of the costs and manpower requirements of running the completed project. This is an often recurring defect, since the Bank's research showed that operation and maintenance is by far the weakest aspect of most village water programs. Poor or nonexistent administrative and technical support and lack of operating funds were cited as the most frequent causes of failure. In one country, 69 out of 79 systems had had difficulties in operation. In another case, village systems were failing almost as fast as new ones were being built.

Methodology. The general lack of a methodology for project selection, discussed further in Chapters 5 and 6, combined with the multiplicity of agencies, has as a result that the rural water program tends to be an aggregation of projects selected by individual agencies, with little regard for overall sector objectives, needs, or development potential. Institutional strengthening and better coordination in planning are necessary to improve the situation.

The administrative framework to be adopted for a village water program must, therefore, have adequate vertical links. Planning, and to some extent construction, can be administered from the top, but to ensure continuing operation, support for the village systems must be readily available, and this implies decentralization. This local support must cover such items as technical advice, operator training, water quality supervision, and keeping a stock of spare parts. It may also be necessary to include recruitment of staff and supervision of operations. The cost of establishing and maintaining this local support structure will be substantial, and is frequently overlooked at the planning stage. It has been emphasized earlier that governments, when they first embark on village water supply programs, must make a commitment to meet these initial costs and also any operating and maintenance costs that cannot, initially, be recovered from the villages themselves.

Alternative Formats

Village water programs may be undertaken in various ways, each requiring a different administrative approach:

- As part of a national or regional water supply program, including both urban and rural elements
- As a rural water supply program
- As part of a regional integrated rural development or similar multisectoral project

In most countries, several ministries and national agencies are active in rural water supply, using some or all of these various formats. The situation is more complex in countries which allow a considerable amount of local autonomy, with little direction and support from central bodies. The administrative arrangements have to be tailored to suit conditions in individual countries. Although no universal pattern can be established, the basic requirements are always the same:

- Efficient execution of the three stages of project implementation (planning, construction, and operation)
- Consistent application of sector policies, design criteria, etc.
- Avoidance of unnecessary proliferation of agencies with sector responsibility

National or regional programs. If village water programs are included in national or regional water supply development programs with both urban and rural elements, an institutional framework such as a national water agency probably already exists. It will need to be expanded and extended to the new areas to be served. This approach is likely to make the best use of scarce technical and administrative talent and to ensure a consistent application of sector policies. Brazil, Ghana, and Tunisia are typical examples of this approach. Brazil, in fact, uses an effective two-tier approach: Broad policies and financing arrangements are decided at the national level, while state water companies are responsible for detailed planning, construction, and operation.

Rural water supply program. Where village water supplies are to be constructed under a rural water supply program, independently of urban water supply developments, the choice of agency to be responsible depends on previous experience. In some countries, rural water agencies have been operating successfully for a number of years, having their own staff and facilities. Strengthened, if necessary, these agencies would obviously be the first choice to run further programs, even though this may mean some overlap with the urban water supply agency. In other countries, rural water has received little attention, and the rural water agency is weak and understaffed. To undertake a major project successfully would require considerable institution building, beginning with manpower development. This would be time-consuming and would place a heavy burden on existing staff. In these circumstances, a careful study has to be made of the relative merits of building up the rural agency, or of amalgamating it with the urban agency and strengthening the combined organization.

Multisectoral projects. The third format for executing village water supply programs is as part of a multisectoral project such as an integrated rural development project. The problem in this case is that the water supply component has to be completed in accordance with the main project schedule. This is feasible provided that institutions for administering village water projects already exist, need little change, and can be called upon for assistance. Where these institutions do not exist or are very weak, design and construction may be contracted out and expatriate personnel employed to supervise construction and later assist in the operation. Sometimes, sufficient time may be lacking to build up the regional water organization, make proper arrangements for village participation, agree on financial policy, and introduce satisfactory operating and maintenance procedures. This problem applies primarily to the water component of the project, where individual villages may have responsibilities for operation, maintenance, and collection of charges; other components such as roads, rural electrification, and irrigation can go forward with existing centralized organizations, since they require much less local input.

If a competent national or regional agency with responsibility for rural water supply exists, it should be entrusted by the main project agency (for example, a rural development agency) with the responsibility for executing the water supply components of the integrated project. This would ensure that, after completion, the new water supply systems are properly operated and maintained. The agency would also make best use of existing expertise, ensure a consistent application of sector policies, and share experience gained from the project with projects in other parts of the country.

If a national or regional agency does not yet exist or is incompetent to undertake the project, two alternatives may be considered:

- Create or strengthen the national or regional water agency
- Establish a water supply unit within the main project agency

The first alternative is preferable, not only for the reasons given above, but also because it avoids proliferation of the number of agencies with responsibilities in the sector. However, the water supply component of the main project may be too small to provide sufficient leverage to improve the water sector institutions to the necessary extent and the second alternative may, therefore, have to be adopted. In such a case, the unit would work closely with the national or regional agency responsible for rural water supply. In particular, the unit would be responsible for ensuring that the water pricing policy adopted for the program would be consistent with the agency's pricing policy, so that the decision of the villagers on the level of service they can afford is based on a realistic assessment of what the cost would be. The unit's exact responsibilities and affiliations would have to be determined for each individual case, but with any arrangement of this kind, special care has to be taken that the water supply component is operated and maintained properly and on a continuing basis.

Chapter 5: JUSTIFICATION FOR INVESTMENT IN VILLAGE WATER SUPPLY

Governments have to take two types of decisions on village water supply investment. The first is intersectoral: Why invest in village water supply rather than in other sectors of the economy? The second is intrasectoral: For a given total investment, in what order should individual village projects be executed? This chapter discusses the first aspect; Chapter 6 examines factors affecting project ranking.

The most important benefit from improving the quality and quantity of village water supplies is an improvement in public health. Although this cannot easily be quantified or expressed in economic terms, the strongly held opinion of public health officials, and in particular of WHO, is that the provision of safe water is of prime importance to public health and, in combination with other sanitary measures, is an essential prerequisite to eradicating many endemic diseases.

In some cases, the benefits may be directly measurable and quantifiable: for example, an improvement of the water supply may allow processing of produce, fish freezing, or yarn dyeing. But in most cases the benefits are difficult to measure adequately, and in this respect investment in village water supply resembles investments in many other "social" sectors such as education. The most important of these unquantifiable benefits are improved public health and greater convenience, both of which may increase productivity. Indirect benefits commonly cited are a slowing down of rural-urban migration, redistribution of real income in favor of the rural poor, and the development of village institutions. Because it is not yet possible to measure these benefits adequately, intersectoral allocation cannot be made on the basis of precise cost/benefit analyses, but is essentially a matter of public policy, reflecting the prevailing sense of national priorities.

It is not the World Bank's role to define what those national priorities should be. The comparison between past investment in all sectors and the investment needed to meet the 1980 UNDD goals for rural water supply shows great variations between countries. It is up to each country to assess its investment priorities. The rationale for village water supply investments is confined here to a description of the benefits so that these and the corresponding costs may be compared with those in other sectors.

A distinction must be drawn between the justification for investments in urban and in village water supply systems. Investment in urban water supply is relatively easy to justify even though not all the benefits can be determined precisely: An adequate supply is essential for industry and commerce; in most urban areas, no satisfactory alternatives to a public system exist; and there is a risk of major epidemics if a proper supply is not provided. In addition, revenues from water charges in urban systems are usually sufficient to meet all costs and provide a reasonable rate of return, which fact can be used as a minimum approximation of economic benefits. However, these factors are progressively less applicable as the size of the service area decreases: Smaller villages have little commercial activity and almost no industry; other sources of water, of varying degrees of reliability, safety, and convenience, usually exist; and an outbreak of disease, should one occur, is likely to be confined to fewer people. In addition, as discussed in Chapter 3, many villages will be unable to meet much more than the costs of operation and maintenance, so that the financial rate of return on the project will be small. To increase these charges in order to obtain a financial performance comparable to urban systems will be extremely difficult in most cases and could cause villagers who have not yet appreciated the benefits of a safe water supply to return to their traditional polluted sources. Justification of village water supply projects, therefore, must depend largely on nonquantifiable factors.

Public Health Benefits

Numerous epidemiological studies have identified contaminated water as the principal agent in the transmission of typhoid, cholera, and shigellosis (bacillary dysentery). Lack of safe water for drinking and washing is also an important factor in the spread of other diarrheal diseases, which form possibly the most important single disease group throughout the developing world: up to half the number of deaths in the developing world, occur in children under five, with diarrheal diseases being the most common cause. Numerous other diseases are also linked to poor water supply or sanitary conditions.[1]

It might, therefore, be expected that an improvement in the community water supply would result in a measurable increase in public health. However, health impact studies to date have not usually been pursued sufficiently far to demonstrate this link conclusively. One obvious difficulty is that some endemic diseases such as

[1] *The relationship between water and health is discussed at greater length in the forthcoming book by Saunders and Warford, and in* Health—Sector Policy Paper, *March 1975, Chapter 2.*

cholera have epidemic characteristics; during an outbreak, the protection afforded by a safe water supply has been clearly shown in many epidemiological studies, but at other times the role of safe water in preventing the spread of the disease is less easily demonstrated. A second difficulty is that few if any diseases are transmitted by only one medium. Typhoid, cholera, dysentery, and, more rarely, hepatitis may be caused by drinking water contaminated with human wastes, but may also be due to contaminated food, milk, and, to a lesser extent, to other vectors such as flies.

