Target 23—Control of hazardous wastes

By 1995, all Member States should have eliminated major known health risks associated with the disposal of hazardous wastes.

Target 24—Human settlements and housing

By the year 2000, all people of the Region should have a better opportunity of living in houses and settlements which provide a healthy and safe environment.

Target 25—Working environment

By 1995, people of the Region should be effectively protected against work-related health risks.

Target 26—A system based on primary health care

By 1990, all Member States, through effective community representation should have developed health care systems that are based on primary health care and supported by secondary and tertiary care as outlined at the Alma-Ata Conference.

Target 27—Rational and preferential distribution of resources

By 1990, in all Member States, the infrastructures of the delivery systems should be organised so that resources are distributed according to need, and that services ensure physical and economic accessibility and cultural acceptability to the population.

Target 28—Content of primary health care

By 1990, the primary health care system of all Member States should provide a wide range of health-promotive, curative, rehabilitative and supportive services to meet the basic needs of the population and give special attention to high-risk, vulnerable and underserved individuals and groups.

Target 29—Providers of primary health care

By 1990, in all Member States, primary health care systems should be based on cooperation and teamwork between health care personnel, individuals, families and community groups.

Target 30—Coordination of community resources

By 1990, all Member States should have mechanisms by which the services provided by all sectors relating to health are coordinated at the community level in a primary health care system.

Target 31—Ensuring quality of care

By 1990, all Member States should have built effective mechanisms for ensuring quality of patient care within their health care systems.

Target 32—Research strategies

Before 1990, all Member States should have formulated research strategies to stimulate investigations which improve the application and expansion of knowledge needed to support their health for all developments.

Target 33—Policies for health for all

Before 1990, all Member States should ensure that their health policies and strategies are in line with health for all principles and that their legislation and regulations make their implementation effective in all sectors of society.

Target 34—Planning and resource allocation

Before 1990, Member States should have managerial processes for health development geared to the attainment of health for all, actively involving communities and all sectors relevant to health and, accordingly, ensuring preferential allocation of resources to health development priorities.

Target 35—Health information system

Before 1990, Member States should have health information systems capable of supporting their national strategies for health for all.

Target 36—Planning, education and use of health personnel

Before 1990, in all Member States, the planning, training and use of health personnel should be in accordance with health for all policies, with emphasis on the primary health care approach.

Target 37—Education of personnel in other sectors

Before 1990, in all Member States, education should provide personnel in sectors related to health with adequate information on the country's health for all policies and programmes and their practical applications to their own sectors.

Target 38—Appropriate health technology

Before 1990, all Member States should have established a formal mechanism for the systematic assessment of the appropriate use of health technologies and of their effectiveness, efficiency, safety and acceptability, as well as reflecting national health policies and economic restraints.

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ELASTICITY OF DEMAND FOR WATER IN KHARTOUM, SUDAN

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Abstract—A survey of the quantities of water purchased from vendors in the squatter areas of Khartoum, Sudan, was used to assess the effect of the price charged for water and of household income on domestic water consumption. Households in two squatter communities—Meiyo and Karton Kassala—were studied by observation and by interview. In spite of the substantially higher charges, water consumption in Karton Kassala was as high as that in Meiyo. Households within these communities showed no tendency to use less water when paying a higher price for it, or when their income was below average. In other words, no price elasticity or income elasticity was detectable. This was all the more striking in view of the high proportion of income that was spent on water; 17% in Meiyo, and 56% in Karton Kassala.

One consequence of this lack of elasticity is that the poorest households devote the greatest percentage of their income to the purchase of water, although the only major item in their household budget which can be sacrificed to make this possible is food. The high price of water in urban Sudan is probably a major cause of the malnutrition prevalent in the squatter areas.

Another consequence is that a low-income household's consumer surplus for domestic water is very high, amounting to a substantial proportion of its total income. This has important consequences for the economic appraisal of urban water supply schemes. It also follows that wealthier households with private connections would be willing to pay at least as much for water as that currently paid by the poor.

Key words—water supply, economics, demand elasticity, Sudan

INTRODUCTION

At the close of the International Drinking Water Supply and Sanitation Decade, a consensus is emerging among the major international donor agencies, and many water agencies in developing countries, that increased rates of progress in extending water supply coverage among the population of the Third World can only be achieved by more effective recovery of the costs from the consumers [1, 2]. However, remarkably little information has been collected, and still less published, regarding the willingness of low-income groups to pay for water supplies [3].

