The Financial Sustainability of Water Supply and Sanitation Services: A Framework for Analysis

BY

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ABSTRACT

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This paper outlines a framework that will facilitate the assessment of the financial sustainability of proposed improvements in water and sanitation facilities. Financially sustainable services are those in which the revenues generated from the service users exceed the cost of providing the service. This analytical framework identifies the levels or amounts of the service that can be financially self-supporting. It will also reveal the extent of any subsidy that would be required for levels of the service at which the costs to provide the service exceed the revenues that can be generated. The framework that is used is the conventional supply and demand model of microeconomic theory. Three case studies illustrate how data from contingent valuation surveys can be readily brought into this framework.

Acknowledgements

Research for this paper was funded under the US AID-sponsored Environmental and Natural Resources Policy and Training (EPAT/MUCIA) project. I conducted this work under the supervision of Dr. John Hoehn. A major objective of Dr. Hoehn's work for the EPAT project is to explore how the techniques of Environmental Economics can be applied in the developing country context. In this paper, I examine how the contingent valuation (CV) methodolgy can be used to evaluate the financial sustainability of water and sanitation services. A shorter version will appear as a Policy Brief publication of the EPAT/MUCIA project.

Thanks are due to my advisor, Dr. John Hoehn, Agricultural Economics Department, Michigan State University, for advice at every step in this paper; to Dr. Eric Crawford and Dr. Allan Schmid, Agricultural Economics Department, Michigan State University, for their advice and comments; and to the following graduate students in the Agricultural Economics Department, Michigan State University, for their comments on earlier drafts: Heinz Jansen, Patrick Diskin, Niama Dembele, Paul Strasberg, Bernard Kupfuma, Greg Heikes, Wayne Roberts, Eric Scorsone. This paper is dedicated to my parents for their support in all my endeavors.

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I Introduction

There is a growing concern that urban services in less developed countries be more financially sustainable. Water-supply and sanitation services are often unable to financially support themselves once initial project funding is used up. Whittington notes that "many sewerage systems have been built that people cannot afford to connect to and are thus not being used. Users are often unable to pay for even the operation and maintenance of large sewerage systems" (1991). For water and sanitation projects to be more successful, it is critical that the economic analysis addresses the question of sustainability.

This paper outlines a method for evaluating the financial sustainability of proposed improvements in water and sanitation facilities. Sustainability is determined by comparing potential revenues with the cost of providing the service. The framework used in this paper is based on the supply and demand model of micro-economic theory. This analytical framework identifies the levels or amounts of the service that can be financially self-supporting. Where costs exceed revenue potential, it also indicates the extent of the subsidy required to provide those levels of service.

I.i The sustainability problem

Two factors are forcing the need to increase the local-sustainability of water and sanitation services. First, external sources of funding for local water and sanitation projects are limited. As Whittington notes, "many central governments in LDCs simply do not have the financial resources to subsidize urban sewerage systems for everyone." Many projects will have to be more self-supporting at the community level.

Second, many times in the past, water and sanitation services have been implemented without asking people what they want, in terms of the type and quality of service, and what they are willing to pay to receive this. The planning process needs to be changed "to one that takes account of the demands of the beneficiaries" (Briscoe, 1990). Services for which people are willing to pay are more clearly the services that they will use.

II A Conceptual Framework

II.i Contingent Valuation

The information that Whittington and Briscoe insist on is the willingness to pay (WTP) for services. A community's willingness to pay (WTP) for services can be measured using contingent valuation (CV). A CV survey asks a sample of people in the community to state the most that they are willing to pay to receive the benefit or service in question[1]. Contingent valuation studies are appealing because of their flexibility. They have the potential to measure WTP for any proposed new service, and in communities that vary widely in socio-economic and demographic characteristics. There is growing evidence to support the validity, or reliability, of data derived by the contingent valuation method (Mitchell and Carson, 1989; Hoehn and Krieger, 1988).

II.ii Contingent valuation and the demand curve of micro-economic theory

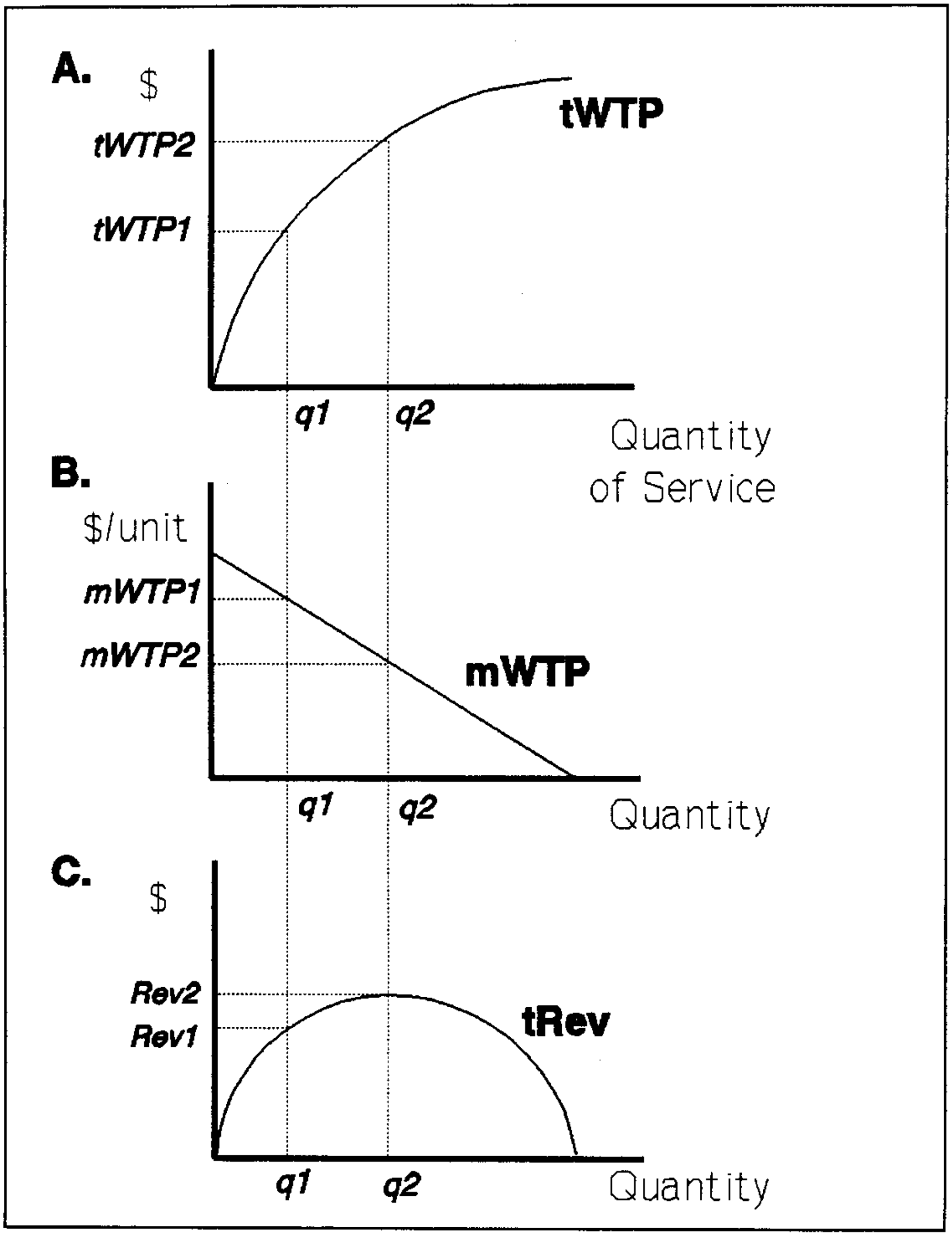
The *total willingness to pay* (total WTP) of the community can be estimated from the data collected in the CV survey. It is the sum of the individual WTP values of the entire population (Mitchell and Carson, 1989). A total WTP curve,

