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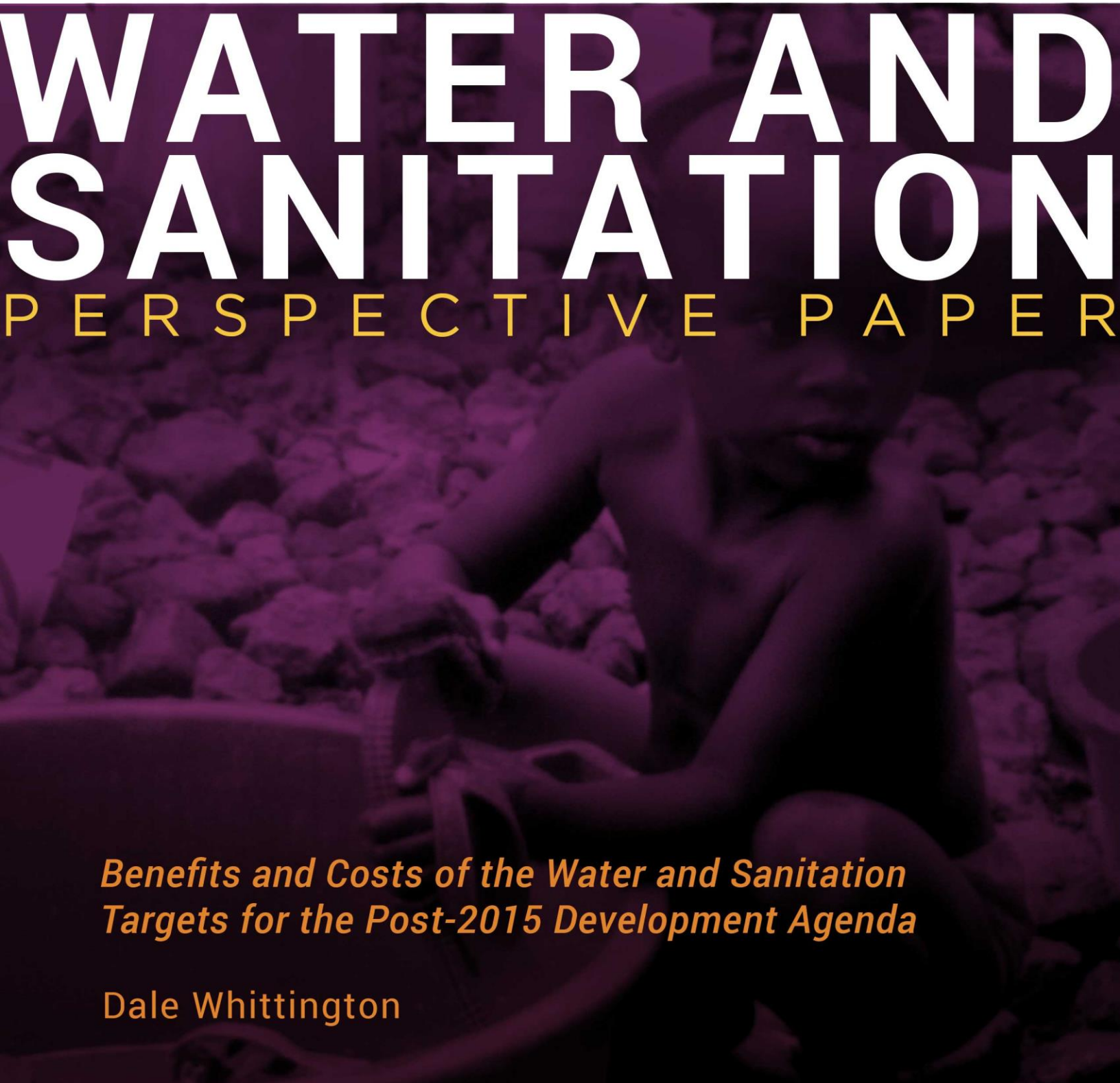

Benefits and Costs of the Water and Sanitation Targets for the Post-2015 Development Agenda

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Benefits and Costs of the Water Sanitation and Hygiene Targets for the Post-2015 Development Agenda

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Introduction[1]