Most studies have used the 'conditional' approach, in which potential consumers are asked how much they would be willing to pay for a given level of service, although the response to such questions may be biased in several ways. Respondents may be unaccustomed to answering hypothetical questions, may answer in such a way as to finish the interview as soon as possible, or may give deliberately false replies with a view to pleasing or impressing the interviewer, or to obtaining a water supply at the cheapest possible price [4]. A further weakness of the approach is that it can only focus on the consumer's decision whether or not to use and pay for the water supply. The method cannot be used to assess the degree to which charging for water will lead consumers to reduce their consumption; those who do not currently pay for water have difficulty enough in stating how much they use at present, without having to guess how much they would use under hypothetical circumstances.

The study of demand elasticity is relevant not only to the financial question of water tariffs, but also to the economic question of cost–benefit analysis for the appraisal of proposed investments in water supply. This is because demand elasticity gives an indication of the consumer surplus. The value to consumers of any item they purchase is generally greater than the price they pay for it. This is shown by the fact that consumers do not cease to purchase a product when its price increases, although they may cut back a little on how much they buy. The difference between the value to the consumer and the purchase price is known as the consumer surplus, and it can be shown theoretically to be inversely related to the elasticity of demand; it is highest when the elasticity is low.

Economists usually argue that the value of the consumer surplus should be included when assessing the worth of the outputs from an investment in economic cost–benefit analysis [5]. In the case of water supply investments, this has not normally been practised, as no objective measurements of the consumer surplus had been made. Measurement of demand elasticity would make it possible.

The relationship between the price of water and the level of consumption assumes greater significance in the light of the accumulating body of evidence that the quantity of water used for hygiene in the home is more important for the control of endemic diarrhoeal diseases than the quality of that water. For example, in their comprehensive review of the literature, Esrey and Habicht [6] found that in most of the cases where water supply improvements were shown to

have brought about a reduction in diarrhoeal disease, these included an improvement in access to water in quantity. Thus, if charging for water were to deter low-income consumers from using it in desirable quantities, it could undermine the important health benefits which investments in water supply seek to achieve.

The present study used the widespread practice of water vending in the squatter areas of Khartoum, Sudan, to measure the impact of price on the water consumption of low-income households. The price charged at the consumer's door by these water vendors depends on several factors, particularly the distance over which they have to transport the water in their donkey carts, the time they must spend queueing at the borehole to fill their carts, and the price of donkey fodder. Since the water price varies from one area to another, comparable low-income households could be interviewed and observed with a view to making an assessment of the price elasticity of their demand for water for domestic purposes.

SURVEY AREAS

Two survey areas were selected in squatter settlements in Greater Khartoum. They were chosen as communities with low but comparable average incomes, unserved by house connections, largely reliant on the services of water vendors. In order to be able to study the price elasticity of demand for water, they were also selected as areas where water was sold at widely differing prices. These two locations were Meiyo, on the southern fringe of Khartoum proper, and Karton Kassala, in Khartoum North.

Meiyo

Meiyo, established in the early 1970s, is situated ten kilometres south of Central Khartoum beyond the 'Green Belt', an area planted with trees to reduce the effect of dust storms on the city. By the time of our survey in early 1987, it had a population of some 80,000; 80% were Muslims. The majority came from Darfur and Kordofan in Western Sudan, but about one third of the population were from areas farther to the west of Khartoum including Nigeria and Chad. The majority (88%) had lived there for over 3 years [7]. Of the 4 boreholes in the area, only 1 was available for public consumption, and water was sold there to vendors at a price of LS 0.50* per donkey cart of 400 l. Water delivered to the consumer's door was then resold for LS 1.50 per 200 l drum.

Karton Kassala

In 1970, Karton Kassala consisted of about 5000 houses built of cardboard, which gave rise to its name. They housed around 35,000 people, but the population has risen since then to nearly 79,000 and continues to grow toward the east, while cardboard has been replaced by mud as building material. Our survey confirmed that roughly half the inhabitants were from the south of Sudan, with most of the remainder being immigrants from Kordofan and Darfur. Fifty percent of the households surveyed were Christian. Many households were supported, at least partially, by remittances from absent male members, for example those serving in the army.