1 Usually, there is an introductory section that describes the good or service to be valued, and clarifies issues such as how the service would be implemented and how payment would be made. This is then followed by the WTP solicitation section. There are a number of ways in which a CV questionnaire can solicit a statement of householders' maximum WTP for proposed improvements in their water supply or sanitation facilities. A questionnaire with an "open ended" format might ask "what is the maximum that you would pay for this service?". Another approach is the "bidding game" which is usually an iterative procedure where the respondent is asked to accept or reject specified bids for the service.

also known as a Bradford Bid curve (for example, Brookshire, Randall and Stoll, 1980) is shown in figure 1a. In this figure, the quantity of the good or service bought or consumed is shown on the horizontal axis, and the total amount that the community is willing to pay is shown on the vertical axis. An example of the "quantity of service" is the number of households that choose to connect to a proposed municipal water supply system, or a municipal sewer system. The WTP for this service is usually in terms of a monthly fee for the service. In figure 1 we look at the implications of the connection of two different numbers of households to the municipal service, q1 and q2 customer-connections. If q1 customers connect to the system their total WTP is $tWTP_1$. If q2 customers connect to the system their total WTP is $tWTP_2$. We can see in figure that total WTP increases with the quantity of service used, Q, or, in this case, with the number of households connecting; that is, **WTP = f(Q)**.

The *marginal willingness to pay* (mWTP) is the value to the community of adding one more customer-connection. It is the slope, or derivative, of the total WTP curve, **dWTP / dQ**, and is shown in figure 1b. The horizontal axis is the quantity of service (in the example above, the number of households connected); the vertical axis is the WTP per unit of the service. The slope of the total WTP curve at q1 (or the marginal WTP at q1) is $mWTP_1$ in figure 1b. The slope of the total WTP curve at q2 level of service is $mWTP_2$. For low, or initial, quantities of the service the slope is steep as it is at q1. It becomes gradually less steep and, as total WTP becomes flat, or plateaus, mWTP approaches zero.

Figure 1. Total WTP, marginal WTP and potential total revenues, conditional on uniform (non-discriminatory) pricing.



The *demand curve* of microeconomic theory is typically plotted as the price that people pay for a good or service, which is the payment per unit of a good or service, over a range of specified total amounts purchased. This price-quantity curve is what we have in figure 1b: the marginal willingness-to-pay curve is also the demand curve[2] for the service. In the typical case of a downward-sloping demand curve, the marginal, or incremental, WTP for a service declines as the quantity of the service utilized increases.

An estimate of *potential total revenues* can be derived from the demand curve, or the mWTP curve. This model is simplified with a pricing policy assumption that one price will be charged to all service users; that is, there is no price discrimination. For any given number of household-connections, the most that all users are willing to pay to receive the service is the mWTP. The maximum revenue that can be generated at this quantity of service (if all users are to pay the same amount for the service - that is, with non-discriminatory pricing) is given by: the Quantity of Service times the mWTP; that is, **tREV = Qx times mWTP(Qx)**. This yields a potential total revenue curve as in figure 1c. For example, if q1 customers were to use the service, the potential total revenues with non-discriminatory pricing would be (q1 times $mWTP_1$) dollars per month. This amount of revenues is represented in figure 1c as REV_1. Similarly, if q2 customers were to use the service, the potential total revenues would be (q2 times

2 The marginal WTP curve is the Hicksian demand curve, or compensated demand curve. Contingent valuation measures WTP for goods and services in the context of constant utility.

$mWTP_2$) dollars per month. This amount of revenues is represented in figure 1c as REV_2. In these two cases, $mWTP_1$ and $mWTP_2$ of figure 1b would be the (non-discriminatory) prices charged to all users for the service.

II.iii The financial sustainability of projects

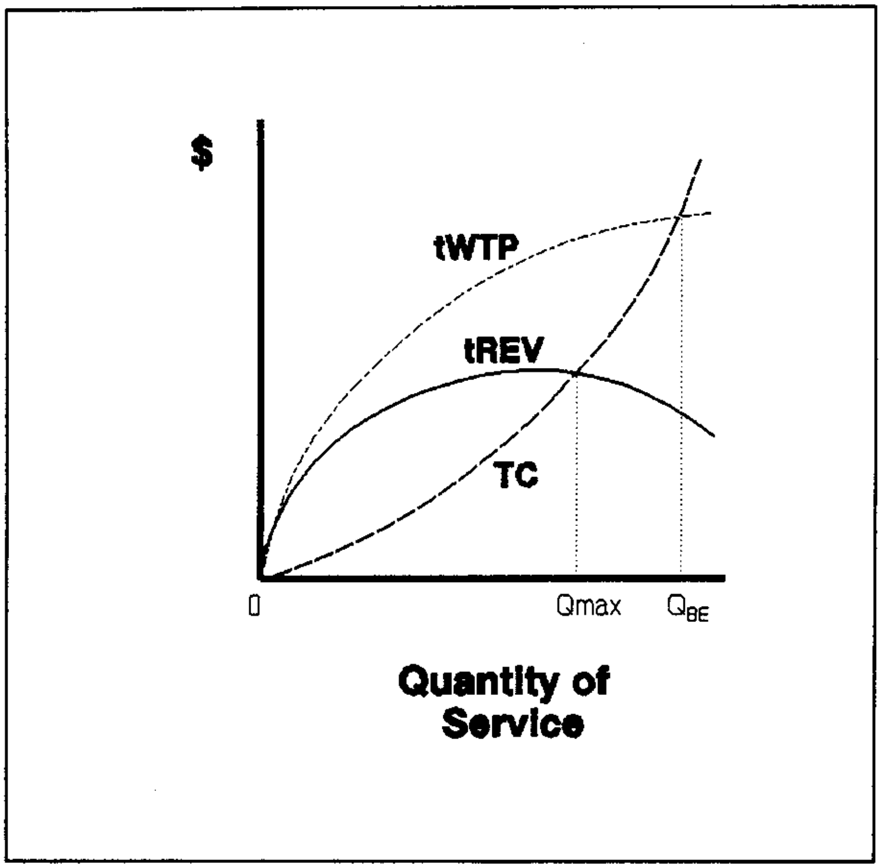
Figure 2 plots total revenues and total costs[3] for a hypothetical water supply service. As in the example above, one unit of the service can be thought of as a household connection to a municipal water supply system. In this figure we can determine whether there are levels of provision at which the service can pay for itself. The service will pay for itself if the revenue collected from the users equals or exceeds the cost to provide the service[4]. Where a project is not financially self-supporting, the framework helps to estimate the extent to which costs will exceed revenues for specified amounts of the service provided and at specific prices charged.

