PN-ABN-083

MAXIMIZING THE ECONOMIC IMPACT OF URBAN WATER SUPPLY AND SANITATION INVESTMENTS

WASH Technical Report No. 82
December 1992

WATER AND SANITATION for HEALTH PROJECT

Sponsored by the U.S. Agency for International Development
Operated by CDM and Associates

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Prepared for the Office of Health,
Bureau for Research and Development,
U.S. Agency for International Development,
under WASH Task No. 154

by

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and
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December 1992

Water and Sanitation for Health Project
Contract No. DPE-5973-Z-00-8081-00, Project No. 936-5973
is sponsored by the Office of Health, Bureau for Research and Development
U.S. Agency for International Development
Washington, DC 20523

RELATED WASH REPORTS

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A Comparison of the Health Effects of Water Supply and Sanitation in Urban and Rural Guatemala. WASH Field Report No. 352. December 1991. Prepared by O. Massee Bateman and Shelley Smith.

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Cost-of-Illness Methodologies for Water-Related Diseases in Developing Countries. WASH Technical Report No. 75. October 1991. Prepared by J.E. Paul and J.A. Mauskopf.

CONTENTS

ACKNOWLEDGMENTS iii
ABOUT THE AUTHORS iii
EXECUTIVE SUMMARY v

1. INTRODUCTION AND BACKGROUND 1

   1.1 Purpose 1
   1.2 Uses of the Report 3

2. WATER SUPPLY AND NATIONAL ECONOMIC GROWTH 7

   2.1 Inadequate and Inefficient Water Supply Limits Economic Growth 8
   2.2 Investment in Water Supply Leads to Economic Growth 11
   2.3 Investment in Water Supply Leads to Job Creation 12

3. WATER SUPPLY AND THE GROWTH OF FIRMS AND MARKETS 15

   3.1 Commercial and Industrial Firms 16
   3.2 Efficiency Gains in Water Supply 19
   3.3 The Behavioral Response of Firms and Markets 23
   3.4 Summary 25

4. CONCLUSION 27

   4.1 Geographic Area 27
   4.2 Water Supply Characteristics 27
   4.3 Characteristics of Existing and Potential Firms 28

REFERENCES 29

FIGURES

1. Total GDP and Urban GDP 4
2. Economic Benefits from Investments in Water Supply 5
3. Economic Development and Industrial Infrastructure 9
4. Production Possibilities for Water Goods and Non-Water Goods 10
5. Effects of Infrastructure Investment in Water Supply on Commercial and Industrial Users 11
6. Conceptual Framework 15
7. Commercial/Industrial Classification 17
8. Water Intake by Major U.S. Industry Groups as Percentages of Total Commercial Water Intake 18
9. Examples of Economies of Scale in Water Systems: Direct O&M Costs 20
10. Water Supply Natural Monopoly 21
11. Average Costs of Expanding Distribution and Capacity of Water Systems 22
12. Effects of Investment in Water Supply on Markets for Goods and Services 24

ACKNOWLEDGMENTS

This study was supported by the Water and Sanitation for Health Project (WASH) funded by A.I.D.'s Bureau for Research and Development, Office of Health. The views expressed are the authors' and should not be construed as representing A.I.D.'s position on the subject. The authors thank Jane Walker and Bill Fox for their comments.

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EXECUTIVE SUMMARY

This report identifies the economic gains from investments in water supply and sanitation (WS&S) and describes the conditions under which these investments yield economic improvement at the firm, industry, and national levels in developing countries.

It is intended to provide planners with guidelines for making informed investment decisions. It reviews empirical evidence that WS&S investments contribute to increased national income, explains the conditions in which this is more likely to occur, and offers a document for use by project design and policy personnel in A.I.D. (and other donor agencies) and developing country planning and budget institutions.

The report describes four sources of direct economic gains from investments in water supply at the firm, market, and national levels: increased efficiency and production of the water supply itself; increased production of all goods and services; increased private investment triggered by a public investment in water supply; and increased job creation and employment.

Economic theory suggests that if investments in water and sanitation lead to lower input costs, firms using these services will respond with some combination of expanded production and employment, reduced prices, and investment of savings in other economic activities. Lower costs of production also may encourage the expansion of existing industries and the emergence of new ones.

Economies of scale, density economies, and technical efficiency improvements are the mechanisms to lower production costs of water and sanitation services. These gains either are passed on to the purchasers of WS&S services or are retained by the WS&S producer for expanding production or investing in other economic opportunities. Gains at the firm and industry levels ultimately translate into increased production and income at the national level.

Water supply investment is likely to bring the greatest return where small distribution systems can be expanded, without exceeding current production capacity, to cover a broader geographic area serving existing and potential commercial and industrial users in urban and peri-urban centers. Smaller systems are likely to achieve economies of scale when the distribution network expands. WS&S systems can most easily realize economies of density in urban and peri-urban centers. Technically inefficient systems are the best candidates for investments to increase the quality and quantity of water.

Key factors in the investment decision are the volume of water used in production by existing firms, the likelihood of high-volume users locating in the area, the current price and quality of alternative supplies, and the size and location of the market for additional goods to be produced.

1

INTRODUCTION AND BACKGROUND

1.1 Purpose

The purpose of this report is to:

- identify the economic gains from investments in water supply and sanitation (WS&S); and
- describe the conditions under which these investments yield economic improvement at the firm, industry, and national levels in developing countries.

Previous research has documented the health and social benefits of WS&S investments (Okun, 1988; Esrey, et. al., 1990), and the gains for the economy from the improved productivity of healthier workers (e.g., Churchill, 1987). Some systematic research and considerable anecdotal evidence support the view that investment in water supply, especially in rural areas, frees up the time spent by individuals collecting and carrying water, time that has an economic value for them however they might choose to use it (Briscoe and de Ferranti, 1988).

Some argue that whether or not this time saved is applied to the production of goods and services is not material to estimating the benefits of investment (Briscoe and de Ferranti, 1988). Others contend that the additional goods and services produced are the only value to be measured (e.g., Whittington, et.al., 1989). In the context of national economic growth, however, these differences in the valuation of household time saved are not important.

Domestic water use (cooking, washing, hygiene) is the least significant from the point of view of economic growth. It accounts for only 6 percent of total water use, while commercial and industrial use accounts for more than 20 percent, and irrigation, which draws on untreated water, accounts for the largest share (Camernark, 1989) of about 75 percent. The demand on an average urban potable water supply system is about 20 percent industrial, 5 percent commercial, and 10 percent social/institutional. With residential demand making up the remaining 65 percent. Commercial and industrial use is the fastest growing component and is closely related to the level of economic development (Rietveld, undated).

Despite the importance of commercial and industrial use, however, there has been little systematic identification of the gains to the productive enterprise and the economy as a whole, or of the conditions under which these gains might or might not be expected to occur. Understanding these conditions is critical in WS&S project design, investment choices, and selection of financing alternatives.

Economic theory suggests that if investments in water and sanitation lead to lower input costs for firms using these services, these firms will respond with some combination of:

- expanded production and employment;
- reduced prices; and
- investment of savings in other economic activities.

The first two responses exploit the availability of cheaper services; the third diverts savings to other activities and may not necessarily benefit the country or region in which the WS&S investments have been made if the beneficiaries transfer the savings to other regions or countries.

Lower costs of production also may encourage expansion of existing industries and the emergence of new ones. Economists label this consumption by new firms or industries "induced demand." Where this occurs, there is less likelihood of "exporting" the savings in the form of higher profits or of investments outside the country, because the new firms provide competition that brings down prices.

Economies of scale, density economies, and technical efficiency are the means by which reduced costs are achieved. They all act to lower the unit costs of production of WS&S services, which then either are passed on to the purchasers of WS&S services as a gain, or are retained by the WS&S producer for expanding production or for investing in other economic opportunities.

