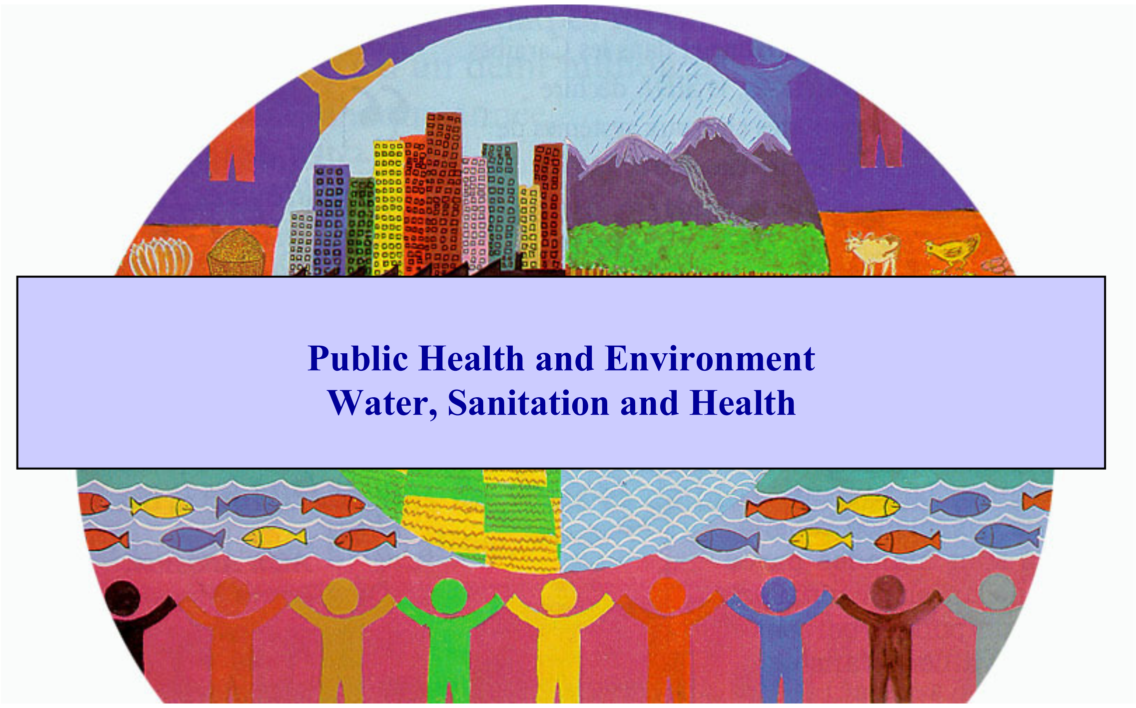
World Health Organization

UNDP

Economic and health effects of Increasing coverage of low cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target 10



Public Health and Environment
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Economic and health effects of increasing coverage of low cost household drinking-water supply and sanitation interventions to countries off-track to meet MDG target 10

Background document to the
"Human Development Report 2006"

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EXECUTIVE SUMMARY

Study aims. At current trends the world is expected to fall short of meeting the drinking water Millennium Development Goal (MDG) target by 354 million people and the sanitation MDG target by 564 million people. Recently it was estimated that 1.7 million deaths per year were attributable to unsafe water supply, sanitation and hygiene. A variety of economic impacts are linked to improved water and sanitation, which is one key contributor to poverty reduction efforts. The aim of this study is to estimate the health impacts and economic costs and benefits of improving water supply and sanitation services, with a focus on the least developed countries that are "off-track" to meet the water supply and sanitation MDG targets. In other words, based on trends from 1990 to 2004, these countries are predicted to fall short of one or both of the MDG targets for water supply and sanitation. The study models the impacts of low cost water supply and sanitation improvements in countries where the predicted coverage in 2015 falls short of the water supply and sanitation MDG targets, with the aim of focusing existing budgets as well as new resource allocations on the achievement of the Millennium Development Goal targets in these off-track countries. The study also estimates the costs and benefits of achieving universal access to improved drinking water supply and sanitation.

Study methods. Results are presented for 6 non-OECD developing world regions, based on the UNDP classification. Predicted reductions in the incidence of diarrhoeal disease were calculated for each intervention based on the expected population receiving these interventions and the relative risk reductions of populations moving to lower risk exposure scenarios. Deaths averted were estimated based on a region- and age-specific case fatality rate for diarrheal disease. The costs of the interventions included the full investment and operation and maintenance (O&M) costs of the selected low-cost interventions. The benefits of the interventions included time savings associated with better access to water and sanitation, gain in productive time due to less time spent ill, economic gains associated with saved lives, and health sector and patient costs saved due to less health seeking.

Study results. The benefit-cost ratios (BCR) shown in the table indicate that all low cost water supply and sanitation improvements are cost-beneficial for all developing world regions. In achieving the water supply and sanitation MDG targets using low cost improvements, an estimated US$ 5 to US$ 36 return on a US$ 1 investment is predicted in the six world regions, with a global average of US$ 8 return per US$ 1 investment for the combined water supply and sanitation MDG target.

The results suggest that achieving the sanitation MDG target is economically more favourable than the water MDG target, with a global return of US$ 9 for sanitation compared to US$ 4 for water, per US$ 1 invested. This is due to the greater relative health impacts of investing in sanitation and the related health cost savings and productivity benefits. 190 million annual diarrhea cases would be averted globally for meeting the sanitation MDG target compared with 72 million for the water MDG target. Also, the time savings per person receiving the intervention are higher for

improved sanitation (assumed 30 minutes per *individual* per day) compared with improved water supply (assumed 30 minutes per *household* per day). However, balancing these effects in the benefit-cost ratio is the higher intervention cost of sanitation improvements per capita.

Benefit-cost ratio for achieving six water and sanitation coverage scenarios

World Region *	Achieving MDG targets for:			Universal access to:		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	2.8	6.6	5.7	3.9	6.5	5.7
Arab States	6.1	5.3	5.4	5.9	12.7	11.3
East Asia & Pacific	6.9	12.5	10.1	6.6	13.8	12.2
South Asia	3.5	6.9	6.6	3.9	6.8	6.6
Latin America & Caribbean	8.1	37.8	35.9	17.2	39.2	36.3
Eastern Europe & CIS	8.3	27.8	18.9	8.9	29.9	27.4
Non-OECD	**4.4**	**9.1**	**8.1**	**5.8**	**11.2**	**10.3**

Economic benefits are estimated to total US$ 38 billion annually for meeting the combined water and sanitation MDG targets. 92% of this value is accounted for by achieving the sanitation MDG target. Sub-Saharan Africa accounts for 41% of the global economic benefit, given that a significant proportion of the off-track countries are in Africa. Other regions benefiting from the interventions include Latin America & Caribbean (22%), East Asia & Pacific (17%) and South Asia (15%). Economic benefits for achieving universal coverage are several times greater, at US$171 billion annually, a gain which is spread between East Asia & Pacific (39%), South Asia (20%), Latin America & Caribbean (17%), sub-Saharan Africa (14%), Eastern Europe & CIS (5%), and the Arab States (4%). These proportions are most heavily weighted by the sanitation component. For universal coverage with water supply, the proportional benefits are considerably higher for East Asia & Pacific (42%), sub-Saharan Africa (36%) and the Arab States (11%), and lower for South Asia (5%) and Latin America & Caribbean (3%).

The contribution to economic benefits varies between water and sanitation. For the case of sub-Saharan Africa, in achieving the water MDG target, 63% of the benefits are attributed to convenience time savings, 28% to productivity gains, and 9% to health care cost savings. Economic benefits of sanitation, on the other hand, are more heavily dominated by convenience time savings at 90% of the total economic benefit, followed by 8% to productivity gains, and 2% to health care cost savings.

For the combined water and sanitation targets, considerable per capita gains are expected. For achieving the combined water and sanitation MDG target, sub-Saharan Africa benefits the most with an average of US$ 17.5 per capita per year, based on the entire population as denominator. In Latin America & Caribbean the average benefit is US$ 13.5 per capita per year. Under universal coverage, all world regions benefit substantially under these improvements, with at least US$ 15 per capita per year for the entire developing world population.

In non-OECD regions, the additional annual cost of achieving the MDG targets is US$ 858 million for water, and US$ 3.81 billion for sanitation, giving a total of US$4.67 billion for the two MDG targets combined. Sub-Saharan Africa accounts for over 50% of the combined MDG target costs, at US$ 2.67 billion, followed by South Asia (18%), and East Asia & Pacific (13%). These costs are incremental costs over and above the current annual investments in W&S services, which during the 1990s averaged an annual investment of 16 billion in Africa, Asia and Latin America and the Caribbean combined.

These annual figures translate into an incremental cost of achieving the combined water and sanitation MDG targets of US$46.7 billion, which would be spent over the period 2005 to 2015. However, this figure assumes MDG targets will be met immediately. If there is a linear scaling up of coverage from 2006 to 2015, the actual cost could be as little as half this figure, at an additional US$23 billion. Based on this linear scaling up, global welfare benefits total US$ 188 billion for a 10 year period. US$23 billion is likely to be a lower bound on the true cost, because in reality a proportion of households, especially in urban areas, will receive higher cost improvements such as household connection to piped water and/or sewerage, with or without sewage treatment.

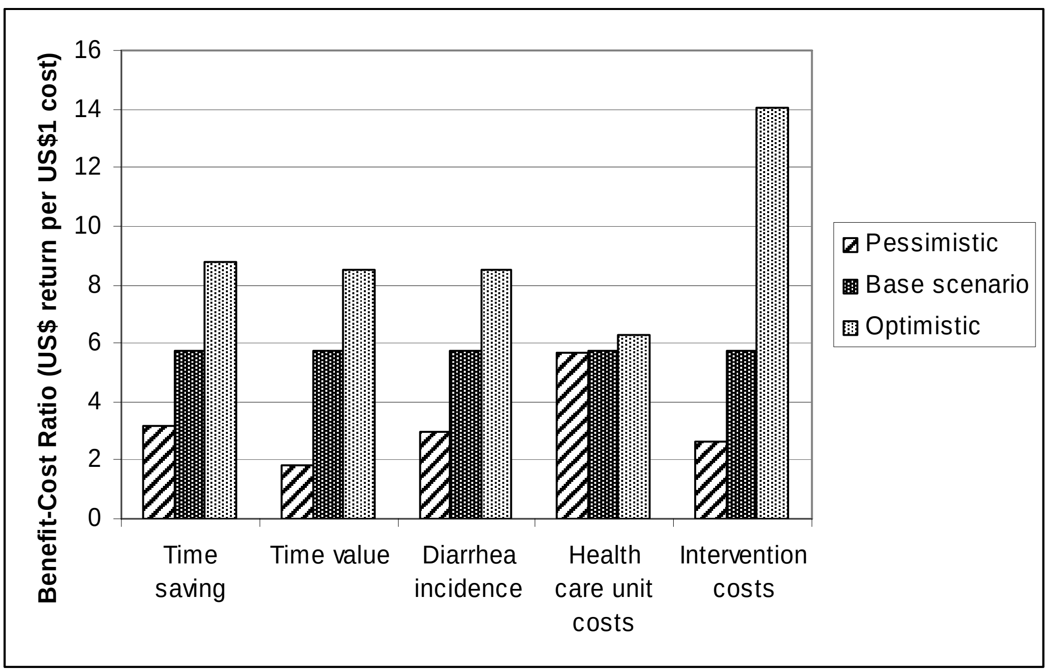
Annual and total costs of meeting water supply and sanitation targets

Variable	**MDG targets**			**Universal coverage**		
	Water	**Sanitation**	**W&S**	**Water**	**Sanitation**	**W&S**
Annual values (million US Dollars)						
Annual cost	858	3,813	4,671	2,075	14,507	16,581
Annual benefit	3,762	34,703	37,689	11,999	163,088	170,508
Total values with immediate achievement of MDG targets in 2006 (million US Dollars)						
Total cost 2006-2015	8,580	38,130	46,710	20,750	145,070	165,810
Total benefit 2006-2015	37,620	347,030	376,890	119,990	1,630,880	1,705,080
Total values, linear scaling up to MDG targets from 2006-2015 (million US Dollars)						
Total cost 2006-2015	4,290	19,065	23,355	10,375	72,535	82,905
Total benefit 2006-2015	18,810	173,515	188,445	59,995	815,440	852,540

In achieving universal coverage in water supply and sanitation, the global annual cost of US$ 16.6 billion is more equally divided between three world regions: sub-Saharan Africa (25%), East Asia & Pacific (33%), and South Asia (31.5%), with the remaining 11.5% going to the other three non-OECD regions. Achieving universal sanitation coverage accounts for 87.5% of the combined water and sanitation universal coverage costs. This is partly explained by the fact that more people receive the sanitation intervention (2.2 billion) compared to the water intervention (0.8 billion) in achieving universal access, and partly because annual per capita costs for sanitation are more expensive than for water by a factor of 2 to 3 times.

Interpretation of results. An important caveat of a global study such as the one conducted here is the uncertainty in the results. One important element of uncertainty is the generalization of epidemiological, cost and economic benefit data from one country or one region to another. Alternative upper and lower values for selected key variables data inputs were tested in one-way sensitivity analysis. The figure below shows the benefit-cost ratios under lower and upper ranges on five parameters for sub-Saharan Africa. Large ranges on the resulting benefit-cost ratios for four out of the five variables tested suggests that the cost-benefit results need to be interpreted with a degree of caution. While at the regional level the input data reflect regional averages and hence do not suggest there will be significant bias in the results, some caution should be maintained in interpreting results for specific country contexts where parameter input values may vary substantially from those used in this regional level analysis. Although the benefit-cost ratio stays above or close to 2 in all one-way analyses, combining pessimistic assumptions on several key sources of uncertainty simultaneously would likely push the BCR below 1. On the other hand, the benefit-cost ratios are conservative given that some potential benefits were omitted such as diseases other than diarrheal disease, water cost savings and incomes from micro-enterprise.

Range on the base case scenario benefit-cost ratio from using pessimistic and optimistic values for selected input parameters



In interpreting the impressive benefit-cost ratios presented in this study, an important further caveat needs to be taken into account. On the cost side, the costs are very tangible, requiring financial input upfront for the interventions to be put in place. On the benefit side, however, the majority of the benefits are not highly tangible, in that the benefits do not bring immediate money 'in the hand'. The reduced number of days spent ill can also lead to direct financial benefits, such as more time spent on income-earning activities, but the majority of time saving is likely to be spent on unpaid productive activities, education or leisure time.

Intervention financing. While cost-benefit analysis can be carried out to identify all the beneficiaries and the (potential) financers of development projects, the analysis does not provide direct answers to the question of who is able to pay. The intervention financing imperative presents a particular challenge to economic evaluation when no single ministry or population group are able to finance the full cost of an intervention. Water supply and sanitation are the domains of many sectors and government line ministries; hence a coordinated financing effort will be needed to ensure interventions are financed, planned and implemented to enjoy the full benefits presented in this analysis, as well as other potential benefits. Cost-benefit analysis presents the benefits which accrue to different beneficiaries, thus implying who may be willing to contribute to intervention financing. However, the main beneficiaries – private individuals and households – do not always understand the full benefits until after the investment is made. Also, most costs are incurred in the first year of the intervention, while benefits accrue over time. These factors together imply that many private consumers would not be willing or capable of financing the initial investment costs up-front. On the other hand, cost savings from switching away from more expensive water supply options (e.g. water vendors or bottled water) provides a financial rationale for investing in improved water supply.

With respect to the question whether the health sector would be willing to finance water supply and sanitation interventions from a cost-benefit perspective, it is clear from this analysis that in most regions and for most interventions there is little incentive for the health sector to make significant contributions to the intervention costs, as the real savings to the sector are small (US$ 641 million for the combined water supply and sanitation MDG target) in comparison to the annual intervention costs (US$4,671). However, from a cost-effectiveness angle – in terms of prioritising budgets to spend on interventions that deliver health benefits at little cost to the health sector, water and sanitation improvements can deliver value for money. The health ministry should therefore be interested in leveraging investment in policies and regulations that support health.

In conclusion, there should exist a variety of financing mechanisms for meeting the costs of water and sanitation improvements, depending on the income and asset base of the target populations, the availability of credit, the economic benefits perceived by the various stakeholders, the budget freedom of government ministries, and the presence of private sector and NGOs to promote and finance water supply and sanitation improvements.