The maximum level of the service that will be financially self-supporting is the largest quantity of the service provided at which the total revenue generated is equal to the total cost to provide that level of service. This quantity of the service

3 This is a schematic representation of the total cost curve. It does not indicate initial capital costs which may be incurred, for example, where infrastructure for the water supply or sewerage system is needed. Also, there is no effect of increasing returns to scale indicated above, which would yield a flatter, or a declining, marginal cost curve.

4 These revenues may be user fees, for example, on a monthly basis for a water or a sewer connection or on a per volume basis for water use. The costs to provide the service include the operating and maintenance costs, and possibly the repayment of a loan used to establish the service. See section IV of this paper for further discussion on the costs of services in the evaluation of financial sustainability.

Figure 2. Total revenue and total cost curves (total WTP superimposed).



is Qmax in figure 2. In this figure, the quantities from 0 to Qmax amounts of the service can be financially self-supporting. In this range of quantities of the service total revenues exceed total costs. If the service is provided at any level greater than Qmax, the increase in the cost incurred will be greater than any increase in revenue that will occur; in that case, the framework will indicate the extent of any subsidy that would be needed to provide the service at levels greater than Qmax.

In figure 2, the total WTP curve is superimposed. It is seen that the total potential revenue (tREV) curve with a non-discriminatory pricing policy lies below the total WTP curve. If it were possible to have perfect price discrimination, that is, where each household paid the most that they were willing to pay for the service, these two curves would be equal. Depending in the actual pricing mechanism the actual tREV curve may lie somewhere between the total WTP curve and the tREV curve of non-discriminatory pricing. With increasing ability to discriminate, or to have service users pay at the level of their WTP for the service, the tREV curve will move up closer to the total WTP line.

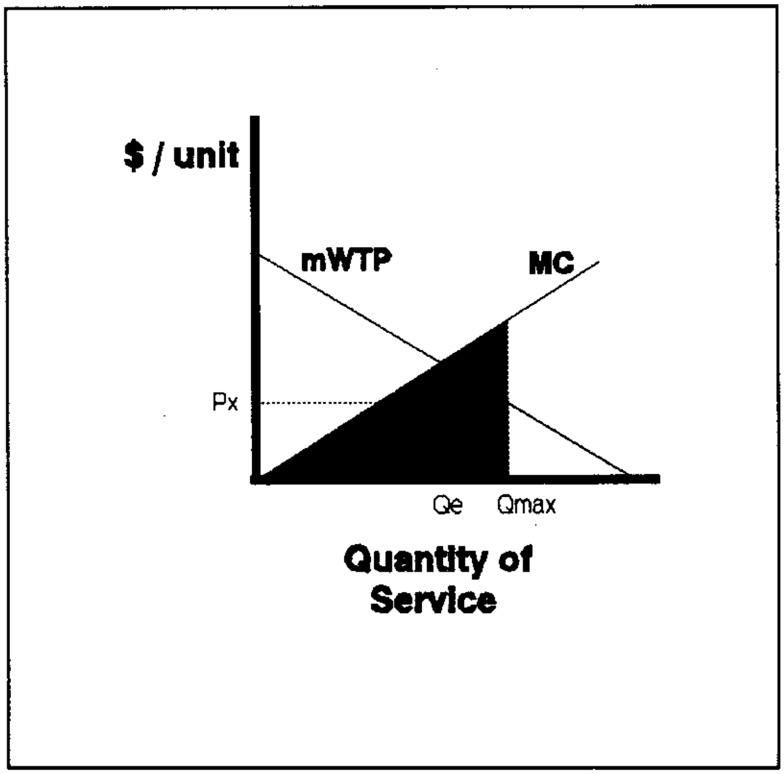
II.iv Financial sustainability and Benefit Cost Analysis

We can also make some observations about the relationship between Benefit Cost Analysis (BCA) and the analysis of financial sustainability from figure 2. BCA compares the (net present value of the stream of) total benefits with the (net present value of the stream of) total costs of a proposed project. In figure 2 these two measures are indicated by the total WTP and the TC curves, respectively. The breakeven point in a BCA is the quantity of service at which total benefits will equal total costs; this is Q_{BE} in figure 2. If the service proves to be financially self-supporting over some range of quantities (of service provision), then total benefits will also be greater than or equal to total costs at those levels of service provision; this is because the value of total benefits always equals or exceeds potential total revenues. However, the reverse is not necessarily true: even though there may be some range or level of the service that proves to be financially self-supporting, then it does not follow that all levels of provision at which benefits exceed costs will be self-supporting. In figure 2, total benefits exceed total costs for the quantities of service provision between Qmax and Q_{BE}, but these levels of service will not be financially self-supporting: total costs exceed total revenues for these quantities of the service.

II.v Financial sustainability and microeconomic theory

The marginal cost (MC) and marginal WTP curves for a water supply service are shown in figure 3. Marginal WTP is the slope of the total WTP curve, and MC is the slope of the total cost curve of figure 2. Qmax still defines the maximum level of the service that will be financially self-supporting. At Qmax, the most that all customers are willing to pay for the service is the marginal WTP at Qmax, which is shown as Px dollars per month in figure 3. Therefore, with non-discriminatory pricing, the potential total revenue with Qmax customer-connections equals the area (Qmax times Px) dollars per month. The total cost to provide Qmax is the area under the marginal cost curve at Qmax, the area ade, which is shaded in figure 3. At Qmax, the total costs equal the revenue generated; that is, area ade equals area (Qmax times Px) dollars per month.

Figure 3. Marginal WTP and marginal cost.



Often in the economic analysis of providing a public good or service we are interested in the quantity at which welfare is maximized. This is the "pareto-efficient" point, and it occurs at the level of service where the marginal cost of providing the good or service equals the marginal WTP; in figure 3, this is at Qe level of service. However, in the analysis of financial sustainability (AFS), the maximum self-sustaining level of service, Qmax, is independent of the pareto-efficient point. Qmax is a breakeven point in AFS, and in figure 3 this is at a quantity of service that is greater than the efficient level.