Gains at the firm and industry levels ultimately translate into increased production and income at the national level. These national gains are not automatic but depend on a number of factors. For example, they are most likely to arise from services in urban and peri-urban rather than in rural areas, where economies of scale and density economies are improbable because insufficient commercial and industrial consumers.

This does not mean that WS&S investment is not warranted in rural areas. There is evidence that increased supplies of water will spur the growth of food service, beverage production, and food processing in small towns and rural villages (Churchill, 1987). Generally, however, the most significant impact will be on health, contributing in turn to economic growth through gains in labor supply and productivity, school attendance, and human capital formation (Paul and Mauskopf, 1991).

This report focuses on the linkage between WS&S investments and economic growth rather than better health or the saving of time. Where WS&S investments are made with this intention, the objective is more likely to be realized in areas where potential commercial and industrial users of the service are concentrated.

This is consistent with other evidence from developing countries that the locus of economic activity has been shifting from rural to urban areas, where more than 50 percent of economic activity already occurs. In the 1980s, for example, Thailand realized more than 70 percent of its gross domestic product (GDP) in urban areas. The World Bank estimates that, by 2000, 80 percent of GNP growth in developing countries will originate in urban areas (World Bank, 1988). For an increasing number of these countries, the economic robustness of urban areas, which range in size from smaller market towns to megacities like Bangkok and Cairo, will be a major determinant of the direction and strength of future growth. Thailand's increase in total GDP and urban GDP from 1960-85 is a dramatic illustration (Figure 1).

Demographic trends reinforce this change. By 2000, more than 50 percent of the population in developing countries will be living in urban areas. Indeed, in Asia and Central and South America, the urban populations already exceed 50 percent, and by 2000 will exceed 70 percent and 60 percent, respectively. In the sub-Sahara region of Africa as a whole, the rural population will not be overtaken until the decade of 2010, but in selected countries such as Zambia, Cote D'Ivoire, and Cameroon that will occur much sooner.

Certain circumstances can severely limit the economic gain from WS&S investment. If the water and sanitation supply matches the current and projected demand of commercial and industrial users at the economic production price, an additional supply will not attract many new users. If the marginal cost of the new supply is increasing, there will be no gains from economies of scale to pass on to users. There is some evidence that these gains are hard to realize when system expansion occurs in less densely populated urban areas (Fox, 1992).

Factors other than urban population most likely to affect the size of economic gains from investment in WS&S are:

- the current source and price of water;
- the size and type of existing firms;
- the volume of water used by existing firms;
- the size and type of industries;
- city size (market potential); and
- the cost and production characteristics of current water suppliers.

This report explains the influence of these factors and offers decision makers some guidelines for making project design and investment choices.

1.2 Uses of the Report

The report

- reviews empirical evidence that WS&S investments contribute to increased national income;
- explains the conditions in which this is more likely to occur; and
- organizes the evidence and the analytical support for the linkage between WS&S investments and productivity gains into a document for use by project design and policy personnel in A.I.D. (and other donor agencies) and developing country planning and budget institutions.

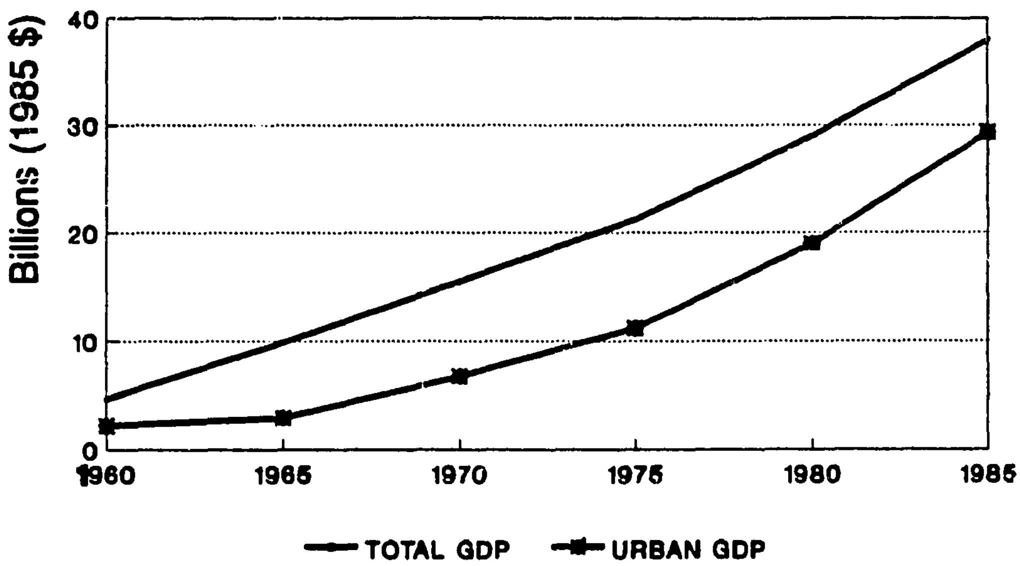

Figure 1

Total GDP and Urban GDP

It describes four sources of direct economic gains at the firm, market, and national levels:

- increased efficiency and production of the water supply itself;
- increased production of all goods and services;
- increased private investment triggered by a public investment in water supply; and
- increased job creation and employment.

Figure 2 presents the potential economic benefits from WS&S investments, including the saving of time by individuals and households, improvemed health, and impacts at the firm, industry and national levels.

The report discusses water supply and sanitation together, although the demand for the two services varies considerably from country to country. Whereas a water supply is *known* to be necessary for commercial and industrial activity, sanitation services are not always *perceived* by consumers to be essential. They often are provided as a regulatory or public health and safety measure. However, once they are in place, the same conditions hold as for economic gains from investment in water supply. In fact, the gains may be even greater.

Another point in the relationship between water supply and sanitation is that an increased water supply could necessitate additional investment in treatment and/or disposal facilities, or could increase costs in the form of environmental degradation. Therefore, the gains from water supply investment must take into account the possible negative impact on sanitation services.

The discussion excludes water used for irrigation because this is not potable. Some commercial users may require water of a lower quality than drinking water, and therefore expansion of the drinking water supply to meet their demands may be inefficient. But commercial and industrial enterprises usually require treated or potable water and most often are located in urban areas, from which the evidence that can be cited generally comes. Limiting the discussion to commercial and industrial applications is justified by the fact that, in all but the very least developed economies, commercial and industrial production is outstripping agriculture and will provide far greater opportunities for employment (Rondinelli and Johnson, 1990; Rietveld, undated).

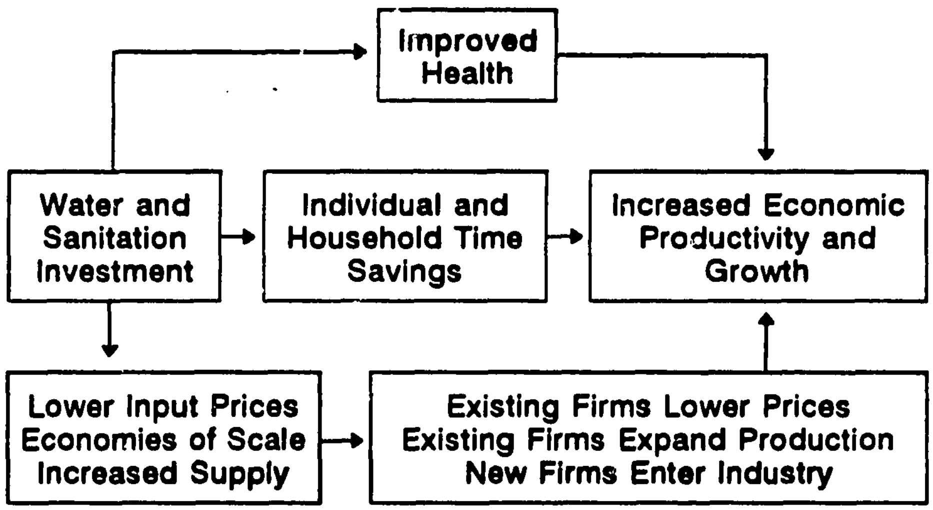

Figure 2

Economic Benefits from Investments in Water Supply

2

WATER SUPPLY AND NATIONAL ECONOMIC GROWTH

A developing economy striving to produce more goods and services must be able to provide the commercial and industrial sector with all the factors of production. These factors are land, labor, and physical capital, and a restricted supply of any one of them places an upper limit on the amount of goods and services the sector can produce.