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ABBREVIATIONS AND ACRONYMS

BCR	Benefit-Cost Ratio
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CER	Cost-Effectiveness Ratio
DALY	Disability-Adjusted Life-Year
EIRR	Economic Internal Rate of Return
GDP	Gross Domestic Product
GNP	Gross National Product
MDG	Millennium Development Goal
NPV	Net Present Value
OECD	Organisation for Economic Cooperation and Development
UNDP	United Nations Development Fund
UNICEF	United Nations Children's Fund
US$	United States Dollar
VIP	Ventilated Improved Pit latrine
W&S	Water and sanitation
WHO	World Health Organization

1. INTRODUCTION

1.1 Water and sanitation coverage

Globally, diseases associated with poor water and sanitation have considerable public health significance. In 2003, it was estimated that 54 million disability-adjusted life-years (DALY) or 4% of the global DALYs and 1.73 million deaths per year were attributable to unsafe water supply and sanitation, including lack of hygiene [1]. During the 1980s and 1990s there was considerable investment in the provision of water supply and sanitation in developing countries. In 2004, however, still a significant proportion of the world's population remained without access to safe drinking water and improved sanitation [2].

The percentage of people worldwide who have access to an improved water supply has risen from 78% in 1990 to 83% in 2004, as shown in Table 1. According to the WHO / UNICEF Joint Monitoring Programme (JMP), some 1,228 million more people have been served during these 14 years (772 million in urban and 456 million in rural areas). At the current rate of progress, the MDG water supply target is close to being met at global level, with a global target of 89% in the year 2015. The rate of increase of household connection with piped water is lower than that for water supply generally, with an increase in 5 percentage points from 49% in 1990 to 54% in 2004.

Table 1. Global access to improved water supply (millions)

Location	Total population		Population served		Population unserved		% population served		% house connection	
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Urban	2,279	3,113	2,171	2,944	108	170	95	95	80	78
Rural	3,001	3,276	1,921	2,377	1,080	899	64	73	26	30
Total	5,280	6,389	4,092	5,320	1,187	1,069	78	83	49	54

Source: WHO / UNICEF Joint Monitoring Programme, 2006 [2]

The percentage of people worldwide who have access to improved sanitation facilities has risen from 49% in 1990 to 59% in 2004, as shown in Table 2. Progress has been achieved within both urban settings - with some 698 million more people served – as well as rural settings, with some 510 million more people served. However, despite at this current rate of progress, the MDG sanitation target is unlikely to be met, with a global target of 74% in the year 2015. The rate of increase of house connection with sewerage is lower than that for sanitation improvement generally, with an increase in 3 percentage points from 28% in 1990 to 31% in 2004.

Table 2. Global access to improved sanitation (millions)

Location	Total population		Population served		Population unserved		% population served	
	1990	2004	1990	2004	1990	2004	1990	2004
Urban	2,279	3,113	1,804	2,502	475	611	79	80
Rural	3,001	3,276	765	1,275	2,235	2,001	26	39
Total	5,280	6,389	2,569	3,777	2,710	2,612	49	59

Source: WHO / UNICEF Joint Monitoring Programme, 2006 [2]

As well as global level, it is important to examine country and regional progress. The WHO / UNICEF Joint Monitoring Programme has provided summaries for the 50 least developed countries[1]. Some 50 countries are listed amongst the least developed countries[2]. The percentage of people served with improved water supply has improved between 1990 and 2004, mainly in rural settings where an increase in coverage of 8 percentage points has been achieved. Urban areas have only seen a small 1% coverage increase. Out of the 220 million new inhabitants, 170 million have gained access to improved water supply between 1990 and 2004. In terms of the MDG target of roughly 75% water supply coverage, increased coverage of a further 17% percentage points needs to be made between now and 2015.

Table 3. Access to water supply in the world's least developed countries (millions)

Location	Total population		Population served		Population unserved		% population served		% house connection	
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Urban	109	201	85	159	24	43	78	79	34	30
Rural	413	540	179	275	234	265	43	51	2	2
Total	522	742	264	434	258	308	51	58	9	10

Source: WHO / UNICEF Joint Monitoring Programme, 2006 [2]

In the same least developed countries, the percentage of people served with adequate sanitation has noticeably improved between 1990 and 2004, with an increase of 14 percentage points. Out of the 220 million new inhabitants living in these countries, 152 million have gained access to improved sanitation during these 14 years. However, for these 50 least developed countries, the MDG target of 61% sanitation coverage is still far off. An increase in coverage over the remaining period of 25 percentage points is needed.

Table 4. Access to sanitation in the world's least developed countries (millions)

Location	Total population		Population served		Population unserved		% population served	
	1990	2004	1990	2004	1990	2004	1990	2004
Urban	109	201	52	111	57	91	48	55
Rural	413	540	65	158	348	382	16	29
Total	522	742	117	269	405	473	22	36

Source: WHO / UNICEF Joint Monitoring Programme, 2006 [2]

[1] http://www.wssinfo.org/en/welcome.html

[2] Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tome & Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sudan, Timor-Leste, Togo, Tuvalu, United Republic of Tanzania, Uganda, Vanuatu, Yemen, Zambia

1.2 Arguments to advocate for increasing water and sanitation coverage

Given the above statistics on progress towards meeting the MDG targets in the least developed countries, and the commitments made by all UN Member States to the MDG targets, there is a clear need for considerably accelerated progress towards the water and sanitation MDG targets. There are indeed many conditions for achieving this much-needed acceleration. One key factor for success is an increased advocacy at international and national levels to boost resource allocations to water supply and sanitation. A second key factor is the provision of good quality global and country evidence for choosing the most efficient water supply and sanitation options, to increase the value-for-money of existing as well as new spending. Such efforts are ongoing by WHO and its partners to develop and pilot test a comprehensive economic evaluation methodology for use at country level. Furthermore, linkages of water supply and sanitation with other MDG targets needs to be made in advocating for increased coverage of water supply and sanitation, such as poverty reduction, child health improvement, gender equality and environmental sustainability. In the current climate where poverty reduction strategies and increased aid effectiveness dominate the development agenda, the potential productivity and income effects of improved water supply and sanitation access is a potentially significant argument to support further resource allocations to the sector.

While there are many criteria for allocating resources to different ministries and government programmes, the relative economic costs and effects of different programmes and interventions are critically important. Cost-effectiveness analysis is becoming an increasingly important tool in the allocation of funds within the health sector [3], although cost-benefit analysis remains the form of economic evaluation most useful for cross-sectoral resource allocation to different government-financed activities [4]. As well as providing key information on intervention efficiency, economic evaluation can provide the basis for provision of other key policy-relevant information on who benefits from water supply and sanitation interventions and therefore who may be willing to contribute to the financing of these interventions [5-9]. Several studies exist on the cost-effectiveness of water supply and sanitation interventions in specific contexts [10-13] as well as generalized analysis [14, 15]. However, aside from the global cost-benefit analysis published by the World Health Organization in 2004 [16, 17][3], there is limited comprehensive information on the global cost-benefits of improved water supply and sanitation interventions. Hence, the purpose of this paper is to further strengthen advocacy efforts, based on a new analysis using the WHO global cost-benefit model.

[3] http://www.who.int/water_sanitation_health/wsh0404/en/index.html

2. METHODS

The current study presents the costs and benefits of selected improvements in water supply and sanitation at the regional and global levels, summarized in the benefit-cost ratio (BCR). The methods and model are based closely on those used in a previous study [16, 17]. However, the current study uses the previous methodology with some key differences, which are described in more detail in this section. In brief, the main differences are that: (a) the study compares the coverage targets against the predicted coverage for the year 2015, to give greater focus to those countries currently off-track to meet the water supply and sanitation MDG targets; (b) some model input data have been updated: baseline coverage levels, diarrheal disease incidence rates and health service unit cost data; (c) costs and benefits to reach sanitation coverage targets are presented alone as well as together with the water supply targets; (d) only low cost interventions have been included, hence excluding the more expensive piped and sewerage options for water supply and sanitation, respectively; and (e) results are aggregated from country level into 6 developing world regions (defined by UNDP) instead of WHO's classification of 14 sub-regions.

2.1 Interventions

The number of options available for improving access to water and sanitation is large. For developing countries, WHO favours intervention options that are effective (in terms of health, economic and social benefits), low cost, technically feasible, and those for which there is evidence of sustainability.

The analysis presented in this paper is based on changes in water and sanitation service levels. Table 5 categorises which types of service are 'improved' and which are considered to be 'unimproved', as defined by the Joint Monitoring Programme of WHO and UNICEF.

Table 5. Definition of 'improved' and 'unimproved' sanitation and water supply

Intervention	Improved	Unimproved **

Sanitation	• Flush or pour-flush to:
	  ◦ Piped sewer system
	  ◦ Septic tank
	  ◦ Pit latrine
	• Ventilated Improved Pit-latrine
	• Pit latrine with slab
	• Composting toilet
		• Flush or pour-flush to elsewhere
		• Pit latrine without slab or open pit
		• Bucket
		• Hanging toilet or hanging latrines
		• No facilities or bush or field

Water supply	• Piped water into dwelling, plot, or yard • Public tap / standpipe • Tubewell/borehole • Protected dug well • Protected spring • Rainwater collection	• Unprotected dug well • Unprotected spring • Cart with small tank/drum • Tanker truck • Bottled water • Surface water (river, dam, lake, pond, stream, canal, irrigation channels)

This table reflects the definition presented in the 2006 JMP report [2], updated from the "Global Water Supply and Sanitation Assessment 2000 Report" [18].

JMP defines services as unimproved not only if they are considered unsafe, but also if they are excessively costly, such as bottled water or water provided by tanker truck. Whilst these generalisations are reasonable at global level, they should be verified and corrected as necessary in country level application.

Deciding which options to choose depends on the socio-economic and environmental conditions of any country and specific locality, where a range of improvements can be considered as in Table 5. However, this present study has selected to model the costs and benefits of basic and simple to deliver improvements only, thus focusing attention on the minimum costs associated with the most affordable solutions for the least developed countries, and their health and developmental benefits. Due to the specific nature of 'ecological sanitation', this approach has not been included in this study, although it merits a separate study due to the additional potential benefits to agriculture and the local economy. Specifically:

- **'Improved' water supply** involves better physical access to water sources as well as protection of those sources. The technical options included in the cost measurement are: stand post, borehole, protected spring or well, and collected rain water. Under this definition, improved water supply does not necessarily mean that the water is entirely safe, but that it is more accessible and that some measures are taken to protect the water source from easily avoidable contamination. Hence, some health gains are to be expected from 'improved' water supply as defined here.

- **'Improved' sanitation** involves better access and safer disposal of human excreta covering septic tank, simple pit latrine, and ventilated improved pit-latrine. Sewerage and treated sewage are considered 'improved', but are not included as a technical option in this present study due to their generally higher unit cost..

The study models the achievement of the MDG targets for water supply and sanitation separately (halving the proportion of people who do not have access to improved water or basic sanitation between 1990 and 2015), as well as the water supply and sanitation targets together. The study also presents results for the achievement of universal access to basic services, as an ideal policy goal. Therefore, six sets of results are presented for the costs and benefits of achieving (see Table 6):

1. Water supply MDG target alone.
2. Sanitation MDG target alone.
3. Water supply and sanitation MDG targets together.
4. Universal access to improved water supply alone.
5. Universal access to basic sanitation alone.
6. Universal access to improved water supply and basic sanitation together.

Table 6. Scenarios presented in this report

Coverage	Water alone	Sanitation alone	W&S together
MDG target	Scenario 1	Scenario 2	Scenario 3
Universal access	Scenario 4	Scenario 5	Scenario 6

2.2 Coverage levels

An important adaptation of this present study to the previous global cost-benefit study is that the analyses focus on the countries and regions that are off target to reach the water supply and sanitation MDG targets. The baseline scenario which provides the comparison for the MDG targets and universal coverage is not the current population coverage as compared to the target year in 2015 [16]. Instead, the baseline scenario is the predicted population coverage of each country in the year 2015. This predicted population coverage is based on an assumption of a continuation of the average linear increase in coverage from the years 1990 until 2004, taken to the year 2015. Therefore, if a country is on course to meet the MDG targets for water, then the costs and benefits in scenario 1 would be zero. Annex 2 presents coverage gaps for countries predicted to miss the water supply and sanitation MDG targets, using projected coverage in 2015[4]. Hence, by choosing the projected 2015 coverage levels as the baseline scenario gives greater emphasis to those countries that are at risk of not meeting the MDG targets. The universal water supply and sanitation access interventions (4 to 6) also give greater attention to the least developed countries, but this analysis also includes all other countries that have not yet reached 100% coverage. However, the lower coverage countries give greater weight to the universal coverage analysis.

Table 7 presents selected exposure scenarios used by the World Health Organization for classifying health risk. As in the previous global cost-benefit study, populations are classified according to whether they have no improved access to either water supply or sanitation services (Level VI in Table 7), access to only improved water supply (Level Vb), access to only improved sanitation (Level Va), or already with improved access to both water supply and sanitation services (Level IV) [19]. The present study, unlike the previous cost-benefit study, does not consider further improvements that make the water or sanitation services safer, such as water disinfection at the point of use or regulated piped water supply [16]. Therefore, Levels III, II, and I in Table 7 are not relevant for the present study. Hence, the cost estimations made in this present study will likely be an underestimation of the actual investments undertaken and recurrent costs incurred, given that piped water supply and sewer connection are not considered here.

[4] Countries not included in the Annex 2 are excluded from the MDG analysis. For some countries, this is because the MDG target is predicted to be met at current projections. For other countries, this is due to missing data to make a projection (either no base year, or no mid-point year such as 2002 or 2004).

Table 7. Selected exposure scenarios

Level	Description	Environmental faecal-oral pathogen load
VI	No improved water supply and no basic sanitation in a country which is not extensively covered by those services, and where water supply is not routinely controlled	Very high
Vb	Improved water supply and no basic sanitation in a country which is not extensively covered by those services, and where water supply is not routinely controlled	Very high
Va	Improved sanitation but no improved water supply in a country which is not extensively covered by those services, and where water supply is not routinely controlled	High
IV	Improved water supply and improved sanitation in a country which is not extensively covered by those services, and where water supply is not routinely controlled	High
III	Improved water supply and improved sanitation in a country which is not extensively covered by those services, and where water supply is not routinely controlled, plus household water treatment	High
II	Regulated water supply and full sanitation coverage, with partial treatment for sewage, corresponding to a situation typically occurring in developed countries	Medium to low
I	Ideal situation, corresponding to the absence of transmission of diarrhoeal disease through water, sanitation and hygiene	Low

Based on Prüss *et al*. 2002 [19]

2.3 Geographical focus

The present study estimated costs and benefits at the country level. In the MDG analysis, countries were only included that are off-track to meet the water supply and sanitation MDG targets. In the universal coverage analysis, all countries were included that are not predicted to reach universal coverage in the year 2015. The results from the country analysis were aggregated to give regional averages, using regions of the United Nations Development Programme: Sub-Saharan Africa, Arab States, East Asia & Pacific, South Asia, Latin America & Caribbean, and Eastern Europe & CIS (see Annex 2). OECD countries were excluded from the presentation of results.

2.4 Cost measurement

An incremental cost analysis was carried out, with an estimate of the costs of extending access to water supply and sanitation services for those currently not having access. Incremental costs include all resources required to put in place and maintain the interventions, as well as other costs that result from an intervention. These are separated into investment and recurrent costs. Investment costs include: planning and supervision, hardware, construction, protection of water sources and education that accompanies an investment in hardware. Recurrent costs include operating materials to provide a service, maintenance of hardware and replacement of parts, emptying of septic tanks and latrines, ongoing protection and monitoring of water sources, and continuous education activities.

The main data source for initial investment costs of water supply and sanitation interventions was the Global Water Supply and Sanitation Assessment 2000 Report [20], which presented investment costs per person covered in three major world regions (Africa, Latin America and the Caribbean, and Asia/Oceania). These data are presented in Table 8 in prices for the year 2000, and for the purposes of the present analysis are updated to reflect 2005 prices using a Gross Domestic Product (GDP) deflator[5]. More up-to-date and UNDP region-specific cost estimates could not be used for this present study, as no further multi-country data have been produced in the intervening period that would give more reliable cost estimates for such a global study [15].

