The Economic Costs and Benefits of Investments in Municipal Water and Sanitation Infrastructure: A Global Perspective

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DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS AND POLICY
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
UNIVERSITY OF CALIFORNIA AT BERKELEY

WORKING PAPER NO. 1027

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February 1, 2006

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Abstract

This paper presents illustrative estimates of the costs and benefits of investments in municipal water and sanitation systems in developing countries. Four sources of information on the economic benefits households receive from improved municipal water and sanitation services are reviewed: (1) prices charged for vended water, (2) avertive expenditures, (3) avoided costs of illness, and (4) stated preference studies. There is little evidence to suggest that the current monthly benefits of improved water and sanitation services exceed the monthly costs. The most important limitation of such comparisons of annual costs and benefits is that benefits per household may well grow over the life of the investments, but this possibility does not ensure that such projects will pass a cost-benefit test.

World Congress Category: Sustainable Development; Renewable Resources: Others

JEL Classifications: O13, Q25, H40, N50

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Introduction

The community of overseas development assistance experts likes to set quantity targets in the pursuit of development goals. It is now a well-established part of the development assistance culture for participants at an international conference to look at where they would like developing countries to be in 10-20 years in terms of progress toward some development goal, and then calculate what is required in terms of additional financial assistance to achieve it. This practice seems to be especially strong in the in the water and sanitation sector. Following the Rio conference on environment and development, the 1980s were designated the “International Water and Sanitation Decade,” and the international community was to work to ensure that everyone in the world had access to at least basic water and sanitation services by 1990. These quantity targets were never met, and at the Johannesburg conference on Sustainable Development in 2000, the global community made a commitment to a set of the “millennium development goals” (MDGs), one of which was to cut the proportion of people in the world living without access to water and sanitation in half by 2015.

There are at least three good reasons for articulating development goals as quantity targets. First, quantity targets provide a means for mobilizing increased overseas development assistance from wealthy countries. They constitute a call for moral action to address income inequality. Poverty—and lack access to water and sanitation services—is characterized as an assault on human dignity. Often using rights-based language, advocates of increased overseas development assistance (ODA) seek to impose a financial obligation on wealthy countries to aid poorer countries.

Second, they are an important form of agenda setting, raising the importance of some development goals, while lowering the priority on others. Third, quantity targets may be accompanied by policy messages or new scientific evidence that the international community wants to communicate to developing countries themselves. In effect, the global community wants to realign national budget priorities to push a global consensus on the best way to reduce poverty.

As part of its global call to action, the international development community typically makes a variety of economic arguments to support its request for increased development assistance and national government budget realignment. Cost-benefit type arguments predominate in this discourse. For example, the case is often made that the economic benefits of water and sanitation investments exceed the costs by some amount or multiple. Typical of such rhetoric is the recent Copenhagen Consensus (Lomborg, 2004), in which the author of the water and sanitation chapter asserts that the benefits of water and sanitation investments exceed the costs by at least eight times. Such economic analyses are only one of numerous arguments made by proponents of increased overseas technical assistance in general, and increased investment in W&S in particular, to promote progress toward quantity targets; indeed, economic arguments are probably not overly important or persuasive in the minds of most overseas development assistance experts. Moral commitment to poverty reduction and reduction in income inequality seem to be more compelling reasons for action.

Still, we believe it is important that the economic analysis of development policies and projects be carefully done and the results honestly presented. At the most fundamental level water and sanitation (W&S) professionals need to know what business they are in, i.e., are they providing humanitarian relief (charity), or are they fostering economic development? Development projects that do not pass a cost-benefit test are likely to be a drag on economic growth, and increased economic growth is one extremely important strategy for the achievement of both poverty reduction and concrete quantity targets such as increased water and sanitation coverage. Also, such cost-benefit analyses can assist proponents of moral action in better understanding the financial (and political) obstacles in their path toward the achievement of quantity targets.

Our objective in this paper is thus to offer a global perspective on the economic costs and benefits of investments in municipal water and sanitation infrastructure in the hopes of assisting W&S professionals to see more clearly the true nature of sector challenges. We believe this overview is timely because it is widely recognized by most donors that W&S projects have been among the most poorly performing investments in their portfolio from an economic perspective.

In the next, second section of the paper we present some general observations that are central to an understanding of the economics of municipal water and sanitation investments. In the third section we focus on the costs of providing improved municipal water and sanitation services. In the fourth section we summarize some empirical evidence on the economic benefits of municipal W&S investments. In the fifth section we discuss the comparison of the economic costs and the benefits and note the limitations of the analytical approach used in most such applications. In the sixth and final section we discuss some of the implications of these results.

Background

By way of introducing the economics of investments in municipal water and sanitation infrastructure in developing countries, it is important to keep in mind five "facts" about the W&S sector. First, the provision of water supply and sanitation services broadly conceived is a huge societal enterprise. In both industrialized and developing countries it often accounts for a substantial share of public sector investment. The cost of reservoirs, canals, water transmission lines, urban distribution networks, pumping stations, water treatment facilities, sewerage collection and conveyance, and wastewater treatment facilities –and the land required for all these facilities—makes this one of the largest "industries" in most industrialized economies. The payments an individual household makes for these assets—both in direct payments for services and indirect taxes- is often a significant household budget expenditure, and a household's share of these assets can represent a substantial portion of its net worth, albeit publicly owned and typically not easily tradable.

Second, the provision of water and sanitation services is very capital intensive. Moreover, in many cases there are significant economies of scale, and the physical capital tends to be long-lived. This has several important implications. It is critical to get the investment planning decisions right because one can make big mistakes by overbuilding, by building too far in advance of demand, by building facilities that no one wants, or by failing to maintain and operate such capital-intensive facilities efficiently. Also, because of this capital intensity, the financing of capital expenditures becomes a central issue in the provision of water and sanitation services. Because so much capital is "at risk," the property rights to the revenue (and benefit) stream from water and sanitation facilities must be clear and well-secured for either private parties or taxpayers to feel confident to undertake such large investments.