The effect on community health of providing a safe water supply depends on the extent to which the community makes use of the supply, and this in turn depends on social customs, an understanding of health implications, and on the level of service provided. If water has to be carried from distant wells or public standpipes, the quantity fetched is usually small. Use of this safe water for drinking and cooking reduces water-borne diseases such as typhoid and cholera, but the supply may be insufficient for proper personal hygiene, so that "water-washed" diseases (for example, trachoma and some skin diseases) cannot be effectively controlled. The risk also exists that the safe water obtained from the source is contaminated in transit or while being stored prior to use. Moreover, continuing use of ponds and streams for laundry and personal hygiene means that the villagers are still vulnerable to parasitic infections such as schistosomiasis (bilharzia) and dracontiasis (Guinea worm).

If it were possible to predict exactly the effects of various levels of service on the reduction in diseases, it would be possible to determine what level of service should be provided in order to maximize net benefits, but this cannot be done with present knowledge. As discussed in Chapter 3, a system supplying consumers through private house connections may cost double the most basic system which only supplies public hydrants, but the evidence is too limited and cannot be generalized to support a conclusion that health benefits would be increased by a similar ratio.

If villagers have frequent contact with polluted water (for example, for laundering, bathing, fishing, or paddy cultivation), improving the water supply will only have a limited effect on reducing diseases such as schistosomiasis; in these cases, additional means must be found to break the chain of transmission. The studies cited by Saunders and Warford suggest that improving both water supply and methods of excreta disposal may be more effective and less expensive than controlling the snail vectors by molluscicides, and similarly, for long-term control, may be more efficient than immunization against cholera and typhoid (cholera immunization, in particular, is of doubtful effectiveness). Excreta disposal systems (usually of a very simple type, such as pit latrines, which have a high self-help component) should be considered as essential counterparts of village water supply programs in improving public health, and should be executed at the same time.

Often villagers do not appreciate the benefits that result from improved water and sanitation systems. Health education programs are necessary to instruct them on the dangers of drinking or coming in contact with contaminated water, and on elementary hygiene. Health educators should make a preliminary visit to villages at an early stage of project preparation in order to stimulate interest in improved systems, and as part of the effort to organize the villages. Health education programs need to be established on a continuing basis, beginning early and extending over several years after the project is completed. This will help to ensure that full health benefits are obtained. These health programs can be expensive. In cases where water is relatively inexpensive (for example, a gravity supply from a spring), the most cost-effective solution may be to provide much better access to service (providing more hydrants, better community facilities, and possibly a greater proportion of house connections) to minimize the need for intensive health education efforts, in order to realize the health benefits.

It is sometimes argued that increasing the quantity of water available to villagers is more important than ensuring its quality. It is true that only a small proportion of daily water usage is actually consumed and, in theory, provided this water were safe, the remainder (used for washing, laundry, etc.) could be of a lower standard. However, experience shows that it is extremely difficult to guarantee the safety of the water used for drinking if the original supply is unsafe: very few people have the patience (or the fuel) to boil water long enough to ensure disinfection, and storing this boiled water hygienically while it cools presents problems. The likely use of the unsafe supply for cleaning cooking utensils or for food preparation means that there is always a risk of contamination.[2]

It is obvious that an unsafe supply (that is, one that is not adequately safeguarded against possible contamination) not only will fail to protect consumers against waterborne diseases but also may serve to transmit these diseases more widely than would have been

[2] *A particular problem is that many of the causative agents of major diseases survive for long periods outside the body, so that one visit by a carrier may provide a reservoir of infection for months: for example, cholera—5 to 16 days; shigellosis—one month to 2 years; leptospirosis—3 to 9 days; typhoid fever—months; amoebiasis—one month. (Source: Arthur P. Miller,* Water and Man's Health, *USAID, 1961, reprinted 1967.)*

the case had consumers still been dependent on their own private sources. The net health benefits of an unsafe source may, therefore, be negative. Moreover, the "quality vs. quantity" dilemma is often more apparent than real. Groundwater supplies, properly located and constructed, are usually safe without additional expenditure on treatment. Surface water supplies frequently need treatment, such as filtration, to make them acceptable to consumers and prevent clogging of pipes by silt, the extra cost of disinfection being only a small proportion of system costs (probably 3 percent to 4 percent—see Annex 2).

At present, it is not possible to predict with sufficient accuracy the effect of improved water supply on sickness and death, let alone its economic consequences. The World Bank has recently retained a high-level panel of medical experts to help determine whether refinement of health-impact studies to precede or accompany village water supply projects is feasible or desirable, and whether such studies will lead to ways of predicting more accurately the extent of disease reduction through improved water supplies. The panel concluded that limited investigations might be considered in selected projects, but that large-scale rigorous investigations were unlikely to be justified. The panel's findings will be published shortly.

Productivity Benefits

Improving village water supply may be an essential step in the development of village industries such as fish processing and freezing, fruit and vegetable production, or cloth dyeing. The benefits from these activities can be measured directly. Improving village water supply can also increase the productivity of the inhabitants in two ways which are readily identifiable but difficult to quantify: reduction in the time and effort spent fetching water,[3] and increasing output through improved health. The latter effect is twofold: absenteeism is reduced, and workers' strength, stamina, and ability to concentrate are increased (however, in the absence of growth potential, it may not be possible to achieve very much real increase in output; as discussed below, the effects may be only to increase underemployment and possibly encourage migration). A reduction in enteric and parasitic diseases also results in better utilization of food, and so avoids a waste of scarce resources.[4]

[3]*See Gilbert F. White, David J. Bradley, and Anne U. White,* Drawers of Water: Domestic Water Use in East Africa *(The University of Chicago Press, April 1962, reprinted July 1967). The authors estimate that for some rural African settlements over one-quarter of one person's daily energy requirements is used in fetching water; for individual households the figure could be as high as 80 percent to 90 percent.*

[4]*For a fuller discussion of this type, see* Health, *op. cit., Chapter 2.*

Slowing of Migration

Most developing countries are experiencing a high rate of migration from rural to urban areas, which strains their social and economic infrastructure. If this flow could be reduced, the cities would be better able to absorb immigrants, generate employment, and cope with internal development problems. Whether or not a slowing of migration is desirable, in the sense that it would represent a net gain in national productivity or improve income distribution, depends on many factors, in particular on the relative marginal productivity of human resources in urban and rural areas and on the rate of rural population growth.

There is little evidence of the effect of improved rural water supplies on migration, and that which exists is contradictory. At the individual level, a better water supply reduces the "push" component of migration from the villages to the towns; on the other hand, it does nothing to reduce the "pull" component (better jobs, higher incomes, greater educational opportunities). Improvements in health associated with a better water supply may, at least in the short term, aggravate the problem of rural underemployment and lead to more migration rather than less (in the longer term, reduction in infant mortality may result in a reduction in desired family size, easing unemployment pressures). At the community level, a good water supply is only one among many infrastructure components (roads, schools, markets, etc.) essential for the development of village growth centers; by itself, it is unlikely to have a significant effect, but its absence will prevent, or at least greatly hinder development.

Another difficulty is how to assess the contribution of local growth centers to a slowing down of migration. Some studies suggest that the typical migration pattern is from the dispersed rural population to the nearest large village and then, after an interval, to a larger urban area. If this is correct, the creation of village growth centers, by making the initial transition from dispersed rural life less difficult, might actually increase migration. This effect might be prevented if the development of the growth center were part of an integrated rural development program which, by providing more agricultural opportunities, would encourage workers to stay on the land.

Income Redistribution Effects

Income redistribution from more prosperous urban areas to less prosperous rural areas is a common feature of rural water supply projects, since most rural projects are not financially viable and need support, whether from central government revenues or from a national water authority. However, unless a water supply development helps associated agricultural or other development, it represents a diversion of the country's limited external and internal resources from investments that would maximize economic growth (which might, for example, require concentrating infrastructure investment in urban areas). The extent to which this should be done in order to achieve essentially social objectives needs more careful examination as part of the decision on intersectoral allocation.

It should be noted that the income redistribution effect of rural water supply schemes is not always as simple as it may appear. In many countries, it is the wealthier villages which receive priority in the allocation of water supply because they are most pressing in their demands and because they also most closely meet the criteria for selection discussed in Chapter 6. The population of these villages may actually be in less need of support than the inhabitants of the urban slums; if this is the case, income redistribution can more effectively be achieved within urban water projects, by cross-subsidies from higher-income urban consumers to those living in the fringe areas.