Table 8. Initial investment cost per capita (US$)

Improvement	**Initial investment cost per capita (US$ year 2000)**		
	Africa	**Asia**	**Latin America & Caribbean**
Water improvement			
Standpost	31	64	41
Borehole	23	17	55
Dug well	21	22	48
Rainwater	49	34	36
Sanitation improvement			
Small bore sewer	52	60	112
Septic tank	115	104	160
Pour-flush	91	50	60
VIP	57	50	52
Simple pit latrine	39	26	60

Source: WHO/UNICEF/WSSCC [20]

Annualised costs of the investment costs were calculated based on an annuitization formula [21]:

$$E = \frac{K - (S/(1+r)n}{A\ (n,r)}$$

Where E is the equivalent annual investment cost
K is the purchase price
S is the resale price (assumed to be 0)
n is the useful life of the equipment (see Table 6)
r is the discount rate (3%)
A (n,r) is the annuity factor (n years at r discount rate)

[5] World Bank Development Indicators

The estimation of recurrent costs was more problematic due to the lack of easily available data sources for approximation at world regional level. Values from the literature were combined with assumptions for the various components of recurrent costs which are presented in Table 9. Cost assumptions were based on the likely recurrent cost as a percentage to the annual investment cost, using values from the literature (World Bank and other project data). Data sources and explanations for selected values are provided in the original report [16].

Table 9. Assumptions used in estimating annualized and recurrent costs

Improvement	Length of life In years (+ range)	Operation, Maintenance, Surveillance as % annual investment cost (+ range)	Hygiene education as % annual cost (+ range)	Water source protection as % annual investment cost (+ range)
Water improvement				
Stand post	20 (10-30)	5 (0-10)	-	10 (5-15)
Borehole	20 (10-30)	5 (0-10)	-	5 (0-10)
Dug well	20 (10-30)	5 (0-10)	-	5 (0-10)
Rainwater	20 (10-30)	10 (5-15)	-	0
Sanitation improvement *				
Septic tank	30 (20-40)	10 (0-10)	5 (0-10)	-
VIP	20 (10-30)	5 (0-10)	5 (0-10)	-
Simple pit latrine	20 (10-30)	5 (0-10)	5 (0-10)	-

* Sewage disposal is assumed to cost US$2/person/year for VIP and simple pit latrine and US$3/person/year for septic tanks.

Total annual costs were then calculated by multiplying the equivalent annual investment cost in formula (1) above by the various recurrent cost factors in Table 9. Table 10 presents the annual costs of each improvement per person reached, based on the intervention costs and assumptions in Tables 8 and 9. It can be seen that the costs vary considerably between different types of improvement. For example, in Africa water improvement varies from US$1.55 per person per year for dug well to US$3.62 for rain water collection. This compares with US$1 for the amortized annual cost per capita of handpump or standpost used in the cost-effectiveness analysis conducted by the recent Disease Control Priorities chapter on water and sanitation [15]. For sanitation, costs vary in Africa from simple pit latrine at US$4.88 to septic tank at US$9.75. These costs were updated to 2005 prices. This compares with US$12 for the amortized annual cost per capita of a VIP and US$0.50 annual cost per capita for sanitation promotion and US$0.20 annual cost per capita for hygiene promotion, used in the cost-effectiveness analysis conducted by the recent Disease Control Priorities chapter on water and sanitation [15].

Table 10. Annual costs for improvements on a per-person-reached basis

Intervention	Annual cost per person reached (US$ year 2000)		
	Africa	Asia	LA&C
Improved water supply			
Standpost	2.40	4.95	3.17
Borehole	1.70	1.26	4.07
Dug well	1.55	1.63	3.55
Rain water	3.62	2.51	2.66
Improved sanitation			
Septic tank	9.75	9.10	12.39
VIP	6.21	5.70	5.84
Simple pit latrine	4.88	3.92	6.44

Data based on annual investment costs (Table 4) and recurrent cost assumptions (Tables 5 & 6)

2.5 Health benefits

Knowledge of the health benefits of water supply and sanitation improvements is important not only for a cost-effectiveness analysis, but also for a cost-benefit analysis as some important economic benefits depend on estimates of health effects. Over recent decades, compelling evidence has been gathered that demonstrates significant and beneficial health impacts associated with improving population access to and use of improved water supply sources and improved sanitation facilities [15, 22, 23]. The routes by which pathogens infect individuals and affect population health via water, sanitation and hygiene are many and diverse. They include [19][6]:

- Water-borne diseases (e.g. cholera, typhoid)
- Water-washed diseases (e.g. trachoma)
- Water-based diseases (e.g. schistosomiasis)
- Water-related vector-borne diseases (e.g. malaria, filariasis and dengue)
- Water-dispersed infections (e.g. legionellosis)
- Chemical contamination of water (e.g. arsenic, fluoride)

While a full analysis of improved water and sanitation services would consider pathogens passed via all these routes, the present study focuses on faecal-oral disease transmission which dominates the burden of disease associated with the water-borne and water-washed routes [19]. This is partly because, at the household level, it is the transmission of faecal-oral diseases that is most closely associated with water supply, sanitation and hygiene [19]. Moreover, water-borne and water-washed diseases are responsible for the greatest proportion of the direct-effect water and sanitation-related disease burden [1, 24].

In terms of burden of disease, water-borne and water-washed diseases comprise mainly infectious diarrhoea. Infectious diarrhoea includes cholera, salmonellosis, shigellosis, amoebiasis, and other protozoal and viral intestinal infections. These are

[6] http://www.who.int/water_sanitation_health/en/

transmitted by water, person-to-person contact, animal-to-human contact, and food-borne, droplet and aerosol routes. Infectious diarrhoea causes the main burden resulting from poor access to water and sanitation, and 90% of the disease burden from diarrhea is in children younger than 5 years [19]. Incidence rates for diarrhoea used in the analysis vary by age group and world region, from 3.7 (WPR-B) to 8.1 (AFR-D) for infants 0-1 years of age (WHO unpublished data). Case fatality rates for diarrhea also vary considerably between developing country subregions, from 1 death in 770 cases (AFR-D) to 1 in 12,700 cases (WPR-B). Hence, as there are data for all regions on the incidence rates and deaths, the impact of interventions in this analysis is exclusively measured by the following two indicators:

- Reduction in diarrheal disease incidence (number of cases averted per year).
- Reduction in mortality rates (number of deaths averted per year)

These two indicators are calculated by applying relative risks taken from a literature review [19] which were converted to risk reduction when moving between the different exposure scenarios elaborated by Prüss and colleagues [1, 19]. Relative risks are presented in Table 11 below. Diarrhoeal disease risk reductions are in the order of 21% for moving from VI to Vb (improved water, with no sanitation), 38% for moving from VI to Va (improved sanitation, with no water) or from VI to IV (improved water supply and sanitation), and 21% for moving from Vb to IV (improved sanitation with water supply already improved).

Table 11. Relative risks with upper and lower uncertainty estimates for different exposure scenarios*

Scenario	I	II	III	IV	Va	Vb	VI
Lower estimate	1.0	2.5	4.5	3.8	3.8	4.9	6.1
Best estimate	1.0	2.5	4.5	6.9	6.9	8.7	11.0
Upper estimate	1.0	2.5	4.5	10.0	10.0	12.6	16.0

* See exposure scenario definitions in Table 7. Table based on Prüss-Üstün et al. 2004 [1]

2.6 Economic benefits

There are many and diverse potential benefits associated with improved water supply and sanitation, ranging from the easily identifiable and quantifiable to the intangible and difficult to measure [25]. Benefits include both reductions in costs associated with poor water supply and sanitation (e.g. health care costs) as well as developmental benefits directly associated with improving water supply and sanitation, such as increasing productive or education time available [21]. Some of these benefits – specifically the direct benefits related to the health intervention – are used in cost-effectiveness analysis (CEA) for calculating the cost-effectiveness ratio (CER) in terms of cost per disability-adjusted life-year (DALY) avoided or cost per case avoided [26]. Cost-benefit analysis (CBA), on the other hand, converts all the identified benefits to economic values for calculating the benefit-cost ratio (BCR), net present value (NPV) and economic internal rate of return (EIRR). Cost-benefit analysis is hence a broader measure of economic efficiency [27, 28][7].

The aim of this analysis is not to include all the benefits, but to capture the most tangible and measurable benefits, and identify who the beneficiary groups are. This approach is adopted not only because of the difficulties of estimating some types of economic impacts resulting from environmental changes [29-31], but also because benefits are highly setting-specific and hence not easily estimable at country or regional level (e.g. other uses of water supply at household level such as home industry or home gardening). The exclusion of context-specific health and economic impacts therefore leads to an underestimation of the overall benefits associated with water supply and sanitation improvements.

For ease of comprehension and interpretation of findings, the benefits of the water and sanitation improvements not captured in the DALY estimates were classified into three main types:

1. Direct economic benefits of avoiding diarrhoeal disease
2. Indirect economic benefits related to health improvements
3. Non-health benefits related to water and sanitation improvements.

These benefits are described in Table 12, grouped by main beneficiary. As a general rule, these benefits were valued in monetary terms using conventional economic methods for valuation [30-32]. Details concerning the specific valuation approaches are described in the original global cost-benefit study [16], and summarised briefly below.

Table 13 summarises the data sources and values used for the valuation of economic benefits. The total health care cost avoided is calculated by multiplying the health service unit cost by the number of cases avoided, using assumptions about health seeking behaviour and health service use per case. Due to a lack of studies presenting data on the number of outpatient visits per case, it was assumed that 30% of cases (range 0.2 – 1.0) would visit a health facility one time each (range 0.5 - 1.5 visits). If hospitalised, the average length of stay was assumed to equal 5 days (range 3 – 7 days). In the base case 8.2% of total cases were assumed to be hospitalised (range 5% - 10%), based on WHO data. The unit costs included the full health care cost (consultation, medication, overheads, etc.). Health service unit cost data is sourced

[7] Traditional measures of cost-benefit analysis include:

- The benefit-cost ratio is the total benefit divided by the total cost of the intervention, presented in a base year. Costs and benefits in future years are discounted back to a common date. The annual discount rate reflects the social time preference.
- The net present value shows the economic gain that can be expected from the intervention in currency units of the base year (usually the start year of the intervention). It is calculated by subtracting the economic costs of the intervention from the economic benefits.
- The economic internal rate of return is the rate of interest at which the future expected stream of benefits equals the future expected stream of costs. The EIRR is then compared with the opportunity cost of capital or a benchmark for target returns for public projects to decide whether the intervention produces an adequate rate of return or not.
- The payback period is the time in years and months that the benefits exceed the costs.

from the Disease Control Priorities Project working paper 'Unit costs of health care inputs in low and middle income countries' [33]. For outpatient care unit costs, figures were used which reflect health centres at 90% population coverage. For inpatient care unit costs, figures were used which reflect primary level inpatient facilities. Non-health care costs related to treatment seeking such as transport costs and incidental costs were also included [34].

Table 12. Economic benefits arising from water and sanitation improvements *

Beneficiary	Direct economic benefits of avoiding diarrhoeal disease	Indirect economic benefits related to health improvement	Non-health benefits related to water and sanitation improvement
Health sector	▪ **Less expenditure on treatment of diarrhoeal disease** ▪ Less expenditure on treatment of other diseases	▪ Value of less health workers falling sick with water and sanitation-related diseases	▪ Convenience of water and sanitary facility availability in health facilities
Person with avoided disease	▪ **Less expenditure on treatment of diarrhoeal disease and related health seeking costs** ▪ Less expenditure on treatment of other diseases ▪ Less time lost due to treatment seeking	▪ **Value of avoided days lost at work or at school, avoided time lost of caretaker of sick children, and economic contribution of a saved life due to diarrheal disease** ▪ Values of the above associated with other diseases	
Consumers affected by the non-health benefits of the interventions			▪ **Time savings related to water collection or accessing sanitary facilities** ▪ User preferences for improved WSH ▪ School and workplace WSH programmes: impact on school attendance by girls and employment choices for women ▪ Productive activities at household level (home industry, home gardening) ▪ Labour-saving devices in household ▪ Switch away from more expensive water sources ▪ Property value rise ▪ Leisure activities and non-use value
Agricultural and industrial sectors	▪ Less expenditure on treatment of employees with diarrhoeal disease	▪ Less impact on productivity of ill-health of workers	▪ Benefits to agriculture and industry of improved water supply, more efficient management of water resources.

* Benefits in **bold** are those captured in the quantitative estimates of this present study

A second benefit included is the productivity effect of improving health [26]. These are traditionally split into two main types: gains related to lower morbidity and benefits related to fewer deaths. In terms of the valuation of changes in time use for cost-benefit analysis, the opportunity cost is the amount in monetary units that the person would earn over the sickness period if he/she were working [32]. This is a relatively easy estimate to make for those of working age. The Gross National Product (GNP) per capita was taken as a minimum value for what people’s working time is worth. For children of school, age, the assumed impact of illness is school absenteeism, which also has an opportunity cost, also valued in this study at the GNP per capita [35]. For children under five, the assumption is made that a parent or caretaker has to spend more time with a sick child than a healthy one, valued at 50% of the GNP per capita. Sensitivity analysis is used to explore the impact of alternative time values on the overall results.

In terms of deaths averted from the water supply and sanitation improvements, a convention used in cost-benefit analysis is to value saved lives at the discounted income stream of the individual whose death is avoided, thus representing the net present value of their economic contribution to society. Therefore, the number of productive years ahead of the individual who would have died needs to be estimated (depending on the age of the person whose life is saved) and the economic value per year of healthy life saved [36]. The GNP per capita is used to reflect the annual opportunity cost of a productive member of society, with a lower value of 30% of GNP and an upper value of the minimum wage. Future benefits are discounted at 3% per year (range: 1% - 5%). For those not yet in the workforce (those in the 0-4 and 5-15 age brackets) the current value for the future income stream was further discounted to take account of the time period before they become income earners.

Due to problems in measurement and quantification/valuation, and also because of substantial variability between settings, many non-health benefits of the interventions were not included in the present analysis [26]. One of the major and universal benefits of water supply and sanitation improvements is the time saving associated with better access. Time savings occur due to, for example, the relocation of a well or borehole to a site closer to user communities, the installation of piped water supply to households, closer access to latrines and shorter waiting times at public latrines. These time savings translate into either increased production, improved education levels or more leisure time. The value of convenience time savings is estimated by assuming a daily time saving per individual for water and sanitation facilities separately, and multiplying these by the GNP per capita daily rate for each sub-region. In this global analysis estimates of time savings per household could not take into account the different methods of delivery of interventions and the mix of rural/urban locations in different countries and regions, due to the lack of data on time uses in the literature. Even within single settings, considerable variations in access have been found.