Land, except for agriculture, is not likely to be the primary constraint on economic growth. Even in highly congested urban areas, free market forces tend to ration land through prices and rents, so that commercial and industrial firms can acquire it at some cost, even if it means locating in peri-urban areas or secondary cities.[1]

An adequate labor force is rarely a problem in developing countries. Certain technical, professional, and managerial skills may be in short supply, but commercial and industrial enterprises usually can find more than enough people willing to work at the prevailing wage.

Economists define physical capital as virtually everything other than land and labor used in the production of goods and services. In contrast to land and labor, it often is a major constraint on economic growth in developing countries because of unavailable or woefully inadequate elements of a basic infrastructure, including quality water, sanitation, reliable electricity, access roads, and communication networks.

Investment in these elements can greatly influence growth and productivity.[2] Recent evidence from the U.S. economy indicates that increased public investment in core infrastructure (water, sewerage, highways, mass transit, airports, electricity, and gas) stimulates private sector output by as much as four to seven times more than the investment (Aschauer, 1989). The high correlation between infrastructure investment and economic growth across a wide range of economies is apparent from Figure 3, taken from the 1987 ***World Development Report***; it is most pronounced for middle-income countries and for the upper end of low-income countries.

Investment in WS&S, as in the other elements of infrastructure, promotes economic growth in several ways. First, it may increase the water supply for the commercial and industrial sector

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[1]Urban land markets in many developing countries restrict access for residential, commercial, and industrial purposes, but the solution to this is more a matter of regulatory and market organization than capital investment. Here the concern is with investment in the infrastructure to support production.

[2]See Fox (1990) for a comprehensive review of the literature on the effect of infrastructure investment on growth.

by system expansion or by rehabilitating the distribution network to reduce water loss. In many developing countries, reducing water loss may bring the greatest gain through cost savings.

Second, investment can make available new or enhanced supplies of water and encourage the formation of commercial and industrial enterprises by removing a major constraint on production. This is induced demand. Anecdotal evidence from Surabaya, Indonesia indicates that several manufacturing companies recently decided not to invest because water supplies were inadequate (WASH, 1991).

Third, investment in WS&S stimulates investment by the commercial and industrial sector. Evidence from 24 developing countries suggests that rather than reducing ("crowding out") private investment, public investment in infrastructure tends to increase ("crowd in") it (Blejer and Khan, 1984). As the commercial and industrial sector grows, revenues are reinvested in productive activity. A recent study in Malaysia indicates that a dollar of infrastructure investment stimulates 25 cents of private domestic investment (World Bank, 1989). A similar study in Turkey shows that private domestic investment increases by 35 cents (Chhibber and van Wijnbergen, 1988). This is a combination of cost savings and induced demand.

Fourth, since expanded output increases the demand for all the factors of production, including labor, investment in WS&S leads to job creation and higher rates of employment. This would not be considered an additional benefit in a formal cost-benefit analysis, as it has appeared already in the first three categories. However, it is important to stress employment generation as an element in the contribution of WS&S investment.

2.1 Inadequate and Inefficient Water Supply Limits Economic Growth

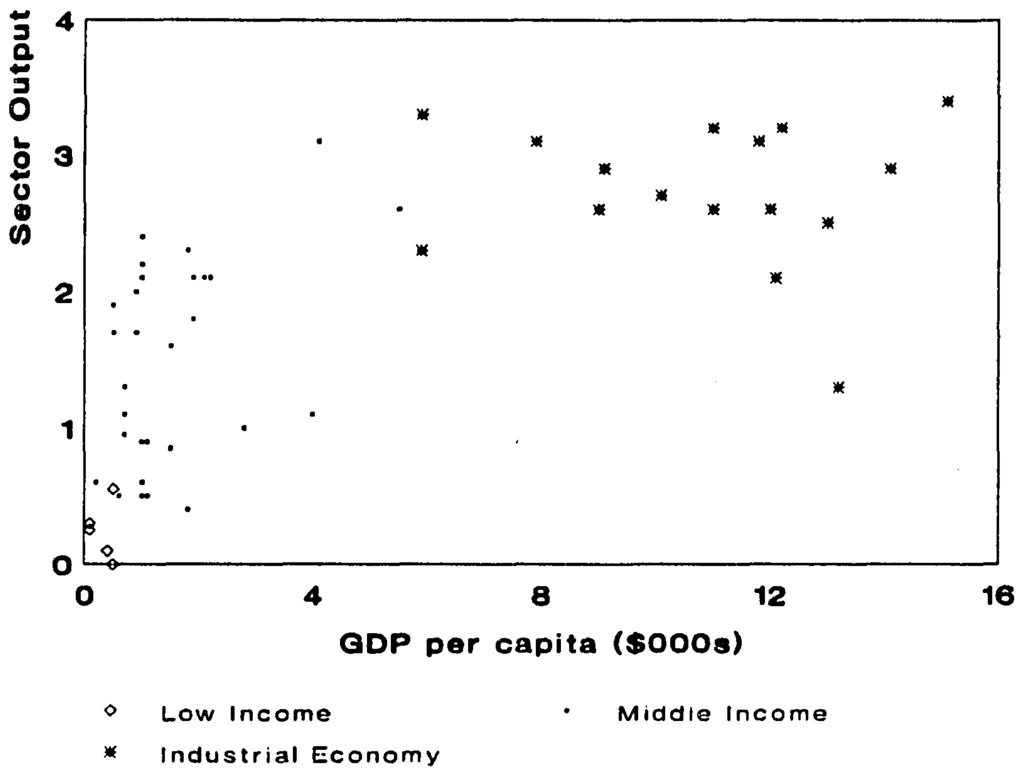
The constraining effect of an inadequate or inefficient water supply for commercial and industrial users can be described in terms of a production possibilities frontier, which is the maximum amount of goods and services that can be produced by an economy when all available resources are fully employed.

Goods and services can be divided into two groups: ***water goods***, that require water as a direct input in the production process; and ***non-water goods***, that do not directly require water in the production process.

Water goods range from those that need a fairly large volume of water for production (e.g., canned vegetables, leather, beer, bricks) to restaurant meals, which use a much smaller volume of water in food preparation and dish cleaning. Non-water goods include such items as furniture, electronics assembly, and retailing.

Using this classification, a national economy can be described in terms of a production possibilities frontier for water goods and non-water goods (Figure 4).

Points along the PPF curve, such as *A* and *B*, represent all the possible combinations of water goods and non-water goods that could be produced by the economy when fully employing



Source: World Development Report: 1987

Figure 3

Economic Development and Industrial Infrastructure
(Gas, Electricity, Water)

all available resources. Point *A*, for example, represents the bundle of water goods, W_A, and non-water goods, NW_A.