Improvements in Village Institutions

Many villages in developing countries lack an organization of community leaders capable of dealing with present-day problems. It is sometimes argued that a community water supply project is one way of encouraging the emergence of such leadership, which would be able subsequently to deal with other community problems. It is also argued that, because the village is required to pay for a valued service such as water supply, it will develop a "habit of payment" for other worthwhile goods, and that this willingness to pay will indicate to planners that the village should be selected for further development. Both of these arguments are intuitively reasonable, but are as yet little supported by evidence.

Lower Per Capita Costs

It is often argued that village water systems serve more people for a given investment than urban systems. This is true to some extent, primarily because systems in villages normally provide a lower standard of service than those in urban areas. Urban systems are normally designed to provide continuous high-pressure piped service, with adequate reserve capacity for emergencies such as fire fighting, and a number of urban consumers will have private house connections. Rural systems, on the other hand, may be quite satisfactory if they provide a safe supply of a few liters per person per day from springs or through protected wells fitted with handpumps. This lowering of the standard of service can more than offset the economies of scale and density in the construction, operation, and administration of water supply systems which normally favor concentrated urban populations. But it is unwise to generalize. If groundwater is not readily available, a rural system which needs a new dam and impounding reservoir may, despite lower standards, be more expensive per capita than an urban system.[5] It may also be relatively inexpensive to *extend* urban services to low-income areas where the supply is to be given through public standpipes.

The problem in determining the true per capita cost in these cases is in valuing the investments already made (in dams, treatment plant, transmission, and primary distribution pipelines) which make this cheap extension possible. However, as discussed earlier in this chapter, investment in urban systems may be essential to serve commerce and industry and to provide water to areas without an alternative to a public supply. For a majority of countries, the "urban vs. rural" choice does not really exist; the question is rather what additional resources can be devoted to rural systems after meeting the pressing needs of urban areas.

Fire Protection

If water supply is readily available, many fires can be extinguished before they cause much damage. In villages, fires are fought using water brought in containers from neighboring public hydrants; the expense of a high-pressure distribution system supplying fire hydrants will not be justified. The benefits of improved fire control depend on a number of factors, including the materials used in house construction and housing density, and distance to the pump or public hydrants, which are difficult to quantify. In economic terms, these benefits may not be large, but the increased security from fire may still be an important factor in villagers' desire for an improved water supply.

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[5] *Of the countries responding to the WHO survey, about one-third estimated that rural water supply was more expensive per person served than urban supply through standpipes. Since the cost estimates for rural water supply generally appear to be more underestimated than those for urban supply, in practice the proportion would be higher than one-third.*

Chapter 6: PRIORITIES—SELECTION OF SUBPROJECTS

However much a government actually may decide to invest in village water programs, the sum will fall considerably short of the need. Decisions, therefore, have to be made on the order in which individual village subprojects will be executed. Since, as discussed in the previous chapter, it is impossible to make rigorous cost/benefit analyses of the effects of village water programs, ranking is in practice a matter of judgment on the merits of various sector objectives and on the characteristics of individual villages. Village enthusiasm for a new water scheme, as shown by a willingness to pay for it, is probably the single most important factor in deciding whether to go ahead with construction.

Sector Policy

A common problem is the lack of sector policy and even of basic information about the water supply sector in a country. A special survey of the sector, involving an inventory and analysis of all relevant data, is frequently necessary. The survey will identify and examine alternative development schemes in the light of the resources that can be gathered, and recommend policies, institutional improvements, and other measures necessary to help deal with the problems identified and assure the program's success.[1] This important and difficult work must be carried out by competent and experienced staff with the government's active support. It may be done entirely by local experts, but often some external assistance is required.[2]

Program Objectives

Typical government objectives for a village water program are—

- To provide safe water to as many people as possible
- To reduce waterborne or water-related diseases
- To encourage rural development
- To improve living conditions for the rural poor

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[1] *The Bank's Public Utilities Department has prepared guidelines in English, French, and Spanish to help governments in carrying out sector surveys.*

[2] *One of the main functions of the WHO/World Bank Cooperative Program is to provide this kind of assistance, without charge, to the country concerned.*

Any countrywide program will normally include all these objectives, since they are to a considerable degree interrelated. However, for a given expenditure, there will always be trade-offs, for example, between maximizing the number of people served and achieving maximum public health benefits.

Factors Affecting Ranking

Within the overall framework of a government's objectives, village subprojects should ideally be so ranked that they maximize the net social and economic benefits per unit of investment. This is difficult to do since many of the benefits of water projects cannot be quantified. The use of financial criteria alone as a screening device is also unsatisfactory, because the many social benefits would be effectively ignored.

The final ranking of subprojects is, therefore, dependent on a largely subjective evaluation of a number of factors. The principal factors are discussed below, divided arbitrarily into three groups: village need, village potential, and system costs. The most important group is probably the first, although, since any program is likely to be subject to fairly severe budget constraints, the third must also carry considerable weight.

Village Need

Village interest. Community interest and involvement is probably the most important single factor, and will be discussed separately under "Village Involvement" below.

Adequacy of existing supply. Adequacy in this context covers not only quantity but also convenience, reliability during drought, and quality.

Prevalence of waterborne disease. Reliable statistics are usually unobtainable, but health officials are frequently aware of areas where waterborne diseases are most common. Evaluation of the weight to be given to this factor is particularly difficult, since there are a number of options on the level of service to be provided. These have very different per capita costs and are likely to result in quite different health benefits, as discussed in Chapters 2 and 3.

Village Potential

Growth potential of the community. Lack of an adequate water supply may prevent the development of villages' economic potential, for example, as markets, food or fish processing centers, or as local health or education centers. The villages may also be unable to obtain sufficient water for productive nondomestic use, for example, for agriculture, livestock, vegetable cultivation, preparing produce for market, or cottage industries such as cloth dyeing.

Village institutions. Generally, villages with strong, competent institutions and good educational levels will be better able to participate in drawing up a program, to collect water charges, and to find operating and maintenance staff from among the villagers than villages where such conditions do not exist.

System Costs

Each subproject must, of course, be examined to make sure that it represents the least-cost means of providing the required service. In addition, certain factors have a bearing on how many least-cost subprojects can be executed within a certain budget ceiling, as follows:

Population distribution. Other things being equal, the larger, more densely populated villages will need lower investment costs per capita. Systems for a group of villages that are close together may be lower in capital cost (possibly using a common source of supply) and cheaper to operate and administer than those for more scattered villages.

Nature of new water source. The effects on costs of the type of source and distance from the village were discussed in Chapter 2.

Level of service. The effect of the level of service on costs was also described in Chapter 2, and village involvement in deciding the most appropriate level is discussed hereunder.

Accessibility. Systems for villages without good road access will be difficult and expensive to construct and maintain.

Village Involvement

Community interest and involvement are implicit in village participation. Experience from many countries indicates that water supply systems are better maintained, less abused, and have a higher level of financial performance, if the villages to be served are selected because they express a real interest in having a new or improved system. In some countries (for example, the Dominican Republic), special "promoters" visit villages to determine their interest. In India, UNICEF is experimenting to find out what are the best media to explain to villagers the benefits of a good water supply and to encourage the village to nominate a person or committee to be responsible for looking after the village pump, collecting water charges, and perform similar tasks. The best evidence of such interest is village willingness to contribute to construction costs and to pay an adequate fee for water use once the system is in operation.

If villagers have to contribute to construction costs and have to meet operating and maintenance expenses, the level of costs obviously becomes a concern to both villagers and planners. The latter may wish to limit the level of service to be provided because this affects the number of people that can be reached with a given amount of resources. On the other hand, the villagers should be given as good a system as they are willing to pay for. This is the basis for the widely held opinion that the system design of each subproject should be decided in consultation with the villagers, who would be told about the alternatives available under the program and the financial consequences of each. This policy helps to ensure that the "right" system will be provided; it also increases the participation of the villagers and, consequently, their sense of responsibility for the system.

In many areas of the poorer developing countries, it will not be practicable to provide much more than a basic service, preferably by handpumps drawing from shallow wells. In these areas, the villagers cannot choose the level of service they would like—neither they nor the country can afford anything more elaborate. But village motivation remains an important factor in choosing which villages to serve, and villagers should be consulted about matters such as the most convenient siting of the wells.

The process of consultation with the villagers requires time. Where programs have to be executed to meet externally imposed timetables (for example, as part of rural development projects), systems may have to be installed with little previous local input, and without clear sectoral policies or a proper analysis of many of the pertinent factors. This is particularly likely to be the case when a decision is taken—whether for political, economic, or other reasons—to improve rural water supplies in all villages throughout a particular region. While such decisions may be essential, it must be recognized that inevitably a number of these systems will fail or prove to be unsuitable, and that the collection of revenue is likely to be particularly difficult.