Table 13. Data sources and values for economic benefits

Benefit by sector	Variable	Data source	Data values (+ range)
1. Health sector			
Direct expenditures avoided, due to less illness from diarrhoeal disease	Unit cost per treatment (health centre)	International estimates [33]	US$1.3-US$3.1 (cost per visit) US$6.1-US$24.8 (cost per day) *Varying by region*
	Number of cases	WHO burden of disease data	Variable by region and age group
	Visits or days per case	Assumptions	30% of cases seek care 0.3 outpatient visit per case (0.5-1.5) 5 days for hospitalised cases (3-7)
	Hospitalisation rate	WHO data	91.8% of cases ambulatory 8.2% of cases hospitalised
2. Patients			
Direct expenditures avoided, due to less illness from diarrhoeal disease	Transport cost/ visit	Assumptions	US$0.50 per visit
	% of patients who use transport	Assumptions	50% of patients use transport (0-100%)
	Non-health care patient costs	Assumptions	US$0.50 ambulatory (US$0.25-1.0) US$2.00 hospitalisation (US$1.0-3.0)
	Number of cases	WHO data	Variable by region
	Visits or days per case	Assumptions	0.3 outpatient visit per case (0.5-1.5) 5 days for hospitalised cases (3-7)
	Hospitalisation rate	WHO data	91.8% of cases ambulatory 8.2% of cases hospitalised
Income gained, due to days lost from work avoided	Days work loss/case	Assumptions	2 days (1-4)
	Number of people of working age	WHO 2002 population data	Variable by region
	Time cost	World Bank	GNP per capita, year 2000
Days of school absenteeism avoided	Absent days / case	Assumptions [37]	3 (1-5)
	Number of school age children (5-14)	WHO 2002 population data	Variable by region
	Time cost	World Bank	GNP per capita, year 2000
Productive parent days lost avoided, due to less child illness	Days sick	Assumptions	5 (3-7)
	Number of infants & young children (0-4)	WHO 2002 population data	Variable by region
	Opportunity cost of time	World Bank data	50% GNP per capita, year 2000
Discounted productive years lost (remaining working life, discounting future years at 3%)	0 – 4 years	Suarez & Bradford [36]	16.2 years (9.5 – 29.1)
	5 – 14 years		21.9 years (15.2 – 33.8)
	15+ years		19.0 years (16.3 – 22.7)
	Opportunity cost per year of life lost	World Bank data	GNP per capita, year 2000
3. Consumers			
'Convenience' – time savings	Water collection time saved per household per day (external access)	International reviews [15, 38]	0.5 hours (0.25-1.0)
	Sanitation access time saved / person	Assumptions	0.5 hours (0.25-0.75)
	Average household size	WHO 2002 population data	6 people (4-8)
	Opportunity cost of time	World Bank data	GNP per capita, year 2000

The existing literature reported in two separate reviews is summarised below [15, 38]:

- Barnes (2003) reports that in India the average time spent per household on water collection is 0.93 hours [39]. A separate study based on a national survey in India undertaken for UNICEF, found that women spend an average 2.2 hours per day collecting water from rural wells [40]. Saksena et al (1995) report average water collection times in a Himalayan region of Northern India, at 30 minutes for both men and women [41].
- Kumar and Hotchkiss (1988) report from Nepal daily water collection times for men (0.1 hour), women (1.15 hours) and children (0.23 hours).
- Mertens et al (1990) report that in Sri Lanka more than 10% of women had to travel more than 1 kilometre to their nearest water source [42].
- The World Bank (2001) reported that in Vietnam the average daily household water collection time to be 36 minutes [43].
- In a 3 country study, Nathan (1997) provides a breakdown for men and women separately for water haulage (hours per day), with the major burden falling on women (figures quoted for women only): Burkina Faso 0.63 hours; India 1.23 hours; and Nepal 0.67 hours [44].
- Results of UNICEF's Multi-Indicator Cluster Surveys in 23 African countries, reported in Cairncross and Valdmanis [15], shows that 44% of households required a journey of more than 30 minutes to collect water.
- In a World Bank study on women and rural transport, Malmberg-Calvo (1994) reports average water collection times per day for four rural sites: Ghana (3 hours/day); Makete, Tanzania (1.8 hours/day); Tanga, Tanzania (2.7 hours/day); and Zambia (0.5 hours/day) [45].
- Thompson et al (2001) reported from 334 study sites from East Africa (Kenya, Tanzania and Uganda) the mean distance from rural unpiped households to their water sources of 622 metres, compared with 204 metres for urban areas [46].
- Whittington et al (1990) reports from Kenya that journeys to a local well in a small town averaged between 10 and 30 minutes (median around 15 minutes); and journeys to a kiosk between 3 and 13 minutes (median around 10 minutes) [47]. However, to collect enough water for the entire household would require more than one visit, thus requiring closer to one hour or more per household per day.
- Biran (2004) reports average time per day for water collection for two rural masai communities – 54 minutes per day for women and 36 minutes per day for girls [48].
- Feachem et al (1978) found in 10 villages in Lesotho that the installation of a water supply had saved the average adult woman 30 minutes per day [49].
- Fieldwork and Zorse (1991) report water collection times per woman per day in Ghana at 1.2 hours in both dry and wet seasons.
- In Mali 6% of a woman's 17 hour day (= 1.02 hours) is taken up with water collection in the dry season, and 7% of a woman's 15 hour day (1.05 hours) in the wet season (undertaken by Sahel Consult, reported in Dutta 2005 [38].

- Whittington et al (1991) report from Nigeria that in the dry season, average journey time to the local springs was 4-7 hours for some rural communities, which does not include waiting time at the spring [5].

Given these wide variations quoted in the literature, as well as the expected enormous differences between settings in water availability (current and future), this analysis made assumptions about time savings following water improvements based on a consolidated assessment of the evidence presented above. It was assumed that, on average, a household gaining access to improved water supply outside the home or plot will save 30 minutes per day (range: 15 to 60 minutes), assuming six members per household, giving 30.4 hours saved per individual per year. Clearly, a 30 minute time saving assumption will underestimate likely time savings in some, especially rural water-scarce areas, whereas it would overestimate likely time savings in some urban or water abundant regions. However, it is likely that 30 minutes is a reasonably conservative assumption that would not lead to gross overestimates of time saving.

For improved sanitation, no data were found in the literature for an estimate of time saved per day due to less distant sanitation facilities and less waiting time. No references have even been made in the literature cited above to time use for going to the toilet, as use of toilet / personal hygiene are rarely if ever included in questionnaires about time use. Cairncross and Valdmanis (2005) report a study from Benin on the benefits of latrine ownership as perceived by 320 rural households, which ranks 'saving time' as 11th out of 20 reasons, with an importance rating of 3.53 out of 4 [50]. Given the need to make several visits per day to a toilet or open defecation site outside the home (especially for women), an assumption was made of 30 minutes saved per person per day, from latrines in the home or compound, giving 182.5 hours per person per year saved.

Valuation of time savings due to better access to water and sanitation is recognised as a tricky issue [15]. In terms of the economic value of time gained, the advantage of a cost-benefit study over a purely financial analysis is that a proxy value of time can be used and applied irrespective of what individuals actually do with their time. In fact, whether the time gained is used in income earning, productive but non-income work, or leisure activities, there is evidence that people value their time at or close to their hourly wage [51] or at close to the minimum wage [52]. For example, studies by Whittington and others in Africa showed that households valued their time spent collecting water at around the average wage rate for unskilled labour [47]. Begoña et al find considerable variation between individuals in how they value their leisure time [53]. The importance of valuing leisure time is also supported by the fact that wage rates for overtime worked are generally higher than the average wage [54], and thus Isley argues that the market wage rate should be used as the lower bound for valuing leisure time [55]. In other words, people need to be paid more than their average wage to give up their leisure time to work. The OECD has also been reported to use GDP per capita as the basis for valuing leisure time[8].

[8] http://www.economist.com/finance/PrinterFriendly.cfm?story_id=5504103

From an equity perspective, it is appropriate to assign to all adults the same economic value of time, so that high income earners are not favoured over low or non-income earners, or men over women, or adults over children. Moreover, variations between different population groups would be difficult to capture in a global study. Therefore, based on the above evidence and considerations, the GNP per capita (in US$) in the year 2005 is used as the average value of time in an economy, with average (weighted) GNP being calculated at the regional level, using a population-weighted average for each sub-region. The annual GNP value is transformed to an hourly value. In the sensitivity analysis, a lower bound of 30% of GNP per capita is used, and an upper bound of the minimum wage rate, using an average population-weighted minimum wage by world region.

2.7 Sensitivity analysis

Many of the data used in the model are uncertain or highly uncertain, which are explored further in sensitivity analysis. However, only a selected few variables were tested for their impact on the overall results, with variables selected based on their expected importance in determining the overall results and the level of uncertainty in the input value used in the base case analysis. These include:

- Time gains due to better access to water and sanitation. Given that the overall results were expected to be heavily determined by time savings, the time saving assumptions used in the sensitivity analysis for improved water access were the following: one quarter of an hour saved per household per day in an average household of 8 persons, giving 11.41 hours saved per person per year in the pessimistic scenario; and one hour saved per household per day in an average household of 4 persons, giving 91.25 hours saved per person per year in the in the optimistic scenario. For sanitation access, the base case value of 182.50 hours per person per year were halved (91.25 hours) and increased by 50% (273.75 hours).
- The value of time. A realistic variation should be reflected for the value of time, giver its key importance in this study as an economic benefit. An alternative lower bound value to the use of GNP per capita as the base case is proposed by WHO, based on an IMF study [56]. This study suggests that people, on average, adults value their time at roughly 30% of the GNP per capita. In this pessimistic scenario, children and infants are given a zero opportunity cost of time. In the optimistic scenario, the minimum wage was applied. According to World Bank data, a minimum wage is not defined in all countries, but in general, in most countries where one exists, it exceeds the GNP per capita. For countries without a minimum wage value, the WHO sub-regional average is applied.
- Diarrheal incidence. Low were based on halving the base case incidence rates and high values were obtained by increasing by 50 base case incidence rates.
- Health care costs. Low and high values are based on those presented in Mulligan et al (2005) [33], for health centre outpatient visit cost and primary hospital inpatient care cost.
- Intervention costs. Low and high cost values were substituted in the model, presented in Table 14 which are based on the ranges provided on the base case assumptions shown in Table 9. Ranges are provided on four input variables to estimating annualized intervention cost: (1) length of life of hardware; (2)

operation, maintenance, surveillance as a percentage of annual cost; (3) education as a percentage of annual cost; and (4) water source protection as a percentage of annual cost. The ranges presented in Table 14 hence reflect the range in annual per capita cost expected to be found in different contexts in the three regions.

Table 14. Low and high values used in sensitivity analysis for intervention unit costs (per capita reached) (US$, year 2000 prices)

Improvement	Africa			Asia			LA&C		
	Low	Mid	High	Low	Mid	High	Low	Mid	High
Water supply									
House connection	2.63	6.18	12.03	2.38	5.57	10.85	3.72	8.72	16.98
Standpost	0.95	2.40	6.27	1.95	4.95	12.95	1.25	3.17	8.30
Borehole	0.67	1.70	4.47	0.49	1.26	3.30	1.60	4.07	10.68
Dug well	0.61	1.55	4.08	0.64	1.63	4.27	1.39	3.55	9.32
Rain water	1.50	3.62	9.12	1.04	2.51	6.33	1.10	2.66	6.70
Sanitation									
Septic tank	3.76	9.75	19.42	3.49	9.10	18.04	4.84	12.39	25.06
VIP	2.66	6.21	14.07	2.45	5.70	12.71	2.51	5.84	13.10
Simple pit latrine	2.13	4.88	10.58	1.76	3.92	8.05	2.74	6.44	14.66

Source: Based on JMP unit cost estimates [18] and ranges on assumptions provided in Table 9

As well as the sources of uncertainty presented above, there is also uncertainty in the predictions used as the population water supply and sanitation coverage in the year 2015. However, changes in these estimates would not considerably change the benefit-cost ratios, but only the absolute sizes of estimated costs and benefits.

2.8 Presentation of results

The model developed for this present study generated a large quantity of data. Selected results are presented for the six interventions and for the six non-OECD world regions, and include (a) the benefit-cost ratios; (b) the intervention costs; (c) the total economic benefits; (d) the number of cases of diarrhoea and deaths prevented per year, and (e) the economic benefits broken down by major benefit categories. Benefit-cost ratios are presented for all costs and benefits together, followed by costs and selected benefits. All costs are presented in US$ in the year 2002. Costs and benefits are presented assuming that all the interventions are implemented within a one-year period, hence requiring the estimation of annual investment costs [21]. All results are presented assuming constant population growth based on 2000 predictions.

In summary, the calculation of the total societal economic benefit is the sum of:
(1) Health sector benefit due to avoided illness
(2) Patient expenses avoided due to avoided illness
(3) Deaths avoided
(4) Time savings due to access to water and sanitation
(5) Productive work days gained of those with avoided illness (at least 15 years old)
(6) Days of school attendance gained of those with avoided illness (5-15 years old)
(7) Baby days gained of those with avoided illness (0-4 years old).

3. RESULTS

3.1 Benefit-cost ratios

Table 15 shows that in meeting the water and sanitation MDG targets using low cost improvements, an estimated rate of return (benefit-cost ratio) of between US$ 5 and US$ 36 return on a US$ 1 investment is achieved in the six world regions, with a global average of US$ 8.1 return per US$ 1 investment for the combined water and sanitation MDG targets. The benefit cost ratio of achieving the combined W&S MDG target also vary by world region: the Arab States (BCR = 5.4), sub-Saharan Africa (BCR = 5.7), South Asia (BCR = 6.6), East Asia & Pacific (BCR = 10.1), Eastern Europe & CIS (BCR = 18.9), and Latin America and the Caribbean (BCR = 35.9). All these ratios reflect a highly favourable result for the interventions evaluated. Some further explanations and qualification are given in the presentation of the detailed results below, to allow a full and appropriate interpretation of these data.

The results suggest that achieving the sanitation MDG target is economically more favourable than the water MDG target, with a global return of US$ 9.1 for sanitation compared to US$ 4.4 for water, per US$ 1 invested. This is due to the greater relative health impacts (and the related health cost savings and productivity benefits) of investing in sanitation and the higher convenience time savings per person receiving the intervention. However, balancing these effects is the higher cost of sanitation improvements per capita (see Tables 8 and 10).

In achieving universal access, benefit-cost ratios are broadly similar as in meeting the MDG targets. This is because the unit cost per person reached and the health and economic benefits are assumed to be the same at whatever level of coverage is achieved, given the lack of information to indicate the shape of the cost curve as coverage increases (e.g. whether economies of scale are present, and whether diminishing returns are likely at high levels of coverage). However, there are some differences in the benefit-cost ratios between MDG coverage and universal coverage, such as for universal coverage of sanitation in the Arab States, where differences become evident due to the different range of countries included in the universal coverage analysis.

Table 15. Benefit-cost ratio for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	2.8	6.6	5.7	3.9	6.5	5.7
Arab States	6.1	5.3	5.4	5.9	12.7	11.3
East Asia & Pacific	6.9	12.5	10.1	6.6	13.8	12.2
South Asia	3.5	6.9	6.6	3.9	6.8	6.6
Latin America & Caribbean	8.1	37.8	35.9	17.2	39.2	36.3
Eastern Europe & CIS	8.3	27.8	18.9	8.9	29.9	27.4
Non-OECD	**4.4**	**9.1**	**8.1**	**5.8**	**11.2**	**10.3**

3.2 Intervention total costs

Table 16 shows that the estimated total annual costs of achieving the MDG targets in non-OECD regions is US$ 858 million for water, and US$ 3,813 million for sanitation, giving a total of US$4,671 million for the two MDG targets combined. Sub-Saharan Africa accounts for over 50% of these costs, at US$ 2,665 million, followed by South Asia (18%), and East Asia & Pacific (13%). These costs are an incremental cost over and above the current annual investments in water supply and sanitation services which during the 1990s averaged an annual investment of 16 billion in Africa, Asia and Latin America and the Caribbean combined [18].

In achieving universal coverage in water and sanitation, the global annual cost of US$ 16,581 million is more equally divided between three world regions: sub-Saharan Africa (25%), East Asia & Pacific (33%), and South Asia (31.5%), with the remaining 11.5% going to the other three non-OECD regions. Achieving universal sanitation coverage account for 87.5% of the combined water and sanitation universal coverage. The considerably higher cost of sanitation is due to the fact that, globally, sanitation coverage is behind water coverage to meet MDG targets and thereby to 'halve the unserved proportion' implies serving a greater number of households and persons. Furthermore, improved sanitation also costs more per person reached than water (see Table 10).

In addition, there is considerable uncertainty in the cost figures, especially for some world regions. This study used cost data available from the Global Water Supply and Sanitation Assessment Report in the year 2000, where data were summarized for three major world regions (Africa, Asia, and Latin America) [20]. Therefore, the cost figures only represent crude cost estimates for these three world regions, thus losing specificity when applied to six different non-OECD world regions in the UNDP regional classification. The implication is that the cost estimates in Table 16, and those used in estimating the benefit-cost ratio, are most likely to be understated for higher income countries (where costs are correspondingly higher) and countries with water scarcity or with low population densities. Therefore, it is likely that costs will be understated for the regions of the Arab States and countries such as Chad and the Sudan (for reasons of water scarcity and low population density), and for countries such as South Africa (who have significantly higher costs than the regional average for sub-Saharan Africa).

Using the annual figures in Table 16, it is possible to estimate an upper bound for the total incremental cost of achieving the MDG targets. Assuming the MDG targets are met immediately, the additional cost from 2006 to 2015 is US$46.71 billion. However, if there is a linear scaling up of water and sanitation coverage from 2006 to 2015, the cost could be as little as half this figure, at an additional US$23 billion.

Table 16. Annual cost estimates (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	479	2,185	2,665	777	3,379	4,156
Arab States	66	188	254	96	492	589
East Asia & Pacific	229	399	628	891	4,576	5,468
South Asia	53	802	856	189	5,033	5,222
Latin America & Caribbean	14	219	233	87	734	821
Eastern Europe & CIS	16	19	35	34	292	326
Non-OECD	**858**	**3,813**	**4,671**	**2,075**	**14,507**	**16,581**

3.3 Intervention total economic benefits

Table 17 shows that economic benefits total US$ 38 billion annually for meeting the combined water and sanitation MDG targets, 92% of which is accounted for the sanitation MDG target. Sub-Saharan Africa accounts for 41% of the global economic benefit, followed by Latin America & Caribbean (22%), East Asia & Pacific (17%) and South Asia (15%). In achieving the water MDG target alone, the contribution of East Asia & Pacific to the US$ 3,762 million is more significant at US$ 1,593 (42%) followed by sub-Saharan Africa at US$ 1,336 million (35.5%).