If there is any range or level of the service that proves to be financially self-supporting, then the efficient level of provision will also be self-supporting.

How can we know this? Assume the service is provided at some financially sustainable level, Qs, greater than Qe; that is, between Qe and Qmax in figure 3. At this quantity of service, the marginal cost is greater than the marginal WTP. In other words, the cost to provide the last unit of the service exceeded the revenue generated from that unit of the service. If the provision of the service had been at one unit less than Qs, the implied cost savings would exceed the revenue foregone, and the system would financially better off. This would be true until the marginal cost equals the marginal WTP. Further reductions in service provision (below Qe) would make the system financially worse off. In other words, if the system is operating below Qe, it can become financially better off by increasing service coverage, up to the level Qe. The efficient point defines the level at which total revenues exceed total costs by the greatest amount.

III Contingent Valuation Case Studies of Water Supply and Sanitation Services:

III.i Introduction

This section takes three contingent valuation case studies and illustrates how the WTP data generated can be used to estimate financial sustainability. In each case the demand curve for the water and sanitation service(s) is estimated. The first study reviewed (Briscoe et al, 1990) assessed financial sustainability using a slightly different approach to that outlined in this paper. This paper makes the case for using a simplified procedure in assessing financial sustainability using the WTP data.

In the second study we see that even though a service may not be financially self-supporting at almost any level of provision, the micro-economic model still proves to be useful in the economic analysis. In this case, the model will reveal the amount of subsidy required to achieve desired levels of coverage (Whittington et al, 1989).

The authors in the third study provided the WTP results that they derived. This provides an excellent opportunity to derive the demand curve directly, as outlined in figure 1. The paper indicates how this micro-economic framework can then be used to assess financial sustainability of the proposed improvement in the water service.

III.ii Case Studies:

1. A contingent valuation study of water supply in Brazil (Briscoe et al, 1990).

John Briscoe (of the Water and Sanitation Division, Infrastructure Department at the World Bank) led a survey of several villages in three rural areas of Brazil in 1987. A major objective of the study was to discover how the municipal water supply system could be made more financially sustainable. At the same time the study team wanted to see how it could be possible to provide adequate water supply service across all income groups in the villages. To achieve these two objectives, they needed to determine what service(s) should be provided in different communities, and what should be charged for each service.

The mean household income in these villages was 4,300 cruzados per month. The study estimated the proportion of families that would use each of two types of municipal water service, a private yard tap and a public tap, over a specified range of monthly price levels. The analysis in this study related the proportion of residents that would connect to these services at each price level, to explanatory variables[5]. Figure 4a reproduces the aggregate demand, or cumulative distribution function, for the yard tap, using the data from the econometric equation estimated.

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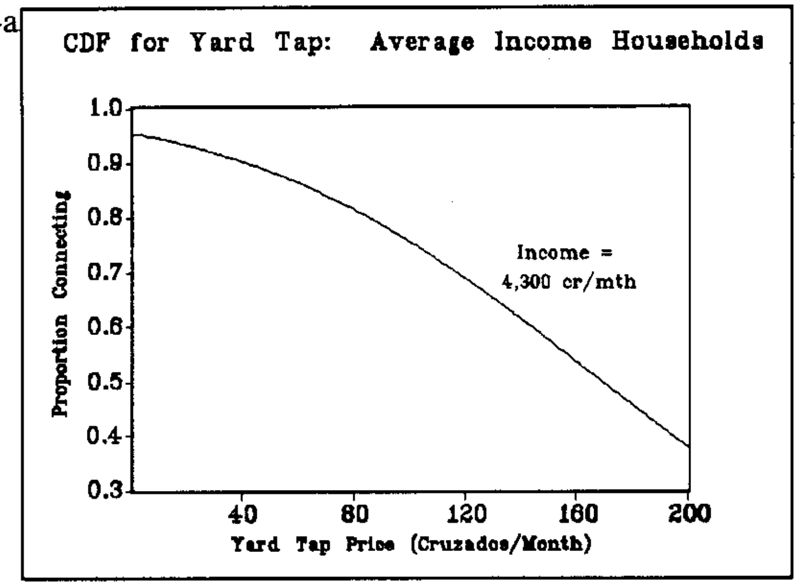
5 A probit (econometric) equation was derived for the yard tap. The significant variables were: monthly household income, wealth ("major household apppliance ownership"), employment in the formal sector, education of the head of the household and the characteristics of the existing village water sources.

Fig. 4a



The study addressed the twin goals of improving the sustainability of the municipal water system and guaranteeing a minimum level of service to all residents, using the cumulative distribution data. At the time of the study the private yard taps and public taps were already in place in some of the study villages. The charge on the private tap was 41 cruzados per month. The researchers found that by increasing the tariff on yard taps, total revenues could be increased; this would be accompanied by a reduction in the number of households that would want a yard tap connection. Raising yard tap prices would thereby improve the financial sustainability of the yard tap system, and the municipal water system.

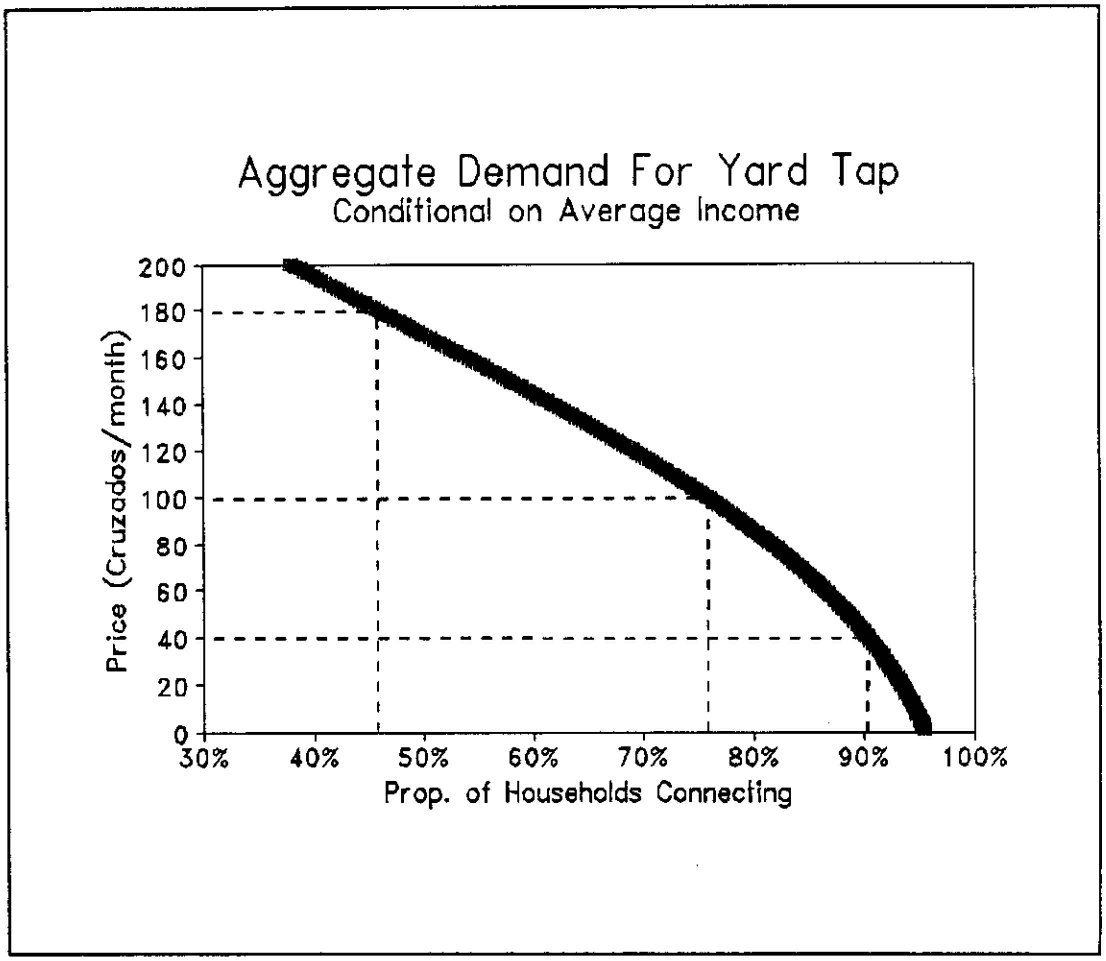
In the case of the public tap, the study found that varying the tariff between zero and 20 cruzados per month had only a small impact on the total revenues of the water system. This was the case at low, medium and high monthly charges for the private yard tap. As one way to achieve the equity objective with only a small impact on the sustainability of the water system, the researchers proposed that the tariff on public taps could either be very small or even zero.