There was no source of water within the settlement at the time of our survey, so that residents were entirely dependent on water transported by donkey cart from one of several sources on the periphery, some 2 km from most households. These included a couple of boreholes to the north and west, where long queues of vendors' carts built up, some households in an adjoining settlement which had private connections, and an irrigation canal to the east. Vendors bought water from the boreholes for LS 0.30 per drum, or LS 0.60 per cart. Water from the boreholes and the piped supply was sold by vendors in Karton Kassala for LS 5.00 per drum (occasionally LS 6.00 or LS 4.00), and canal water at LS 2.50 to 3.00 per drum in recognition of its poorer quality.

Water was not always so expensive in Karton Kassala. According to local informants, the canal running along the southern edge of the settlement served as a convenient source until July 1986, when it was shut off. Later that year, and shortly before our survey in early 1987, the borehole servicing Karton Kassala was also shut down, ostensibly to prevent further house construction. As these two measures progressively reduced the availability of water, obliging vendors to travel farther and wait longer in queues, the price of water rose from LS 1.50 to LS 3.00 and then to LS 5.00 per drum.

SURVEY METHODS

A sample of households was selected in each community, using sampling points marked at random on a map (for Karton Kassala, an aerial photograph) to give an even spread throughout the community. The 5 households nearest to each point were identified on the ground. In Meiyo, one of these was chosen at random for interview; in Karton Kassala, all five were interviewed. A detailed interview schedule was followed to ascertain levels of income, household size and other characteristics, water price and the volume of water used during the previous 24 hr. The interviews were conducted in Arabic by local women, who had previously been trained to identify and assess the capacity of the various vessels commonly used for water, and who sought out and interviewed the senior woman in each household. The interviewers had also been trained to collect information on a variety of possible income sources including the brewing of drinks, selling of foodstuffs and other commodities, rearing of livestock, and receipt of remittances from absent relatives as well as wage labour.

*At the exchange rate for the Sudanese pound prevailing at the time of the survey LS 1.00 = U.S.$0.30 approximately.

In order to verify the accuracy of the interview responses, 14 of the 27 households interviewed in Meiyo were also observed from 6 a.m. to 6 p.m. over 2 days, and interviewed twice each day regarding the use and storage of water which had been seen to be purchased.

RESULTS

Validity of interview data

Figure 1 compares the results of the interviews and of household observation with regard to total daily water consumption. The agreement is reasonably good, both in terms of the aggregate consumption of the 14 households observed, and that of the individual families. Such discrepancies as appear are within the range of difference between observed water collection and stated water consumption which is likely to arise from overnight storage of water. It is understandable that there should be better agreement between observation and interview data in this case than in other studies of domestic water consumption; it is easier for households which pay for water to remember how much they have purchased than for families to recall the amounts they have used from a free and unlimited supply.

Less precision can be attached to our data regarding the quantities of water used for specific purposes. These are not accurate enough for a comparison between the study areas, but are given here to provide an overall picture of the prevailing pattern of water use.

In the following discussion, all the consumption figures used are those derived from the household interviews.

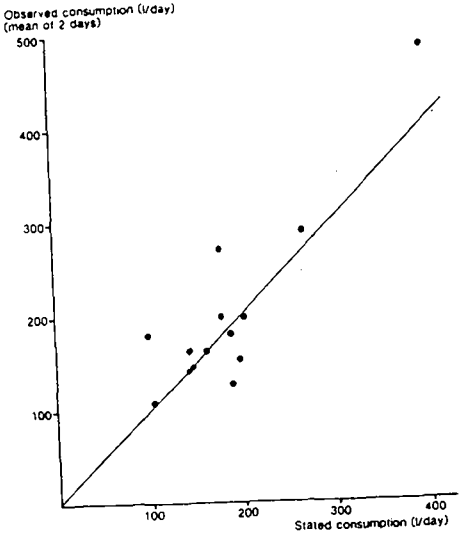

Fig. 1. Comparison between stated and observed household consumption. All subsequent figures refer to stated consumption.