Economic benefits for achieving universal coverage are several times greater, at US$171 billion annually, a gain which is spread between East Asia & Pacific (39%), South Asia (20%), Latin America & Caribbean (17%), sub-Saharan Africa (14%), Eastern Europe & CIS (5%), and the Arab States (4%). These proportions are most heavily weighted by the results of universal coverage for sanitation. For universal coverage with water supply, the proportion is considerably higher for East Asia & Pacific (42%) and for the Arab States (11%), and lower for South Asia (5%) and Latin America & Caribbean (3%).

Table 17. Total economic benefit (US$ millions) estimates for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	1,336	14,359	15,292	3,006	21,963	23,566
Arab States	403	1,005	1,375	572	6,230	6,680
East Asia & Pacific	1,593	5,003	6,364	5,883	63,093	66,825
South Asia	186	5,507	5,635	733	34,305	34,706
Latin America & Caribbean	110	8,287	8,352	1,498	28,787	29,801
Eastern Europe & CIS	133	542	671	307	8,711	8,930
Non-OECD	**3,762**	**34,703**	**37,689**	**11,999**	**163,088**	**170,508**

The contribution to economic benefits varies between water and sanitation, as shown in Figure 1 for the case of sub-Saharan Africa. In achieving the water MDG target, 63% of the benefits are attributed to convenience time savings, 28% to productivity gains, and 9% to health care cost savings. Economic benefits of sanitation, on the other hand, are more heavily dominated by convenience time savings, at 90% of the total economic benefit, followed by 8% to productivity gains, and 2% to health care cost savings.

Figure 1. Contribution of major benefit categories to total economic benefit in sub-Saharan Africa for meeting water (left) and sanitation (right) MDG target

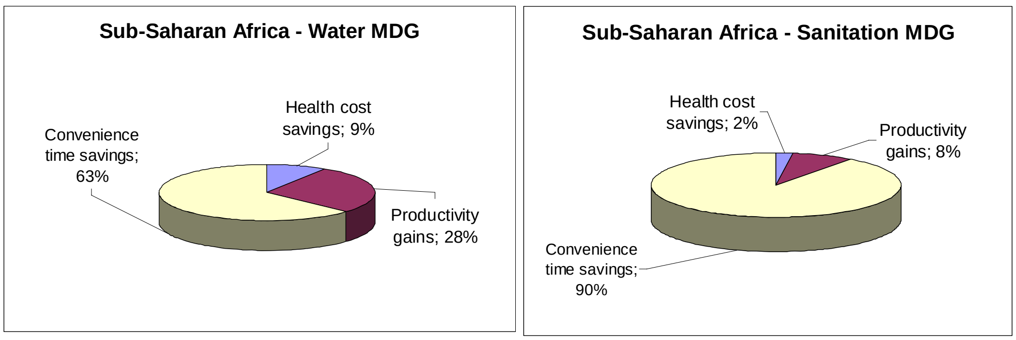
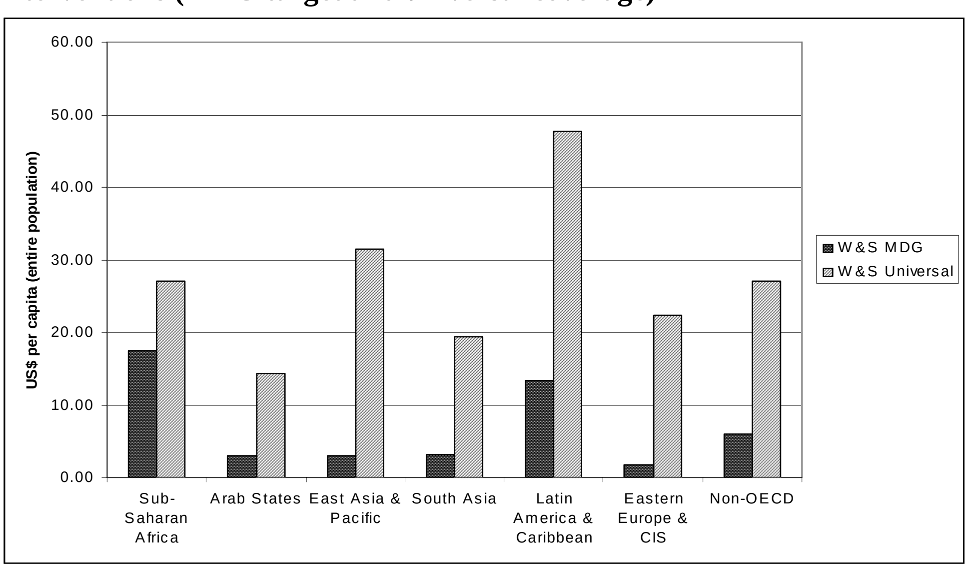


Figure 2 shows the per capita annual economic benefit of combined water and sanitation interventions, for the two targets: the MDG target and universal coverage. For achieving the combined water and sanitation MDG target, sub-Saharan Africa benefits the most with an average of US$ 17.5 per capita per year, based on the entire population, and not just the population receiving the intervention. The next region benefiting is Latin America & Caribbean, at US$ 13.5 per capita per year. Under universal coverage, all world regions benefit substantially under these improvements, with at least US$ 15 per capita per year for the entire population. Under universal coverage, Latin America & Caribbean has the highest per capita gain at US$48.

Figure 2. Per capita annual economic benefit of combined water and sanitation interventions (MDG target and universal coverage)



In order to interpret the economic benefits related to improved water supply, it is important to note that these relate solely to community supply of water, and not household supply. In previous cost-benefit analyses, household supply was included as one of several interventions to improve water coverage [16]. This analysis excludes household improvements in order to focus on the lowest cost interventions. Therefore, other economic benefits related to household supply such as the greater opportunity to ensure water safety (which gives more health benefits) and the closer proximity of water sources (thus giving further time savings) are excluded from this present analysis.

3.4 Number of people getting improvement

Table 18 presents the population sizes targeted under the six different coverage scenarios. Globally, a total population of 354 million who will not to have access to water in 2015 (at the current trend rate of coverage change from 1990 to 2004) will benefit from having access in achieving the water MDG target. Of this figure, 207 million beneficiaries (58%) are from countries in sub-Saharan Africa, and 25% from East Asia & Pacific.

Table 18. Total populations (millions) receiving interventions for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	207	315	364	335	486	490
Arab States	28	28	42	40	73	80
East Asia & Pacific	89	64	114	345	733	740
South Asia	21	129	134	73	807	809
Latin America & Caribbean	4	27	28	26	89	89
Eastern Europe & CIS	6	2	8	12	37	39
Non-OECD	**354**	**564**	**690**	**831**	**2,226**	**2,248**

For sanitation, a total population of 564 million who will not have sanitation coverage in 2015 (at the current trend rate of coverage change from 1990 to 2004) will benefit from having access in achieving the sanitation MDG target. 315 million beneficiaries (56%) are from countries in sub-Saharan Africa, and 23% from South Asia. For the combined water and sanitation MDG targets, a total population of 690 million is expected to benefit from either water supply, sanitation coverage, or both. Over half (53%) of this population is from sub-Saharan Africa.

However, uncertainties in these MDG target figures are high, given that projections for coverage are based on an assumption of linear progress in coverage from 1990 to 2004, and beyond to 2015. These uncertainties therefore impact on the cost and benefit figures presented above. However, the benefit-cost ratios presented above are unlikely to be sensitive to these uncertainties.

The population to be covered under the universal water coverage scenario is roughly three times the population size than for the MDG target, at 831 million population to be covered, in addition to the current projected growth in coverage until 2015. For sanitation, the population to be covered under the universal coverage scenario is roughly five times the population size than for the MDG target, at 2.23 billion population to be covered. These figures show clearly that, globally, target coverage is further from being achieved for the two sanitation targets (MDG targets and universal coverage) than for the water targets.

3.5 Impact on population health

Table 19 presents the number of predicted diarrhea cases averted under the six coverage scenarios. In achieving the MDG targets, the investment to close the gap between the predicted coverage and the MDG target coverage, would bring 72 million fewer cases of diarrhea from water coverage and 190 million fewer cases for sanitation coverage. Roughly 60% of these are averted in sub-Saharan Africa. This considerable proportion is this region is to be expected due to the large proportion of the population receiving the interventions coming from sub-Saharan Africa (Table 18, and Annex 2). When combining the W&S MDG targets, the number of cases averted increases to 218 million (note that the combined MDG target is not the sum of the two MDG targets separately, as some of the targeted population receive both water and sanitation, and not just one). The incremental health impact of meeting the water MDG target after meeting the sanitation MDG target is 28 million cases of diarrhea averted (218 minus 190 million); whereas the incremental health impact of the meeting the sanitation MDG target after meeting the water MDG target is 146 million cases of diarrhea averted (218 minus 72 million).

Table 19. Predicted diarrheal cases (millions) averted from achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	**Sanitation**	**W&S**	**Water**	**Sanitation**	**W&S**
Sub-Saharan Africa	42.6	113.0	123.3	112.5	247.4	247.4
Arab States	4.5	10.1	11.8	9.4	25.6	25.6
East Asia & Pacific	18.3	24.0	37.7	70.2	194.7	194.7
South Asia	4.3	32.6	34.0	16.8	175.1	175.1
Latin America & Caribbean	0.8	9.0	9.4	6.9	26.2	26.2
Eastern Europe & CIS	1.2	0.7	1.9	1.4	4.1	4.1
Non-OECD	**71.7**	**189.5**	**218.1**	**217.3**	**673.1**	**673.1**

Universal coverage of improved water supply results in 217 million averted cases of diarrhea, while for universal coverage of improved sanitation results in 673 million averted cases of diarrhea. The combined W&S universal coverage bring the same health benefit as sanitation alone, as the relative risk reductions used assumes that moving from scenario VI (neither improved water or sanitation) to Va (improved sanitation) is the same as moving from VI to IV (improved water and sanitation).

Figures 3 and 4 show a summary breakdown of diarrhea cases averted by age group and by world region from meeting the water and sanitation MDG targets, respectively. In sub-Saharan Africa, the population benefiting most from achieving the water MDG target and the sanitation MDG target is the 1-4 year old group, followed by the 0-1 age group. The pattern is similar in other world regions except in East Asia & Pacific, where the population most benefiting is the 15-59 age group. This result is explained by the fact that a large proportion of the population (65%) is in the 15-59 age group in its most populous nation, China. As more of the world's population moves into older age categories, the benefit of improved water and sanitation will increase as older populations are more susceptible to disease and have a higher case fatality rate. Annex 2 Tables 1 to 6 present figures by region for the six coverage scenarios.

Figure 3. Diarrheal cases averted by age group (water MDG target)

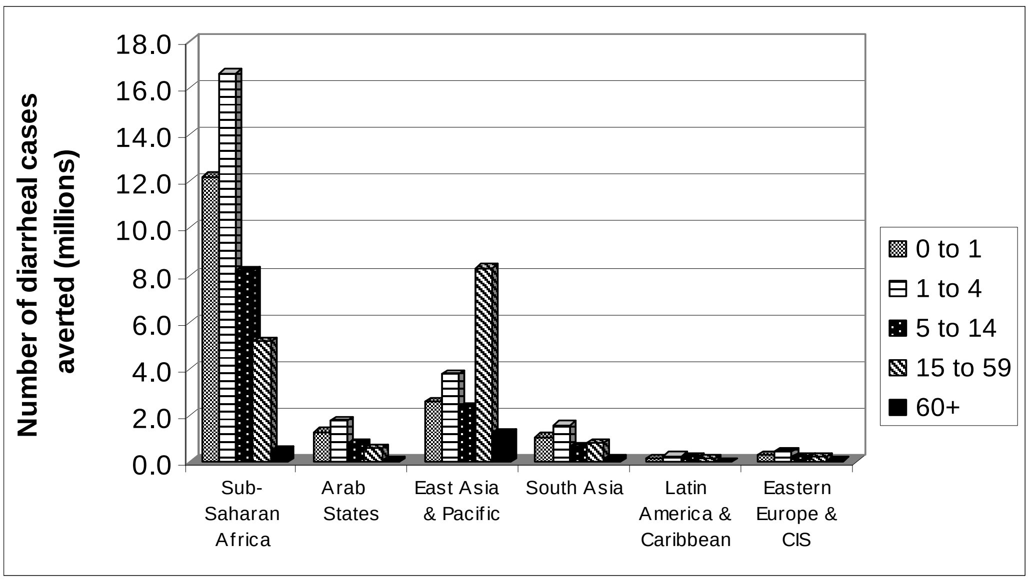
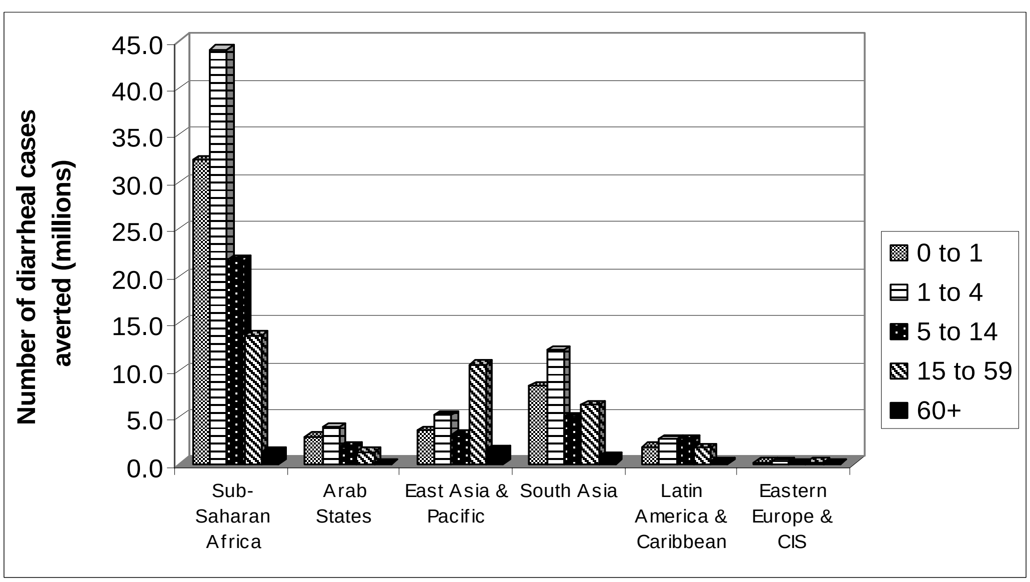


Figure 4. Diarrheal cases averted by age group (sanitation MDG target)



The predicted number of deaths averted is shown in Table 20. From meeting the water MDG target, almost 66,000 deaths are averted annually, while for meeting the sanitation MDG target it is 180,000 deaths annually. The average global case fatality rate is roughly 1 death per 1,000 cases of diarrhea. Universal water coverage results in 190,000 averted deaths annually, while universal sanitation coverage results in 592,000 averted deaths annually. In estimating the global avertable burden of disease from water and sanitation-related diseases, it should be noted that incidence of disease and fatalities would be averted from achieving complete coverage in some OECD countries where universal access to water supply and sanitation coverage has not yet been reached. Additionally, it should be noted that the estimates of deaths averted due to diarrheal disease does not account for the feedback 'loop' from malnutrition which would lead to significant additional reduction of disease burden. Environmental risk factors, of which a major one is poor water, sanitation and hygiene, are estimated to account for around one quarter of burden of disease due to malnutrition [24]. Furthermore, malnutrition causes vulnerability and increases the risks of a range of adverse health outcomes, especially in children.

Table 20. Predicted deaths averted due to diarrhea from achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	42,958	113,865	124,240	113,334	249,213	249,213
Arab States	4,539	10,197	11,972	9,573	25,891	25,891
East Asia & Pacific	12,475	16,757	25,290	44,650	124,063	124,063
South Asia	4,064	31,157	32,539	16,093	167,471	167,471
Latin America & Caribbean	697	7,582	7,855	5,811	21,970	21,970
Eastern Europe & CIS	1,135	624	1,741	1,353	3,732	3,732
Non-OECD	**65,870**	**180,182**	**203,637**	**190,814**	**592,339**	**592,339**

Figures 5 and 6 show a summary breakdown of deaths averted due to diarrhea by age group from meeting the water and sanitation MDG targets, respectively. In all regions, the population benefiting most from achieving the water and sanitation MDG targets is the 0-4 year old group, due to a combination of the high number of diarrhea cases and the higher case fatality rate in that age group. Annex 2 Tables 7 to 12 the present figures by region for the six coverage scenarios.

