3

Economic assessments of improvements in drinking-water supply – the global evidence

Chris Edwards and John Cameron

Even if access to safe water is a constitutional human right (as it is in some countries), improvements to drinking-water are likely to be provided only if they can be shown to be a good use of public funds in comparison with the whole cross-sectoral range of possible interventions. This chapter builds on the previous chapter and aims to help policy-makers and other experts understand the global empirical evidence that has been used to criticise and promote drinking-water and closely associated sanitation interventions. It further develops the argument that economic assessments can play a significant role in arriving at an informed judgement of whether or not improvements in water supply are a good use of public funds.

Some of the terms introduced in the previous chapter and used throughout this book are described in Box 3.1 and Table 3.1.

There are three forms of economic assessment that can be usefully applied to estimate whether the public sector should finance (completely or in part) improvements in access to safe drinking-water. The simplest is least-cost analysis, which costs proposed interventions that are designed to achieve a specified improvement (a given improvement in quality for a particular population) and finds the least-cost intervention. The second is cost–effectiveness analysis, which is more ambitious in its aims of seeking to compare costs of differing health interventions for different populations against some standard of physical improvement. In this book we use the WHO standard of savings in disability-adjusted life years (DALYs), but any physical measure of improvement (for example, a reduced number of episodes of diarrhoea) would potentially suffice. The third approach is social cost–benefit analysis, which seeks to compare costs across all possible uses of public funds in terms of net benefits to society. Table 3.1 summarizes the three forms of economic assessment.

### THE NEED FOR PUBLIC SECTOR INTERVENTIONS

Before looking at the three forms of economic assessment in more detail in Chapters 8, 9, 10 and 11, it is worthwhile answering the following questions:

- Why does the public sector have to be involved?
- Why can the financing of water improvements not be left to households themselves to finance?
A simple but wrong answer to these questions might be that water facilities are public goods and as such should be financed by the public sector in order to ensure sufficient provision.

This answer is analytically flawed because water improvements are not public goods in a strict economic sense. For a rigorous economist, public goods are those goods which, even if consumed by one person, can still be consumed by others. An example of a public good is a lighthouse on a dangerous coast. If the light is shining, then “consumption” of that service by one ship does not reduce the consumption available to another ship. This non-rivalry of consumption means that it is

<table>
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<th>Table 3.1 Forms of economic assessment</th>
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<tr>
<td><strong>Form of economic assessment</strong></td>
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<tr>
<td>Least–cost analysis</td>
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<td>Cost–effectiveness analysis</td>
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<td>Social cost–benefit analysis</td>
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impossible to exclude anyone from consumption except at a prohibitive cost. As a result, for the economist, public goods are characterized by non-rivalry and non-excludability in consumption.

By contrast, water services are usually (but not always) private goods, even if not supplied right into the household. If water is provided to a village standpipe, one household’s consumption is likely to reduce the amount available to other households – while one container is filling, another cannot be filled. And the less the water available, the more likely there is to be rivalry in consumption and the more likely it is to not be a public good.

Thus, water services are generally public goods, though they may have positive externalities in terms of preventing epidemics of infectious diseases, which may justify an element of subsidy. Similarly, if adding households onto a scheme can be done at low incremental or marginal cost, then again an element of subsidy for all households in the scheme may be economically justified.

But generally water can in principle be bought and consumed exclusively by households, even if an element of public sector subsidy is offered. So the next question arises:

- Why, if water services are not public goods, can households not finance their own facilities?

To answer this, we need to ask two further questions:

- How much do poor rural households spend on water?
- Is this enough to finance improved water supplies?

Whittington & Hanemann (2006) showed that amounts (converted to US$ per month) paid by households to vendors for water in 1998 ranged from 4.4 in Ghana, 6 in Nicaragua, and 7.5 in Pakistan to 13.9 in Côte d’Ivoire. In 2007 prices, this would be equivalent to a range between US$ 6 and US$ 18 per month.

Is this enough to finance improved supplies? As long ago as 1975, Okun, an experienced water supply engineer, thought so. He said that “if daily expenditures made to a water carrier were invested in a proper piped supply, a far more economical and better water service could be provided” (Okun, 1975). One objection to this is that poor people do not, in general, get the whole of their water from vendors. They cannot afford to. There are indications, however, that poor people do spend a significant proportion of their income on water.