The data in figure 4a can be brought into the more conventional micro-economic framework by reversing the axes, that is, by placing the price of the yard tap on the vertical axis, and the proportion of the population that would be willing to pay for the service on the horizontal axis. This is shown in figure 4b.

The micro-economic framework could also be readily achieved by plotting the slope of total WTP for these services. This standardized framework should prove helpful for two reasons: first, for the researcher it is a useful model for analysis of financial sustainability (AFS), that can be readily derived from the primary survey data. Secondly, those not involved in the project analysis are likely to understand the analytical procedure more quickly if is in a standardized framework.

In this framework we can estimate the proportion of the population that will connect to the yard tap system at various price levels. We can then calculate the revenues that would be generated at each price level. The total revenues will be the price charged times the number of households connecting at that price; that is, **tRev = Px times Q(Px)**. In figure 4b, at the current yard tap price of 41 cruzados per month, 90 percent of average income households will connect to the

Figure 4b. A conventional framework.



system. At 100 cruzados per month, 76 percent of households will connect; and at 180 cruzados per month, 46 percent will use the yard tap service.

2. A contingent valuation study of sanitation facilites in Kumasi, Ghana (Whittington et al, 1991).

Dale Whittington (from the Department of Environmental Sciences and Engineering at the University of North Carolina at Chapel Hill) led a study in Kumasi, Ghana in 1989 to assess how people in the city can improve on their sanitation facilities. At the time of the study, Kumasi was a city of over half a million people and growing rapidly. It is a relatively low-income city with very crowded housing conditions and less than adequate sanitation facilities. World Bank estimates of per capita gross national product were US$ 390 per year[6].

The survey solicited WTP for five different types of water and sanitation improvement, including one called a Kumasi Ventilated Improved Pit latrine (KVIP). The questionnaire used an "abbreviated bidding procedure": for each service evaluated, the first question asked the respondent if they would pay a specified monthly fee. In order to avoid starting point bias, different questionnaires with low and high starting values for the initial fee question were assigned randomly to the survey sample. Then, in the second or third question the interviewer asked the respondent to state the most that they would pay per month for the new service.

The researchers conducted a detailed benefit-cost analysis for each of the five proposed new services: they compared average WTP per household (total WTP divided by the number of households) with the capital costs per household

6 The researchers estimated per capita income in Kumasi to be even lower, at about US$ 180 per year.

to provide each service[7]. A problem with an economic analysis based on the average WTP, which the Ghana study does not address directly, is that it does not reveal whether there are individual households or apartment buildings that are willing to pay more than the cost to gain a particular service. In addition, it does not reveal whether there are some households among this averaged group that would not want the service at all, even if it cost very little or nothing. A marginal analysis (that is, using the demand curve) would reveal the numbers of both of these groups, in addition to the size of any subsidies that are needed for those who do want the service, but cannot afford the full cost.

However, the study team did calculate and graph the total amount of subsidy that would be required to achieve various levels of coverage for each service. In the case of the KVIP, it appears from the graph that less than 3 percent are willing to pay the full costs of the KVIP. Full costs would be met for all residents currently without a WC at a subsidy of US $200 per KVIP, or a total of US $4million[8]. The data for KVIP coverage is shown in table 1.

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7 They did this for different sizes of apartment buildings, from 1- to 45-household buildings. They also ran these benefit-cost comparisons for both the current tight financial market conditions (30% annual interest rate and 3-year loans) and for an improved financial market (lower interest and longer-term loans). The cost estimates did not include operation and maintenance of the facilities, which are a significant part of total costs. Adding these costs would alter any estimates of sustainability.

8 There were 450,000 households that could benefit from a KVIP. "KVIP coverage" is not 1 per household; each KVIP unit will be shared by several households in an apartment building.