A point like *C* within the boundary of the production possibilities frontier represents a bundle of water goods and non-water goods when the economy's available resources are not fully employed or are used inefficiently. This is in fact the case in many urban water supply systems, where 50 percent or more of water production is lost to leakage or illegal taps. This loss causes the economy to die at point *C* or some other point within the production possibilities curve FE. A point such as *D* outside the production possibilities frontier represents

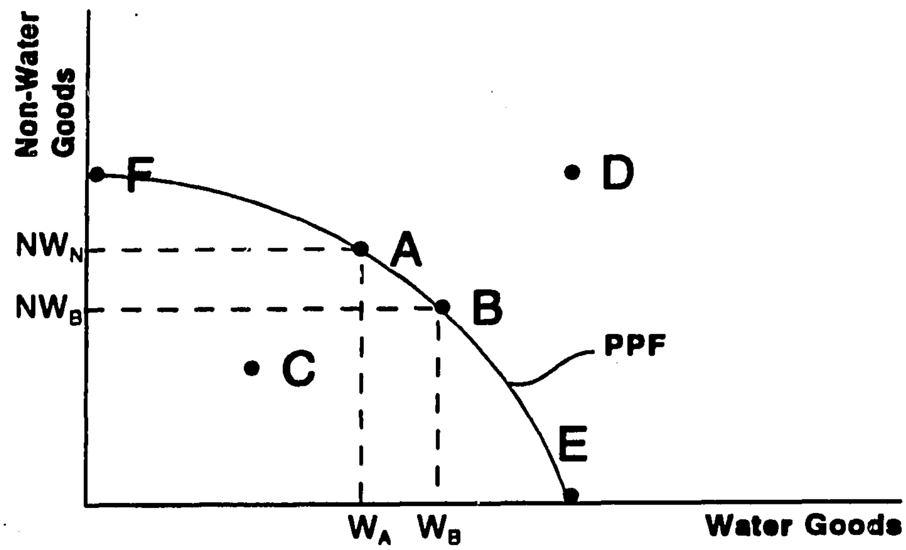


Figure 4

Production Possiblities for Water Goods and Non-Water Goods

a production combination that is not attainable by the economy with its available factors of production. Point *E* on the curve represents the maximum amount of water goods that can be produced if no non-water goods are produced. Point *F* represents the maximum amount of non-water goods that can be produced if no water goods are produced.

Any point on the PPF curve requires that all resources are fully employed and are employed efficiently. The position of the production possibilities frontier is partly determined by the water supply infrastructure available to the economy. If <u>all</u> possible commercial and industrial demands for water as a direct input in the production process cannot be met, then the production possibilities of the economy are effectively restricted to the PPF curve in Figure 4. An increase in the output of water goods beyond Point *E* is not possible without additional investment in water supply infrastructure.

Even changes in the combination of goods along the frontier toward the production of more water goods come at the expense of non-water goods. A movement from Point *A* to Point *B* in Figure 4, for example, would increase the production of water goods (from W_A to W_B) but decrease the production of non-water goods (from NW_A to NW_B). Resources (land, labor, buildings, machines, etc.) used in the production of non-water goods would have to be shifted to the production of water goods.

2.2 Investment in Water Supply Leads to Economic Growth

An expanded water supply infrastructure promotes growth in the national economy.[3] This is the key conceptual link at the macroeconomic level between infrastructure investment and the supply of goods and services. A capital stock investment to provide additional water supply for commercial and industrial purposes will have the effect of shifting the production possibilities frontier outward, as illustrated by the curve PPF' in Figure 5.[4]

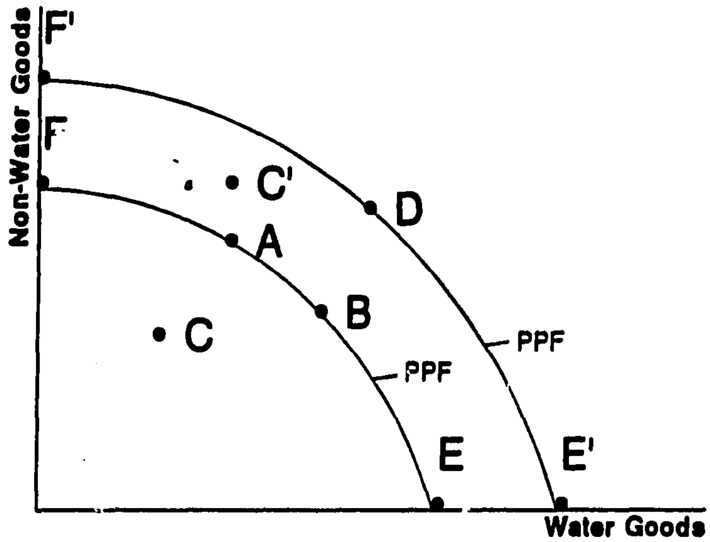


Figure 5

Effects of Infrastructure Investment in
Water Supply on Commercial and Industrial Uses

[3]The increased investment in the water supply can come from increased efficiency in the water sector, increased growth in the overall economy, allocations from other sectors, external donors, or decreases in consumption. For example, to the extent that taxes reduce personal consumption, additional taxation for water supply (or other investment) may be the source. Taxation in this instance "reallocates" resources from whatever uses taxpayers may have had for the funds to the investment decided by government.

[4]If the new capital investment comes from domestic sources, the production possibilities curve will move inward during the period in which the investment is made. The shift outward illustrated in Figure 5 represents the net outward shift in the production possibilities curve after the water improvements are in place. If the new capital investment is from external donor or private sources, the production possibilities curve simply shifts outward as shown. If funds from the external donor are in the form of a loan, this of course creates a demand against future domestic investment or consumption as the loan is repaid.

Making potable water available to existing and potential commercial and industrial users has the effect of increasing the maximum amount of water goods that may be produced (Point *E'* in Figure 5), increasing the maximum amount of non-water goods that may be produced (Point *F'*), and increasing all the production possibility combinations of water and non-water goods along the frontier (Point *D*, for example).

The production possibilities of non-water goods (Point *F'*) are expanded because public investment in water supply stimulates additional private investment for the production of both water and non-water goods. Production possibilities that were unattainable before the capital stock investment in water supply, like Point *D*, are now attainable.[5]

The other mechanism that will move the production possibilities frontier (or an inefficient interior point like Point *C*) outward is an investment that increases the technical and economic efficiency of existing water supply inputs. Public sector investment can achieve economies of scale, density economies, and technical efficiency gains in the production of water, and lead to economic efficiency gains in the commercial and industrial sector.

These economic efficiency gains expand the production of goods and services and the productive capability of the economy. This effect will be especially pronounced where:

- public sector investment replaces inefficient small-scale private (or public) water supply infrastructure;
- more firms are supplied within the coverage area to achieve density economies; or
- better maintenance or reduction in leakages reduces life-cycle costs.

2.3 Investment in Water Supply Leads to Job Creation

As the commercial and industrial sector expands the production of both water and non-water goods and services, it will require additional workers (as well as additional land and capital). Thus, water supply investment generates new jobs and an increased demand for all the factors of production.

Even if the economy initially does not use all its resources or uses them inefficiently (Point *C* in Figure 5, for example), a common situation in developing countries, the expansion of production will have a positive effect on employment as more workers are hired to produce additional goods and services. In Figure 5, this effect is shown by the movement from Point *C* to *C'*.

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[5]The initial effect of the WS&S investment may be to rotate the production possibilities curve outward from the point where the economy specializes in water goods (Point E) as capital is attracted for use in production of water goods. In the long run, however, the production possibilities curve also shifts outward from the point of specialization of non-water goods (Point F'), because increased profits from the production of water goods can be invested in the production of all goods and services.

The job creation benefit from investments in water supply is particularly relevant for developing countries because of the large and steady migration from rural to urban areas. One of the most dramatic demographic changes in developing countries in the last 40 years that is projected to continue well into the next century is rapid urban population growth. Of the 3.1 billion population increase expected in developing nations between 1985 and 2025, 2.7 billion will occur in urban areas (United Nations, 1987). Rapid urban population growth has greatly increased the labor supply and unemployment.