Rural development projects are usually designed greatly to increase villagers' cash incomes. At the start, villagers may be able to afford only a handpump or a public hydrant system, and regard this as adequate to meet their needs, but in a few years improved incomes may result in a demand for house connections. The dilemma for the project authorities is whether to allow for this anticipated development, and install an expensive system with capacity to supply house connections in due course, or to put in only the most basic system, which will later need to be reinforced. There is no general or easy solution to this problem.

Approaches to villages to enlist their participation should be made only when the project can be implemented promptly. Several studies have shown that when an interval of months or even years occurs after consultation and before any results are apparent, the villagers become disillusioned and cooperation is severely reduced.

The Final Ranking Decision

The final ranking of subprojects should be based on an evaluation of all the factors discussed above. The discipline of formulating alternative rankings and estimating the extent to which they are likely to meet objectives ensures that recognition is given to the subjective weightings implicit in eventual project selection. Different weightings may be found appropriate for different regions within the same country. The process may also indicate that certain of the objectives are not suitable and should be changed. Planners should be flexible in applying their criteria.

The preparation of water supply programs must be very pragmatic. It will usually develop in response to the obvious needs of villages and the desires of the government. What may appear to be a complex process of setting priorities will in practice be a commonsense approach. Frequently, the original plans will need to be modified as the program unfolds. Careful monitoring, especially in the initial stages, is therefore essential to test the soundness of the approaches being used and identify problems so that timely changes can be made if necessary.

Chapter 7: IMPLICATIONS FOR THE WORLD BANK

Lending for village water supplies would not involve a major departure from World Bank policy, but would mean an increase in emphasis upon one aspect of a sector with which the Bank has been associated for many years. The Sector Working Paper, *Water Supply and Sewerage,* of 1971, which was primarily concerned with urban water supply and waste disposal, stated that the World Bank would be prepared to finance well-justified rural water supply projects, despite the considerable institutional and financial difficulties involved. More recently, several World Bank projects have included the provision of potable water in rural areas, but present involvement so far remains minor.

Helping extend potable water (and sanitation) to people in rural areas clearly proceeds from the World Bank's policy to help spread the benefits of development to the poor, and from the rising concern for health conditions in the poorest countries. The enormous needs involved, the particular state of neglect of rural water supplies in most parts of the developing world, and the complexity of the problem, all indicate that a particular focus needs to be maintained on this subsector within the Bank, as well as in individual countries and the international community. The work of the international panel on rural water supply, which the Bank helped sponsor, is part of this effort.

Principles must now be further translated into practical programs. The problems which have been researched and identified may be broadly categorized as being mainly of an institutional and organizational nature. It is in these areas that the Bank's assistance will be most significant, aiding in building up local capability for project planning, execution, and operation. In view of the diverse conditions in developing countries, the problems can best be dealt with on the basis of actual lending experience, stemming from preparing, appraising, and monitoring rural water supply projects. Monitoring is particularly important, both to signal actions required to ensure that the intended benefits are achieved and to identify those experiences that may be useful in projects in other areas. Health benefits are an essential but most difficult aspect to monitor. Steps are being taken to develop a methodology for monitoring the health impact of water supply which can then be tested in selected rural projects, in accordance with the recommendations of an international panel of experts convened by the Bank.

Rural water supply projects may be classified into two broad categories:

Type A — Projects in sectors such as agriculture, integrated rural development, fisheries, etc., where water supply forms one component of the project infrastructure

Type B — Water supply projects, either for rural water supply alone or as part of a national program with both urban and rural elements

Because of the problems and uncertainties inherent in World Bank lending for village water supply, it is not presently possible to make specific recommendations on the amount of future Bank lending for these operations. In the short run, lending will develop largely in response to the needs of Type A operations in the rural development sector, particularly integrated rural development projects. Several projects of Type B are currently being developed, but their number is expected to increase only gradually. Most governments continue to view the needs of the sector largely in terms of urban systems, whose requirements are also great and more visible.

To develop balanced programs and successful projects of either type requires a long lead time. This may be reduced if expert attention is given at an early stage to all the many and diverse issues involved. In many countries, one of the Bank's important functions will be to provide assistance in improving sector knowledge, formulating sector policies, and developing investment programs designed to serve rural areas.

The following notes recapitulate the general principles or aspects that need to be taken into consideration and suitably adapted to local circumstances:

1. *Government support.* A long-range government commitment is essential to the success of rural water supply operations, particularly with regard to (a) availability of construction funds and possibly operating subsidies, and (b) development of executing agencies with sufficient authority, personnel, and equipment to perform their tasks on a continuing basis.

2. *Sector development programs.* Sector development programs should be gradually evolved, setting realistic goals for extending access to water supplies in rural areas and for dealing with the constraints of money, manpower, and institutional structure—and even information.

3. *Preinvestment studies.* Both technical and socioeconomic studies need to be carried out before rural water supply programs

can be successfully planned. These should be based on a representative sample of the villages to be supplied, and should contain enough information to establish pricing policies, criteria for project selection, and appropriate levels of service. They should also identify the level of technology which would be appropriate to the project area. Since groundwater is in most cases the cheapest and the preferred source, such studies should include an assessment of its availability.

4. *Institutions.* Strong water supply institutions at the national and local level are the key to lasting success in rural water programs. Experience suggests that the World Bank should only finance rural water supply in conjunction with effective administrative arrangements (including adequate staff), or when careful plans have been prepared for establishing appropriate institutions. The implementing agency should be capable not only of preparing and executing the project, but also of ensuring continued operation and efficient maintenance. Plans and methodology for involving villagers in operation and maintenance and in the collection of charges should be defined during the project development phase, and appropriate arrangements made within the project before a loan is made. It is, in general, desirable for rural water supply projects to include a substantial training component. In the first stages of a national program, model installations may be useful for in-service training and facilities provided for group instruction, demonstration, and practice.

5. *Justifications for investment.* The benefits from rural water supply investments cannot be fully measured in quantitative terms. In particular, the criterion often applied in selecting urban water supply projects—consumers' willingness to pay—will not usually be a sufficient guide for rural projects: consumers may fail to appreciate the potential benefits, they may be too poor to pay the full costs, or the government may be unwilling to enforce such payments. To assess the merits of a proposed rural water supply operation, its costs should be weighed against the expected benefits—both quantitative and qualitative—using the framework of national priorities for public health and social services. Such a frame of reference is necessary even for the rural water supply components of Type A projects, which overall may show a satisfactory rate of return. Where projects of Type B include both rural and urban components, the rate of return on each of these should be assessed separately to determine whether the network could legitimately be expanded into increasingly high-cost and/or low-income areas.

6. *Financial considerations.* Village water supply programs will probably not achieve the standards of financial performance of ur-

ban projects. The pricing policies of a rural program should be such that all consumers who are able to do so pay the full cost of service, and that others make as large a contribution as their means allow. The village should normally agree to pay at least all operating and maintenance costs for the system, and to contribute at least 10 percent (either in cash or in kind) to construction costs. Operating and maintenance costs may either be computed village by village, or averaged over all program villages within a region, depending on local conditions and customs. The basic facilities to be provided in a village would normally be wells or public hydrants reasonably accessible to all inhabitants. Although house connections are desirable, they should only be installed in cases where villagers are prepared to meet a substantial proportion of the extra costs. Programs should stress village motivation, should encourage villagers' involvement, and provide for agreement with villagers on the level of service, if the proposed financial policies permit a choice. Refusal to make a reasonable contribution to construction costs raises sufficient doubts about village interest and motivation to suggest that it be excluded from the program. Programs should have a clear financing plan, that will specifically enable the implementing institutions to meet the recurrent costs of service. The foreign exchange costs[1] of village water projects will usually be low; this suggests that the financing of local costs will need to be considered in most cases.

7. *Demonstration projects.* Demonstration projects can be extremely useful for testing or developing different approaches, improving the basis for cost estimates, developing larger projects, and training personnel. Where possible, they should be used to test the suitability of standard designs and to assess the ways in which self-help may be used more extensively and made more effective. Where initial demonstration projects and project preparation cannot be financed from other sources, or cannot be so financed without undue delay, the World Bank can make a significant impact by lending the relatively small amounts required, as part of other projects.

8. *Development of local capability.* The development of local capability in the manufacture of components, groundwater exploration and exploitation, and construction, should be encouraged either through assistance to local public sector institutions or to private industry. Proposed methods could be tested in demonstration projects. Additional benefits could be generated in certain circumstances by including funds for applied research in loans for rural

[1]*Foreign exchange costs may vary from 15 percent to 50 percent, averaging 35 percent, according to the WHO survey, but this may refer only to the percentage of the costs of materials. The percentage of total costs would then be much lower.*

water supply programs. Frequently, only limited finance is needed to assist local bodies in adapting established approaches to local conditions.