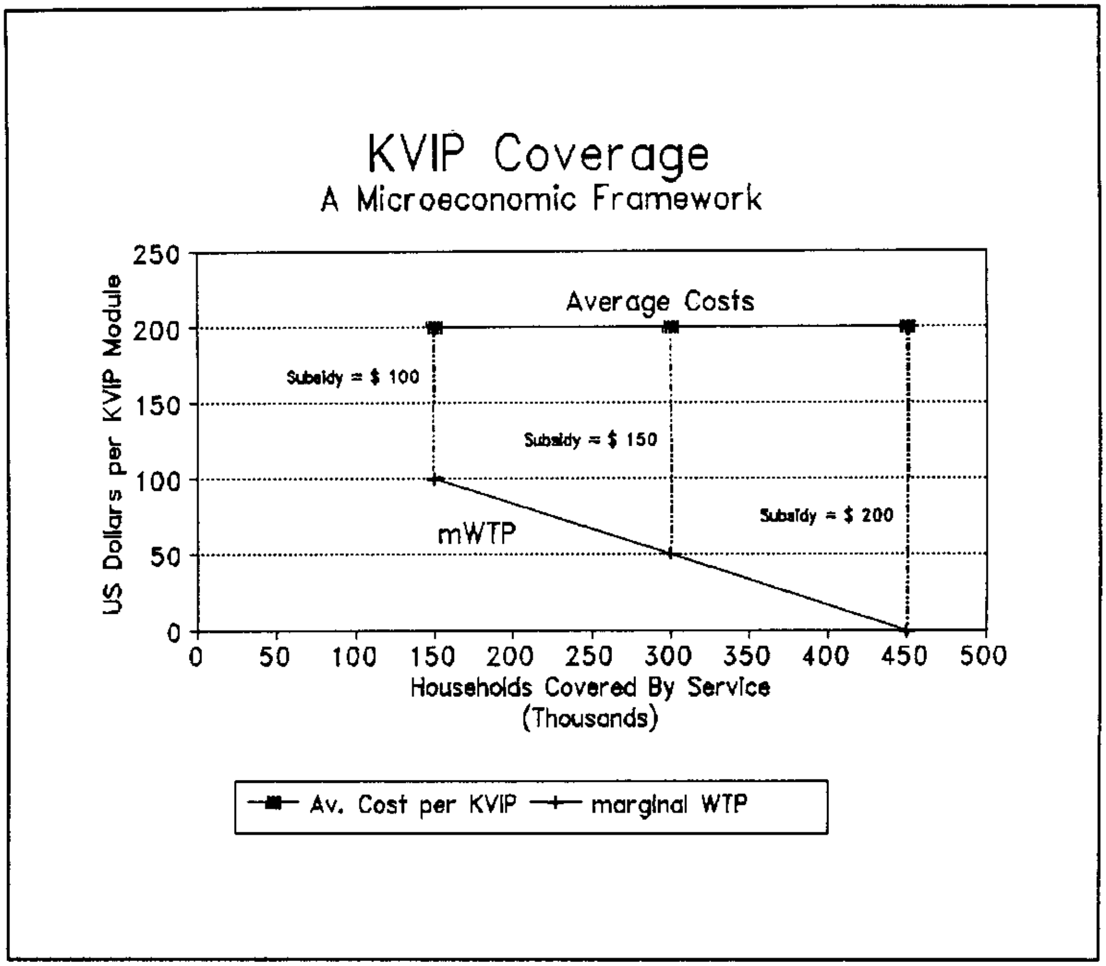
Table 1. Effect of subsidy on KVIP coverage (Whittington, 1991)

Subsidy (US $ per KVIP module)	$ 100	$ 150	$ 200
Coverage: Number of Households (% of Households)	150,000 (30-35%)	300,000 (65%)	450,000 (100%)

The data in table 1 could be represented in a microeconomic framework: the marginal WTP per module for the KVIP would be derived as the average cost per module to provide a KVIP minus the subsidy required. This is shown in figure 5. A microeconomic framework can also be generated directly, using the WTP data collected in the survey. In that case, the marginal WTP curve would be plotted as the slope of the total WTP curve, as described in Section II, figure 1.

The researchers did not attempt to use the demand-function model. A micro-economic framework for analysis can be useful in the policy process, even where a service is not completely self-supporting. In Kumasi, it is likely that improvements in sanitation will only be achieved by a combination of local revenue and external funding. In the micro-framework, the maximum amounts of revenue that can be raised locally for any specified levels of coverage are estimated. Levels of service coverage which can be sustainable, using a

Figure 5. KVIP: Average Costs and Subsidies in a Microeconomic Framework.



combination of local and external funds, can then be determined.

3. A contingent valuation study of water quality improvement (Mitchell and Carson, 1986).

In 1985, Robert Mitchell and Richard Carson conducted a WTP contingent valuation study to value the benefits from improving the quality of drinking water. This study was commissioned by the U.S. Environmental Protection Agency (EPA) to Resources for the Future, in Washington DC. The study focussed on the risk of mortality due a group of toxins that result from the chlorination of drinking water, called TriHaloMethanes (THMs). It was conducted in Herrin in Southern Illinois; Herrin is in a region where THM levels had frequently exceeded EPA standards.

This was an experimental study that was not primarily concerned with the financial viability of implementing the improvements valued. However, this paper indicates how the data obtained could be applied to the question of sustainability. The main objective of this study was to design a questionnaire that would accurately measure WTP for reductions in risk of death. Mortality risk is an elusive entity for people to comprehend and to then put money values on. The risks assessed in this study are very small and people do not readily identify with how they can be personally affected by such small risks of death. Therefore, the study team spent a lot of time researching the study population before designing the questionnaire.

The survey questionnaire asked people to vote, or state, in each of three hypothetical cases whether or not they would want the level of THMs in their drinking water to be lowered to the EPA standard. They were told the relative change in mortality that would be involved for each case. Those who voted "yes" (to have the THM level brought down to the EPA standard) in any of the three cases were then asked the maximum that they would pay for that improvement. Those who voted "no" were recorded as willing to pay $0 for that level of risk reduction. All respondents were given a chance later to revise their answers, if they wished to.

There were two versions of the questionnaire (assigned randomly among respondents). One version used a set of lower risk reductions, the A-series questionnaire, and a second version of the questionnaire used a set of higher risk reductions, the B-series. The results of the A and B series questionnaires are shown in table 2.

From the A-questionnaires the study found that the mean WTP for a reduction of 0.4 deaths per million was $3.78 per month; the mean WTP for a reduction of 4.3 deaths per million was $11.37; and the mean WTP for a reduction in risk of death of 13.3 deaths per million was $23.73. The data from the B-series questionnaire is shown graphically in figure 6a[9].