Third, household demand for very small quantities of drinking water is extremely price inelastic because people must have water to live. If there are no other sources of water, the amount of money someone will pay for 3-4 liters of water a day is limited only by her income and the budget share required for food. This extremely inelastic demand for small quantities coupled with shortages of water supply can combine to create situations in the developing world that are beyond the experience of people in richer countries. For example, in some places in rural Tanzania a 20-liter bucket of water can cost a day's wages of an unskilled laborer. You can take your choice: walk all day for water, or work all day in the fields and buy a bucket of water. In parts of Mozambique, one of the poorest countries on earth, the price of a 20-liter jerrican of water can be four times the cost desalinated water. During the civil war in Angola, a liter of water could cost more than a liter of gasoline (although this was in large part due to the subsidized price of gasoline).

The fact that the price inelasticity for small quantities of water is so low, and the provision of services is very capital intensive, means that one can make a lot of money if s/he can gain control of the capital assets and pursues an objective of maximizing monopoly profits rather than the public welfare. We should thus not be surprised to see water utilities engaged in complex rent-extracting arrangements in societies with poor governance and high levels of corruption (Lovei and Whittington, 1993; Davis, 2004). The capital-intensity of investments also provides large opportunities for bribery and kickbacks on construction contracts and equipment purchases. These problems greatly increase the transaction costs of doing business, and thus the total cost of providing improved water and sanitation services in many developing countries.

Fourth, from a technological perspective, water is very different than electric power when it comes to storage and transport. The storage of water is relatively easy, while transporting water long distances to urban centers is expensive because water is so heavy. With electricity, by contrast, storage is expensive and transportation is easy. Because water is typically expensive to transport long distances, it can be prohibitively expensive to provide customers with very high levels of service reliability. Pricing and other demand management tools are required to manage water shortages because one cannot expect to be able to import large supplies of water at short notice from distant locations during droughts or periods with limited production capacity.

In industrialized countries good reservoir sites are often already used, and constructing new reservoirs is increasingly expensive and politically infeasible. However, many developing countries have relatively very little water storage, and thus have little protection against drought. The capital and associated financing needs for additional storage and other components of the water and sanitation system are very large.

Fifth, there is a strong correlation between W&S coverage and household income. As incomes increase in developing countries, more and more people are getting improved infrastructure services. Progress is occurring, particularly China and India. Figure 1 shows the percentage of households at different income levels that have four infrastructure services (piped water, sewer, electricity, and telephone); the data come from interviews with over 55,000 households in 15 developing countries (Komives et al, 2002). For households in this sample, at all income levels, more people have electricity than piped water or sewer. Very few of the poorest households have piped water or sewer, but almost a third of these households have electricity service. As monthly household income increases from very low levels to US$300 per month, coverage of all of these infrastructure services increases rapidly; above US$300 coverage increases at a slower rate.

Although most households would certainly like improved water and sanitation services, this is typically *not* their most important personal priority. Water and sanitation planners often present the need for improved services as a moral imperative or a basic human right, arguing that water and sanitation services are "merit goods." But given the choice, many households in developing countries would appear to want electricity before an in-house piped water or sewer connection In fact, it is unusual for a household in a developing country to have a piped water connection and *not* have electricity. The fact that water itself is a necessity does not necessarily mean that people prefer piped water service over electricity service. Indeed, because water is a necessity, households must already have access to some water source. The question is thus how much *improved access* is worth to them.

Costs of Municipal Water and Sanitation Services

The preference for fresh, clean water supplies for drinking and washing lies deep in people's collective subconscious, and is reflected in all of the world's major religions (Priscoli, 2000). Some people still long for a lost world in which wondering nomads could visit an uncontaminated, refreshing spring. In a world of 5+ billion people, such places are sadly few and far between, and even with the most stringent water pollution control measurements, there are very few places where people can expect to safely drink untreated water from natural sources. The treatment and delivery of water to households, and the removal and treatment of the wastewater generated cost serious money.

Of course, costs vary depending on individual circumstances, and estimates of what it will cost to provide a certain level of service may vary widely. Also, most investments are incremental in nature. Only rarely would a community incur the costs of complete ("full-service") piped water and sanitation systems at a single point in time. Nevertheless, some rough calculations are illustrative. The approach here is to present some average unit costs of providing an urban household with modern W&S services. First, we look at representative unit costs per cubic meter for different components of W&S services. Second, we provide some typical quantities of water that different representative households use in a month. Third, we multiply representative unit costs by typical monthly household water use to obtain estimates of the monthly economic costs of providing a household with improved, piped W&S services.

The economic costs of providing a household with modern water and sanitation services are the sum of seven principal components:

1. Opportunity costs of diverting raw water from alternative uses to the household (or resource rents)
2. Storage and transmission of untreated water to the urban area
3. Treatment of raw water to drinking water standards
4. Distribution of treated water within the urban area to the household
5. Collection of wastewater from the household (sewerage collection)
6. Treatment of wastewater (sewage treatment)
7. Any remaining costs or damages imposed on others by the discharge of treated wastewater (negative externalities).

Table 1 presents some illustrative average unit costs for each of these seven cost components, expressed in U.S. dollars per cubic meter. The unit costs of these different cost components could vary widely in different locations. For example, in a location with abundant fresh water supplies, item 1 (the opportunity cost of diverting water from existing or future users to our illustrative household) and item 7 (the damages imposed by the discharge of treated wastewater) may, in fact, be very low or even zero. However, in more and more places these opportunity costs associated with water diversion and the externalities from wastewater discharge are beginning to loom large.

Some cost components are subject to significant economies of scale, particularly storage and transmission (item 2), the treatment of raw water to drinking water standards (item 3), and the treatment of sewage (item 6). This means that the larger the quantity of water or wastewater treated, the lower the per-unit cost. On the other hand, some cost components are experiencing diseconomies of scale. As large cities go father and farther away in search of additional fresh water supplies, and good reservoir sites become harder to find, the unit cost of storing and transporting raw water to a community increases. There are also tradeoffs between different cost components: one can be reduced, but only at the expense of another. For example, wastewater can receive only primary treatment, which is much cheaper than secondary treatment; but then the negative externalities associated with wastewater discharge will increase.