Table 1. Typical wage levels in Khartoum, early 1987

Occupation	Monthly wage (LS)
Shop assistant	150
Driver	150
Janitor	150
Factory worker	80–150
Machine operator	180
Merchant	500–1000
Soldier—average	200
Soldier—in war zone	350

Wage levels in Khartoum are very low; a typical unskilled wage rate in Khartoum at the time of the survey was LS 150/month. Many households in both areas therefore had more than one source of income. Foreseeing some difficulty in collecting reliable information on all these, the interviews included questions relating to the type, size and ownership of the house, and to possession of items such as radios and bicycles, as observable indicators of the socio-economic status of each household. In the event, direct information regarding all sources of income was readily forthcoming from 22 of the 27 households in Meiyo and 28 of the 30 in Karton Kassala.

The average household incomes derived from these interviews are similar to those found in other surveys in similar areas of Khartoum [8, 9]; if anything, we found slightly higher average incomes. Moreover, the wage rates quoted by individual households were in good agreement with estimates for the corresponding occupations, arrived at by consensus in a number of group discussions with various informants in the communities studied (Table 1). Finally, reported household incomes were associated with the observable proxy indicators of socio-economic status. For example, in Karton Kassala the mean reported income of households which owned a working radio was more than twice that of those which did not. These considerations give us confidence in the general reliability of the household income data, though some degree of error is inevitable in such surveys.

The proxy indicators were therefore not used in the following analysis, except to indicate the approximate comparability of the two areas (Table 2). No households refused to be interviewed.

Comparison between the two areas

The comparison of the two areas with regard to mean household size, income per head, water price

Table 2. Comparison of the two survey sites with regard to socio-economic indicators

	Meiyo (n = 27)	Karton Kassala (n = 30)
Percentage of households:		
—owning house	62	80
—with latrine	85	57
—owning bicycle	31	30
—owning radio or cassette	62	33
—receiving remittances	32	76
—mean water storage capacity per household (l)	314	287

Table 3. Comparison of mean household size and income, water prices and water consumption in Meiyo and Karton Kassala

	Meiyo (n = 22)	Karton Kassala (n = 28)
Mean[1] household size	7.3	8.3
Mean[2] household income per head (LS/month)	42	47
Mean[1] water price (LS/drum)	1.50	4.64
Mean[2] water consumption (l.c.d.)	24.2	27.0
Mean[1] % of income spent on water	16.5	55.6

Notes: [1]Averaged by household.
[2]Averaged by individual.

and water consumption is shown in Table 3. The average water consumption in Meiyo was 24.2 litres per capita per day (l.c.d.), a fairly typical figure for standpipe users in urban Africa [10]. Remarkably, the mean water consumption in Karton Kassala was 27.0 l.c.d.—no less (but not significantly higher) than the figure for Meiyo where water cost one third the average price. Our unexpected failure to find lower water consumption in Karton Kassala cannot be accounted for by the difference in mean household size, as larger households were found to use less, not more, water per capita. Nor can it be explained by the slight difference in average income between the two areas, which is more than offset by the difference in the price of water. The influence of religion can also be ruled out as a factor, because Muslim households, more prevalent in Meiyo, tended to use slightly more water than others, particularly before prayer and after defecation. However, no statistically significant association was found between household water consumption and ethnic origin.

Figure 2 shows the purposes for which the water was used in the two study communities. Personal hygiene, in the form of bathing and washing clothes, accounted for some 60% of the total in both study sites. Typically, a bucket of water holding about 18 l was used daily for bathing by each adult, and about half that for each child. The frequency of bathing was sometimes reduced to every second day in winter. Women were also observed to wash their feet before leaving the home. A further 2 l per person per day were used in Muslim households for the washing of face, forearms, hands and feet before prayer.

Most of the remainder of the available water was used for the washing of food and utensils—another hygienic purpose—and for cooking and drinking. Other uses, amounting to less than 10% of the total, included the watering of gardens and livestock, and anal cleansing after defecation. For this last purpose, mainly found in Muslim households, about half a litre was used on each occasion.

These data refer to the first use of water, but to minimise consumption a considerable amount was re-used, particularly for washing and rinsing clothes, and even used a third time on the garden or to dampen the dusty ground in the compound.

The brewing of alcoholic drinks, an important economic activity in the study area, did not occur in the sample households during our survey. It was an infrequent activity, but typically required some 300 l of water on a brewing day.

Each household's monthly expenditure on water may be estimated by multiplying the daily consumption figures by 30, to obtain an estimate of monthly consumption, and then multiplying by the price paid for water. Of course, any given household's consumption on the day of the survey may not be representative of its water use over an entire month, but daily variations are likely to even out when the results are taken together over a number of households.