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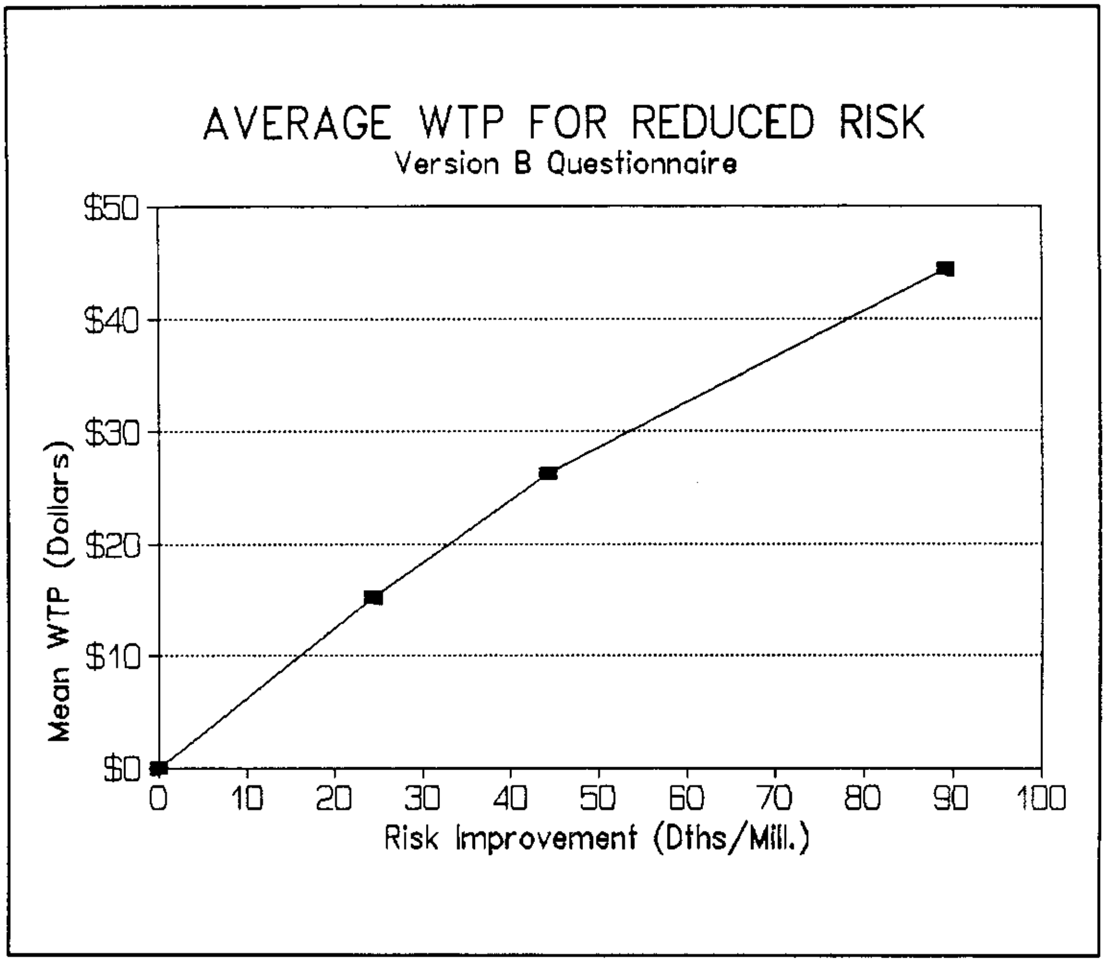
9 In figure 6a, the average WTP is the total WTP divided by the number of households.

Table 2. WTP for reduced risk of death, Mitchell and Carson, 1986

A-series Questions	a1	a2	a3
Risk Reduction (Annual Deaths per Million)	0.4	4.3	13.3
Mean WTP (dollars per month)	3.78	11.37	23.73
B-series Questions	b1	b2	b3
Risk Reduction (Annual Deaths per Million)	24.3	44.3	89.3
Mean WTP (dollars per month)	15.23	26.25	44.27

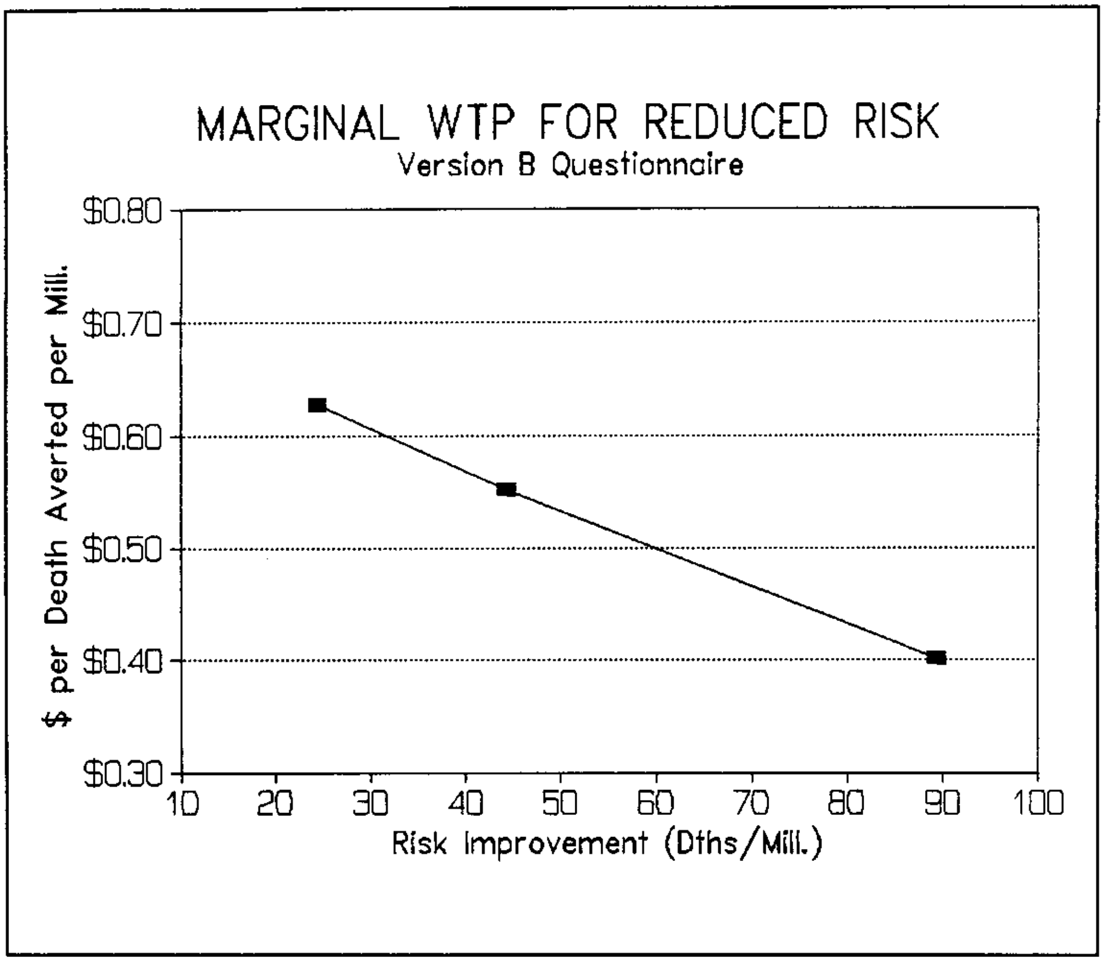
If the demand function for water in this community is known, then the WTP data obtained in this survey can be represented as a movement, an outward shift, of this demand curve. However, in the absence of the baseline demand curve, an alternative is to depict the WTP data as 'the demand for improvement in the quality of the drinking water'. The latter demand curve is plotted as the slope of the average WTP curve - seen in figure 6b - at the original data points. For example, the slope between the first and second points of analysis in figure 6a is: ($26.25 - $15.23) divided by (44.3 - 24.3), or $0.55 per death averted per million population.

Figure 6a.



Note that in figure 6b, the horizontal axis is still the degree of risk reduction, in number of deaths averted per million; the vertical axis is now the WTP per death averted. As the size of the risk improvement increases, or the number of deaths averted per million population increases, we can see in figure 6b that the WTP per death averted declines. This is similar to the demand for goods and services that are more commonly analyzed in this kind of microeconomic framework.