The cost estimates in Table 1 include both capital expenses and operation and maintenance expenses. The calculation of annual capital costs use a capital recovery factor of 0.12, assuming a discount rate of 10% and an average life of capital equipment and facilities of 20 years. The opportunity costs of raw water supplies (item 1) are still quite low in most places, on the order of a few cents per cubic meter. Even in places where urban water supplies are diverted from irrigated agriculture or valuable environmental assets, the unit costs will rarely be above US$0.25 per cubic meter. Desalinization and wastewater reclamation costs will set an upper limit on opportunity costs of raw water of about US$1.00 per cubic meter for cities near the ocean, but the opportunity costs of raw water are nowhere near this level in most places.

Raw water storage and transmission and subsequent treatment (items 2 and 3) will typically cost US$0.30 per cubic meter. Within a city the water distribution network and household connections to it (item 4) comprise a major cost component, in many cases on the order of US$0.75 per cubic meter. The collection and conveyance of sewage to a wastewater treatment plant (item 5) is even more expensive than the water distribution; this will cost about US$1.00 per cubic meter, 40% of the total cost. Secondary wastewater treatment (item 6) will cost about US$0.35 per cubic meter. Damages resulting from the discharge of treated wastewater are very site-specific, but environmentalists correctly remind us that that they can be significant, even for discharges of wastewater receiving secondary treatment. Let us assume for purposes of illustration that these costs are of the same order of magnitude as the opportunity costs of raw water supplies (US$0.05).

As shown, total economic costs are about US$2.50 per cubic meter in many locations. We emphasize that costs shown here are not intended to represent an upper bound. For example, in small communities in the arid areas of the western United States costs of W&S services can easily be double or triple these amounts per cubic meter. Note too that these cost estimates assume that financing is available at competitive international market rates, and that countries do not pay a high default or risk premium.

Table 2 presents a reasonable lower-bound estimate of unit costs of piped W&S services. Here the opportunity cost of raw water supplies and the damages from wastewater discharges are assumed to be zero. Only minimal storage is included, and the only intake treatment is simple chlorination. Costs for the water distribution network assume the use of PVC pipes and shallow excavation. Wastewater is collected with condominial sewers, and the only wastewater treatment is provided by simple lagoons. Given all these assumptions, one can manage to reduce unit costs of piped W&S services to about US$1.00 per cubic meter.

How much water does a typical household in a developing country "need"? The quantity of water used by a household will be a function of the price charged, household income, and other factors. Currently most households in developing countries are facing quite low prices for piped W&S services. One can look at typical water use figures from households around the world to see how much water one might expect a household to use for a comfortable modern lifestyle. For households with an in-house piped water connection, in many locations residential indoor water use falls in the range of 110 to 220 liters per capita per day. For a household of six, this would amount to about 20 to 40 cubic meters per month (Table 3). At the current low prices prevailing in many cities in developing countries, such levels of household water use are not uncommon. Other things equal, households living in hot, tropical climates use more water for drinking, bathing, and washing than households in temperate or cold climates.

Assuming average unit costs of US$2.50 per cubic meter, the full economic costs of providing 20 to 40 cubic meters of water to a households (and then dealing with the wastewater) would be US$50 to US$100 per month (Table 4), more than most households in industrialized countries pay for the same services and far beyond the means of most households in developing countries.

One would expect poor households in developing countries with in-house water connections to respond negatively to high W&S prices: they might curtail use to as little as 50 to 60 liters per capita per day. For a household with six members, at 55 liters per capita per day, total consumption would then amount to about 10 cubic meters per month. The full economic costs of this level of W&S service at this reduced quantity of water use (assuming our unit costs of US$2.50 per cubic meter remained unchanged) would then be US$25.00 per month per household. At entirely plausible levels of water use (110 liters per capita per day), the total economic cost would be about US$50 per month for the same household. With the unit costs of the low-cost system depicted in Table 2, the full economic cost of providing 10 cubic meters per month would be US$10 per household per month. This estimate should be regarded as a lower bound on the full economic costs of piped W&S services in most locations.

In industrialized and developing countries alike, most people are unaware of the magnitude of the true economic costs of municipal water and sanitation services. There are several reasons why these economic costs are so poorly understood.

First, the capital costs are heavily subsidized by higher levels of government, (and, in developing countries, by international donors), so that households with services do not see the true capital costs reflected in the volumetric prices they pay. Second, in many cities tariff structures are designed so that industrial water usage subsidizes residential usage; households thus do not even see the full operation and maintenance costs in the prices they pay. Third, because many water utilities run financial deficits (in effect running down the value of their capital stock), water users in aggregate do not even see the full costs of supply. Fourth, most cities do not pay for their raw water supplies: typically the water is simply expropriated from any existing water sources (and their users) in outlying rural areas. Fifth, wastewater externalities are typically imposed on others (downstream) without compensation.

Sixth, the subsidies provided to consumers of water and sanitation services are not only huge, but also regressive. It is often not politically "desirable" for the majority of people to understand that middle- and upper-income households, who generally use more water, are thus actually receiving the most benefit from subsidies. Tariff designs may in fact be made overly complicated in order to offset this reality and appear to be helping poorer households (Komives et al., 2005). Most fundamentally, poor households are often not connected to the W&S network at all and hence cannot receive the subsidized services. Even if they do have connections, the poor use less water than richer households, thus receiving lower absolute amounts of subsidy.

The estimates presented here are intended merely to suggest the likely magnitude of W&S costs in many developing countries. A reasonable question to ask is whether costs differ much across countries in the developing world and between industrialized and developing countries. Labor costs are obviously lower in developing countries, but because W&S projects are capital-intensive, this cost component has less of an impact on total costs than for other goods and services. To our knowledge there are no publicly available international indices of W&S project construction costs. To illustrate the magnitude of international cost differentials for some related goods and construction costs, Table 5 compares costs of rebar, cement, and industrial construction in eleven large cities in both industrialized and developing countries. Costs are indeed lower in cities such as New Delhi and Hanoi than in London and Boston, and lower costs for inputs such as cement and steel will translate into lower costs for W&S projects.