9. *Adopting a sector-loan approach.* Except in cases where village water supply operations form a part of larger projects (such as integrated rural development), and in order to make the most efficient use of Bank staff, a "sector-loan" approach should be considered in planning any World Bank operation in this area. This entails financing a package of village water systems which forms either a "time slice" of the national sector program, or a concentrated program in a geographic region. Because so many existing water systems are for various reasons inoperative, the first sector loan to any country might most usefully be for system rehabilitation and institution building, including establishment of the methods and policies which would govern the program. The criteria for selecting villages, and the general principles of the designs to be used, would be agreed upon during loan negotiations, with final decisions to be taken during project execution. Detailed design of the systems would not normally be undertaken before the loan is made; cost estimates would be based on standard designs and preliminary visits to the villages. A substantial contingency item (25 percent to 35 percent) would need to be included. The number of villages to be served would be adjusted during project execution, in the light of actual costs.

10. *Public health education.* A village water supply program should normally provide for education in basic public health, both during preparation, to stimulate village interest, and during implementation, to ensure that full benefits are obtained from the new systems.

11. *Other sanitary facilities.* It is desirable that any village in which the water supply is being improved should be provided with other sanitary facilities, latrines in particular, since these are also highly significant for public health. It may often be possible to encourage the construction of latrines on a self-help basis. (Waterborne sewerage systems are unlikely to be feasible or justifiable in the great majority of villages. They should only be installed if villages show a real willingness to pay for them and if the number of houses that can afford water-flushed toilets is sufficient to ensure that the system will not become clogged.) The construction of public laundry and bathing facilities should be encouraged if these are likely to be appreciated and used. While the costs of materials for latrines constructed on private property should be borne by the householders,

the construction costs of central latrine, laundry, and bathing facilities should be considered as part of the overall project cost.

12. *Monitoring projects.* Close monitoring will be required to ensure the success of existing and future projects in specific environments, and to gain some experience that would be transferable to different areas. Effective monitoring requires that proper procedures be established early in the preparation of projects. In the initial stages, the appropriateness of the assumptions, the design criteria, and the method of approach all need to be evaluated. Subsequently, the impact of the project needs to be carefully assessed, and steps taken to ensure that the service is provided as planned, and the health and other benefits are being realized as intended.

ANNEXES

DATA DERIVED FROM SURVEY BY WORLD HEALTH ORGANIZATION[1]

Notes:

Due to rounding errors, values in these tables may not agree exactly with those published by WHO.

The boundaries of WHO regions are not the same as those of World Bank regions; for example, both Pakistan and Ethiopia are included in WHO's Eastern Mediterranean region.

[1] *World Health Organization, "Community Water Supply and Sewage Disposal in Developing Countries,"* World Health Statistics, *Vol. 26, No. 11, 1973 (survey carried out in December 1970).*

Table 1:1

Population of Countries Surveyed

(Millions)

Region	Population			Percentage rural population
	Urban	Rural	Total	
Africa	31	152	183	83
Latin America and the Caribbean	156	118	274	43
Eastern Mediterranean	65	169	234	72
Europe[1]	24	42	66	64
Southeast Asia	158	693	851	81
Western Pacific	38	75	113	66
Total	472	1,249	1,721	73

(1)Three countries only: Algeria, Morocco, and Turkey.

Table 1:2

Percentage of Population with Reasonable Access[1] to Safe Water[2]

Region	Urban			Rural	Total
	House connection	Public hydrant	Total		
Africa	29	39	68	11	21
Latin America and the Caribbean	59	17	76	24	54
Eastern Mediterranean	58	26	84	18	33
Europe[3]	50	23	73	44	55
Southeast Asia	36	17	53	9	17
Western Pacific	65	10	75	21	40
Weighted average	49	19	68	14	29

(1)"Reasonable access" is defined as follows: in urban areas, within 200 m. of a public hydrant; in rural areas, sufficiently close that family members do not spend a disproportionate part of the day in fetching water.

(2)"Safe water" includes treated surface water or untreated but uncontaminated water such as that from springs, protected boreholes, or sanitary wells. Other waters of doubtful quality are classified as unsafe.

(3)Three countries only: Algeria, Morocco, and Turkey.

Table 1:3

Population without Reasonable Access[1] to Safe Water[2]
(Millions)

Region	Urban	Rural	Total
Africa	10	135	145
Latin America and the Caribbean	33	89	122
Eastern Mediterranean	10	138	148
Europe[3]	7	23	30
Southeast Asia	74	632	706
Western Pacific	10	59	69
Total	144	1,076	1,220

[1] "Reasonable access" is defined as follows: in urban areas, within 200 m. of a public hydrant; in rural areas, sufficiently close that family members do not spend a disproportionate part of the day in fetching water.
[2] "Safe water" includes treated surface water or untreated but uncontaminated water such as that from springs, protected boreholes, or sanitary wells. Other waters of doubtful quality are classified as unsafe.
[3] Three countries only: Algeria, Morocco, and Turkey.

Table 1:4

Forecast of Population in 1980
(Millions. In parentheses: percentage increase since 1970.)

Region	Urban	Rural	Total
Africa	53 (72)	188 (24)	241 (32)
Latin America and the Caribbean	235 (51)	131 (11)	366 (34)
Eastern Mediterranean	103 (59)	216 (28)	319 (36)
Europe	42 (71)	48 (15)	90 (36)
Southeast Asia	240 (52)	874 (26)	1,114 (31)
Western Pacific	61 (26)	90 (19)	151 (22)
Total	734 (52)	1,547 (24)	2,281 (32)

Annex 1
Table 1:5

Target Population to be Served by 1980

(Millions)

Region	Total population to be served			Increase over 1970[1]			1980 population served as proportion of 1970[1]		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
Africa	52	47	99	32	31	63	2.6	3.0	2.7
Latin America and the Caribbean	213	60	273	96	31	127	1.8	2.1	1.9
Eastern Mediterranean	102	54[2]	156	49	37	86	1.9	3.2	2.2
Europe	42	12	54	24	3	27	2.3	1.3	2.0
Southeast Asia[3]	240	218	458	157	163	320	2.9	4.0	3.3
Western Pacific	61	22	83	32	8	40	2.1	1.6	1.9
Total	710	413	1,123	390	273	663	2.2	3.0	2.4

(1)Some discrepancies are apparent between Tables 3 and 4 of the WHO statistics. The figures given here for absolute increase have been taken from the WHO tables without resolving the inconsistencies; the percentage figures are, therefore, only indicative.

(2)Less than 100 percent of population (of Table 1:4). No reason given.

(3)Excludes Bangladesh (total 1980 rural population estimated at 24 million).

Table 1:6

Per Capita Cost of New Water Supplies

(US$)[1]

Region	Urban: House connection	Urban: Public hydrant	Rural
Africa	$ 53	$ 28	$ 20
Latin America and the Caribbean	40	—	24
Eastern Mediterranean	30	11	13
Europe	120	25	20
Southeast Asia	16	9	8
Western Pacific	22	20	6
Weighted average	$ 35	$ 14	$ 12
Range	6 (Bahrain) to 300 (Mauritania)	1 (Somalia) to 280 (Mauritania)	1 (Madagascar, Afghanistan, Bangladesh, to 150(Barbados)

(1)Basis not stated. Assumed to be 1970 dollars.

Table 1:7

Estimated Investment in Water Supply Needed to Meet Development Decade Goals
(US$)[1]

Region	Urban: House connections	Urban: Public hydrants	Urban: Total	Rural	Total
Africa	$1,200	$ 300	$ 1,500	$ 600	$ 2,100
Latin America and the Caribbean	3,900	—[2]	3,900	700	4,600
Eastern Mediterrranean	700	300	1,000	500	1,500
Europe	1,500	300	1,800	100	1,900
Southeast Asia[3,4]	1,400	600	2,000	1,200	3,200
Western Pacific	300	400	700	—[5]	700
Total	$9,000	$1,900	$10,900	$3,100	$14,000

[1] Basis not stated. Assumed to be 1970 dollars.
[2] As policy, public hydrants not provided.
[3] Totals for Southeast Asia differ from WHO tables due to typographical errors in the latter.
[4] Excludes Bangladesh.
[5] $50 million; shown as nil due to rounding.

Table 1:8

Progress of Population Served with Water Supply, 1962-70

Region	Urban population served (millions) 1962	1970	Increase	Percentage of urban population served 1962	1970	1970 population served as proportion of 1962
Africa	9	20	11	50	67	2.2
Latin America and the Caribbean	85	116	31	86	76	1.4
Eastern Mediterranean	29	53	24	71	86	1.8
Europe	12	18	6	74	73	1.5
Southeast Asia	33	81	48	31	53	2.5
Western Pacific	13	27	14	49	75	2.0
Total	181	315	134	59	69	1.7

Table 1.9

Water Supply Investments in 1970

(US$ millions)

Region	Urban	Rural	Total
Africa	$ 72	$ 20	$ 92
Latin America and the Caribbean	263	46	309
Eastern Mediterranean	198	36	234
Europe	27	67	94
Southeast Asia	142	44	186
Western Pacific	63	4	67
Total	$765	$217	$982

Table 1:10

Comparison of Public Investments (1970) and Necessary Rural Water Supply Investments

Asia	(1) Public investments (GDFI) 1970 (US$ millions)	(2) Annual average rural water supply investments 1971-80, to meet UNDD goals (US$ millions)	Ratio: (2) as percentage of (1)	Assumed per capita cost of rural supplies ($)
India	$3,186.7	$90.0	2.8	$ 8
Indonesia	486.0	13.1	2.7	4
Pakistan	518.1	13.3	2.6	9
Philippines	113.2	1.7	1.5	5
Thailand	490.4	7.4	1.5	10
Sri Lanka	66.9	6.3	9.4	21

Notes:

Figures in column (1) derived from World Bank data, not WHO survey.