New commercial and industrial enterprises are more likely to be located in urban than in rural areas. Evidence from large cities in both developed and developing countries shows that from 60 to 80 percent of new jobs are created by newly established small firms in the central city (Lee 1981, 1985). Urban infrastructure investment that provides the necessary factors of production, like a supply of quality water, will attract such enterprises. In developing countries, these small firms are most likely to come from the informal sector, where low-income families accustomed to poor or nonexistent services routinely pay higher prices for water purchased from vendors. Expanding the water distribution system to serve small producers will allow them to expand production capacity. And expanding production, rather than accumulating profit, is the most likely response of small producers because the number of competitors is large.

3

WATER SUPPLY AND THE GROWTH OF FIRMS AND MARKETS

It has been established that, under certain conditions, additional investment in water supply is justified by the economic benefits that accrue in the form of increased production and employment. These conditions must be identified in the context of specific project design applications in specific country settings. A conceptual framework to guide the discussion, shown in Figure 6, traces the effects of WS&S investments on firms, industries, and the national economy.

The investments are assumed to bring about a decrease in the price of water and perhaps an improvement in quality. The expected behavioral response by firms will be to increase output (and employment) and lower prices (or increase profits). The more competitive the market, the less likely are firms to hold production constant and increase profits. As firms expand, so do the market for their goods and the national economy.

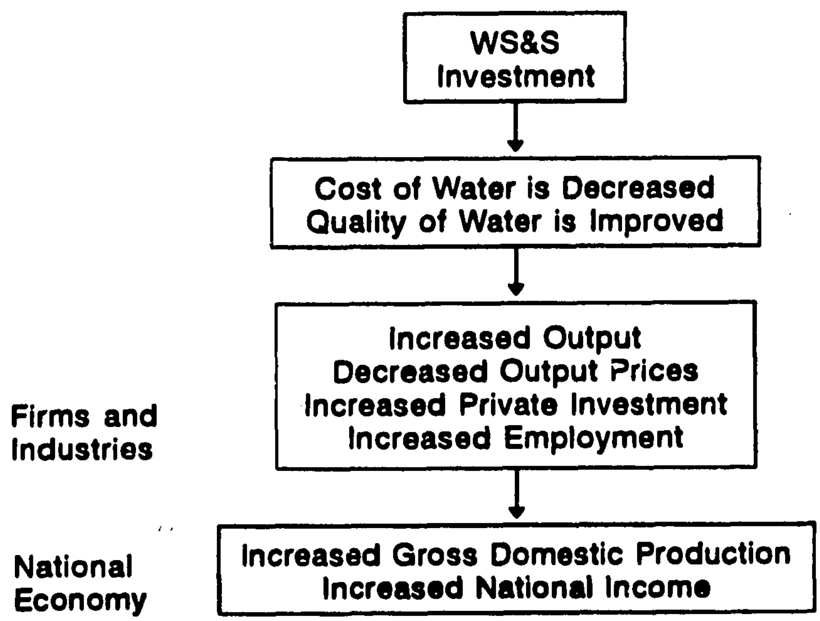


Figure 6

Conceptual Framework

The starting point for identifying the conditions under which economic growth will be spurred by investment in WS&S is an analysis of the existing water supply within the project boundaries. This may be prompted by a general assessment of unemployment and under-employment in the region as a prelude to devising strategies to increase the rate of job generation.

Such an assessment often will focus on a number of influencing factors such as the availability of investment capital, technical and managerial expertise, regulatory requirements, and infrastructure. The quantity and quality of water are among the constraints that affect a broad spectrum of commercial and industrial firms.

3.1 Commercial and Industrial Firms

It is tempting to consider the water needs of only the large industrial firms since they are the largest producers and employers. However, in terms of commercial and employment expansion, the smaller formal and informal sector producers in most rapidly urbanizing developing countries are most likely to be the major sources of growth in the next two decades (Rondinelli and Kasarda, 1992; Schwartz and Rondinelli, 1991). Project designers, therefore, must not ignore their concerns.

Lee and Anas (1989) used a seven-level classification of firms according to employment size in their research on infrastructure constraints in Nigeria. This classification is useful for distinguishing different levels of response but does not pinpoint sensitivity to infrastructure constraints. A better classification is one that focuses on the types of commercial and industrial activity and the physical facilities required for the conduct of business within a local economy (Figure 7).

Clearly, many commercial enterprises are largely independent of water except for personal use by their employees. Most street economy activities fit this description. However, these very activities are affected vitally by the transportation and drainage networks. Likewise, domestic service activities are more affected by transportation than by any other element of the infrastructure. Figure 8 shows water use by major industry groups in the United States as an illustration of the possibilities for increased production stimulated by increased water supply.

Water and sanitation investments are likely to have the greatest effect on the growth of home industry activities such as food preparation for vending; microenterprises, especially tanning and dyeing; construction activities; some types of industrial and manufacturing activities such as large-scale fabric and leather preparation and breweries; and large-scale "backbone" industries such as iron and steel, aluminum, and paper milling and production.

Figure 7

Commercial/Industrial Classification

Activity	Location	Example
Home Industry	Household	Manufactures: food for vending, handicrafts, clothing. Services: washing and ironing, sewing. Trading: retail goods
Street Economy	Street/Ambulatory	Trading: food stalls, vending. Services: shoe shining, portering, transport, entertainment.
Domestic Service	Employer Household	Services: maids, cooks, gardeners, nannies, chauffeurs
Microenterprise.	Rented Space	Manufactures: shoes, tailoring, tanning, metal working. Services: plumbing, radio repairs, car repairs. Trading: retail goods Services: day laborers, bricklayers, electricians, carpenters
Construction Work	Onsite	Commercial: wholesale and retail trade establishments, service establishments.
Industrial/Commercial	Factory/Establishment	Industrial: paper milling and production, iron, steel, and aluminum production, breweries, and fabric and leather production

Figure 8

Water Intake by Major U.S. Industry Groups as Percentages of Total Commercial Water Intake

Industry Group	Percent of Total
Food and Kindred Products	5.69
Tobacco Products	0.03
Textile Mill Products	12.54
Lumber and Wood Products	12.08
Furniture and Fixtures	0.18
Paper and Allied Products	15.11
Chemicals and Allied Products	33.29
Petroleum and Coal Products	9.02
Rubber, Miscellaneous Plastics Products	1.44
Leather and Leather Products	0.07
Stone, Clay, Glass Products	1.59
Primary Metal Industries	26.11
Fabricated Metal Products	0.69
Machinery, Except Electrical	1.27
Electric, Electronic Equipment	0.89
Transportation Equipment	1.80
Instruments, Related Products	0.27
Miscellaneous Manufacturing Industries	0.06

3.2 Efficiency Gains in Water Supply

For WS&S investments to pay off, they must lead to economic efficiency gains in the supply of water. Simply making quality piped water available may be sufficient to attract new firms. However, the cost of this water to existing firms must fall in order to provide them with an incentive to expand production. Because of the nature of the water supply industry, it is likely that investments will accomplish these gains in efficiency.

In both developed and developing countries, it is a fairly common practice to establish regulatory boards or commissions to oversee water suppliers that are essentially granted monopoly rights. These bodies often control the prices charged for water.

The justification for allowing a regulated monopoly to supply all the water needs in a geographic area is economies of scale in production and distribution and the avoidance of unnecessary duplication of pipe systems by more than one supplier. Scale and density economies show up in lower average costs, especially for operation and maintenance, as the size of the physical plant and water distribution system increases, particularly when small water systems are enlarged. Figure 9 illustrates declining average operation and maintenance cost curves for water systems in Botswana, Cote d'Ivoire, and Sri Lanka.