It is, of course, less expensive to provide intermediate levels of W&S services (such as public taps and communal sanitation facilities) than the costs in Table 2 would indicate. Monthly household costs for such services are, however, often quite considerable, roughly US$5 to US$10 per month for much smaller quantities of water and much lower levels of sanitation services. These costs are often reported to be as low as US$1.00 to US$2.00 per household per month, but such accounts often systematically underestimate key capital cost components and rarely reflect the real costs of financially sustainable systems.

Economic Benefits of Improved Water and Sanitation Services

There are four main types of information available where one can look for insight into the economic benefits households receive from improved municipal water and sanitation services: (1) prices charged for vended water, (2) avertive expenditures, (3) avoided costs of illness, and (4) stated preference studies.

Market Data: Water Vending

The first is the evidence on what households in developing countries are now paying water vendors . Table 6 shows some of the prices vendors have charged households in selected cities, and illustrates that many of these prices are in fact higher than our estimated costs of both improved water and sanitation services. Millions of households in developing countries are purchasing relatively small quantities of drinking and cooking water from vendors, and for many of these households the benefits of improved water services would typically exceed the costs.

The data on water vending must, however, be interpreted with caution. The vast majority of households in developing countries do **not** buy water from vendors. This fact tells us that for most people the perceived private benefits of vended water services (as measured by the household's willingness to pay) are *less* than the price a vendor would charge. Water vending data from selected World Bank's Living Standards Measurement Surveys for Ghana, Nicaragua, and Pakistan show that less than one percent of the sample households were purchasing water from vendors. In Cote D'Ivoire 15% of sample households were purchasing from vendors. The average household purchasing from water vendors was spending US$4.40 per month in Ghana, US$6.00 in Nicaragua, and US$7.50 in Pakistan (Table 7) –substantial amounts no doubt, but still probably less than the full economic cost of piped services. Only in Cote D'Ivoire was the monthly expenditure of households purchasing from vendors (US$13.90) probably greater than the full economic cost of improved piped water services. Of course, there are numerous places like Cote d'Ivoire where water vending is widespread, but in communities where vendors do not sell water, this is usually a clear signal that there is no market of such high-priced water vendor services.

Also, for some households improved piped water services are not an unambiguously better service than purchasing vended water. Water vendors offer an important advantage over networked piped water services: households have better (tighter) control over their water expenditures. If a child leaves a tap running, the household must pay for this water. This is no such financial risk if one purchases from vendors. Also, purchasing from vendors gives a household greater control over cash flow. If money is tight one month, the household can stop purchasing from vendors and perhaps collect water from a public tap at much less cost.

Avertive Expenditures: Coping Costs

A second source of information on the benefits of improved water supplies is evidence about the amounts of money households in developing countries spend coping with unreliable, poor quality public supplies. In many developing countries households spend considerable amounts of both time and money trying to improve the poor services to which they currently have access. Many households incur expenses installing household storage capacity to ensure that they have water when the pipes run dry. Others undertake a wide vary of activities to treat contaminated water in their home to make it safe to drink. These range from boiling, a common practice in many parts of Southeast Asia, to the installation of home filtration and disinfection systems. People incur time and expenses walking to water sources outside their home to collect water from public taps or unimproved, traditional water sources. Such "coping costs" should represent something close to a lower bound on the benefits households would receive from improved W&S services; a household might well be willing to pay considerably more for improved W&S services than what they are spending now trying to deal with the deficiencies in the status quo.

A recent study by Pattanayak et al (2005) attempts to quantify these "coping costs" for households in Kathmandu, Nepal. The existing public water system in Kathmandu is typical of the poor service in many Asian cities. About 70% of the population has a piped connection and receives low-quality water 1-2 hours per day. Households pay $1-2 per month for this poor water service. The other 30% of the population obtains its water from a combination of public taps, vendors, and private wells. Pattanayak and his colleagues estimated that the average monthly costs of coping with poor quality, unreliable water supplies were about US$4 per month. These estimates do not include the costs of coping with poor sanitation facilities, and coping costs may well be somewhat higher in other locations. However, neither these estimates nor others in the literature provide evidence that the costs of coping with poor quality W&S services are generally in excess of our estimates of the full economic costs of piped water services.

Avoided Costs of Illnesss

The third source of data on the benefits of improved W&S services is calculations of the avoided costs of illness of waterborne diseases. The logic is that many people currently become ill as a consequence of poor water and sanitation services, and as a result both the public sector health system and households incur a variety of costs, ranging from money spent on medicines, physicians' time, lost labor of the patient, and the lost labor of household members who take care of the patient. If W&S services were improved, the incidence of such waterborne diseases would be reduced, and these "costs of illness" would be avoided. Thus, the cost of illness avoided is one component of the benefits of the W&S improvements.

In some respects these COI avoided calculations are the least useful source for insight into the benefits of improved W&S improvements. It is widely understood by economists that these estimates of the COI avoided are lower bound estimates of the health benefits of W&S improvements because they do not include the economic value of either the pain and suffering associated an episode of illness, or the reduced risk of mortality. Neither do these COI estimates place any value on the nonhealth-related benefits of improved water supplies, such as reduced coping costs or time savings. Moreover, the avoided costs of illness cannot easily be added to the nonhealth related coping costs because coping costs incurred by boiling water or other disinfection methods also result in the reduced COI.

The avoided COI calculation is complicated by the fact that:

(1) for a given population, improved water and sanitation services result in a reduction in the number of infections of several major diseases, including typhoid, cholera, shigellosis, and rotaviruses; and

(2) improved water and sanitation services reduce but do not eliminate the risk of infection from these various diseases.[1]

Esrey (1996) found that probably the best one could hope for from improved W&S services would be a reduction in overall diarheal incidence by 30-40%. The effect of improved W&S

[1] Actually, this statement may be somewhat over-optimistic. Attempts to measure the health impacts of W&S have had a long and chequered history, as Cairncross (1990) has noted. Cairncross argues for the importance of *behavioral change* as a key factor in health impacts from W&S. He observes that, in those cases where a significant health impact was found, it was accompanied by improved hygienic behavior such as the washing of hands, food, and utensils. But, the change in behavior did not always occur and, without it, there was little health impact. Similar evidence that the provision of piped water is not a sufficient condition for improved child health is presented by Jalan and Ravallion (2003).

services on specific diseases in a specific location is still largely a matter of professional judgment and conjecture.