Figure 5. Deaths averted due to diarrhea by age group (water MDG target)

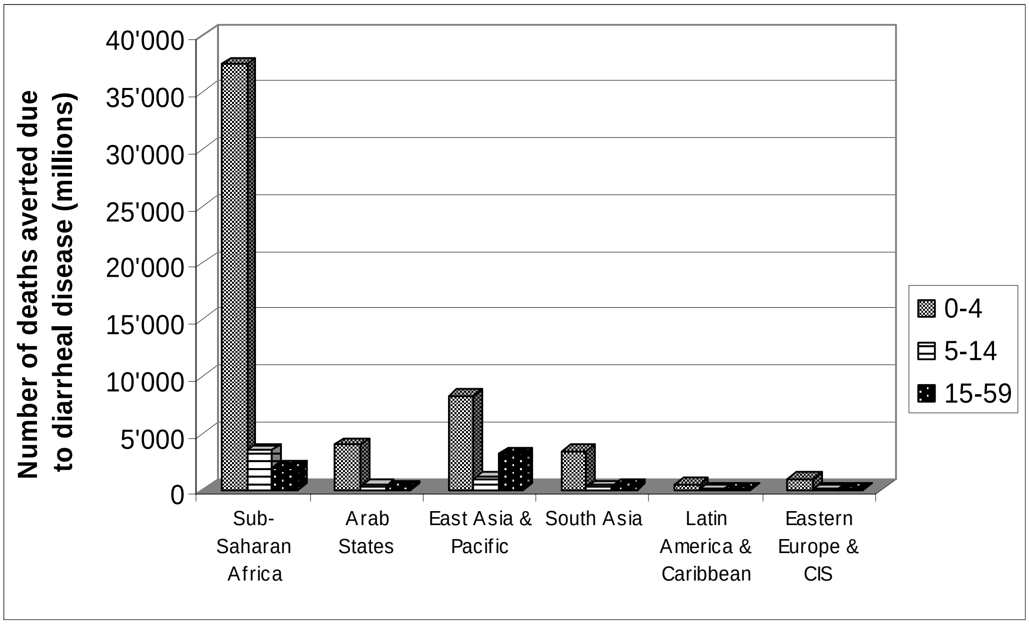
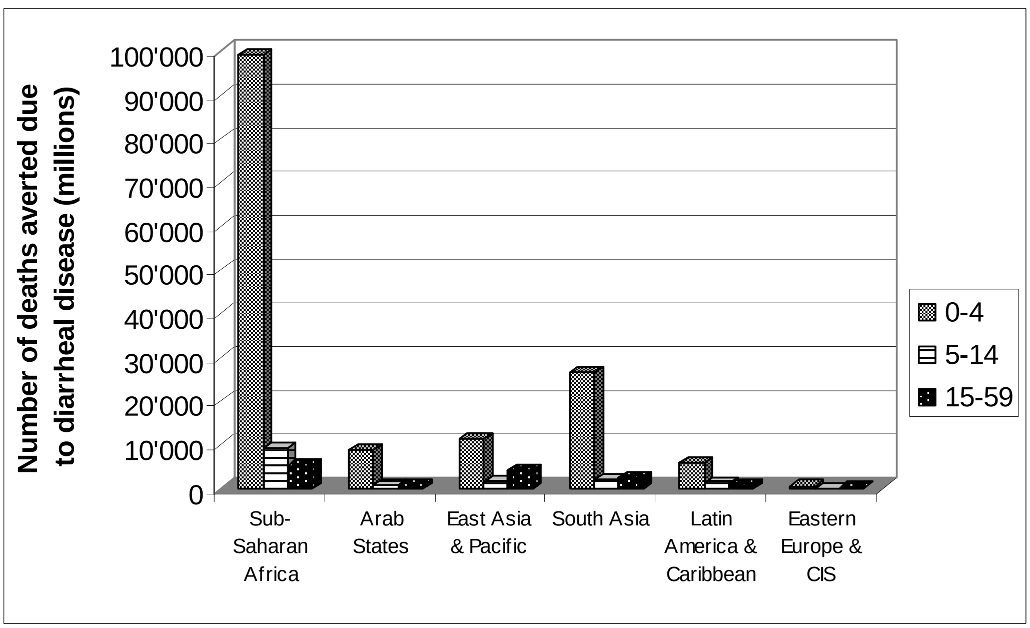


Figure 6. Deaths averted due to diarrhea by age group (sanitation MDG target)



3.6 Treatment costs saved

Table 21 presents the estimated health system costs saved for the six coverage scenarios. By meeting the MDG target, US$ 205 million (water MDG target) and US$ 552 million (sanitation MDG target) are estimated to be saved annually, in terms of economic costs. For the combined water and sanitation MDG targets, the expected economic savings are US$ 641 million annually. Roughly half of these savings are in sub-Saharan Africa. These costs includes both marginal costs (such as drugs and supplies) and fixed costs (staff, equipment, buildings), and therefore represents economic opportunity cost and not expected financial savings. Under a scenario of universal coverage, between 2 and 3 times these savings are expected.

Table 21. Estimated health system costs saved (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	105	279	304	277	610	610
Arab States	21	35	44	23	63	63
East Asia & Pacific	54	71	112	173	480	480
South Asia	11	85	88	41	432	432
Latin America & Caribbean	7	79	82	17	65	65
Eastern Europe & CIS	6	4	10	4	10	10
Non-OECD	**205**	**552**	**641**	**536**	**1,659**	**1,659**

Table 22 presents the estimated non-medical patient costs saved for the six coverage scenarios. By meeting the MDG target, US$ 22 million (water MDG target) and US$ 57 million (sanitation MDG target) are estimated to be saved annually. These costs reflect transport and food costs, and therefore reflect an expected financial cost saving to households. In countries where patients are charged fee-for-service, households will also be saved these fees when health seeking is averted. These costs are not reflected in Table 22 due to the fact that medical costs are already included in Table 21. However, given the variation by country in the proportion of the cost paid by the patient (both directly under fee-for-service and indirectly via health insurance), it is not possible in this global study to estimate the total health care user fees likely to be saved by patients. Under a scenario of universal coverage, roughly 3 to 4 times these savings are expected.

Table 22. Estimated patient non-medical health-seeking costs saved (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	13	34	37	34	75	75
Arab States	1	3	4	3	8	8
East Asia & Pacific	6	7	11	21	59	59
South Asia	1	10	10	5	53	53
Latin America & Caribbean	0	3	3	2	8	8
Eastern Europe & CIS	0	0	1	0	1	1
Non-OECD	**22**	**57**	**66**	**66**	**203**	**203**

3.7 Value of work loss days gained

Table 23 presents the economic value of work loss days avoided for the six coverage scenarios. In achieving the MDG targets, an annual economic value of US$ 293 million (water MDG target) and US$ 1,056 (sanitation MDG target) are expected to be gained by households due to less time spent ill. For the water MDG target, sub-Saharan Africa and East Asia & Pacific account for 77% of these benefits, while for the sanitation MDG target the benefits are more evenly spread among four of the six regions. Under universal coverage, the major share of benefits shift from sub-Saharan Africa (US$451 out of US$ 1,087 million) to ast Asia & Pacific (US$ 1,058 out of US$ 3,470 million).

These figures reflect not only the expected immediate work productivity of adults (15-59) and adults caring for small children (0-4 years), but also the hypothetical and implicit value of children being able to attend school regularly, and without taking time off school due to illness. Thus, these figures should not be interpreted as being immediate and direct economic gains to a country or region, as would be reflected in statistics of economic activity. Under universal coverage, the economic gains are estimated to be roughly 3 to 4 times those of achieving the MDG targets.

Table 23. Economic value of work loss days avoided (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	110	452	451	332	897	851
Arab States	25	34	48	49	162	152
East Asia & Pacific	126	153	192	349	1,396	1,058
South Asia	15	131	124	58	709	646
Latin America & Caribbean	9	272	253	161	784	712
Eastern Europe & CIS	8	14	19	12	61	53
Non-OECD	**293**	**1,056**	**1,087**	**961**	**4,010**	**3,470**

Table 24 presents the economic contribution of saved lives deaths for the six coverage scenarios. In achieving the MDG targets, an annual economic value of US$ 739 million (water MDG target) and US$ 1,718 (sanitation MDG target) are expected to be gained by households due to less premature death. Sub-Saharan Africa account for over one-third of these benefits, while East Asia & Pacific accounts for almost one half of the benefits for the water MDG target and just under one-third for the sanitation MDG target. Under universal coverage, the economic gains are estimated to be roughly 3 to 4 times those of achieving the MDG targets, with around half of the economic benefits going to East Asia & Pacific (US$ 3,533 out of US$ 7,294 million).

Table 24. Economic contribution due to saving lives (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	267	715	778	712	1,623	1,623
Arab States	20	32	44	38	97	97
East Asia & Pacific	343	518	731	1,269	3,533	3,533
South Asia	41	188	202	165	1,073	1,073
Latin America & Caribbean	18	226	231	231	775	775
Eastern Europe & CIS	50	39	89	64	193	193
Non-OECD	**739**	**1,718**	**2,073**	**2,479**	**7,294**	**7,294**

In interpreting these figures, it is important to bear in kind that they reflect the immediate loss of economic contribution by adults who die prematurely, as measured by the discounted future average income earnings. They also reflect the future loss of earnings of children and infants who die, further discounted by the delay between the event of their death and them entering the productive workforce, assumed at age 15. Given that an individual consumes him- or herself a large proportion of their income, these figures do not reflect net economic gains from saving lives, but instead their total (estimated) economic contribution to society.

The economic value of saving lives (Table 24) is higher than the value of work loss days due to morbidity (Table 23), because although death is a significantly less common event, the estimated productivity cost per death is significantly greater than a morbidity episode.

3.8 Value of convenience time savings

Table 25 presents the economic value of convenience time savings for the six coverage scenarios. In achieving the MDG targets, an annual economic value of US$2,503 million (water MDG target) and US$31,320 (sanitation MDG target) are expected to be gained by households due to savings in time due to water haulage and travel to (or waiting time at) sanitation facilities. Roughly 40% of these economic benefits are in sub-Saharan Africa, followed by Latin America & Caribbean (23%), and East Asia & Pacific and South Asia (16% each).

Under universal coverage, the economic gains are estimated to be roughly 3 times (water) to 5 times (sanitation) compared to the gains of achieving the MDG targets. The distribution between world regions is different than the MDG target, with East Asia & Pacific taking the largest share (39%), followed by South Asia (21%), Latin America & Caribbean (18%), and sub-Saharan Africa (13%). The economic value of meeting the combined water and sanitation coverage targets is exactly the sum of the two targets separately, as the convenience time savings of each intervention are independent.

Table 25. Economic value of convenience time savings (US$ millions) for achieving six water and sanitation coverage scenarios, by world region

World Region	MDG target			Universal access		
	Water	Sanitation	W&S	Water	Sanitation	W&S
Sub-Saharan Africa	841	12,880	13,722	1,651	18,758	20,409
Arab States	335	900	1,236	460	5,900	6,360
East Asia & Pacific	1,064	4,254	5,318	4,070	57,626	61,697
South Asia	118	5,093	5,211	464	32,038	32,502
Latin America & Caribbean	76	7,707	7,783	1,086	27,155	28,242
Eastern Europe & CIS	68	485	553	227	8,445	8,673
Non-OECD	**2,503**	**31,320**	**33,823**	**7,958**	**149,923**	**157,882**

3.9 Sensitivity analysis

In the initial sensitivity analysis, alternative values were entered for five selected areas of data uncertainty than represented the largest areas of uncertainty or the most important determinants of the benefit-cost ratios.

Range on time savings assumption. Given the high level of uncertainty in the base scenario time saving assumptions, a wide range was employed to reflect possible high and low values on time savings (see methods section 2.6). Figure 7 shows the benefit-cost ratio is sensitive to these alternative assumptions, ranging from 1.5 to 6.1 for sub-Saharan Africa for achieving the water MDG target, and from 3.7 to 9.6 for achieving the sanitation MDG target. Despite the sensitivity of the results, the conclusion holds that the interventions are cost-beneficial.

Figure 7. Benefit-cost ratios under alternative time saving assumptions for achieving the six water and sanitation targets, for sub-Saharan Africa

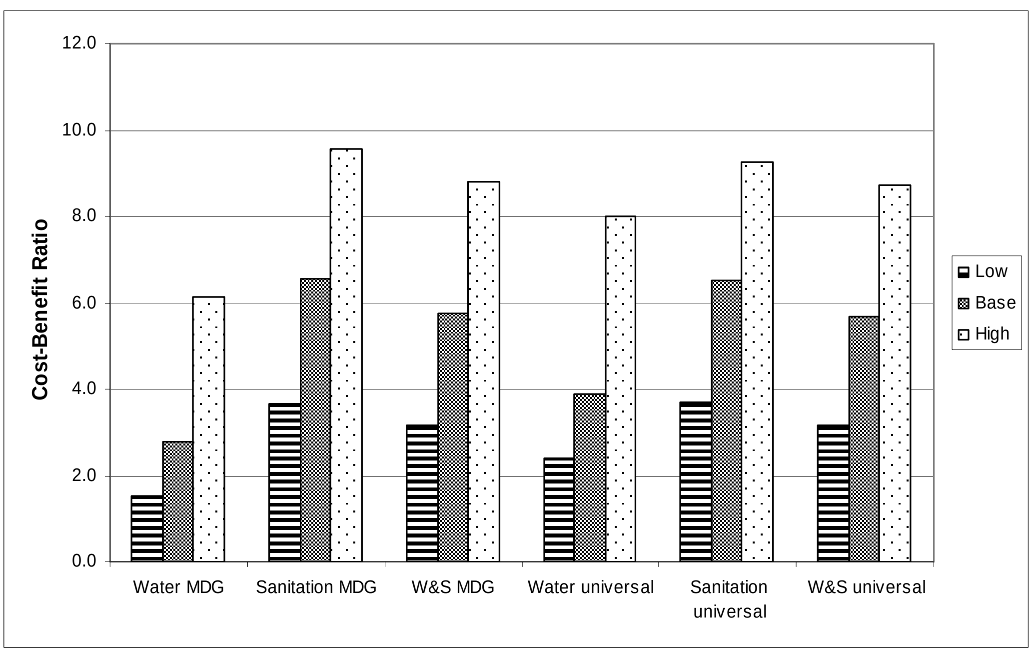
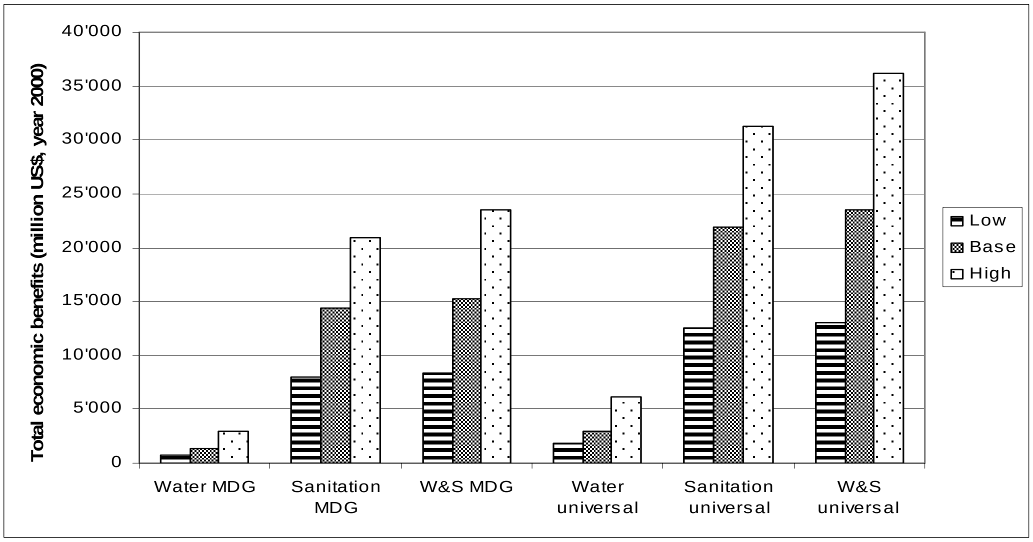


Figure 8 shows the sensitivity of the economic benefits to time saving assumptions, showing wide variation around the base case results.

Figure 8. Total annual economic benefits under alternative time saving assumptions for achieving six water and sanitation targets, sub-Saharan Africa



Range on time value assumption. Given the high level of uncertainty in the base scenario time value assumptions, alternative values were employed to reflect possible high and low values on the value of people's time (see methods sections 2.5.3 and 2.6). Figure 9 shows the benefit-cost ratio is highly sensitive to these alternative assumptions, ranging from 1.1 to 5.3 for sub-Saharan Africa for achieving the water MDG target, and from 2.1 to 9.5 for achieving the sanitation MDG target. Hence, at the lower time value assumptions (30% of GNP for adults, and zero for infants and children), the water intervention alone is only marginally cost-beneficial.