The Assessment paper on Water and Sanitation written by Guy Hutton is the latest in a series of publications over the past decade supported by the World Health Organization and the World Bank. The results of these studies suggest that the benefits of water and sanitation interventions in developing countries are an order of magnitude or higher than the costs of improved services (Hutton and Haller, 2004; Haller, Hutton, and Bartram, 2007; Hutton, 2012; World Bank, 2008.). These analyses utilize up-to-date, high quality global data sets on water and sanitation coverage from the WHO-UNICEF Joint Monitoring Programme (JMP), and make a large number of assumptions and expert judgments to estimate costs and benefits at the country, regional, and global level. The methodology has been refined and reviewed over the years by professionals in the WASH sector, and these papers and reports have been widely cited in the sector as demonstrating conclusively the economic case for water and sanitation investments. But to the best of my knowledge the findings from these efforts have never been published in professional economics journals, or reviewed by economists from outside the WASH sector.

My review of the Assessment paper is challenging for three main reasons. First, the equations used in the benefit-cost calculations are not included in the Assessment Paper. Some (but not all) of the parameters and assumptions used to calculate benefits and costs are included in the paper. Because the calculations are complicated, it is probably unrealistic to expect that all the assumptions and parameter values be available to the reader, so this is not intended as a criticism of the Assessment paper. Nevertheless, the bottom line is that I am unable to replicate the estimates of costs and benefits in the Assessment paper, so it is possible that I have misinterpreted some of what has been done.

Second, the Assessment paper does not present any estimates of the benefits or the costs of the WASH interventions studied, either at the per capita, household, or regional levels; only the benefit-cost ratios are included. So, for example a benefit-cost ratio of 20 could mean that the results show household benefits of US$40 per month and costs of US$2 per month, or benefits of US$4 per month and costs of US$0.20 per month. It is thus hard to judge the reasonableness of the calculations without results for the benefits and costs, which I am unable to replicate.

Third, the paper is missing the concluding section, so I am not sure precisely how the author of the Assessment paper interprets the accuracy of the reported benefit-cost ratios. However, the abstract of the Assessment paper does say that there are no large certainties associated with the findings of this global cost-benefit exercise, so one can infer that the author believes that the findings have a high degree of precision.

In this review I will focus my comments on a few of the key assumptions that are mentioned in the Assessment paper and that underpin the benefit-cost calculations. I suspect but do not demonstrate that the reported benefit-cost ratios are quite sensitive to these assumptions. I

[1] This perspective paper is a response to a draft of Guy Hutton's assessment paper, received on 18 December 2014. Some of the comments in this perspective paper were incorporated into the final version of the assessment paper.

conclude that there is much more heterogeneity in the benefit-cost ratios of specific WASH interventions than implied by the analysis and discussion in the Assessment paper, and that the results must be viewed with caution.

Background: an overview of the cost-benefit calculations in the Assessment paper

In this section of the review, I present a summary of my understanding of how the benefit-cost ratios presented in the Assessment Paper were calculated. The analysis in the Assessment paper uses a multiyear spreadsheet model that takes country-level population forecasts and current WASH coverage statistics, and then forecasts WASH coverage from 2015 to 2030 in both rural and urban areas by wealth quintile and age cohort. WASH coverage is scaled up over the planning horizon to achieve universal access of basic services by 2030. Coverage is increased over the planning horizon for both households that are unserved in 2015 and new households that are created due to population growth. The assumptions that determine how quickly coverage is increased over the planning horizon (i.e., the trajectory of assumed coverage from 2015 to universal coverage in 2030) are not stated.

Increases in coverage over the planning horizon require that costs be incurred, and result in benefits accruing to "covered" households. Benefit-cost ratios are calculated based on the discounted sequence of annual costs and benefits over the planning horizon. Country-level benefit-cost results are aggregated to the regional and global level.