As a lower bound estimate of benefits, the *ex-ante* COI estimate (i.e. the expected value of COI, taking into consideration the incidence of the disease) would only tell us much if it were higher than the full economic costs of providing W&S services. In fact, most estimates of *ex-ante* COI estimates are rather low. To illustrate this point, we use as an example a recent calculation of the *ex-ante* COI of a case of typhoid in one of the poorest slums in New Delhi where the incidence of typhoid fever was probably as high as almost anywhere in the world. Bahl et al. (2005) estimated the *ex-ante* private and public COI for different age groups in this slum (Table 9). For a household of five, the total monthly *ex-ante* COI was about US$0.65 per month.

Because these *ex-ante* COI estimates are for a single disease (typhoid), they will be an underestimate of the total *ex-ante* COI avoided from improved W&S services. The World Health Organization estimates that roughly a quarter of the deaths due to poor water and sanitation in developing countries are due to typhoid fever. Assuming costs of illness of other water-borne diseases would be similar in magnitude to typhoid, one might crudely increase these *ex-ante* COI of typhoid by a factor of four (US$2.60 per household per month). But to obtain an estimate of the reduced COI avoided due to W&S, one would need to reduce this to reflect the fact that improved W&S services would only reduce the incidence by 35% (US$2.68 x 0.35 = US$0.91), or about US$1 per month per household.

This calculation is obviously extremely crude and is clearly inflated by the extremely high incidence of typhoid in this particular slum. In most locations in developing countries the incidence of typhoid would be one or two orders of magnitude less than in this particular slum, and the *ex ante* COI much lower than this estimate. However, the general point is that the empirical estimate of COI avoided is much less than the costs of improved W&S services, and, contrary to conventional wisdom in the sector, does not provide much economic justification for W&S investments.

Stated Preferences: Household Willingness to Pay for Improved Water and Sanitation Services

A fourth source of evidence on the perceived household economic benefits of improved W&S services in developing countries comes from a few dozen studies conducted over the last 18 years in which households were asked directly whether improved W&S services would be worth a specified amount per month (i.e., whether the household would be willing to pay a specified monthly water bill if they could be assured of receiving higher quality services).[2]

At the time these CV surveys began to be conducted in developing countries in the mid-1980s, W&S professionals commonly believed that households in developing countries were too poor to pay anything for improved W&S services. The CV surveys revealed that people were in fact often willingness to pay considerably more for improved W&S services than anyone then expected. In some instances the results of these CV surveys were used for financial analysis of water utility operations, not for cost-benefit analysis of new investments. Some W&S sector professionals were delighted to incorporate this evidence from CV surveys and from water vending surveys into a new conventional wisdom that held (1) people were willing and able to pay higher tariffs for improved W&S services; (2) tariffs could be raised; and (3) private operators could recover the full costs of providing W&S services.

Actually the CV surveys of household demand for improved W&S services did not suggest that households' perceived economic benefits of improved W&S services would commonly exceed the full economic costs of providing W&S services. Indeed, as some selected CV results for improved water services shown in Table 10 illustrate, households' stated willingness to varied a great deal from place to place, and in many cases was far below the costs of providing improved services. For those skeptical of the accuracy of CV estimates, the fact that

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[2] Many economists are in fact skeptical of the validity of such "contingent valuation" (CV) surveys because respondents do not actually have to do what they say to the interviewer (i.e., face a real budget constraint). In some cases however, as Griffin et al. (1995) demonstrate, stated preference using CV can provide the researcher with a better prediction of behavior than revealed preference

even hypothetical WTP for improved W&S services was so low in some places raises serious doubts as to whether the perceived private economic benefits exceed the full economic costs.

On the other hand, some CV studies revealed quite high household WTP for improved services. CV studies for improved water services from a small market town in Uganda and from Kathmandu revealed expressed willingness to pay by many households for improved water services of US$10 per household per month, probably close to the full economic costs of providing modest amounts of water. CV studies for improved sanitation services conducted in Latin America (Russell et al., 2001) revealed much higher WTP (e.., US$10 per household per month) than CV studies in Africa and Asia (Whittington et al. 1993, Choe et al., 1996) where willingness to pay was often extremely low, e.g., US$1-2 per household per month .

The economic goal of an investment project is not of course to have benefits equal to the costs, but to have benefits *exceed* the costs. We know of no CV studies from anywhere in the developing world that show that a majority of a city's population would be willingness to pay substantially *more* than the full economic costs of supplying W&S services.

Comparing Costs and Benefits

Table 11 summarizes some of these benefit and cost estimates for Kathmandu, Nepal. As shown, there is little to suggest that the current monthly benefits *exceed* the monthly costs. The results of such benefit-cost calculations may be quite different for other locations, but for many places they are likely to look much worse. WTP for improved services in Kathmandu is much higher than in similar CV studies elsewhere.

Such simple comparisons of monthly household costs and benefits have not, however, persuaded many people that development aid for improved water and sanitation services is unwise or unnecessary. Advocates for increased aid for water and sanitation services in developing countries see five main problems or limitations with the kind of cost-benefit calculations presented in Table 11.

First, they argue that cheap, more appropriate technology can result in much lower unit cost estimates. In fact, it is true that handpumps and improved ventilated pit latrines are considerably cheaper than networked water and sewer services, but it is clear from the results of the CV surveys that the perceived benefits of such “intermediate” service levels are also much lower. People are willing to pay much less for access to public taps and handpumps than they are for an in-house water and sewer connection, so both the benefits and the costs of simpler technologies are lower.

Second, advocates for increased aid for W&S investments argue that households’ *perceived* economic benefits are not accurate reflections of the *actual* benefits people will received from improved services. Many health professionals do not believe that people have an adequate understanding of the link between improved W&S services and human health, and thus *ex-ante* undervalue W&S services.[3] They posit that *ex-post* households will fully appreciate the health benefits, but that it is unrealistic to expect that households will understand these benefits *ex-ante*. *Ex-ante* preferences, however they are measured, are thus not a sound guide to *ex-post* benefits. In effect, they contend that the CV estimates of willingness to pay for improved services are too low. From this perspective, it is the role of the health professionals and government to provide households improved W&S services because it is good for them and they will appreciate it later.