Figure 9. Benefit-cost ratios under alternative time value assumptions for achieving six water and sanitation targets, sub-Saharan Africa

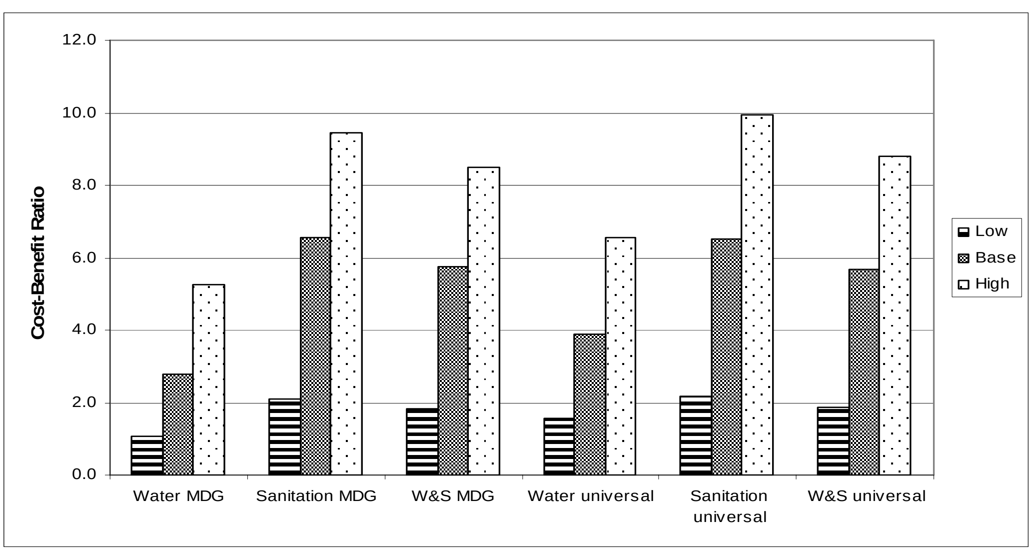
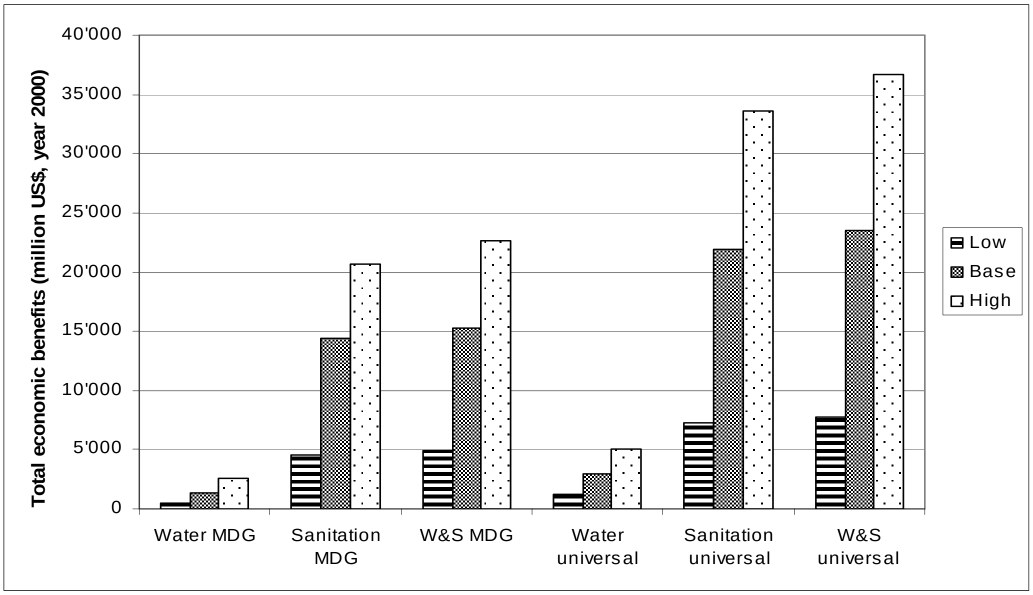


Figure 10 shows the sensitivity of the economic benefits to time value assumptions, showing wide variation around the base case results.

Figure 10. Total annual economic benefits under alternative time value assumptions for achieving six water and sanitation targets, sub-Saharan Africa



Range of diarrheal disease incidence. Under the assumption of different diarrheal disease incidence rates, Figure 11 also shows wide variation in the benefit-cost ratios.

Figure 11. Benefit-cost ratios under alternative diarrheal disease incidence assumptions for achieving six water and sanitation targets, sub-Saharan Africa

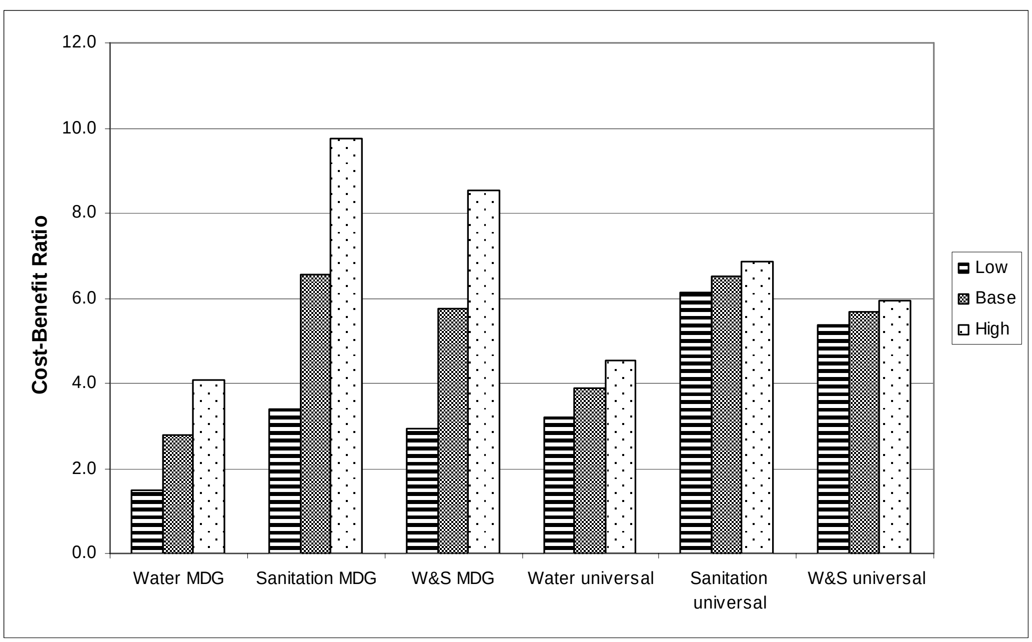
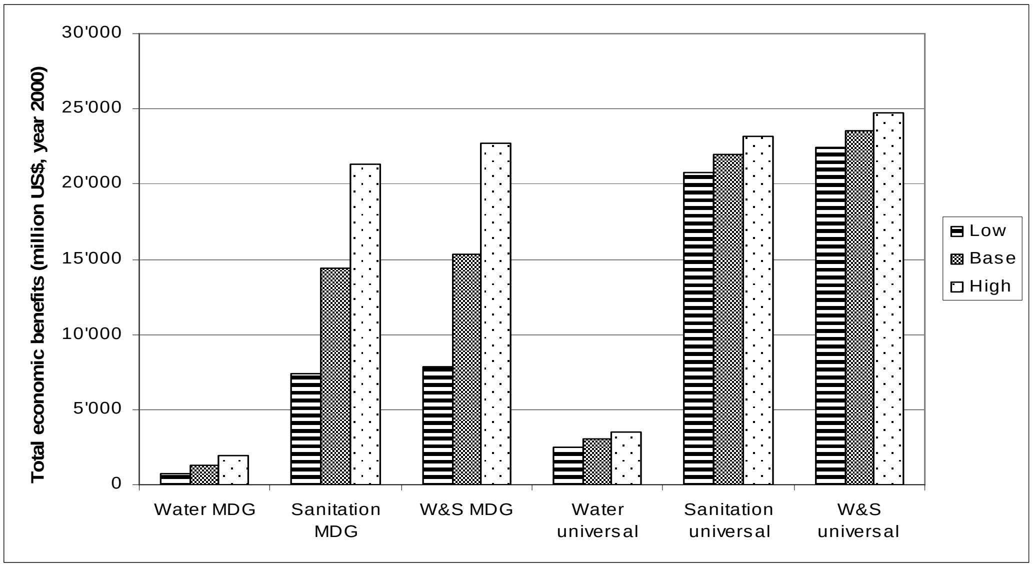


Figure 12 shows the sensitivity of the economic benefits to diarrheal disease incidence assumptions, showing wide variation around the base case results for the MDG targets, but a less important variation for the universal coverage target.

Figure 12. Total annual economic benefits under alternative diarrheal disease incidence assumptions for achieving six water and sanitation targets, sub-Saharan Africa



Range on health care cost values. Under the assumption of different health care unit cost assumptions, Figure 13 shows insignificant variation in the benefit-cost ratios. In fact, as there appears to have been greater uncertainty for the upper value for health care unit costs, the range on the benefit-cost ratio is correspondingly larger on the upper end.

Figure 13. Benefit-cost ratios under alternative health care unit cost assumptions for achieving six water and sanitation targets, sub-Saharan Africa

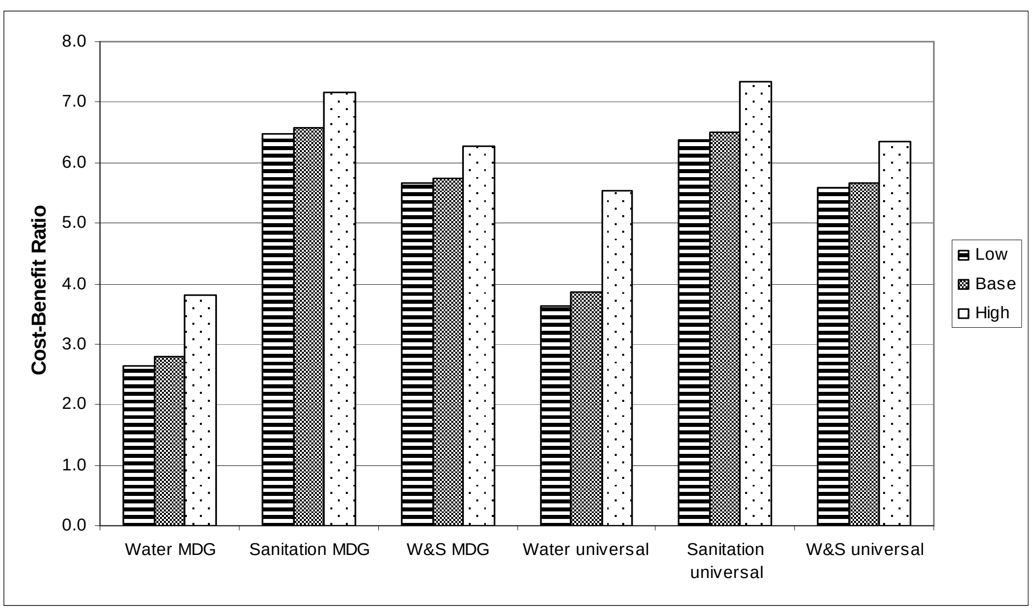
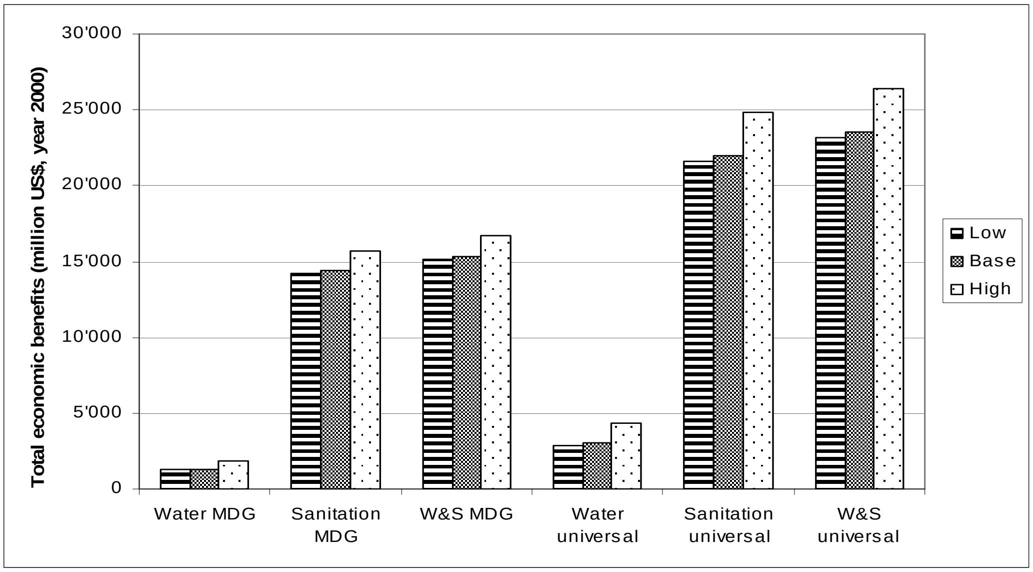


Figure 14 shows the sensitivity of the economic benefits to health care unit cost assumptions, showing only limited variation around the base case results. The impact is limited because health care costs contribute only a small proportion (under 10%) of total economic benefits.

Figure 14. Total annual economic benefits under alternative health care unit cost assumptions for achieving six water and sanitation targets, sub-Saharan Africa



Range on cost estimates of improved water and sanitation coverage. Under the assumption of different intervention cost assumptions, Figure 15 shows significant variation in the benefit-cost ratios.

Figure 15. Benefit-cost ratios under alternative intervention cost assumptions for achieving six water and sanitation targets, sub-Saharan Africa

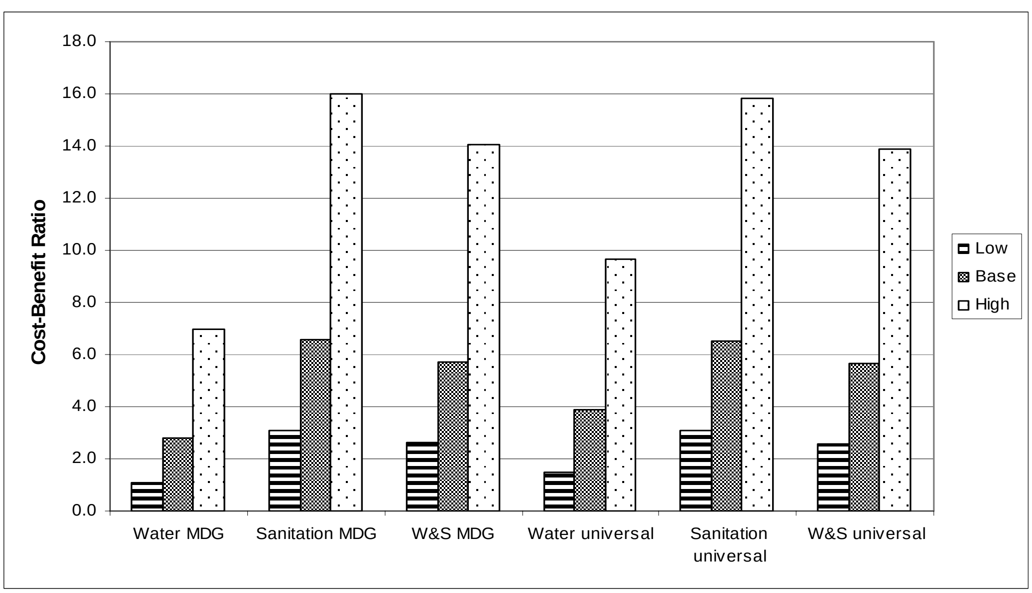


Figure 16 shows the sensitivity of the total economic costs of the interventions to the cost assumptions, showing wide variation around the base case results.