The spreadsheet model calculates the benefit-cost ratio of the following four WASH targets:

1. Eliminate open defecation
2. Achieve universal access to basic drinking water, sanitation and hygiene for households, schools and health facilities;
3. Halve the proportion of the population without access at home to safely managed drinking water and sanitation services; and
4. Progressively eliminate inequalities in access

Assumptions are made about the technology required to meet these targets, and different technologies entail different costs. For example, it is assumed that the target of eliminating open defection is met by the construction of a private or shared traditional latrine in rural areas and by private or communal toilets in urban areas. The calculations in the Assessment paper assume that a communal toilet (latrine) is shared by no more than five families.

The mix of basic sanitation facilities assumed to be used by households differs in rural and urban areas. In rural areas, the Assessment paper's calculations assume 50% of the unserved population is served by a pour-flush latrine and 50% by a dry pit latrine. In urban areas it is assumed that 50% of the unserved population are served by a flush toilet discharging to a septic tank, and 50% by any type of pit latrine.

For basic water supply the Assessment paper uses the following coverage indicator from the Joint Monitoring Programme (JMP): "Percentage of population using a protected community source or piped water with a total collection time of 30 minutes or less for a roundtrip including queuing." The Assessment paper assumes that unserved populations are supplied by different basic sources: 50% by a protected community borehole/tubewell and 50% by a protected dug well.

The Assessment paper also includes some calculations in which handwashing coverage is increased. The technology to meet the handwashing target is "handwashing stations," which includes a sink and adequate soap and water.

The Assessment paper estimates the economic benefits of the WASH interventions as the sum of health benefits and non-health benefits. The health benefits consist of two components: the mortality benefits and the morbidity benefits. The morbidity benefits include both time savings from not being sick and medical expenditures avoided. The spreadsheet model tracks three age cohorts over time (0-4 years, 5-14 years and 15+ years). Health benefits are calculated separately for each of the three groups because disease incidence is different in each cohort, and thus the consequences of moving to improved WASH services are different.

The nonhealth benefits include the time savings from not having to walk as far to collect water from sources outside the home and not having to walk to open defecation sites. The Assessment paper notes that several benefits of WASH interventions are not included in the analysis, and thus the benefit-cost ratios presented should be viewed as lower bounds.[2] To the extent that the reported benefit-cost ratios are accurate, this is correct.

Five Concerns about the Cost-benefit Calculations in the Assessment Paper

In the remainder of this review I comment on the following five aspects of the cost-benefit calculations that are mentioned in the Assessment paper:

1) Estimates of the monetary value of time savings and mortality risk reductions
2) Household Usage of WASH interventions
3) Estimation of the costs of WASH interventions
4) Discounting procedure
5) Sensitivity analysis

Concern No. 1 - Estimates of the monetary value of time savings and mortality risk reductions

Benefit-cost analysis rests on two assumptions:

1) Each person's well-being is to count, and is to count according to her own valuation, and

[2] However, I note that 'rise in value of property' is listed as one of the excluded benefits in the Assessment paper. Including this 'excluded benefit' would result in double counting.

2) The valuation placed on a specific change by a person is also the valuation placed on the change by society itself.

The challenge for the benefit-cost analyst is thus to learn about individuals' preferences for the consequences of an intervention (a policy, project, or regulation), and to measure the strength of these preferences in monetary terms, either the willingness to pay (WTP) of individuals for the new 'state of the world' with the intervention, or the willingness to accept (WTA) compensation to forego the change to the new 'state of the world." In practice, measuring individuals' WTP or WTA is typically challenging and/or time consuming, and analysts often take shortcuts or make assumptions to facilitate the calculations. But the test of the shortcuts or assumptions must be how well they approximate individuals' preferences.

Sector experts, especially in the health sector, are often uneasy or reluctant to measure the benefits of interventions in terms of individuals' preference because they may believe that ex ante individuals do not fully understand how beneficial the intervention will be ex post. Experts also worry that individuals may not understand the causal relationships between, say, clean water, improved sanitation, and health. They are thus inclined to substitute their own assessment of the benefits into the benefit-cost calculation. In some instances this may make sense if there is evidence that individuals' ex-ante preferences (i.e., before the project is completed) change ex-post (after they have experience with the outcomes of the intervention), and experts' judgments closely correspond to individuals' ex-post preferences.