A related argument is based on the observation that poor people cannot clearly assess the value of future reductions in health risk and have very high rates of time preference. They thus put little value on the stream of benefits provided by W&S investments that may extend far into the future. Some people feel that it is the role of the state to override such “misguided” preferences and act to protect the welfare of both existing and future generations.

[3] But see our caveat in footnote 1 about whether there is actually solid empirical evidence that improved W&S is a sufficient condition for an ex post improvement in health.

Third, proponents argue that there are positive health externalities associated with W&S investments that are not captured by estimates of individual households' benefits (Ali et al., 2005). This public goods argument would seem to be much stronger for sanitation than for improved water services, but empirical evidence on the magnitude of the economic value of the positive health externalities associated with sanitation improvements is quite limited. Moreover, even the private health benefits of improved water and sanitation investments are not as clear-cut or dramatic as many people often assume. There are numerous pathways for pathogens to infect people in a poor community besides contaminated drinking water, and in some situations bringing clean piped water but not improved sanitation to houses can even exacerbate the spread of infectious agents.

Fourth, the economic benefits of improved water and sanitation are not limited to households. Businesses and industries need piped water for many kinds of activities. Of particular importance to understanding the economic value of piped water and sanitation services is the macroeconomic risk economies can face from outbreaks of diseases such as cholera. The emergence of SARS in 2003 and the recent cholera outbreak in Peru illustrate how epidemics can cause havoc with general macroeconomic conditions by curtailing travel, tourism, trade, and investment. Because improved water and sanitation services improve long-run health conditions, they represent a form of insurance against macroeconomic shocks. However, the evidence that improved water services greatly enhance business productivity and that business enterprises value improved W&S services much more highly than households is largely a matter of conjecture. Davis et al. (2001) find that businesses in a small market town in Uganda actually place very little value on improved water services

Fifth, investments in improved W&S investments provide developing countries economic benefits in the form of another kind of insurance. W&S investments are an important means of diversifying a development aid portfolio. A water supply reservoir and transmission line is likely to provide a city raw water through both good economic times and bad. Unlike some forms of development assistance that only deliver benefits if economic growth is strong, water and sanitation supply projects tend to be less sensitive to cyclical changes in the business cycle. They thus provide households with a valuable service when they need it most.

There is little in the literature on the empirical magnitude of these five types of “additional” economic benefits. Proponents argue that such “intangible” benefits easily tip the balance in favor of increased investment in improved W&S services, but this may be just special pleading. Advocates of most other forms of development aid also argue for unquantifiable positive externalities, poor household understanding of the “true” benefits of specific development projects, unquantified macroeconomic benefits, and benefits from portfolio diversification.

Moreover, proponents of increased water and sanitation investment only rarely explicitly address the investment risk that the W&S projects will fail. In fact, W&S investments have been particularly prone to failure. The benefit-cost comparison above is based on the assumption that the W&S investments will, in fact, deliver high-quality services and positive health outcomes. For example, the CV estimates of households’ willingness to pay for improved W&S services are *contingent* on the provision of potable, 24-hour water supply actually reaching the household. If the W&S project does not deliver this level of service, then the CV estimates of household benefits will be much too high. Sadly, experience has shown that many W&S investments in developing countries do in fact fail by almost any measure of success. This risk of project failure must also be factored into any systematic assessment of costs and benefits.

Discussion

From our perspective, the biggest limitation of the kind of benefit –cost calculation presented in Table 11 does not lie with the five types of proposed intangible benefits discussed listed above. It is rather that the benefit stream associated with capital-intensive W&S investments is assumed to be static. In fact, the benefits that flow from W&S investments may growth over time, due largely to economic growth. As illustrated in Figure 1, there is a strong association between household income and the provision of both piped water and sewer services. There is limited evidence, however, that investments in municipal W&S services actually *cause* economic growth.[4] Higher-income households definitely want improved W&S services, and, as incomes grow, the demand for such services grows. So even in the absence of a causal relationship, the benefit stream of W&S services becomes more valuable as economic growth proceeds.

Even though the benefits of improved W&S services increase with economic growth, they must still be discounted back to the initial period to compare the present value of the benefit stream with the high initial capital costs and the present value of the operation and maintenance expenditures. The magnitude of the present value of the benefit stream is very sensitive to the discount rate chosen. This is an old, well known problem in the economic appraisal of water infrastructure projects. How the growth in the demand for W&S services affects the cost-benefit analysis of a W&S investment project is largely determined by the relative magnitude of three parameters: (1) the rate of economic growth over the planning period, (2) the elasticity of WTP with respect to income, and (3) the discount rate (Whittington et al. 2004).

In practice it has proved almost impossible for national governments or donor agencies to conduct rigorous economic appraisals of W&S projects that address this level of complexity. As Hirschman pointed out,

> The trouble with investment in social overhead capital (*e.g., water and sanitation investments*) . . . is that it is impervious to investment criteria. . . . As a result social overhead capital is largely a matter of faith in the development potential of a country or region. . . . Such a situation implies at least the possibility of wasteful mistakes. (1958, p. 84, emphasis added)

This is precisely what we have witnessed in the water and sanitation sector, where "white elephants" and poorly performing projects have been a standard feature of the sector landscape

[4] The available evidence for the United States is mixed but generally negative; for a summary, see Hanemann (2006).

(Therkildsen, 1988). Whenever it appears that a particular project might not pass a cost-benefit test, water professionals appeal to intangible benefits to argue that the investment will in fact pass the test.[5]

In conclusion, it is not our intention to imply that all investments in municipal W&S infrastructure will fail a rigorous economic test. Indeed, we expect the benefits of many projects, properly estimated, to exceed the costs. But it is not helpful for sector professionals to present inflated calculations that show that benefits exceeding costs by an order or magnitude or more. The economic reality is typically more nuanced and the attractiveness of W&S investments less clear-cut. Especially in situations where long-term macroeconomic economic growth prospects are uncertain or even unlikely, large capital investments in municipal W&S infrastructure should often be viewed with considerable skepticism.