The UNDP 2006 Human Development Report pointed out that: “The poorest 20% of households in El Salvador, Jamaica and Nicaragua spend on average more than 10% of their household income on water” (UNDP, 2006). The UNDP
report was referring to 2004 figures. In that year, the average income per capita of the poorest 20% in these three countries was (according to official statistics) about US$ 430 per year or about US$ 36 per month.\(^1\) This means that, in spending more than 10% of their income on water, poor households spent about US$ 3 to US$ 4 per month on water.

Is this enough to finance water supply improvements? To answer this, we need to know the investment costs of water supply improvements.

Unfortunately, information on the investment costs of water facilities is not available for El Salvador, Jamaica and Nicaragua. For Eastern European and Central Asian countries, the capital cost of protected dug wells serving 100 people is given as about 4000 euros in 2005 (see Environmental Action Programme, 2007, pages 3–8), equivalent to about US$ 5000 or US$ 50 per capita. This compares with an estimate of US$ 48 per capita given by Jamison et al. (2006, Figure 41.1). The match is quite good considering that the estimate given by Jamison et al. is at year 2000 prices, and some allowance needs to be made for price increases between 2000 and 2005.

The annual income of a poor household of six people in El Salvador, Jamaica and Nicaragua is the per capita income of US$ 430 multiplied by six, or about US$ 2580 for the household. Therefore the capital cost of a dug well (at US$ 5000) is equal to almost two years of total household income for the poorest 20% in El Salvador, Jamaica and Nicaragua, and equivalent to almost 20 years of water expenditure (at 10% of total income).

This is likely to be far too much for one poor household to finance, even if the household manages to borrow the money. To illustrate this, assume that a dug well lasts for five years without major maintenance. To repay the cost of US$ 5000 over five years at an interest rate of 5% per annum would mean an annual payment of US$ 1155, whereas at an interest rate of 20% per annum the annual repayment (including interest) would be US$ 1670. As Table 3.2 shows, both these payments are many times the household’s annual expenditure on water, which is about US$ 258. And so the dug well is not affordable by one poor household alone.

The dug well can, however, provide water for up to 100 people. The next question is:

- If the 100 people (or 17 households) join together to finance a dug well, does it then become affordable?

\(^1\) This is equivalent to US$ 320 per capita. This estimate compares with an estimate of US$ 144 per capita for Latin America given by Jamison et al. (2006, page 772). Thus the estimate of US$ 320 per capita may be on the high side, although again it needs to be noted that the Jamison et al. estimate is at year 2000 prices.
The answer is almost certainly yes, because even at a high annual interest rate of 20%, the annual repayment cost of US$ 1670 is only about four-tenths of the annual amount being spent on water by the 17 poor households. A small-scale water improvement such as a dug well may, therefore, be affordable—but only if the poor households pool their resources.

This might lead to a further question:

- Is a larger-scale scheme such as a piped water scheme likely to be affordable?

The answer is probably not. According to the Environmental Action Programme (2007, pages 3–13), the cost of a piped water scheme is about US$ 1.6 million.¹

Even though such a piped water scheme serves up to 5000 people (or 833 households of six people), it is not likely to be affordable unless the poor households spend at least 1.7 times as much as they currently spend on water (see Table 3.3).² This 1.7 multiple assumes that people can borrow the money at 5% per annum. If they have to pay a real interest rate of 20% per annum (not unusual in an informal credit market), they would have to spend 2.5 times what

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¹ This estimate may be pessimistic, given that a life of only five years is assumed. On the other hand, no allowance has been made for operation and maintenance costs.