However, the divergence between individuals' and experts' assessment of project benefits does create a challenge for the cost-benefit analyst. If the expert expects the ex-post benefits to be very high relative to costs (e.g. a benefit-cost ratio = 20), but ex-ante individuals do not, individuals may not use the project. So if experts substitute their own judgments of the benefits for those of individuals assumed to use the project, the resulting cost-benefit analysis will depend crucially on both 1) the accuracy of the expert's estimates of monetary values of, for example, time savings or mortality risk reductions (how well they match beneficiaries' ex-post assessment of the benefits, and 2) how many individuals will actually use the project's outcomes, given that their own ex ante assessment of the benefits. Put another way, if the benefit-cost ratio of a WASH intervention is 10:1, or even 20:1 as suggested in the Assessment paper, why don't individuals rush to adopt these interventions?

Although the Assessment paper does not report a breakdown of the magnitude or relative size of different components of the economic benefits, it does report that …
"Overall mortality contributes a small share of the overall economic benefit. The majority benefit comes from time savings."

It would seem then that the reasonableness of the total benefit estimate will depend largely on the accuracy of the quantification of the time savings, so I will try next to show how this calculation was done.

Time savings result from …

1) bringing improved water sources nearer to unserved households;
2) time savings from not being sick and from not caring for sick individuals in the household; and
3) not walking from home to an open defecation site.

Consider the third source of time savings – not walking to an open defecation site. Table 1 shows my attempt to reconstruct the estimates of the monetary value of the time savings associated with the provision of basic sanitation for adults and children in rural and urban areas reported in the Assessment Paper. If we assume a rural household of two adults and three children, the monthly benefits estimated in the Assessment paper would be about US$5 per month.

Is there any evidence that rural households in India (where open defection is common) would be willing to pay US$5 per month for the time savings associated with a shift from open defecation to a basic latrine? There is no such evidence that I know of. Indeed, there is evidence that many people prefer to practice open defecation rather than use a simple private or shared latrine (Coffey et al. 2014). One can reasonably argue that rural households do not understand the health benefits of ending open defecation practices, but it seems less plausible to me that rural households would not understand the value of time savings of ending an activity that they do every day. The benefit calculations in the Assessment paper of time savings resulting from a shift away from open defecation must be considered highly speculative and subject to a high level of uncertainty.

Similarly for mortality component of the health benefits, the Assessment paper substitutes expert judgments for empirical evidence about individuals' willingness to pay for mortality risk reductions. The Assessment paper uses a human capital approach to value the lives saved by different WASH interventions …

> "Mortality is valued using the human capital approach. The human capital approach estimates the total present value of future earnings of productive adults, hence considering their future life expectancy. The GDP per capita is used to reflect the economic contribution of the average member of society. To promote equality within policies influenced by cost-benefit analysis, all people within the same country are given the same value, irrespective of age and wealth quintile." (p. 15-16)

Table 1 – Calculations of time savings from the elimination of open defecation

	Urban - adults	*Urban - child*	*Rural - adult*	*Rural child*
Round-trip travel time before sanitation intervention	*15 min. per day*	*15 min. per day*	*20 min. per day*	*20 min. per day*
Round-trip travel time after sanitation intervention	*5 min. per day*	*5 minutes per day*	*5 minutes per day*	*5 minutes per day*
Time savings	*10 min. per day*	*10 minutes per day*	*15 min. per day*	*15 minutes per day*
Monetary value of time savings				
GDP per capita	*US$1500 per year*	*US$1500 per year*	*US$1500 per year*	*US$1500 per year*
Labor hours per year	*2500 hours*	*2500 hours*	*2500 hours*	*2500 hours*
GDP per hour	*US$0.60 per hr*	*US$0.60 per hr*	*US$0.60 per hr*	*US$0.60 per hr*
Monetary value of time savings	*(0.3) US$0.60 per hr = $0.18 per hour*	*(0.15) US$0.60 per hr = $0.09 per hour*	*(0.3) US$0.60 per hr = $0.18 per hour*	*(0.3) US$0.60 per hr = $0.09 per hour*
Monetary value of time savings (per day)	*US$0.03 per day*	*US$0.015 per day*	*US$0.05 per day*	*US$0.025 per day*
Monetary value of time savings per month	*US$0.90 per month*	*US$0.45 per month*	*US$1.50 per month*	*US$0.75 per month*