Figures in column (2) in 1970 US dollars.

Ratio in column (3) assumes uniform rural water investment during decade. However, it is unlikely that during 1971-75 these investments were actually made, so the actual ratio would have to be significantly higher during 1976-80, if the UNDD goals are to be met.

GDFI = Gross domestic fixed investment.

COSTS OF FACILITIES AND ECONOMIES OF SCALE

The per capita costs of village water systems vary widely from country to country and from village to village, depending on local conditions and the type of system installed. No generalized cost figures can, therefore, be used for estimating; they need to be prepared for a specific set of conditions in each country. The cost data in this annex, although based on actual projects, are presented only for the purpose of comparing the comparative costs of various types of systems and the effects of economies of scale.

Rudimentary Systems, Small Communities

Table 2:1A illustrates how typical costs for a village of 1,000 inhabitants supplied through wells fitted with handpumps might range from $0.50 to $3.00 per capita, depending on the type of well required. Drilled wells are the most expensive alternative. Where such wells are needed, their number may have to be reduced, at the expense of making the supply somewhat less convenient to the villagers. Table 2:1B considers the same village and types of wells as Table 2:1A, but assumes motorized pumps and a rudimentary distribution system serving public hydrants: per capita costs increase to $7.20 to $10.00. Where wells have to be located at some distance from the village, additional costs will be incurred for the transmission pipeline.

In any planning of rudimentary systems, the possibility of using springs or of rehabilitating existing wells should always be examined, since they may provide an adequate supply at low cost. No general cost estimates can be given for sources of this type.

Where groundwater is not readily available, surface water will have to be used. Comparative cost estimates for surface water systems are not given because the costs of the components may vary widely: The supply may be by gravity (diverted mountain stream), handpumped (village by river), or pumped over a considerable distance; the intake works may be well points or infiltration galleries in alluvial gravels, or major weirs or similar structures; treatment may be omitted for isolated mountain streams, or full sedimentation, filtration, and chlorination provided where contaminated sources must be used. Some of these factors are illustrated in later sections of this annex. As a rule, surface water systems will never be cheaper than groundwater systems, but may be several times more expensive.

Basic Water Supply Systems for Rural Communities
(US$)

Village population: 1,000
Per capita consumption: 20 lcd.
Average daily total consumption: 20 $m.^3$ per day

A. Ground water supplies and handpumps		Number of units	Cost per unit	Total cost	Cost per capita
Driven well	(6 m. depth)(1)	3	$ 175	$ 525	$ 0.50
Dug Well	(15 m. depth)(1)	3	1,000	3,000	3.00
Tube well	(5 cm. diameter,(2) 30 m. depth)	6	400	2,400	2,400
Drilled well	(10 cm. diameter,(3) 40 m. depth)	2	1,500	3,000	3.00

B. Groundwater supplies and motorized pumps, piped supply to hydrants(4)		Number of units	Cost per unit	Source cost	Storage and distribution cost	Total cost	Cost per capita
Driven well	(6 m. depth)	2	$ 350	$ 700	$6,500	$ 7,200	$ 7.20
Dug well	(15 m. depth)	1	1,400	1,400	6,500	7,900	7.90
Tube well	(5 cm. diameter, 30 m. depth)	2	600	1,200	6,500	7,700	7.70
Drilled well	(10 cm. diameter, 40 m. depth)	2	1,750	3,500	6,500	10,000	10.00

Notes:

Surface water supplies are not included for comparison because their cost varies too widely depending on the distance to the source, the height of the village above the river, the type of intake and treatment facilities required. For a village on the banks of a river where an infiltration gallery can be constructed, per capita costs will be of the same order as for *dug well systems—$3 to $8 per capita depending on whether a distribution system is provided or not. Other systems will be more expensive.*

These costs are for illustration only, based on late 1974 prices, and should not be used for estimating.

(1) Number of units based on 12 hours use per day, pumping 45 minutes per hour, 30 strokes per minute, with 5 cm. pump cylinder and 20 cm. stroke.

(2) Pump size as above, but number of units doubled because of slower pumping with increased lift of water.

(3) For high lift, rotary pump operated by two persons will be necessary to maintain reasonable output (up to 15 liters per minute) and avoid need for a larger number of costly units. However, two pumps per 1,000 people is a low service level; three pumps would be preferable, increasing per capita cost to $4.50.

(4) Two units provided, to give 100 percent standby, except in dug well, where 100 percent standby on pump and motor provided. Eight hydrants per village, i.e., 125 persons per hydrant. Note that storage and distribution costs dominate in overall cost.

More Sophisticated Systems, Larger Communities

Table 2:2 gives comparative costs for groundwater and surface water systems requiring various degrees of treatment and providing various levels of service, for a community of 1,000 people. Some values are also given for a larger community of 10,000 people. The table illustrates certain general points:

- There are considerable economies of scale in village water systems; for similar systems, the per capita cost of a system for a village of 10,000 may be only 40 percent of that for a village of 1,000.
- Use of surface water requiring full treatment may be twice as expensive as of treated groundwater.
- Providing a high percentage of house connections may double the per capita cost of the system.

Table 2:2

Capital Cost Implications of Service Levels and Treatment for Larger Systems

Village population	Service level(1)	Assumed per capita water use (lcd.)	Daily village water use (m.3 per day)	Water source	Treatment	Typical costs ($ per m.3)(2) Source works	Treatment	Storage and distribution	Total	Cost per capita
1,000	PH	40	40	Well	None	70	—	195	265	10
1,000	50% PH 50% HC	100	100	Well	None	28	—	176	204	20
1,000	PH	40	40	Clear surface water	Chlorination	10	10	195	215	9
1,000	50% PH 50% HC	100	100	Clear surface water	Chlorination	10	8	176	194	19
1,000	PH	40	40	Contaminated or turbid surface water	Filtration and chlorination	10	200	195	405	16
1,000	50% PH 50% HC	100	100	do.	do.	10	150	176	336	34
10,000	PH	40	400	do.	do.	5	40	158	203	8
10,000	50% PH	100	1,000	do.	do.	4	18	108	130	13

(1)HC = House connections.
PH = Public hydrants provided at one for each 100 population.
(2)Costs are at 1973 levels, for illustration only, and should not be used for estimating.

Economies of Scale

The figures in Table 2:3 are based on estimates prepared in November 1973 for a rural development project in Tanzania, adjusted where necessary according to unit cost curves derived from other projects. They are intended to illustrate economies of scale in similar systems supplying villages of varying size, and should not be used for estimating.

Table 2:3

Economies of Scale—Basic Assumptions of Typical Systems(1)

Basic assumptions				
Village population	1,750	2,500	3,500	5,000
Per capita consumption (lcd.)	30	30	30	30
Average daily consumption ($m.^3$)	52.5	75	105	150
Raw water main length (m.)	2,000	2,000	2,000	2,000
Elevation difference,(2) source-village (m.)	100	100	100	100
Distribution main length (m.)	4,000(2)	5,500	8,500	11,300
Public hydrants	12	18	26	36
Persons per hydrant	146	139	135	139
Costs (US$)				
Preparatory works	$ 950	$ 950	$ 950	$ 950
Intake	150	220	300	430
Pump house	1,280	1,280	1,280	1,280
Pumps	4,160	4,160	5,120	5,370
Rising main	3,310	3,720	4,670	4,700
Storage tank	1,680	2,130	2,910	3,240
Distribution system	8,760	11,970	18,540	24,820
Hydrants	380	570	820	1,140
Construction plant costs	950	950	950	950
Transportation	2,190	2,920	4,380	5,840
Subtotal	$23,810	$28,870	$39,920	$48,720
Overhead and contingencies (30 percent)	7,140	8,660	11,980	14,620
Total	$30,950	$37,530	$51,900	$63,340
Total cost per capita	$ 17.7	$ 15.0	$ 14.8	$ 12.7

(1) *Typical system* —Infiltration system at river, diesel-driven centrifugal pumps drawing from a well lined with concrete rings delivering water to an elevated storage tank made from concrete blocks, with distribution through public hydrants.