[5] This is particularly the case in the evaluation of rural W&S investments in developing countries, where neither donors nor national agencies attempt serious project appraisal of W&S projects.

References

Ali, M., M. Emch, L. Von Seidlein, M. Yunus, D. Sack, M. Rao, J. Holmgren, J. Clemens (2005). "Herd immunity conferred by killed oral cholera vaccines in Bangladesh: a reanalysis." *Lancet*. 366: 44-49.

Altaf, A., D. Whittington, V. K. Smith, and H. Jamal. (1993). "Rethinking Rural Water Supply Policy in the Punjab, Pakistan." *Water Resources Research*. Vol. 29, No. 7, July. pp. 1943-1954.

Briscoe, J., P. Furtado de Castro, C. Griffin, J. North, and O. Olsen. (1990). "Toward Equitable and Sustainable Rural Water Supplies: A Contingent Valuation Study in Brazil." *The World Bank Economic Review*. Vol. 4, No. 2. pp. 115-134.

Cairncross, A.M. (1990) "Health Impacts in Developing Countries: New Evidence and New Prospects." *Journal of the Institute of Water & Environmental Management*,4 (6) 571-577.

Choe, K., D. Whittington, and D.T. Lauria. (1996). "The Economic Benefits of Surface Water Quality Improvements in Developing Countries: A Case Study of Davao, Philippines." *Land Economics*. Vol. 72, No. 4. November. 519-537.

Davis, J., A. Kang, J. Vincent, and D. Whittington. (2001). "How Important is Improved Water Infrastructure to Microenterprises? Evidence from Uganda." *World Development*. October, 2001 issue. 29:10.

Davis, J. (2004). Corruption in public services delivery: Experience from South Asia's water and sanitation sector. *World Development, 32.1*, 53–71.

Bahl, R., A. Sinha, C. Poulos, D. Whittington, S. Sazawal, R. Kumar, D. Mahalanabis, C. J. Acosta, J.Clemens, M.K. Bhan. "Costs-of-illness of typhoid fever in Indian urban slum community: implications for vaccination policy." *Journal of Health, Population, and Nutrition.* Vol. 22, No. 3, pp. 304-310, 2004.

Esrey, Steven. (1996). "Water, Waste, and Well-being: A Multicountry Study." *American Journal of Epidemiology*. Vol. 43, No. 6. pp. 608-623.

Griffin, C., J. Briscoe, B. Singh, R. Ramasubban, and R. Bhatia. (1995). "Contingent Valuation and Actual Behavior: Predicting Connections to New Water Systems in the State of Kerala, India." *The World Bank Economic Review*. Vol. 9, No. 3, pp. 373-395

Hanemann, W. M. (2006) "The Economic Conception of Water" in P. P. Rogers, M. R. Llamas, and L. Martinez-Cortina (eds) *Water Crisis: Myth or Reality?* Taylor and Francis, 61-91.

Hirschman, A. (1958). *The strategy of economic development*. New Haven: Yale University Press.

Jalan, J. and M. Ravallion (2003), "Does Piped Water Reduce Diarrhea for Children in Rural India?" *Journal of Econometrics*, (112), 153-173.

Komives, K., D. Whittington, and X. Wu. (2003). Infrastructure coverage and the poor: A global perspective. Chapter 3 (pp. 77–124) in *Infrastructure for poor people: Public policy for private provision*. Edited by P. Brook and T. Irwin. The World Bank Public-Private Infrastructure Advisory Facility.

Komives, K., V. Foster, J. Halpern, and Q. Wodon. (2005). *Water, electricity, and the poor: Who benefits from utility subsidies?* Directions in Development. Washington D.C.: World Bank.

Komives, K., B. Akanbang, R. Thorsten, B. Tuffuor, M. Jeuland, W. Wakeman, E. Larbi, A. Bakalian, and D. Whittington. (2006). Post-construction support activities and the sustainability of rural water projects in Ghana. Report to the World Bank. Draft.

Lomborg, B. (editor) (2004) *Global Crises, Global Solutions*. Cambridge University Press.

Lovei, L., and D. Whittington. (1993). Rent-seeking in the water supply sector: A case study of Jakarta, Indonesia. *Water Resources Research, 29.7* (July), 1965–1974.

Pattanayak, S. J.C. Yang, D. Whittington, and B. Kumar. (2005). "Coping with Unreliable Public Water Supplies: Averting Expenditures by Households in Kathmandu, Nepal." *Water Resources Research*. Vol. 4, No. 2, Feb. 2005. W02012. 11 pages.

Priscoli, J.D. (2000). "Water and civilization: using history to reframe water policy debates and to build a new ecological realism." *Water Policy.* Volume 1, Issue 6, 9 March. 623-636.

Russell, C., W. J. Vaughan, C. D. Clark, D. J. Rodriguez, and A. Darling. (2001). *Investing in Water Quality: Measuring Benefits, Costs and Risks*. Inter-American Development Bank.

Therkildsen, Ole. (1988). *Watering white elephants: Lessons from donor-funded planning and implementation of rural water supplies in Tanzania*. Uppsala: Scandinavian Institute of African Studies.

Whittington, D., M. Mujwahuzi, G. McMahon and K. Choe (1988). *Willingness to Pay for Water in Newala District, Tanzania: Strategies for Cost Recovery*. WASH Field Report No. 246. October. Washington, D.C.: USAID Water and Sanitation for Health Project. 57 pages plus appendices.

Whittington, D., J. Briscoe, X. Mu, and W. Barron. (1990). "Estimating the Willingness to Pay for Water Services in Developing Countries: A Case Study of the Contingent Valuation Method in Haiti." *Economic Development and Cultural Change*. January, Vol. 38, No. 2, pp. 293-311.

Whittington, D., D.T. Lauria, A.M. Wright, K. Choe, J.A. Hughes, and V. Swarna. (1993). "Household Demand for Improved Sanitation Services in Kumasi, Ghana: A Contingent Valuation Study." *Water Resources Research*. Vol. 29, No. 6. pp. 1539-1560

Whittington, D., J. Davis and E. McClelland. (1998). "Implementing a Demand-driven Approach to Community Water Supply Planning: A Case Study of Lugazi, Uganda. *Water International*. Vol. 23, pp. 134-145.