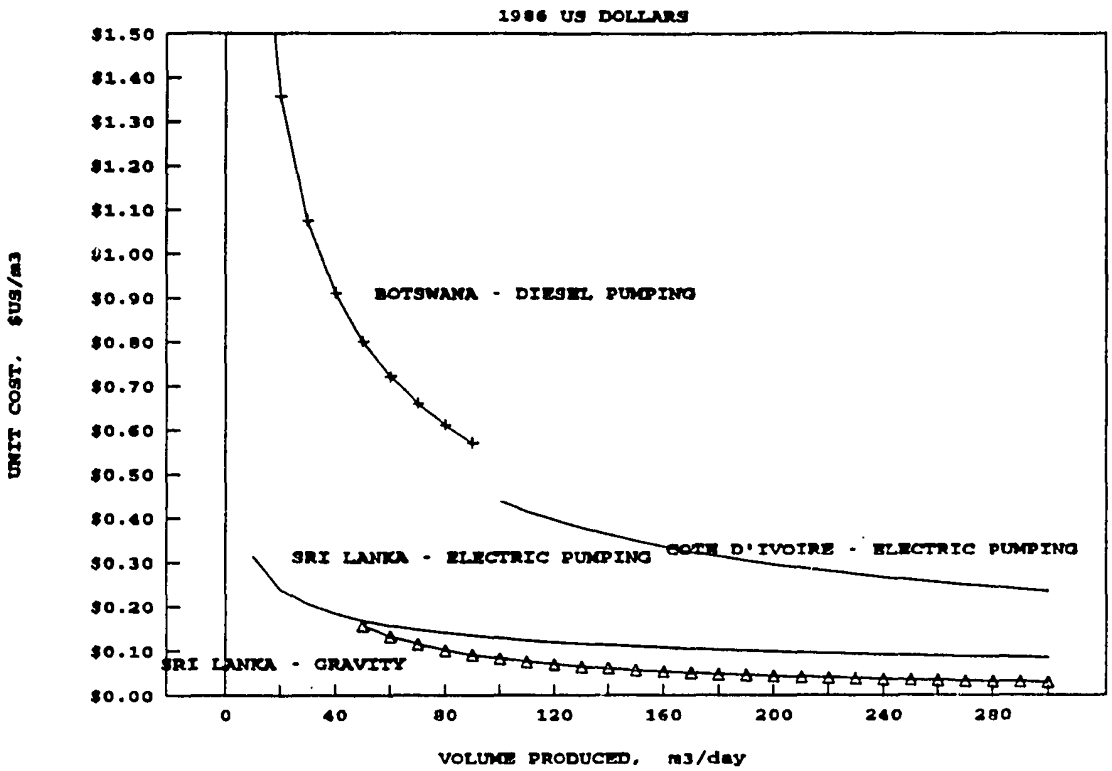
The presence of a single water supplier to satisfy the demands of an entire market creates what economists label a *natural monopoly*.

Natural monopolies tend to become more efficient as they become larger and capture a greater share of the market. If many competing suppliers served a geographic area, there would be considerable duplication of equipment (water pipes, for example) and each supplier would serve only a portion of the market, incurring much higher average production costs than a single supplier would.

In the long run, a large supplier would drive away its less efficient competitors by lowering its rates as it increased output and reduced its average costs of production and distribution. Consumers would benefit from this expansion and enjoy the lower prices made possible, but only up to a point.

An unregulated supplier with monopoly power could restrict the supply of water and charge prices that would yield greater profits than possible under competitive conditions. A *natural* monopoly derives its position from a process of *natural* competition among firms that leaves one large supplier satisfying the entire market demand. The final result is a price for water that exceeds marginal costs and overstates the scarcity of resources used to supply the water.

Figure 10 shows average and marginal cost curves for a water supplier whose average costs decline with output, and the market demand and marginal revenue curves for water. If the supplier is allowed to function as an *unregulated* natural monopoly, it would charge the monopoly price P_M and produce the quantity of water Q_M (the profit-maximizing price and quantity at the intersection of the marginal revenue [MR] and marginal cost [MC] curves).



Source: Wyatt, 1990

Figure 9

Examples of Economies of Scale in Water Systems:
Direct O&M Costs

Consumers benefit from *regulated* water monopolies because proper regulation can ensure lower average costs of production and lower prices than would be possible if there were many small, high-cost suppliers. A single supplier granted a monopoly by a regulatory authority can expand output to the point where the market demand for water is met at the lowest possible average cost of production. Figure 10 shows this point is reached at the output quantity Q_{AC}, larger than an unregulated monopoly would supply, at a price P_{AC}, lower than an unregulated monopoly would charge.

Research on U.S. water suppliers indicates that water utilities do experience substantial economies of scale for both residential and nonresidential water supply treatment. But these

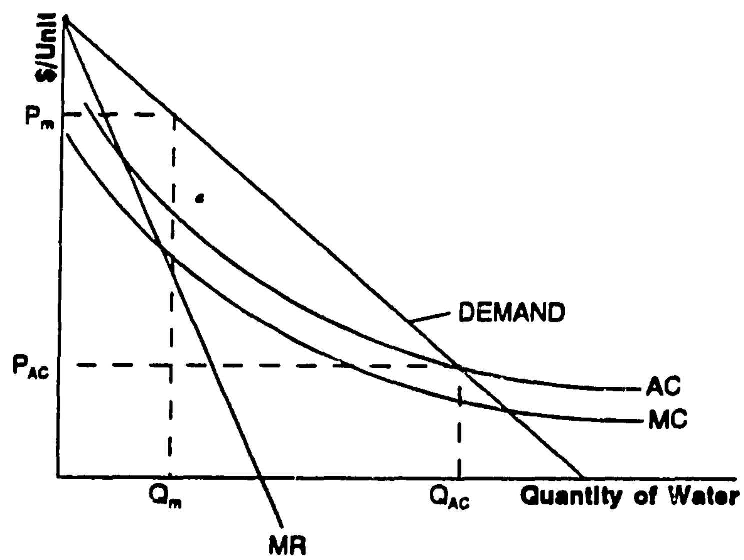


Figure 10

Water Supply Natural Monopoly

economies are determined mainly by nonresidential water users (Kim, 1985).[6] This is expected to be true for developing countries as well.

Because water supply is inherently a natural monopoly, investments in new and existing water supply infrastructure can lead to lower unit costs for distribution and lower prices (or subsidies). To enable existing firms that produce water-dependent goods and services to expand output and to attract new water-dependent firms, an increase in capacity must be accompanied by a more efficient water system and lower prices. Investments in water supply should be made with this goal in mind and should be preceded by a careful cost analysis of existing systems and planned improvements.

Investments may lead to lower subsidies rather than lower prices. In most developing countries, the marginal cost of water production and distribution is not reflected in the price. Thus, greater efficiency may result in lower government subsidies for the water sector rather than lower water prices for firms. But economic gains would still arise from better use of the nation's resources.

Additional investment in large systems operating at full capacity may actually increase average costs in the short run. New water that must be brought in from very long distances, or the use

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[6]Hayes (1987, p.422) also found scale economies for relatively small U.S. water producers. Fox and Hofler (1986) found modest economies of scale for U.S. rural water systems for the distribution, but not the production, of water.

of expensive advanced technology, for example, can raise costs. In such cases, the conditions for economic growth from investment are not likely to be met.

A water supply system has two components: distribution and capacity. *Distribution* includes the distribution mains and the laterals for individual connections. A distribution network can usually be expanded in a short time (depending, of course, on the extent of the expansion), provided the expansion does not exceed the capacity of the system. The *capacity* of a system comprises surface water reservoirs, dams, water treatment facilities, and trunk mains. Expanding the capacity usually requires a major investment and construction that could take a year or more.

Figure 11 illustrates the average costs of alternative water systems and highlights the difference between expanded water systems that could decrease or increase average costs.

Suppose the water system is supplying Q_A amount of water at C_A average cost, on the average cost curve AC_1. An investment to expand supply by expanding the distribution system will result in decreasing average costs up to the capacity of the current system, the quantity denoted by Q_{CAP}. Thus, a movement from Point *A* to Point *B* on the average cost curve AC_1 indicates decreasing average costs of supplying water.