(2) If the transmission main had been 4,000 m. long and the elevation difference 120 m., calculations using data under "Proximity to Source" below show that even greater economies of scale would apply:

Total cost (including overhead and contingencies)	$46,550	$52,600	$66,300	$80,000
Total cost per capita	26.6	21.0	18.9	16.0

The typical per capita costs given in Table 2:4 are taken from an appraisal report prepared by the Inter-American Development Bank (IDB) in 1974, for a project to supply a rural population totaling 87,000 distributed over 90 rural localities, with populations ranging from 100 to 2,000. (The project was designed to have a capacity to the year 1995.) Where possible, the systems will be fed by gravity, by diverting streams or springs, with treatment limited to chlorination. At the request of the villages, the supply will be through house connections, not public hydrants. Per capita consumptions are estimated at 50-100 lcd., depending on the community.

Table 2:4

Per Capita Costs—Inter-American Development Bank
(1974 appraisal report. US$ per inhabitant.)

Present population	Cost based on: Present population	Cost based on: Design (1995) population
100 - 200	$137	$ 86
201 - 400	93	58
401 - 600	79	49
601 - 1,000	58	36
1,001 - 2,000	43	27
Weighted average	$ 59	$ 37

Proximity to Source

The wide variation that may occur in transmission costs of surface water systems was mentioned earlier under "Rudimentary Systems." This is illustrated by the figures in Table 2:5 which are also based on the November 1973 estimates for the Tanzania project. The data are intended solely to illustrate the effect on capital costs of increasing the difference in elevation or the horizontal distance between the source of water and the village, and should not be used for estimating. All figures include 30 percent for overhead and contingencies.

The costs in Table 2:5 are capital costs for the pump and pipeline, and do not include capitalized running costs. Running costs are proportional to the total lift provided by the pump, that is, the sum of the difference in elevation and the head lost due to friction in the transmission main. The latter is usually small compared to the former, as illustrated by the typical figures in Table 2:6 (which are *not* taken from the project estimates for Tanzania and, therefore, are not directly related to Table 2:5).

Table 2:5

Variations in Proximity to Source for Surface Water Systems

Village population	1,750	2,500	3,500	5,000
Flow (m.^{3} per day)	52.5	75	105	150
Installed costs (US$)				
50 m. elevation difference, 500 m. horizontal distance				
Pump	$ 4,670	$ 4,670	$ 4,930	$ 4,930
Pipe	900	900	900	1,230
Total	5,570	5,570	5,830	6,160
Total per capita	3.2	2.2	1.7	1.2
50 m. elevation difference, 4,000 m. horizontal distance				
Pump	$ 4,930	$ 4,930	$ 4,930	$ 5,730
Pipe	7,780	7,970	9,870	10,380
Total	12,710	12,900	14,800	16,110
Total per capita	7.3	5.2	4.2	3.2
120 m. elevation difference, 500 m. horizontal distance				
Pump	$ 5,410	$ 6,340	$ 6,990	$ 7,630
Pipe	1,580	1,610	1,610	1,610
Total	6,990	7,950	8,600	9,240
Total per capita	4.0	3.2	2.5	1.8
120 m. elevation difference, 4,000 m. horizontal distance				
Pump	$ 6,340	$ 6,340	$ 6,990	$ 7,970
Pipe	13,130	13,130	13,870	14,940
Total	19,470	19,470	20,860	22,910
Total per capita	11.1	7.8	6.0	4.6

Table 2:6

Typical Figures for Head Loss in Village Water Supply

Village population	1,750	2,500	3,500	5,000
Flow (m.^{3} per day)	52.5	75	105	150
Pumping rate (m.^{3} per hr.)[1]	2.92	4.17	5.83	8.33
Assumed pipe diameter (mm.)	80	80	100	100
Head loss (m.)				
in 500 m. length	0.3	0.5	0.3	0.6
in 4,000 m. length	2.2	4.3	2.6	5.0

[1] Assumed to be 1.33 x average rate; i.e., 18-hour pumping day.

In an area where electric power was available from the grid, and assuming a tariff of $0.05 per kilowatt-hour and a pump efficiency of 65 percent, the figures given in Annex Table 2:7 can be calculated.

Table 2:7

Costs of Water Supply Provided through Electric Power

50 m. elevation difference, 500 m. horizontal distance				
Installed horsepower	0.8	1.2	1.6	2.3
Power cost: per year	$201	$288	$402	$ 579
per person per year	0.1	0.1	0.1	0.1
120 m. elevation difference, 4,000 m. horizontal distance				
Installed horsepower	2.0	2.9	4.0	5.8
Power cost: per year	$489	$711	$981	$1,431
per person per year	0.3	0.3	0.3	0.3

Supply-System Storage

Piped water systems have to be designed to meet a peak daily demand which will be several times the average daily demand rate. The ratio between peak and average demands will vary with systems: It may be as low as 1.5 for a system giving supplies mainly through public hydrants, from which most water is drawn more or less uniformly during an 18-hour period each day, or as high as 3 for a system with a high proportion of private house connections. It is usually uneconomical to meet this peak demand by providing adequate capacity in the source works (pumps, transmission lines). Instead, the source works are sized for a smaller flow, and the excess at times of peak demand is met from storage provided within the system. This is referred to as balancing storage. The volume of water used during peak periods is replenished once the peak has passed. The amount of balancing storage required should be determined for each individual case by an engineering economy study, and will depend on the relative costs of pumping, transmission and storage, magnitude of the anticipated peak flow, and the number of hours each day that the source works are operated. In simpler systems, storage equivalent to one-quarter of one day's average demand will often be adequate for balancing flow fluctuations.

In addition to this balancing storage, it is desirable to provide further storage in order to maintain supply during brief breakdowns of the source works, such as power failure or bursts of the transmission main. The amount of emergency storage to be provided depends on judgments on a number of factors, such as the likelihood and duration of power failure or electric grid outages; the likely time needed to repair a burst; and the minimum supply that should be maintained during an emergency. In remote areas, one day's emergency storage is often the minimum desirable, but this may be too expensive for the village to afford.

Storage tanks show considerable economies of scale, and are also cheaper to build at ground level than elevated on columns. This is illustrated in Table 2:8.

Table 2:8

Costs of Storage Tanks[1]

Capacity ($m.^3$)	Total cost (US$)		Unit Costs (US$ per $m.^3$)	
	Elevated	Ground level	Elevated	Ground level
10	$ 5,250	$ 2,650	$525	$265
20	8,000	3,500	400	175
40	11,250	4,650	280	115
100	18,500	7,350	185	75
200	—[2]	11,850	—	60
400	—[2]	18,750	—	50

[1]Based on: Standard Unit Costs for Mexico (Zone III-B, 1974), as established by the Comisión de Construcción Ingenieria Sanitaria.

[2]For these large sizes, elevated storage is uneconomic; a small elevated tank is used in conjunction with ground level storage and pumps.

One consequence of the much higher cost of elevated tanks is that, if the topography is suitable, it may be economical to site the storage on high ground at a distance from the village, and lay additional lengths of main to connect this ground-level tank to the system. This possibility should always be examined, but on the whole the use of elevated storage tanks is the most likely for small village systems.

Standpipes, rather than tanks on legs, are normally well suited to village conditions and may be cheaper to construct. They provide additional storage for water at lower pressures, which is an added advantage where greater reserve capacity is required. However, they are less suited for construction using local materials, because of the fairly high internal water pressure in the lower parts of the standpipe.

The example in Table 2:9 considers four villages, each using the same average quantity of water per capita, and each requiring balancing storage equivalent to one-quarter of one day's average demand; it illustrates the additional costs needed to provide one-quarter day or one-half day's emergency storage. It is assumed that elevated storage will be provided.

Table 2:9

Additional Costs Needed for Emergency Storage

Village population	1,750	2,500	3,500	5,000
Average consumption (lcd.)	30	30	30	30
Average consumption ($m.^3$ per day)	52.5	75	105	150
Case 1 - Balancing storage only				
Storage needed ($m.^3$)	13.1	18.8	26.3	37.5
Total cost	$ 6,250	$ 7,750	$ 9,250	$10,800
Cost per capita	2.6	3.1	2.6	2.2
Case 2 - Balancing storage plus 1/4 day's emergency storage				
Storage needed ($m.^3$)	26.3	37.5	52.5	75
Total cost	$ 9,250	$10,800	$12,750	$15,400
Cost per capita	5.9	4.3	3.6	3.1
Extra cost over Case 1	3,000	3,050	3,500	4,600
Extra cost over Case 1, per capita	1.7	1.2	1.0	0.9
Case 3 - Balancing storage plus 1/2 day's emergency storage				
Storage needed ($m.^3$)	39.4	56.2	78.8	112.5
Total cost	$11,200	$13,250	$15,800	$18,800
Cost per capita	6.4	5.3	4.5	3.8
Extra cost over Case 1	4,950	5,500	6,550	8,000
Extra cost over Case 1, per capita	2.8	2.2	1.9	1.6
Extra cost over Case 2	1,950	2,450	3,050	3,400
Extra cost over Case 2, per capita	1.1	1.0	0.9	0.7

The figures in Table 2:9 show that in Cases 2 and 3 the costs of providing the additional emergency storage are reasonably low, both in absolute and in per capita terms, when compared to the basic requirements for balancing storage. Even so, the extra costs will probably be excessive for large, low-budget programs, and will only be affordable in the larger villages or in villages with a high proportion of house connections, whose inhabitants are willing to pay more for a higher standard of reliability. Again, it must be emphasized that these figures are for illustration only, and should not be used for project estimation.