As Mishan (1971) pointed out in his cost-benefit textbook over 40 years again, there is no theoretical justification for using this human capital approach for measuring the economic value of mortality risk reductions. Nor is there any justification for assuming that everyone in a country would value mortality risk reductions the same. The theoretically correct approach to estimating the monetary value of a life saved (VSL) is to use an *ex-ante* measure of willingness to pay to avoid a given mortality risk (Viscusi & Aldy, 2003). Because mortality risk reduction is a normal economic good, poor households are willing to pay less for mortality risk reduction than high-income households. Some view this as implying that the lives of poor people are worth less than the lives of rich people, and many noneconomists still use the human capital approach, substituting expert judgment for individuals' preferences.

In this instance, as with the time savings associated with the elimination of open defecation, there are two results of using expert judgments instead of empirical information on individuals' preferences. The first is to give the appearance of greater certainty in the benefit estimates than actually exists. The second is, in many situations, to inflate the economic benefits of mortality risk reductions.

Concern No. 2 - Household Usage of WASH Interventions

There is no mention in the Assessment paper regarding assumptions made about the uptake of WASH interventions by unserved households. It thus seems likely that usage is assumed to be 100%, i.e., if an improved water source or shared latrine is made available to unserved households, that 100% of households in the community and 100% of household members will use the facility 100% of the time. Experience in the sector shows that this is unlikely to be the case.

There are two problems. First, some or all members of a household may decide not to use the new, improved facility. On a population basis, it is almost never true that 100% of households in a community switch to the new WASH facility. For example, if a new handwashing station is provided, some people still do not wash their hands there, even though it is nearby. Second, household members may use the new improved facility some, but not all, of the time. Household members may switch between using improved and unimproved water sources, or use a shared latrine sometimes and continue open defecation practices at other times (Whittington et al, 2009).

To the extent that WASH interventions are not used or used only part of the time, both the health-related and nonhealth-related benefits will be overestimated in the Assessment paper.

Concern No. 3 - Estimating the Costs of WASH Interventions

The Assessment Paper uses the following procedure to estimate the costs of WASH interventions when cost data are missing for a specific country:

"If the unit cost is US$30 in the source country (Country A), with a GDP at purchasing power of $1000, then the extrapolated unit cost to Country B with a GDP at purchasing power of $500 would be US$ 15."

Some of the cost components of water and sanitation interventions do vary with GDP, but many do not. The costs of unskilled labor may vary with GDP, but these are a small proportion of the cost of most WASH interventions. The cost of drilling a borehole, steel, PVC pipe, cement, skilled engineering services are more important, and are not likely to be that much cheaper in a country with a low GDP per capita than in a country with a higher GDP per capita. In some cases such costs will actually be higher in poorer countries.
It is not reported in the Assessment paper how often this procedure was needed to estimate missing cost data for countries. But the assumption that there is a perfect positive correlation between the costs of WASH interventions and GDP per capita will likely reduce the cost estimates and inflate the benefit-cost ratios reported in the Assessment paper.

Concern No. 4 - Discounting protocol

In the Cost Estimation section of the Assessment paper, it is reported that a discount rate of 8% was used to calculate the present value of the time profile of costs (expenditures) for WASH interventions, and that sensitivity analyses were conducted with two lower discount rates (3% and 5%) and one higher discount rate (12%).[3,4] However, in the results section the baseline discount rate is reported as 3%, with an alternative set of results in Annex 2 with a 5% discount rate. I am concerned that in the baseline case the costs may have been discounted at 8% and the benefits at 3%. Because more of the benefits will accrue in future periods, a lower discount rate for the benefits than for the costs will increase the present value of the benefit stream and increase the benefit-cost ratio. If the same discount rate was used for both benefits and costs, it is not clear what this discount rate was.[5]

Concern No. 5 - Sensitivity Analysis and the level of confidence in the benefit-cost ratios

The Assessment paper uses one-way sensitivity analysis to show how changes in the value of a single parameter such as the discount rate affect the benefit-cost ratio of various WASH interventions in different regions. This is useful and appropriate, but it does not give an accurate picture of the overall uncertainty in the reported benefit-cost ratios. In my judgment, the author's conclusion that there are no significant uncertainties in the findings is thus unwarranted.