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### Table 3.3 Can poor households afford improved water supplies? – piped water example

<table>
<thead>
<tr>
<th></th>
<th>US$ per capita</th>
<th>US$ per household of six people</th>
<th>Piped water</th>
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<tr>
<td>Repayment cost divided by household water expenditure:</td>
<td></td>
<td></td>
<td>Capital cost of piped water serving up to 5000 people (or 833 households)</td>
</tr>
<tr>
<td>For one household</td>
<td>4.5</td>
<td>6.5</td>
<td>US$ 1,600,000</td>
</tr>
<tr>
<td>For 17 households</td>
<td>0.3</td>
<td>0.4</td>
<td>Repayment factor per year over 5 years</td>
</tr>
<tr>
<td><strong>Repayment costs for piped water</strong></td>
<td>US$ at 5% per year</td>
<td>US$ at 20% per year</td>
<td>Repayment cost per year</td>
</tr>
<tr>
<td>Annual repayment cost for piped water</td>
<td>US$ 369,600</td>
<td>US$ 534,400</td>
<td></td>
</tr>
<tr>
<td>Repayment cost divided by household water expenditure:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For one household</td>
<td>1,432.6</td>
<td>2,071.3</td>
<td></td>
</tr>
<tr>
<td>For 833 households</td>
<td>1.7</td>
<td>2.5</td>
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</tbody>
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they currently spend. That is, instead of spending 10% of their income on water, they would have to spend 25% of their income on water supplies.

Clearly, on the basis of these figures, there are three problems that poor households will face in financing even small-scale improved water supplies: a loan is likely to be required to finance the improvement; even with a loan, a high element of risk is involved; and a great deal of coordination is required among the households. Therefore, the poorest 20% of households are likely to face problems in financing even small-scale rural water supplies.

In contrast, cost is not necessarily the main barrier to low-cost sanitation improvements. Indeed, Cairncross & Valdmanis (2006) argue against the use of subsidies for such improvements.

But there may well be a strong case for sanitation facilities being provided from public funds on the grounds that these investments are particularly important for environmental quality and health. Without public sector pressure or even financing, external diseconomies are likely to be commonplace, an external diseconomy being the costs imposed by one person (suffering disease from poor sanitation) on another (even though the latter may have adequate sanitation). For an illustration of the external diseconomies from a lack of sanitation, see Box 3.2. In a situation where external diseconomies are common, a private market is likely to provide too little investment (World Bank 1993).

**Box 3.2 “External diseconomies” from the lack of sanitation in the United Kingdom in the 19th century**

In 1858 the stench of sewage from the River Thames in London forced Parliament to close temporarily. But relatively little was done about sanitation until the mid-1880s. As a result, between 1840 and the mid-1890s, average income in the United Kingdom doubled but child mortality slightly increased. Between the mid-1880s and the mid-1900s per capita investment by the public sector on sanitation increased by more than four times and infant mortality fell, during these two decades, from 160 per 1000 to less than 120.

*Source: UNDP (2006).*

There still may be a case for public sector support for both water and sanitation improvements, though for slightly different reasons. For water improvements, support from the public sector (at the very least in the form of credit) is likely to be necessary because of the indivisibility of the investment. This is in line with the UNDP position that “in countries with high levels of poverty among unserved [with water] populations, public finance is a requirement
for extended access regardless of whether the provider is public or private” (UNDP, 2006). Thus, it is likely that rural water facilities will have to be coordinated – even financed – from outside the households, even though these households may be required (and able) to pay for a major proportion, if not all, of the annual costs.

**THE NEED FOR AN ECONOMIC ASSESSMENT**

If the public sector is to provide the finance and coordinate the investments for water improvements, then two questions arise:

- Do investments in water interventions give a higher rate of return (in social cost-benefit terms) than other investments, and should they therefore have a greater priority in national and international budgets than they have at the moment?
- In a specific, poor, rural setting, how does a policy-maker decide on the best investment to provide drinking-water? And how can the decision be justified?

It is the job of economic assessment to answer these two questions. As we outlined in previous chapters, there are broadly three methods that are advocated to do an economic assessment of water and sanitation improvements. These are:

- least-cost analysis
- cost–effectiveness analysis
- social cost–benefit analysis.