Figure 6b.



The Mitchell and Carson study did not address the question of the financial sustainability of improving the quality of the city drinking water. However, the analysis above indicates that WTP data obtained from the CV survey method have the potential to be used in this way: to assess the financial sustainability of a quality improvement in a water or sanitation service, distinct from the sustainability of establishing and maintaining the service. How can this be done? If, for example, a reduction in THM levels corresponding to a reduction in risk of death of 50 lives per million were to be implemented, figure 6b shows the marginal WTP per household for this improvement is about 52 cents per death averted per million. With a non-discriminatory pricing mechanism, a potential total increase in revenues would therefore be $0.52 times 50, or $26.00 per household. To evaluate the sustainability of this improvement, this estimate of revenue increase is compared to the estimate of the cost to implement this level of improvement. In order to identify whether there is a range of THM reductions that could be financially self-supporting, the schedule of potential revenue increases should be compared with the corresponding schedule of total costs of implementing the quality improvements, as shown (in graph form) in figure 2, section II. Levels of improvement at which potential total revenue is greater than total costs can be financially self-supporting. For levels of improvement that will not be self-supporting, the analysis will indicate the extent to which external funds would be needed for implementation.

IV Further Research: Theory and Practice

There are a number of aspects of the contingent valuation method and the analysis of sustainability of water and sanitation projects that need to be explored more fully. The first relates to the WTP value solicited by the CV survey. The total WTP value obtained in CV is considered to be the value of total benefits that the community would derive from the good or service in question. However, in the case of CV surveys of water and sanitation services, there is speculation that the statement of WTP by respondents may not be a good estimate of the total benefits that accrue to the project. It is possible that respondents either omit or understate the value of some benefits, notably health benefits. If this proves to be the case, then it has important implications both for any benefit cost analysis (BCA) or analysis of financial sustainability (AFS) that uses this data.

IV.i WTP and the "true" value of services

Ideally, the total WTP value obtained should be a good estimator of the "value" of the service to the community. This is critical in BCA, in which the total WTP is taken as an estimate of total benefits. It might be possible to modify, or improve the CV survey to make sure the WTP measure is close to the "true" value of the service. If the benefits that will accrue to the service are known to the researcher conducting the survey, it may be possible to include a description of these in the introduction, prior to the solicitation section(s) of the questionnaire.

(The third case study reviewed in this paper, Mitchell and Carson, 1986, provides an excellent example of how this can be done.) However, for most water and sanitation projects, it may prove difficult to inform respondents of likely benefits with any degree of specificity. Health benefits in particular have been notoriously difficult to value ex-post; an ex-ante estimate of health benefits would be even more difficult to define. In many cases, therefore, a qualitative description may be the extent of information on anticipated benefits that can be cited with any degree of certainty.

If total WTP understates the value of the service to the community, the analysis of financial sustainabiltiy will be more discouraging than analysis with a total WTP measure that is closer to the value of the service to the community. As with benefit cost analysis, it will be desirable to derive a good estimate of total WTP, and the procedure above may be useful. In addition, it may be wise to check the reliability of the total WTP value recorded. One way that this might be done is by expanding the contingent valuation survey, to include a section that asks the respondents to name the benefits that they anticipate they will receive from the service, and if possible, to quantify or value them also. In this way the researcher can make an estimate of the extent to which the WTP value obtained fully includes the benefits that are anticipated from the improved service.

IV.ii Non-monetary contributions

A second area that should be explored is the extent to which the costs of a project can be covered by non-cash contributions from the local community. This paper assumes that the total cost of the project is known or can be calculated (for example, Porter, 1993). Some of this total cost may be paid for by a sponsor from outside the community, such as the city or national government, or an international donor. The remainder will then have to be met by the local community. Of the cost to be covered by the local community, it is possible that some of this can be covered by non-monetary contributions, especially labor, but also including equipment and materials. Where this is the case, the costs that can be met by various non-cash contributions should be identified. Then, the extent to which the people in the local community are willing to contribute in these ways towards the project should be measured. It may be possible to do this in the contingent valuation survey. The extent to which non-cash contributions will be made should then be deducted from the total cost borne by the local community, in determining financial sustainability.

IV.iii The pricing mechanism

A third issue important to the financial sustainability of services is the pricing mechanism. The model outlined in this paper used a simplifying assumption of non-discriminatory pricing, that is, where all service users are charged the same rate (for example, per month per connection) for the service.

However, it may be possible to increase revenues and improve sustainability with some type of "discriminatory" pricing. In this form of pricing, the prices that households would pay is more closely matched with their willingness to pay for the service. Customers with lower WTP's would pay less than those with higher WTP's for the service. The means of implementing such a pricing mechanism is all-important: it must be done in a way that is socially acceptable and does not provoke dissatisfaction in the community.

One example of price discrimination for a water service is a progressive price structure based on the volume of water used by a household. Households in this system pay an increased fee per volume of water used, as they use more water. For example, the first 100 gallons per month might be charged at 2 cents per gallon, the second 100 gallons per month at 4 cents per gallon, and so forth. It is possible that there will be greater costs associated with a discriminatory pricing policy, as compared to uniform or non-discriminatory pricing: in the case above, the volume of water used would have to be monitored. Therefore, when estimating financial sustainability, it will be important to include the costs of implementing the pricing policy.

The Brazil study reviewed in this paper provides a second example of how a form of price discrimination might be implemented. Typically, price discrimination is thought of in terms of discriminating in the pricing of one particular service. In the Brazil study, however, different pricing mechanisms were proposed for the two types of service within the municipal water system.

This approach can give the policy-maker more flexibility, in that the sustainability of a system of services can be improved, without the need for each individual service to be self-supporting.

V Summary and Conclusion

If water and sanitation services in developing countries are to be more successful, they will have to be more financially sustainable than has been the case in the past. An economic analysis that specifically addresses the question of financial sustainability is critical. Sustainability is determined by comparing potential revenues with the cost of providing the service. This paper outlines a framework for evaluating sustainability based on the supply and demand model of micro-economic theory.

The micro-economic model is particularly well suited to be a standardized framework for the assessment of financial sustainability. It the advantage that WTP data derived in contingent valuation studies is closely related to the demand function of micro-economics. In this framework, the analysis of sustainability is performed quickly and easily, with few calculations that require only a minimum degree of mathematical ability. The evaluation of sustainability will be very valuable in the planning process, by identifying the types and amounts of services that will be both used and sustained in the community.

It should be kept in mind that although a project might pass the test of financial sustainability, this is not a guarantee that it will then be successfully implemented. There are many other factors, in addition to the economic analysis, that can influence the outcome of projects. Elinor Ostrom outlined how institutional structures, and the incentives they present to decision-makers, will affect the sustainability-outcome of projects (1993). An appropriate economic analysis is important, but is only the first step in the process of developing sustainable water and sanitation services.

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