Point *B* represents the capacity of the existing water system. To increase the supply beyond Q_{CAP}, a new system with larger capacity will be necessary. Because such a system may require investment in new technology or water source improvements, the average cost of supplying more water may actually be higher in the short run (Point *C* on AC_2).

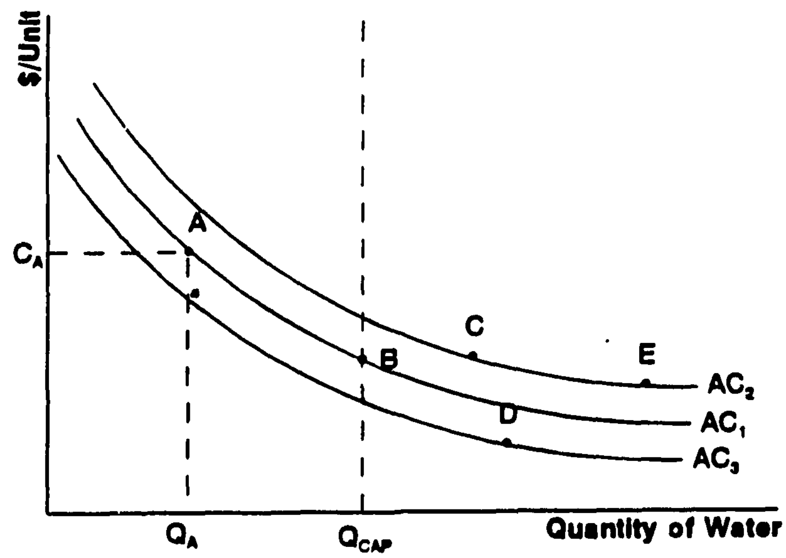

Figure 11

Average Costs of Expanding Distribution and Capacity of Water Systems

However, in cases where the added capacity is not more expensive, the average cost of water may actually decline (Point *D* on AC_3). Moreover, even if the new average costs are initially higher, economies of scale will bring them down as the distribution network is expanded (Point *E* on AC_2), so that eventually they will be lower than those of the original system at its full capacity.

All this suggests that water supply investments will achieve the most likely efficiency gains when the distribution network can be expanded to provide broader geographic coverage to commercial and industrial areas without exceeding current capacity. Given the water loss in urban systems in most developing countries, increasing the quantity of water used productively by investments in rehabilitation and expansion of the distribution system is the best course. As water systems are expanded, economies of density will be attained from the distribution of potable water to commercial urban areas previously not served, and will lead to lower unit costs for all users, including new and existing firms. In addition, investment in the supply of water yields its own economic benefits in the employment of a larger staff for initial construction and for continued operation and maintenance.

Another important factor that should be considered in investment decisions is the price of substitutes for piped water. In Bangkok, for example, only 150 out of 700,000 water connections are for manufacturing firms. Most firms use ground water, available at one-seventh the price of surface water. This widespread practice, incidentally, contributes to the subsidence problem (Lee, 1988). Thus, an investment that reduced the difference in price between surface and ground water would assist industrial growth.[7] Scale and density economies would indeed enable an efficient public utility to produce water more cheaply than private providers. But to make the switch to piped water, firms would have to be sure of getting a reliable supply of acceptable quality at an attractive unit cost.

The opportunity for investment in an expanded piped water system is demonstrated by the situation in Onitsha, Nigeria, where 275 tanker trucks carrying water from 20 privately owned boreholes sell it to businesses and households at a higher price than consumers would pay if a piped water supply was available (Whittington, Lauria, and Mu, 1989). However, there may be situations where this is not necessarily true.

3.3 The Behavioral Response of Firms and Markets

Firms that use water in the production of goods and services can be expected to increase output and decrease prices (or use profits for private investment), and new firms will be induced to start business, in response to public sector investments in WS&S. The economic principles that dictate these responses are illustrated in Figure 12.

[7]The cost of ground water does not reflect the cost of depletion or abstraction. Correct pricing of scarce resources requires a depletion tariff or tax on ground water, which would also reduce the price difference between piped and ground water.

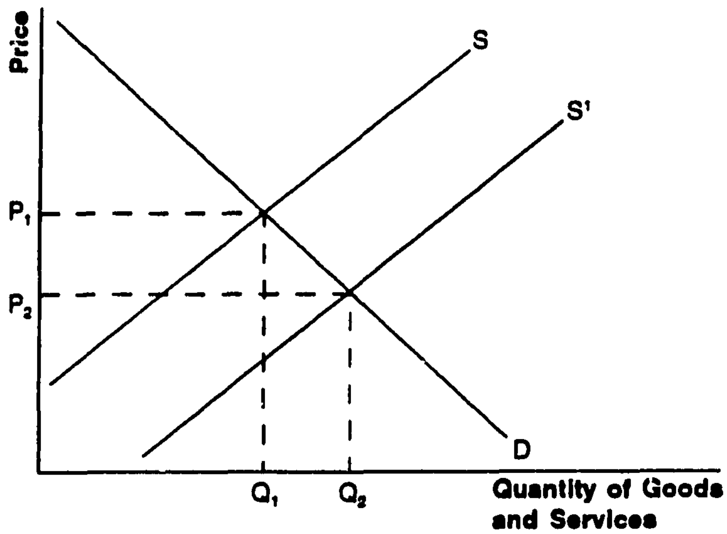

Figure 12

Effects of Investment in Water Supply on Markets for Goods and Services

A basic economic tenet is that firms respond to changes in the price of inputs, one of which is water in this case. The supply curves *S* and *S'*, are determined by input prices and the number of firms in the market. The shift from *S to S'* reflects an increase in the quantity of goods and services exchanged in the market from Q_1 to Q_2, accompanied by downward pressure on the prices of goods and services from P_1 to P_2.

In imperfect markets, firms may elect not to pass along all cost savings to consumers, preferring instead to invest some. This investment, however, stimulates economic growth, and in the long run excess profit will attract new firms and drive consumer prices down[8].

Expanded output by existing firms and the emergence of new firms also create a demand for labor. As noted earlier, the most likely employment growth in rapidly urbanizing economies will come from small-scale enterprises, many of them involving low-skilled individuals and households attempting to move from the street economy or domestic service to employment by, or ownership of, microenterprises. These microenterprises are most likely to be dependent on vendors for their water supply and to pay from 10 to 40 times what the local utility charges, a price that usually prohibits business expansion or new entry into the market (WHO, 1989; Peterson, 1990).

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[8]The gain to the domestic economy from lower water prices will depend partly on whether the primary beneficiaries are domestic or foreign firms. The benefit will be lower if foreign firms repatriate profits.

For both small- and large-scale producers, the infrastructure, such as water, drainage, and streets, is as important a prerequisite as financial capital and legal services, for example. Water supply and sanitation services must be planned with consideration for the needs of firms of different types. Of course, if such factors as poor roads, insufficient electricity, and distance from markets impede expansion, the availability of water will have little influence by itself in attracting business. Manufacturing firms tend to locate where the infrastructure can meet the needs of their particular operations.

Small firms generally start business near the city center or in an old industrial area with easy access to good utilities and other essential services. As they expand, space and infrastructure constraints lead them to move out of the city but not so far that deliveries and commuting distances become a problem (Lee 1981, 1985). Large cities with poor infrastructure cannot offer the "incubator" environment for small firms, for whom the burden of an inadequate public supply of water is especially severe. Since most new jobs come from small firms, a poor water supply will impede the generation of employment and income. Conversely, there are high returns for selectively improving the water supply and other services for particular users at particular locations (Lee and Anas 1989).

The key factors that influence the economic gains from water supply investment are flow rates, the size and location of the market for additional goods to be produced, the current volume of water used in production, the likelihood of high-volume users establishing business in the area, and the price and quality of privately supplied water.

3.4 Summary

There are three essential conditions for investments in water supply to bring about economic growth.