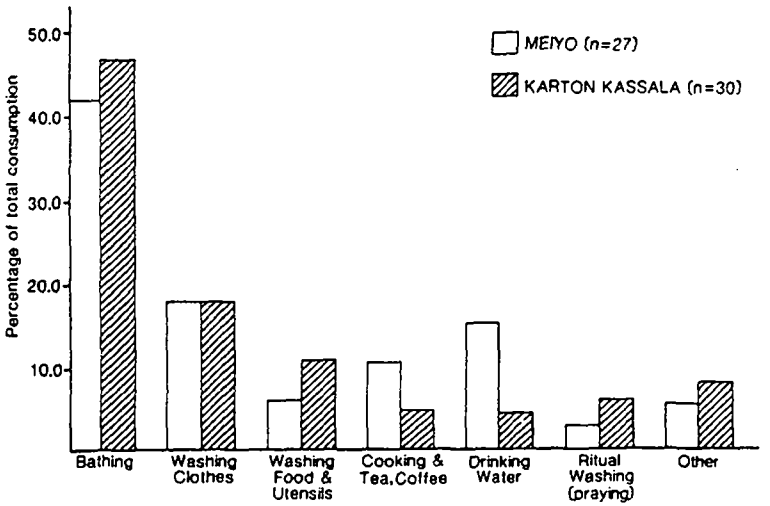

Fig. 2. The proportion of water used for each purpose in Meiyo and Karton Kassala.

By comparing monthly expenditures on water with household incomes, it is possible to arrive at an estimate for the proportion of income spent on water by each household. Thus it was estimated that the average household in Meiyo spends 16.5%, and in Karton Kassala a staggering 55.6% of its income on the purchase of water from vendors.

Averaging the percentage on a household basis could give an exaggerated figure for this mean, inflated by some very large percentages arising from occasional peaks of consumption by certain households on the day of the survey. However, the median percentages spent on water were very similar; 15% in Meiyo and 56% in Karton Kassala. By either reckoning, the residents of Karton Kassala pay three times more for water than the people of Meiyo in relation to their incomes, but this does not reduce their consumption. That is to say, the price elasticity of demand judged from these data, is effectively zero.

Users of borehole and canal water in Karton Kassala

Overall, the majority of households in Karton Kassala (20 of the main sample of 30) used only the cleaner but more expensive borehole water. The other ten households were not significantly poorer than average, with a mean household income *per capita* of LS 45 per month, very close to the average for the area as a whole (see Table 3). Discussions with householders and water vendors indicated that it was not so much the lower price that encouraged women to buy the dirtier water, as the fact that vendors working from the cleaner sources, already working at full capacity, were not willing to sell to them. Households using canal water were especially common in Hila Moroo, and so a further 15 households there were interviewed so that the relationship between price and consumption could be examined within Karton Kassala. There are advantages in comparing consumption between households within a single community, rather than between the two communities of Meiyo and Karton Kassala, because the potential impact of extraneous confounding variables is reduced.

However, the result was the same. The average level of household water consumption of those exclusively purchasing borehole or tap water, of those buying only the cheaper canal water, and of those using both sources, was not significantly different (Table 4). The small differences between the three mean consumption figures are of the same order as the standard error of each of them (±3 l.d.c.).

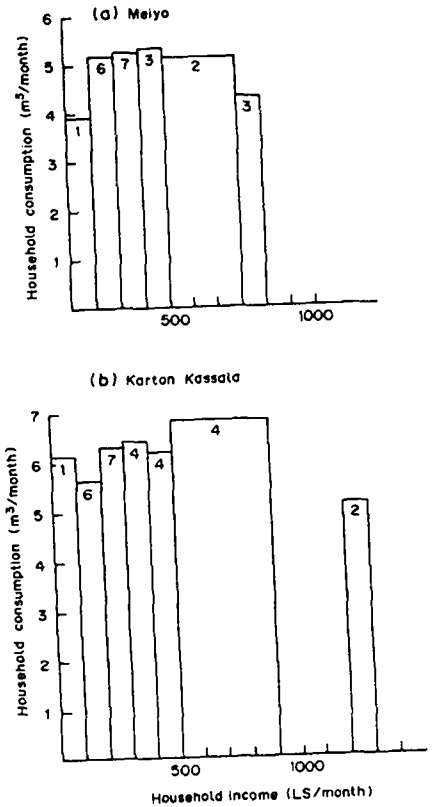

Fig. 3. Household water consumption plotted against income, for (a) Meiyo and (b) Karton Kassala.