Least-cost analysis is a method of choosing the appropriate improvement by choosing the one with the lowest cost (see Carlevaro & Gonzales, 2011). However, as Carlevaro & Gonzales admit:

> when the appropriate [water and sanitation] technologies present differences in the levels or quality of services, a least-cost choice will not necessarily be the one that is economically optimal, as some other appropriate technologies can have benefits that compensate their exceeding costs with respect to the least-cost solution. This is the most common situation, and costing analysis will not provide sufficient information to select the most appropriate technologies. Thus least-cost analysis can be applied when the prioritization decision is solely concerned with choosing between technical interventions offering a similar outcome in terms of improved access to safe drinking-water for the same group of people.
Cost–effectiveness analysis is widely used by national and international agencies, including WHO. In the health sector, cost–effectiveness analysis is used to select a health intervention which provides a given physical outcome benefit at the lowest cost or the maximum physical outcome benefit for a given budget.

**COST-EFFECTIVENESS ANALYSIS AND THE CASES FOR AND AGAINST PRIORITIZING DRINKING-WATER IMPROVEMENTS**

A controversy arose as the result of an article by Walsh & Warren (1979). They claimed that prioritization between different uses of health expenditure was an imperative. That meant comparing health interventions, which is a strength of cost–effectiveness analysis. Walsh & Warren claimed that higher health spending was not always associated with better health outcomes, and that health budgets could be spent more cost-effectively. Few disagreed with this view, which was to be endorsed in the World Bank’s 1993 *World Development Report* (see Box 3.3).

**Box 3.3 Higher health expenditure does not mean better health**

At any level of income and education, higher health spending might be expected to yield better health, but this is not the case. The World Bank’s 1993 *World Development Report* showed that there was no relationship between health spending as a percentage of gross national product and health (as defined by life expectancy), after allowing for levels of income and education. The World Bank pointed out that “China… spends a full percentage point less of its GNP on health than other countries at the same stage of development but obtains nearly ten years of additional life expectancy” and that; “Singapore spends about 4 per cent less of its income on health than others at the same level of development but achieves the same life expectancy”. By contrast; “… it is possible both to spend more than predicted on health care and still achieve unexpectedly poor results. The United States is an extreme case spending 5 per cent more of GNP than predicted to achieve several years less of life expectancy than would be typical for its high income and educational level”.

*Source: World Bank (1993).*

What *was* controversial about the Walsh & Warren (1979) paper was the case they made for a “selective primary health care” programme and the way in which that case was made. A year earlier, in 1978, a worldwide primary health care
movement had been launched under the slogan “Health for All by the Year 2000” at a conference held by WHO and UNICEF at Alma Ata in the then, USSR (WHO, 1978). In 1979, the Walsh & Warren paper was presented at a Rockefeller Foundation Conference in Bellagio, Italy (reported in Warren, 1988). In it, the authors advocated a selective primary health care programme, and the paper was published in the *New England Journal of Medicine*. 

Walsh & Warren argued that infant and child mortality could be reduced most effectively by primary health care that was selective in terms of types of interventions. They claimed that the deaths from many of the most prevalent diseases could be best prevented by immunization, oral rehydration, universal breast-feeding and by antimalarial drugs for African children. In the following years, immunization programmes were adopted. The influence of this approach was reflected in the 1993 *World Development Report* in which the World Bank endorsed an expanded programme on immunization (EPI), stating that the programme could be enlarged still further to include supplements such as vitamin A and iodine, and other vaccines, particularly those for hepatitis B and yellow fever. The World Bank stated that: “in most developing countries, such an ‘EPI Plus’ cluster of interventions in the first year of life would have the highest cost-effectiveness of any health measure available in the world today” (World Bank, 1993).

The Walsh & Warren approach was widely supported by UNICEF and by a number of bilateral and multilateral donor agencies, but it was also heavily criticized (Warren, 1988). Given the widespread adoption of selective primary health care, why was the approach so heavily attacked?

Walsh & Warren (1979) drew up priorities on the basis of cost–effectiveness calculations. In the paper, health-promoting interventions were ranked in terms of their cost-effectiveness in achieving very specific, physical health outcomes, notably in terms of infant and child mortality. The paper was attacked on two grounds. John Briscoe of the School of Public Health in North Carolina was an important exponent of the group that criticized the paper.