The first is that the expanded system must result in greater efficiency and lower prices. If costs, and therefore prices, do not change, water dependent firms may not increase production of goods and services, although new firms may be attracted because no source (or only a very expensive source) of water was available to them before.

The second condition is that publicly supplied water for commercial and industrial users must be cheaper than available substitutes. If it is not, firms will make no cost savings and will have no incentive to increase production or relocate to the targeted geographical area. A survey of the price of alternative supplies should be conducted prior to new WS&S investment.

The third consideration is that investment in water supply must complement other components of the infrastructure. New commercial and industrial areas must provide adequate roads, electricity, and communications for economic growth to occur.

4

CONCLUSION

Water supply investment is likely to bring the greatest return where small distribution systems can be expanded, without exceeding current capacity, to cover a broader geographic area serving existing and potential commercial and industrial users in urban and peri-urban centers.

Key factors in the investment decision are the volume of water used in production by existing firms, the likelihood of high-volume users locating in the area, the current price and quality of alternative supplies, and the size and location of the market for additional goods to be produced.

4.1 Geographic Area

The economic impact of water supply investments will be greatest in large and growing urban and peri-urban areas because:

- there is greater water demand by existing commercial and industrial users;
- there is a greater potential for new commercial and industrial users of water to start business;
- the necessary infrastructure (roads, electricity, communication network) to support new commercial and industrial development is likely to be in place;
- the concentration of economic activity in developing countries is shifting from rural to urban areas;
- small new firms are "incubated" in central cities;
- there is a larger potential market for goods and services that rely on water as an input in the production process; and
- the labor force and the demand for goods and services is growing as a result of rural migration.

4.2 Water Supply Characteristics

The impact of water supply investments will be greatest where expansion will effect significant economies. This is most likely where:

- the capacity of the current system is relatively small;

- the distribution system can easily be expanded to increase coverage to commercial and industrial areas without exceeding current capacity; and
- the price of present supplies, either from the current system, vendors, or other sources, is higher than what the investment can promise.

4.3 Characteristics of Existing and Potential Firms

Firms dependent on water to produce goods and services and therefore most likely to reward water supply investments are:

- small-scale home industries such as food preparation for street vending;
- microenterprises, especially tanning and dyeing;
- large-scale fabric and leather industries;
- breweries;
- construction companies; and
- industries that require large quantities of water for cooling and cleaning.

REFERENCES

Anas, A. and K. S. Lee. *Infrastructure Investment and Productivity: The Case of Nigerian Manufacturing*. World Bank Discussion Paper. Report INU 14. Infrastructure and Urban Development Department, The World Bank, (1988).

Aschauer, D. A. Is Public Expenditure Productive? *Journal of Monetary Economics*, 23: 177-200 (1989).

Blejer, M. and M. S. Khan. *Government Policy and Private Investment in Developing Countries*. IMF Staff Papers, 31. Washington, D.C., June (1984).

Briscoe, J. and D. de Ferranti. *Water for Rural Communities*. The World Bank (1988).

Camemark, C. *Water Resources: An Agenda for Bank Consideration*. Draft mimeo. World Bank, Infrastructure Division (1989).

Chhibber, A. and S. van Wijnbergen. *Public Policy and Private Investment in Turkey*. World Bank Policy Planning and Research Working Paper, No. 120 (1988).

Churchill, A. A. *Rural Water Supply and Sanitation: Time for a Change*. World Bank Discussion Paper, No. 18 (1987).

Esrey, S. A., Shiff, C., Roberts, L., and J. B. Potash. *Health Benefits from Improvements in WS&S: Survey and Analysis of the Literature on Selective Diseases*. WASH Technical Report No. 66, Water and Sanitation for Health Project (1990).

Fox, W. F. Private correspondence (1992).

Fox, W. F. *The Contribution of Infrastructure Investments to Growth: A Review of the Literature*. Unpublished manuscript. University of Tennessee (1990).

Fox, W. F. and R. A. Hofler. Using Homothetic Composed Error Frontiers to Measure Water Utility Efficiency. *Southern Economic Journal*, 53(2): 461-477 (1986).

Hayes, K. Cost Structure of the Water Utility Industry. *Applied Economics*, 19: 417-425 (1987).

Ingram, G. K. *Note on the Macroeconomic Linkages of Infrastructure*. Unpublished manuscript. The World Bank (1989).

Kim, H. Y. *Economic Modelling of Water Supply: An Econometric Analysis of the Multiproduct Firm*. Environmental Protection Agency. Water Engineering Research Laboratory, Cincinnati, OH. EPA/300/S2-85/019 (1985).

Lee, K. S. Intra-urban Location of Manufacturing Employment in Columbia. *Journal of Urban Economics*, 9: (1981).

Lee, K. S. *An Evaluation of Decentralization Policies in Light of Changing Location Patterns of Employment in the Seoul Region*. Urban Development Discussion Paper UDD-60, The World Bank. (1985).

Lee, K. S. *Infrastructure Constraints on Industrial Growth in Thailand*. World Bank Working Paper. Report INURD WP#88-2, Urban Development Division, Policy, Planning and Research Staff, The World Bank (1988).

Lee, K. S. and A. Anas. *Manufacturers' Responses to Infrastructure Deficiencies in Nigeria: Private Alternatives and Policy Options*. World Bank Discussion Paper. Report INU 50. Infrastructure and Urban Development Department, The World Bank (1989).

Okun, D. The Value of WS&S in Development: An Assessment. *American Journal of Public Health*, 78(11): 1463-1467 (1988).

Paul, J. E. and J. A. Mauskopf. 1991. *Cost-of-Illness Methodologies for Water-Related Diseases in Developing Countries*. Technical Report No. 75. Arlington, Va: WASH Project.

Peterson, G. E. *Financing Urban Infrastructure in Less Developed Countries*. Draft report. Urban Institute (1990).

Rietveld, C. *Water Supply and Sanitation in Fast Growing Cities*. Unpublished manuscript (undated).

Rondinelli, D. A. and R. W. Johnson. Third World Urbanization and American Foreign Aid Policy: Development Assistance in the 1990s. *Policy Studies Review*, 10, 3 (1990).

Rondinelli, D. A. and J. Kasarda. *Job Creation Needs in Third World Cities*. Forthcoming in J. Kasarda and A. Parnell (eds.), *Urbanization, Migration and Development*. Newbury Park, CA: Sage Publications (1992).

Schwartz, J. B. and D. A. Rondinelli. *Forecasting the Impact of Urbanization on Job Creation and Municipal Investment Needs in Developing Countries*. Research Triangle Institute Staff Working Paper. Center for International Development, Research Triangle Institute (1991).

Shah, A. *Public Infrastructure and Private Sector Profitability and Productivity in Mexico*. World Bank working paper. Report WPS 100. Policy, Planning, and Research Department, The World Bank (1988).

United Nations. *Prospects of World Urbanization*. ST/ESA/SER.A/101, New York: UN (1987).

Water and Sanitation for Health Project (WASH). *Private Sector Participation in Urban Water Supplies Issues for Investment in Indonesia* (1991).

Whittington, D., D. T. Lauria, and X. Mu. *Paying for Urban Services: A Study of Water Vending and Willingness to Pay for Water in Onitsha, Nigeria*. Infrastructure and Urban Development Department, Case Study, Report INU 40, World Bank (1989).

World Bank. *Malaysia: Matching Risks and Rewards in a Mixed Economy*. World Bank Country Study (1989).

World Bank. Housing, Macro Policies: Tracing the Links. *Urban Edge* (Vol. 12, p. 2, 1988).

World Bank. *World Development Report 1987*. New York: Oxford University Press (1987).

World Health Organization. *Cost Recovery in Community Water Supply and Sanitation*. Report of the Fourth Consultation on Institutional Development (1989).

Wyatt, A. *Water Loss in Rural Water Systems in Developing Countries*. Working paper. Center for International Development, Research Triangle Institute (1991).