[3] On page 12 - "A fourth uncertainty is the present value of future costs, which is calculated using a baseline discount rate of 8%."
[4] Although not stated, one assumes that this is a real (not nominal) discount rate.
[5] It is also not clear how the benefit-cost ratios in the Assessment paper were calculated. One option used is to discount the time stream of benefits to the initial period and discount the time stream of costs to the initial period, and then take the ratio of the present value of the benefits and the present value of the costs. A second option one sometimes sees is to calculate net benefits in future periods (subtracting reoccurring or operating costs from gross benefits) and then comparing the discounted value of the net benefit stream to the discounted value of initial capital costs or the discounted stream of CAPEX expenditures. These two approaches will yield different benefit-cost ratios.

To illustrate the nature of the problem, consider the calculation of the benefits due to mortality risk reduction. To monetize the health benefits of a WASH intervention, the analyst must first estimate the number of deaths avoided due to the intervention, and then assign a monetary value to the numbers of deaths avoided. To illustrate the basic calculation (and abstracting from the time profile of project outcomes and usage of the intervention), suppose the analyst wants to calculate the mortality reduction benefits that result from implementing a WASH intervention in a target population (Pop). We need four parameters.

The first is the baseline incidence of water-related disease before the intervention (Inc_{before}). Second, we need the effectiveness (Eff) of the project at reducing the incidence of diseases in the target population if a specified number of individuals adopt the intervention (Inc_{after} = (1-Eff) x Inc_{before}). This implies that the intervention reduced the number of cases by:

$$\Delta \text{ Cases} = \text{Pop} \times \text{Eff} \times Inc_{before} \quad (1)$$

Third, we must calculate the change in the number of deaths due to the project by multiplying the number of cases avoided by the case fatality rate (CFR):

$$\Delta \text{ Deaths} = \text{CFR} \times \text{Pop} \times \text{Eff} \times Inc_{before} \quad (2)$$

Fourth, to monetize the benefits of avoiding these deaths, we further multiply by the value of a statistical life (VSL). The resulting mortality risk reduction benefits are given by:

$$\text{Mortality risk reduction benefits} = \text{VSL} \times (\text{CFR} \times \text{Pop} \times \text{Eff} \times Inc_{before}) \quad (3)$$

Typically none of the values of these four parameters --Inc_{before}, CFR, Eff, or VSL-- is known with much certainty for a specific location where the new WASH intervention is to occur. Values of all four parameters are likely to vary widely even within a single country. Public health planners typically focus a great deal of attention on the estimation of Eff, but often more is already known about this parameter than about the other three.

The important point about the mortality risk reduction benefits in equation 3 is that it results from the multiplication of the four uncertain parameters. If each of these parameters is uncertain, their product will be highly uncertain (Whittington et al., 2012). Varying just one of these four parameters at a time will not reveal the extent of the uncertainty about the product. Monte Carlo analysis is needed to better understand the likely frequency distribution of the benefit-cost ratio that will result from a WASH intervention (Jeuland and Whittington, 2009).

Concluding Remarks

To summarize, I am not arguing in this review of the Assessment paper that WASH interventions will fail a cost-benefit test. In fact, I believe that carefully done cost-benefit analyses will show that many WASH interventions will be economically attractive investments. But the analysis needs to be done. It should not simply be assumed based on the type of calculations presented in the Assessment paper that all WASH interventions have

benefit-cost ratios so large that sector professionals do not need to do economic analysis of the investments they propose.

There can be a wide range of cost-benefit outcomes depending on local conditions. For example, baseline diarrhea incidence and case fatality rates from infectious diarrhea vary widely in different socioeconomic and climatic settings. The value of time savings depends crucially on local labor market conditions. It thus should not be a surprise that estimates of the economic value of the health and nonhealth benefits of WASH interventions will show great heterogeneity across time and space. Such differences need to be taken into account by sector professionals. Global averages of benefit-cost ratios will reveal little useful information about the attractiveness of WASH investments in specific local settings.

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