First he argued that such specific physical indicators understated the general health benefits of water and sanitation programmes. He pointed out that a review of the health effects of water supply and sanitation programmes carried out in 1983 revealed that the reduction in the incidence of diarrhoeal diseases in the population at large was typically between 30% and 40%, many times greater

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3 There were other, broader criticisms focusing on issues of organization and power. Smith & Bryant (1988) suggested that the attention “given to the delivery of ‘selective’ packages of interventions has often diverted energy and resources from the essential task of developing comprehensive, efficient and effective health services”
than the 5% assumed for standpipe water in the Walsh & Warren paper (Briscoe, 1984). This empirical claim suggested that health benefits were spread widely in the population benefitting from a drinking-water intervention, as well as more infant and child deaths being prevented.

The second and more important criticism was that the large non-health benefits generated by water and sanitation improvements were ignored in the Walsh & Warren cost–effectiveness approach. If these non-health benefits (notably time savings in collecting water) were deducted from the costs, the net economic cost of water supply improvements would be much smaller than the gross cost and the picture would be very different (Briscoe, 1984).

Briscoe (1984) argued that, as a result “it is apparent that the cost–effective calculations of the [selective primary health care] approach are fundamentally flawed when dealing with community water supplies” and he complained that “the [selective primary health care] approach in general and the downgrading of water and sanitation, in particular, seem to have been accepted implicitly by many development agencies”. He also pointed out that

“just three years after the proclamation of the International Drinking Water Supply and Sanitation Decade by the United Nations General Assembly, the Decade is being pronounced ‘dead’ in some quarters”. (Briscoe, 1984)

This example shows the limitations of cost–effectiveness analysis for deciding between interventions in terms of conceptualizing indicators of benefits (e.g. mortality, incidence of diarrhoeal episodes, time saved in collection), specifying data to be empirically collected and identifying disagreements on the estimates of indicators made from the collected data.

This book advocates both for extending the conceptual range used in cost–effectiveness analysis and for improving the quality of data being collected, especially for small-scale drinking-water interventions.

SOCIAL COST–BENEFIT ANALYSIS AND THE UNDP 2006 HUMAN DEVELOPMENT REPORT

The points made by Briscoe (1984) were dramatically endorsed more than 20 years later in studies carried out by Hutton, Haller and Bartram (Hutton & Haller, 2004; Hutton, Haller & Bartram, 2006). These studies placed monetary values on costs and benefits, and claimed high ratios of benefits to costs for water and sanitation investments. These high benefit–cost ratios were highlighted in the 2006 UNDP Human Development Report. The Hutton, Haller and Bartram studies seem to support the Briscoe claim that the non-health benefits of water and sanitation improvements are very large indeed when converted into their monetary
equivalents. Indeed, according to Hutton, Haller & Bartram (2006), the non-health benefits (especially time savings) formed the vast majority of the total, as shown in Table 3.4.

**Table 3.4** Benefits and costs for sub-Saharan Africa from meeting the year 2015 MDG targets for water and sanitation over the period 2005–2015

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<tr>
<td>Number of people getting improved water or sanitation (million)</td>
<td>207</td>
<td>315</td>
<td>Table 14</td>
</tr>
<tr>
<td>Annual costs (US$ billion)</td>
<td>0.48</td>
<td>2.19</td>
<td>Table 14</td>
</tr>
<tr>
<td>Annual benefits (US$ billion)</td>
<td>0.12</td>
<td>0.31</td>
<td>Tables 17, 18</td>
</tr>
<tr>
<td>–health system and patient costs saved</td>
<td>0.11</td>
<td>0.45</td>
<td>Table 19</td>
</tr>
<tr>
<td>–value of time saved from less illness</td>
<td>0.27</td>
<td>0.72</td>
<td>Table 20</td>
</tr>
<tr>
<td>–value of access time saved</td>
<td>0.84</td>
<td>12.88</td>
<td>Table 21</td>
</tr>
<tr>
<td><strong>Total benefits (US$ billion)</strong></td>
<td>1.34</td>
<td>14.36</td>
<td>Table 13</td>
</tr>
<tr>
<td>Benefit/cost ratio</td>
<td>2.8</td>
<td>6.6</td>
<td>Table 11</td>
</tr>
<tr>
<td>Percentage of total benefits from access time saved</td>
<td>63</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

It is clear that most of the benefits from water and sanitation improvements come not from improvements in health (for example, from a reduction in illness or death), but from a saving in time in accessing water sources and sanitation facilities. Table 3.4 shows that for water supply improvements in sub-Saharan Africa, 63% of the annual benefits come from time savings and only 37% from savings associated with a reduction in illness.