Standby Source Works

Provision of standby capacity at the source should always be considered, whatever the amount of system storage provided. A village, dependent on a single pump, will have no water in case of a breakdown until the pump is repaired, which may take weeks or months.

For basic systems with handpumps, this standby usually exists in any case, since a number of pumps have to be provided and, if one fails, a higher load is placed on the others. For motorized systems, standby pumps and motors should normally be provided. For example, a large village (10,000 population) with a high proportion of house connections might require 1,000 $m.^3$ per day. This could be provided by one 30 cm. well (cost about $5,500), but would be better provided by two 20 cm. wells (costing $3,800 each, or a total of $7,600). If one fails, a 50 percent supply is maintained; the extra cost of this safety measure is $0.21 per capita. For greater security, three 20 cm. wells could be provided, so that 100 percent output would be supplied even with one out of service. On the same basis, this would cost $11,400, an extra $5,900 ($0.59 per capita) over the basic single 30 cm. well.

For a smaller village, the cost of duplicating wells will be more expensive. A supply of 100 $m.^3$ per day may require one 15 cm. well (costing about $2,800). Because of limitations in the size of pumps, a 50 percent standby cannot be provided by replacing this single pump by two smaller (say 10 cm.) pumps; a duplicate must be installed, providing 100 percent standby. If this village has 1,000 inhabitants, the per capita cost of this standby is $2.80.

EXCRETA DISPOSAL FOR RURAL COMMUNITIES

The excreta disposal facilities required for a village will be determined by village size, density of housing, soil and drainage conditions, cultural patterns, and level of development. This annex describes some typical installations.[1]

Latrines. Latrines are the least-cost solution to disposal of body waste in uncongested areas, and when properly located, constructed, and maintained, they meet all public health requirements. Pit latrines are generally the least expensive type, but in certain soils borehole latrines, constructed by using a hand auger, may be quicker and cheaper to install, and equally effective. Pits and boreholes are not cleaned, but are sealed with earth when nearly full, and the slab and shelter moved to a new site. Vault latrines are more expensive and more permanent. Depending on the size of the vault and the care given, the frequency of cleaning may vary from one to 10 years. Costs of latrines may range from under $10 per unit for a pit or borehole, where labor and the shelter are provided by the household and the only cash expenditure is for the slab, to around $200 if a masonry vault, concrete slab, and a reasonably sound shelter are installed.

Householders in smaller villages who wish to install water-flushed toilets will usually need individual sewage disposal facilities. In areas with sand and gravel soils, and with no water wells in the vicinity, simple leaching pits curbed with rock, brick, or concrete blocks can be constructed at costs ranging from a few dollars up to $200, depending on labor and materials used. Where soils are less pervious, or where larger volumes of sewage must be disposed of, septic tanks are employed, discharging either to leaching pits or to tile fields (a network of buried drainpipes, allowing the effluent to soak away). Costs range from $100 to $1,000 depending on the size of the tank, the material, and the type of soil absorption system required. The higher figures apply where a tile field of substantial length is required and where no labor or materials are contributed. Disposal of septic tank effluents to road ditches, while a common

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[1]*See Edmond G. Wagner and J.N. Lanoix,* Excreta Disposal for Rural Areas and Small Communities, *WHO Monograph No. 39, 1958, World Health Organization, for a full discussion of excreta disposal for rural areas.*

practice, is not satisfactory because of the public health and environmental problems it causes. It is sometimes possible to discharge into systems serving some other purpose, such as storm drains. This is not generally recommended, but it may be used for a limited number of houses as a temporary measure until there are enough houses to warrant construction of a sewer system.

Community sewer system. For large villages where the density of housing is high, where the space surrounding houses is insufficient to permit construction of latrines, or where soils are impervious, a community sewer system should be considered. Such systems are expensive and will function only if a sufficient number of houses have water-flushed toilets so as to ensure a flow in the sewers adequate to scour the piping and prevent clogging. Considerable problems may arise if materials such as coconut husks or corn cobs are used for personal cleansing. Because usually only a few, frequently widely dispersed, houses have water-flushed toilets, few villages will find it technically feasible to construct sewer systems.

Effluent disposal. Where a sewer system is provided, the means of effluent disposal has to be considered. In some communities, adjacent watercourses provide sufficient dilution to allow direct discharge, but in many countries with a monsoon-type climate, stream beds are empty during the dry season and some form of treatment is desirable. In most developing countries, waste stabilization ponds will be found to be the simplest, cheapest, and most reliable treatment process.[2]

Because of their high cost and operating and maintenance problems, sewer systems should not be used in villages except in the rare cases when no cheaper alternative can be found.

Community toilets. While not uncommon, community toilets are not a suitable facility for village use except to serve market areas and places of assembly. Often they are not maintained in a hygienic condition and for this reason, and because of their distance from individual households, they may not be used by many of the people they are designed to serve.

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[2]*See Ernest F. Goyna,* Waste Stabilization Ponds, *WHO Monograph No. 60, 1971, World Health Organization, for details of their design and construction.*

INTER-AMERICAN DEVELOPMENT BANK RURAL WATER PROJECTS

From 1961 to January 1975, the Inter-American Development Bank (IDB) made 17 loans for rural water supply and five other loans which had rural water components. These loans were made to national water supply agencies and ministries of health in 11 countries. The total amount of loans for rural water supply in these projects was $78.6 million for a total project cost of $144.2 million. On the basis of the experience gained from these projects, general criteria and policies were developed.

Each country's definition for rural communities was accepted. The size of the community generally ranged from 300 to 2,000 inhabitants. The rural water supply projects included the design and construction of water systems to serve a large number of rural communities, and placing them into operation within a stated period of time. These systems could serve individual communities, or under favorable circumstances, several villages. The projects also included the investigation and development of water sources, engineering, community development, and technical assistance for institution building, training, and planning.

Design Criteria, Service Level

Each country has developed criteria which include the type of materials to be used, the per capita consumption by house connections and public standpipes, service pressure, service storage requirements, design period, and estimates of future growth. The trend from the early loans has been to move from systems having a predominance of hydrants to systems with numerous house connections. This trend in policy has occurred because of the demands of the communities and the difficulties of charging for the water and the wastage where only public hydrants are installed. The systems are now generally designed and built with at least 50 percent of the houses provided with house connections, and financing covers up to as much as 70 percent of the total project cost, including house connections. In some countries, a few water meters have been installed for the larger consumers with flow-control devices for the others. All rural water projects have been concentrated on communities rather than the dispersed populations.

Water Quality

Preference is given to gravity supplies from safe sources that require no treatment such as springs and infiltration galleries and then deep wells with pumps. Sources that require filtration or special treatment are used as a last resort. Disinfection by chlorination is practiced where there is technical support from a regional or district office, and chemicals are not difficult to obtain.

The physical and chemical standards employed are those prevailing in the country and are similar to those of the WHO International Standards. In some areas where it is difficult to obtain water, such as parts of Argentina, higher concentrations of chemicals are allowed. Bacteriological standards such as those of WHO are used as a basis for the initial selection of the sources but are seldom monitored once the systems are built.

Selection of Communities

In the initial loans, the basic country criteria for selecting the communities were accepted but some refinements have been added over a period of years. The essential factor is that community desire and participation be demonstrated before undertaking the water system.

Recently, attempts have been made to develop a priority rating system for the villages. Many factors such as accessibility of water, density of population, accessibility of village, cost of the system, nearness to other villages, health conditions, and population growth of the village are given relative weights, and a rating for each village is obtained. From these ratings, a list of villages is worked out.

Community Participation

Community participation includes the decision to have a system, the formation of a group to operate the system, the contribution to construction, and the payment for receiving service from the system.

The contribution to the construction of the system has been found to be the equivalent of 3 percent to 20 percent. Generally, 10 percent is now accepted as the average amount of community contribution. The contribution has been in the form of services such as storage areas, transportation of materials (e.g., sand, gravel, rock, bricks, and lumber), labor, and cash.

Rates and Charges

For each project, a system of rates and charges is established that takes into account the socioeconomic level of the villagers. It usually does not exceed 3 percent to 5 percent of the head of the family's income and produces a revenue sufficient to pay at least for operating and maintenance costs.

A rate of 5 percent can be expected to produce revenues sufficient to cover the costs of operation, maintenance, and depreciation for average cost systems.

Experience has shown that in very few cases have the communities been able to pay rates exceeding the 5 percent level.

Costs

Per capita costs on IDB projects show a wide range reflecting differences in water sources, varying levels of technical assistance, and organizational efforts required to prepare communities. On 20 projects the per capita cost range has been from about $30 to $50 with an average of about $40. These systems have generally been designed to serve about 50 percent of the houses with connections in the form of either water to a tap in the house or to a point on the property, usually not further than 3 m. from the main.

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