Whittington, D., S. Pattanayak, J.C.Yang, and B.Kumar. (2002). "Household Demand for Improved Piped Water Services in Kathmandu, Nepal." *Water Policy*. Vol. 4, Issue 6. pp. 531-556.

Whittington, D., D. T. Lauria, V. Prabhu, and J. Cook. (2004). "An Economic Reappraisal of the Melamchi Water Supply Project, Kathmandu, Nepal." *Portuguese Journal of Economics*. Vol. 3, No. 2, 2004.

Table 1. Cost estimates: improved water and sanitation services

No.	Cost component	US$ per m^3	% of total
1	Opportunity cost of raw water supply	0.05	2%
2	Storage and transmission to treatment plant	0.15	6%
3	Treatment to drinking water standards	0.15	6%
4	Distribution of water to households (including house connections)	0.75	30%
5	Collection of wastewater from home and conveyance to wastewater treatment plant	1.00	40%
6	Wastewater treatment	0.35	14%
7	Damages associated with discharge of treated wastewater	0.05	2%
	Total	2.50	100%

Table 2. Cost estimates: improved water and sanitation services for low-cost option for private water and sewer connections

No.	Cost Component	US$ per m^3
1	Opportunity cost of raw water supply (steal it)	0.00
2	Storage and transmission to treatment plant (minimal storage)	0.10
3	Treatment of to drinking water standards (simple chlorination)	0.05
4	Distribution of water to households (PVC pipe)	0.30
5	Collection of wastewater from home and conveyance to wastewater treatment plant (condominial sewers)	0.35
6	Wastewater treatment (simple lagoon)	0.20
7	Damages associated with discharge of treated wastewater (someone else's problem)	0.00
	Total	1.00

Table 3. Range of estimates of monthly water use (in-house, private connection)

Per capita daily water use	Persons per household	Days per month	Monthly household water use
55 liters	6 persons	30 days	10 m^3
110 liters	6 persons	30 days	20 m^3
220 liters	6 persons	30 days	40 m^3

Table 4. Range of estimates of the full economic cost of providing improved W&S services (in-house, private water connection; piped sewer)

Monthly household water use	Average cost = US$1 per m^3	Average cost = US$2.50 per m^3
10 m^3	US$10	US$25
20 m^3	US$20	US$50
40 m^3	US$40	US$100

Table 5. Comparison of costs of rebar, cement, and industrial facility construction in 11 cities

City	Rebar (US$/ton)	Cement (US$/ton)	Industrial Construction (US$ per m^2)
London	981	96	850
Boston	1100	85	915
Los Angeles	992	135	699
Shanghai	435	43	592
Jakarta	528	68	269
Bangkok	482	63	301
Hanoi	349	62	409
New Delhi	600	64	247
Durban	1028	137	516
Nairobi	n.a.	n.a.	291
Buenos Aires	765	82	n.a.

Source: *Engineering News Record* (2004).

Table 6 - Examples of Prices Charged by Water Vendors – Selected Countries

Continent	Location	Type of Water Vendor	Price of Water (Dry season)
Africa	Ukunda, Kenya	Distributing vendor	US$9.40 per m^3
Central America	Tierra Nuevo, Guatemala	Tanker truck	US$2.00 per m^3
Asia	Delhi, India	Distributing	US$6.00 per m^3
Asia	Jakarta, Indonesia	Tanker truck	US$1.80 per m^3

Table 7 - Median Monthly Household Expenditures on Water (1998 US$)

	Households with in-house piped water connection	Households purchasing from water vendors
Cote d'Ivoire	US$12.40	US$13.90
Ghana	US$4.90	US$4.40
Nicaragua	US$4.60	US$6.00
Pakistan	US$1.00	US$7.50

Table 8 - Averting Expenditures-Coping Costs: Kathmandu, Nepal (US$ per month)

[Averages for 1500 households – 2001]

Type of Coping Cost	HHs with piped connection	HHs without piped connection
Collection (time spent)	US$1.57	US$1.60
Pumping	US$0.50	US$0.46
In-house treatment	US$0.78	US$0.83
In-house storage	US$1.22	US$1.29
Total	US$4.07	US$4.18

Table 9 - *Ex-Ante* costs of illness of typhoid – New Delhi slum (US$ per month)

Age group	Private	Government (Public Sector)	Total
0-2 yr.	US$0.07	US$0.04	US$0.11
2-5 yr.	US$0.13	US$0.42	US$0.55
5-19 yr.	US$0.08	US$0.04	US$0.12
≥ 19 yr.	US$0.03	US$0.03	US$0.06
All ages	US$0.06	US$0.07	US$0.13

Table 10 - Households' Willingness to Pay for Water Services: A Summary of Eight Contingent Valuation Studies

Author(s)	Study Location	Date of Study	Monthly WTP for Public Tap (unconnected HH)	Monthly WTP for new private connection	Monthly WTP for improved service
Whittington et al. (1990)	Rural Haiti	1986	US$1.10	US$1.40	
Whittington et al. (1988)	Rural Tanzania	1987	US$0.32		
Briscoe et al. (1990)	Rural Brazil	1988		US$4.00	
Altaf et al. (1993)	Rural Pakistan	1989		US$1.50	
Whittington et al. (1993)	Kumasi, Ghana	1989		US$1.50	
Griffin et al. (1995)	Rural India	1989		US$1.38	
Whittington et al. (1998)	Lugazi, Uganda	1994	US$3.70	US$8.63	
Whittington et al. (2002)	Kathmandu, Nepal	2001	US$3.19	US$11.67	US$14.35

Table 11 – Comparing Monthly Costs and Benefits of Improved W&S services

(US$ per household per month)

Benefits	**Costs**
Reduced water vending expenditures – minimal	US$20
Coping costs avoided - US$4	
COI avoided - < US$1	
CV estimate of WTP – US$11-14	

Note: Benefit estimates can be summed to obtain total benefits.

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