Whereas the study by Walsh & Warren (1979) had provided decisions-makers with reasons not to go ahead with drinking-water improvements, a quarter of a century later the UNDP 2006 *Human Development Report* was pointing to the high benefit–cost ratios to be obtained from such investments. Thus the UNDP *Human Development Report* gives good reasons to go ahead with water improvements prior to many interventions in other sectors of the economy.

As a basis for priority-setting, social cost–benefit analysis is able to compare investments across sectors because all benefits and costs are converted into monetary equivalents.
As Hutton, Haller & Bartram (2006) put it: “these results give to water and sanitation advocates a powerful basis for arguing for increased water and sanitation investments”.

The UNDP 2006 *Human Development Report* estimated that the investment outlay needed to reach the MDG targets for water and sanitation with low-cost sustainable technology would amount to about US$ 10 billion a year, whereas the monetary equivalent of the benefits would be well over this, at about US$ 38 billion a year (UNDP, 2006). When the costs are spread over their economic life, the economic return is high. Each dollar spent yields a return of about US$ 8 in costs averted and productivity gained (UNDP, 2006). According to UNDP, these figures probably understate the gains from water investments since they do not capture the benefits from education, from empowering women, from human dignity, or from the reduced anguish and suffering associated with lower rates of child deaths.

The *Human Development Report* states that: “Ultimately, the case for public action in water and sanitation is rooted in human rights and moral imperatives. At the same time, cost–benefit analysis suggests that economic common sense makes a powerful supporting case” (UNDP, 2006).

The fact that water investments give a mix of benefits is clearly something of a political disadvantage. As Walsh (1984, page 1167) said:

“A health planner, faced with the charge of improving health with the few resources available, may decide not to make capital investment in water supply and sanitation a top priority…. Possibly it would be more appropriate for the agricultural, or public works, or planning and development department, with collaboration from the health sector, to invest in an improved water supply and sanitation because all these sectors will benefit”.

Water supply improvements provide a mix of health and other benefits. Advocates for water and sanitation improvements are therefore at a disadvantage, because the ministry likely to bear the costs may feel it receives insufficient credit for benefits that are perceived to come under the mandate of a number of other ministries.

**THE WAY FORWARD**

Few social cost–benefit analyses seem to have been made of improvements to drinking-water facilities, perhaps as a result of the predominance of public health experts in debates. If such analyses exist, they have not made their way into the public domain.
Cost-effectiveness analyses are more widely used by national and international agencies, including WHO. In the health sector, cost–effectiveness analysis is used to select a health intervention which provides a unit of physical output at the lowest unit cost. Thus a physical rather than monetary indicator of output is chosen, and the option which has the lowest cost per unit of output is preferred. Cost–effectiveness analysis can play an important role in comparing different health interventions. The basic data on benefits can often easily be derived from standard health statistics, and calculations and interpretations can be made by non-economists. Cost–effectiveness analysis has consequently been widely applied in analysing different drinking-water interventions. One of the most comprehensive of the cost–effectiveness studies is that of Clasen et al. (2007), and Chapter 10 includes a discussion of that study.

Encouraging decision-makers to rely not only on cost–effectiveness analysis, but also on the more comprehensive information provided by social cost–benefit analysis, is a major aim of this book. Social cost–benefit analysis has the merit of being able to break out of the health sector and offer comparisons with any intervention claiming to improve human well-being. This is important in making claims for better funding of drinking-water interventions from the general public purse – whether they be to improve lives of smaller groups of currently underprovided people in richer economies or to finance general improvements to achieve the health MDG (and assist in the achievement of other MDGs) in poorer economies. The drawback of social cost–benefit analysis is that it is based on highly technical economics concepts, and hence requires the greater involvement of economists – a profession generally not admired for its lucidity and communication skills.

REFERENCES