Income elasticity of demand

No discernable, still less significant, relationship was found between household size and income; the average number of members in the households surveyed showed no consistent variation, in either study area, over the full range of income levels [11]. Thus the relationship between income and water consumption—the income elasticity of demand for water—can be examined without the risk of confounding by the household size.

Figure 3 shows the mean total water consumption for the households at each level of income, with the results presented separately for Meiyo and Karton

Table 4. Water consumption by households using water bought at different prices in Karton Kassala

Source of water	No. of households	Mean household size	Typical water price (LS/drum)	Mean water consumption (l.c.d.)
Borehole or tap only	22	7.8	5.0	30.1
Borehole and canal	14	8.1	5.00 and 3.00	26.5
Canal water only	9	7.2	3.00	27.7

Kassala. Both show the same pattern, with a marked uniformity of consumption over the full range of incomes encountered in the surveys. In other words, the income elasticity of demand, like the price elasticity, is effectively nil.

DISCUSSION

These data show that both the price and income elasticity of demand for water bought from vendors in the squatter areas of Khartoum was negligible, and in practice undetectable. Similar conclusions were reached from three distinct approaches to analysis of the data; by comparing the communities paying very different prices, by comparing households paying different prices within a single community, and by examining income elasticity within each of the two communities studied. This is a remarkable and, to many people an unexpected result; few would have predicted that households spending more than half their incomes on water would use the same quantities as those paying less than one tenth. Yet it is strengthened by the consistency of the findings between the different methods of analysis.

With hindsight, it is possible to draw an analogy between this result and the findings of studies which have examined the relationship between water consumption in rural areas and the distance over which it must be carried. The time spent carrying water has its price, and distance is a measure of that price. Those studies also have found water consumption to be remarkably constant between households whose water source is only a few minutes from the home and those collecting it from a distance of a kilometre away [10, 12, 13]. In other words, over a wide range of distances, the elasticity of demand with respect to distance is equally small.

All three of the studies cited above reported a threshold of distance beyond which water consumption began to fall. No equivalent threshold of price was found in the present case, although it is hard to see how it can fail to exist. Clearly it is impossible for a household to spend more than its income on anything. Nevertheless, some of the households we studied seem to have come perilously close to doing so.

The lack of income elasticity in water consumption means that the poorer households pay a higher percentage of their income for water. Low-income communities pay water vendors several times more per litre of water they consume than those who have house connections; the water rates paid by the latter amount to less than LS 0.40 per drum. Moreover, within each low-income community, the percentage paid for water out of each family's budget will on average vary in inverse proportion to its income. For example, households with half the mean income will spend twice the average percentage on water, while those with twice the mean income will pay half. Indeed, it is expensive to be poor in Khartoum.

Among the poorest households, the only major item of expenditure available for sacrifice to meet the cost of water is their food budget. It is therefore probable that the high cost of water in the squatter areas is a major contributor to the high rates of malnutrition which prevail there [9], and hence that a reduction in this price has a significant impact on the nutritional status of the poor, as well as permitting expenditure on other items such as health care.

It can only be concluded that low-income households in Khartoum set a high value on their water consumption, and consider that they have reduced it to the bare minimum beyond which they are not prepared to go. Since malnutrition and child mortality are related, it would appear that their children sometimes pay for water with their very lives.

The high value set by the poor on their water consumption can also be seen in terms of the consumer surplus. When the elasticity of demand is effectively nil, as in this case, the consumer surplus is very large indeed. That is to say, the value of water to the low-income residents of Khartoum has been shown here to be greater than the already large amounts which they pay for it, and a substantial proportion of their total income. Wealthier households with house connections would presumably set at least as great a value on water as the poor, although they actually pay substantially less for it. The consumer surplus for them is therefore likely to be larger. Such a valuation, if used for appraisal of water supply projects by international funding agencies, would yield cost–benefit ratios or rates of return far more favourable than those obtained hitherto.

There is now an urgent need to examine the degree to which these findings are applicable to other poor urban communities in the developing world, and also to reassess the policies of urban water supply agencies towards the informal market in water vending, as it meets the needs of the poorest, whom they frequently fail to serve.

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