Figure 16. Total annual economic costs under alternative intervention cost assumptions for achieving six water and sanitation targets, sub-Saharan Africa

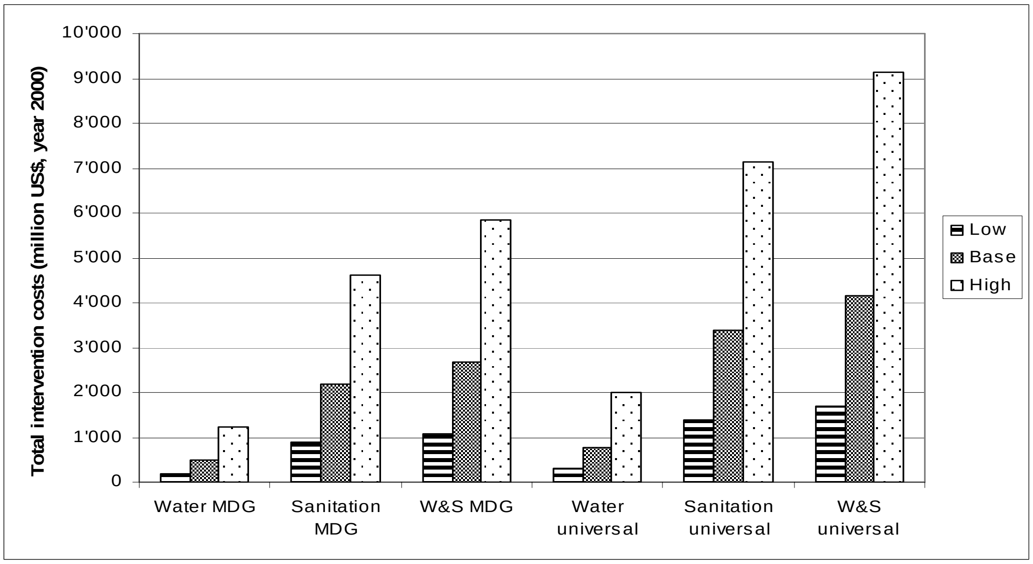


Table 26 shows the low, base and high annual intervention costs for three selected regions and globally for the six intervention scenarios. Base case values of unit cost per person reached (Table 7) were recalculated under alternative assumptions, based on using ranges for four variables used in estimating annualized intervention cost: (1) length of life of hardware; (2) operation, maintenance, surveillance as % annual cost; (3) education as % annual cost; and (4) water source protection as % annual cost.

Table 26. Total annual economic costs under alternative intervention cost assumptions for achieving six water and sanitation targets, three selected regions

World region	Water MDG	Sanitation MDG	W&S MDG	Water universal	Sanitation universal	W&S universal
Sub-Saharan Africa						
Low costs	192	896	1,088	312	1,386	1,697
Base case costs	479	2,185	2,665	777	3,379	4,156
High costs	1,238	4,620	5,857	2,006	7,144	9,150
East Asia & Pacific						
Low costs	91	164	256	355	1,883	2,238
Base case costs	229	399	628	891	4,576	5,468
High costs	595	827	1,423	2,314	9,485	11,799
South Asia						
Low costs	21	330	351	75	2,071	2,146
Base case costs	53	802	856	189	5,033	5,222
High costs	138	1,663	1,801	490	10,433	10,922
World (Non-OECD)						
Low costs	343	1,565	1,908	829	5,961	6,790
Base case costs	858	3,813	4,671	2,075	14,507	16,581
High costs	2,220	8,017	10,236	5,375	30,289	35,665

4. DISCUSSION

This study has analysed the costs and impacts of low cost water supply and sanitation coverage improvements under two main target scenarios: the scenario of meeting the MDG targets for water and sanitation, and the target scenario of universal coverage. The first of these, the MDG target scenario, compared costs and benefits associated with achieving the MDG target with a baseline of the projected coverage levels in 2015 based on current rate of progress. Hence, these results focussed on regions and countries that are at greatest risk of not achieving the water and sanitation MDG targets. Such an analysis should be considered a useful addition to previous global cost-benefit analyses which did not take into account the rate of progress over the first period (1990 to 2003) [16]. The usefulness of this analysis lies in the fact that both international and national fund holders and policy makers need to be alerted to the additional costs required to meet the MDG targets and in which countries additional efforts need to be made, as well as the benefits foregone of not making renewed efforts to meet the MDG targets. In other words, if countries, donor governments and international organisations continue with "business as usual" between now and the year 2015, there will be major missed opportunities for improving the lives of those currently without access to improved water supply and sanitation services. This study comes at a time when the international community needs further mobilisation to achieve the MDG targets, especially in countries that appear to be making only limited (if any) progress towards them.

The cost-benefit analysis results of the selected water and sanitation coverage goals are highly favourable, standing at between US$3 and US$21 economic benefit per US$1 invested for all developing world regions. The benefit-cost ratio remains above US$1 even under less optimistic assumptions for some of the key variables in the analysis. These results provide further evidence to support the further investment in value-for-money water supply and sanitation investments. Hence, investments in water supply and sanitation to reduce disease can be made from the economic argument as well as the health argument, where for example it has been previously shown in Afr-E region that control of diarrheal disease through improved treatment (oral rehydration therapy) is relatively cost effective with an incremental cost-effectiveness ratio of $ 106 per DALY averted (valued at International Dollars, including only marginal costs) [57].

The cost estimates made in this study are additional costs over and above the spending trend which has delivered higher coverage to a growing population from 1990 to 2004. It should also be noted that a proportion of households, especially in urban areas, will receive higher cost improvements such as household connection to piped water and/or sewerage, with or without sewage treatment. Hence the real spending may be higher than the total cost estimate of US$23 billion from 2005 to 2015 at linear scaling up.

Annual and total costs to meet the water supply and sanitation MDG targets have been estimated by a variety of agencies, ranging from 7 billion per year to 75 billion per year [58]. However, these figures include levels of investment required to meet the MDG targets in all countries, including those on-track to meet the MDG targets. Furthermore, different studies use different methods for cost estimation. Hence the cost estimates presented in this present study are not easily comparable with other studies that estimate the entire cost of meeting the MDG targets.

The main contributor to the cost of the low technology interventions selected was found to be the investment cost. However, recurrent costs are important for the proper functioning of the improvements, especially water supply, as well as ensuring the facilities do indeed last as long as they are assumed to in calculating average annual cost. Annualised capital costs could be considerably higher if facilities are not maintained and hence the length of life is shorter than the assumed ones (Table 9).

The main contributor to the overall economic benefits was the time saving associated with more convenient access to water supply and sanitation, while health-related productivity gains and health care cost savings were also important.

While at the regional level the input data reflect regional averages and hence do not suggest there will be significant bias in the results, some caution should be maintained especially in interpreting results for specific country contexts where parameter input values may vary substantially from those used in this regional level analysis. Furthermore, while the benefit-cost ratio stays above or close to 2 in all one-way analyses, combining pessimistic assumptions on several key sources of uncertainty simultaneously would likely push the BCR below 1.

In interpreting the impressive benefit-cost ratios presented in this study, an important caveat needs to be taken into account. On the cost side, the costs are very tangible, requiring financial and time input upfront for the interventions to be put in place. On the benefit side, however, the majority of the benefits are not highly tangible, in that the benefits do not bring immediate money ‘in the hand’. The benefits involve possible money savings from less health service use, accruing to both the health sector and the patient. The reduced number of days spent ill can lead to direct economic benefits, such as more time spent on income earning activities, or to other benefits such as more leisure time or more time spent at school, which have limited <u>immediate</u> economic benefits. On the other hand, the benefits related to time savings due to less time spent collecting water or accessing sanitation services can also be argued to be valuable to household members, as it increases their time spent in productive activities.

Therefore, while this analysis attempted to make realistic assumptions about the economic value of these potential savings, it is recognised that the real economic benefits accruing to the population may not be financial in nature, nor will they be immediate. Also, the real benefits depend on a number of factors related to the individual or household, such as what activities are done instead when time is saved or illness avoided, and what health seeking behaviour does he/she engage in. Furthermore, the assumptions about the value of time may overestimate the actual economic value, due to the presence of unemployment, underemployment or seasonal labour, which together determines the income earned when more time is available for work. In some cases the changes in time uses will lead to income gains, but data from micro-economic studies to support the assumptions used in this study are limited.

On the other hand, despite these uncertainties about the benefits, it is in fact likely that intervention benefits are instead underestimated. Several potential benefits have been left out altogether, such as other health effects, water cost savings from switching away from costly vendors, micro-enterprise at household level, environmental quality, water resource improvement which impacts fish and agricultural productivity and provides aesthetic and non-use welfare benefits to the population [15, 50]. Also, the water supply and sanitation situation in a country or specific site will have implications for incomes from tourism, foreign direct investment as well as local businesses. All this range of potential benefits were left out for a variety of reasons, including the difficulty of making generalized region-wide estimates of the necessary data inputs, difficulties in choosing an appropriate economic valuation technique, and difficulties in demonstrating the specific links of these positive impact with sanitation. Hence this is a clear area where further research would be valuable to support further investments in water supply and sanitation interventions.

While cost-benefit analysis can be carried out to identify clearly all the beneficiaries and the (potential) financers of development projects, the analysis does not provide direct answers to the question of who is able to pay. The intervention financing imperative presents a particular challenge to economic evaluation when no single ministry or population group are able to finance the full cost of an intervention. Water supply and sanitation are the domains of many sectors and government line ministries; hence a coordinated financing effort will be needed to ensure interventions are financed, planned and implemented to enjoy the full benefits (and more) presented in this analysis. However, cost-benefit analysis presents benefits to different beneficiaries, thus implicitly suggesting who may and would be willing to contribute to intervention financing. While this study did not include all the benefits, the most widespread benefits were included, which were generally the benefits where country and regional averages could be estimated. Some benefits, like those accruing to agriculture and industry, are very setting-specific, and thus country-specific estimation of economic gains is a challenging task.

One of the problems associated with identifying beneficiaries in order to identify those willing to pay for the costs is that the main beneficiaries – patients and consumers – do not always understand the full benefits until well after the investment. Also, most costs are incurred in the first year of the intervention, while benefits accrue over time. These factors together lead to a type of market failure, and implies that many private consumers cannot be expected to finance the initial investment costs up-front. On the other hand, water supply improvements may in fact involve a lower annual cost than the current options, if water trucks, water vendors or bottled water are presently used. This means that certain groups could be convinced that a household water connection is often cheaper in the long- and even short-term, thus providing persuasive proof that the intervention is worthwhile from a household financial perspective.

With respect to the question whether the health sector would be interested in financing the interventions, it is clear from this analysis that in most regions and for most interventions there is little incentive for the health sector to make significant contributions to the costs, as the real savings to the sector are small in comparison to the annual intervention costs. Compared to the potential cost savings reported in this study, it is unlikely that the health sector would recover these full costs, as only a small proportion are marginal costs directly related to the treatment cost of the diarrhoeal episode. Most costs, such as personnel and infrastructure, are fixed costs that do not change with patient throughput in the short-term. The health ministry should be interested, on the other hand, in reducing the burden to the health system of patients presenting with diarrhoea, thus freeing up capacity in the health system to treat other patients.

The implication of these arguments is that there should exist a variety of financing mechanisms for meeting the costs of water and sanitation improvements, depending on the income and asset base of the target populations, the availability of credit, the economic benefits perceived by the various stakeholders, the budget freedom of government ministries, and the presence of NGOs to promote and finance water supply and sanitation improvements. The health sector, with the meagre budget, cannot be expected to fund major water supply and sanitation improvements, although it does play a key role in providing software components of water supply and sanitation programmes, such as education for behaviour change.

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ANNEX 1. W.H.O. WORLD SUB-REGIONS

Countries classified according to W.H.O. epidemiological sub-regions

Region*	Mortality stratum**	Countries
AFR	**D**	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome And Principe, Senegal, Seychelles, Sierra Leone, Togo
AFR	**E**	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic Of The Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
AMR	**B**	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela
AMR	**D**	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
EMR	**B**	Bahrain, Cyprus, Iran (Islamic Republic Of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
EMR	**D**	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
EUR	**B**	Albania, Armenia, Azerbaijan, Bosnia And Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Slovakia, Tajikistan, The Former Yugoslav Republic Of Macedonia, Turkey, Turkmenistan, Uzbekistan, Yugoslavia
EUR	**C**	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
SEAR	**B**	Indonesia, Sri Lanka, Thailand
SEAR	**D**	Bangladesh, Bhutan, Democratic People's Republic Of Korea, India, Maldives, Myanmar, Nepal
WPR	**B**	Cambodia, China, Lao People's Democratic Republic, Malaysia, Mongolia, Philippines, Republic Of Korea, Viet Nam
		Cook Islands, Fiji, Kiribati, Marshall Islands, Micronesia (Federated States Of), Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

* AFR = Africa Region; AMR = Region of the Americas; EMR = Eastern Mediterranean Region; EUR = European Region; SEAR = South East Asian Region; WPR = Western Pacific Region
** B = low adult, low child mortality; C = high adult, low child mortality; D = high adult, high child mortality; E = very high adult, high child mortality

ANNEX 2. COUNTRIES INCLUDED IN MDG ANALYSIS

Remaining proportion of population to be served to reach Millennium Development Goal target, compared to the 2015 forecast (by country)

Country*	Remaining % population to be served to reach MDG target compared to the 2015 forecast (based on current trends)	
	Water MDG target	Sanitation MDG target
World Region 1: Sub-Saharan Africa		
Angola	1	33
Benin	11	5
Botswana	0	26
Burkina Faso	0	36
Burundi	0	41
Cameroon	0	22
Central African Republic	0	29
Chad	0	43
Comoros	16	35
Cote d'Ivoire	0	12
Dem. Rep. Of the Congo	22	18
Eritrea	0	44
Ethiopia	39	29
Ghana	0	36
Guinea	16	35
Kenya	5	26
Liberia***	14	50
Madagascar	18	10
Malawi	0	3
Mali	2	15
Mauritania	0	26
Mozambique	23	20
Namibia	0	38
Niger	16	35
Nigeria	30	22
Rwanda	0	20
South Africa	0	23
Togo	21	33
Uganda	0	28
United Rep. of Tanzania	1	26
Zambia	7	9
Zimbabwe	4	21
World Region 2: Arab States		
Algeria	20	0
Djibouti	12	6
Jordan	0	5
Morocco	4	0
Sudan	11	32
Yemen	23	14
World Region 3: East Asia & Pacific		
China	4	3
Cook Islands	0	0
Dem. People's Rep. of Korea	0	0
Fiji	0	10

Country*	Remaining % population to be served to reach MDG target compared to the 2015 forecast (based on current trends)	
	Water MDG target	Sanitation MDG target
Indonesia	7	9
Kiribati	0	5
Marshall Islands	18	0
Micronesia, (Fed. States of)	0	35
Palau	4	0
Philippines	12	0
Samoa	11	0
Vanuatu	20	0
World Region 4: South Asia		
Bangladesh	10	8
India	0	9
Maldives	23	0
Nepal	0	2
World Region 5: Latin America & Caribbean		
Bolivia	0	10
Brazil	0	7
Colombia	2	0
El Salvador	0	7
Haiti	16	21
Jamaica	1	3
Nicaragua	1	26
Peru	0	5
Trinidad and Tobago	6	0
World Region 6: Eastern Europe & CIS		
Azerbaijan	1	0
Georgia	6	4
Russian Federation	0	6
Slovakia	0	0
Uzbekistan	21	0

* Countries not included in the table are excluded from the MDG analysis. For some countries, this is because the MDG target is predicted to be met at current projections. For other countries, this is due to missing data to make a projection (either no base year, or no mid-point year such as 2002 or 2004).

ANNEX 3. HEALTH IMPACT BY AGE GROUP

Table 1. Diarrheal cases (millions) averted by age group from achieving intervention 1 (water MDG target)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	12.2	16.6	8.2	5.2	0.5	42.6
Arab States	1.3	1.8	0.8	0.6	0.1	4.5
East Asia & Pacific	2.6	3.8	2.3	8.3	1.3	18.3
South Asia	1.1	1.6	0.7	0.8	0.1	4.3
Latin America & Caribb.	0.2	0.2	0.2	0.2	0.0	0.8
Eastern Europe & CIS	0.3	0.5	0.2	0.2	0.0	1.2
Non-OECD	**17.6**	**24.5**	**12.4**	**15.2**	**2.0**	**71.7**

Table 2. Diarrheal cases (millions) averted by age group from achieving intervention 2 (sanitation MDG target)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	32.4	44.1	21.7	13.6	1.3	113.0
Arab States	2.9	4.0	1.8	1.3	0.1	10.1
East Asia & Pacific	3.6	5.2	3.1	10.5	1.6	24.0
South Asia	8.3	12.2	5.0	6.3	0.8	32.6
Latin America & Caribb.	1.8	2.7	2.6	1.8	0.2	9.0
Eastern Europe & CIS	0.2	0.2	0.0	0.2	0.1	0.7
Non-OECD	**49.1**	**68.3**	**34.2**	**33.8**	**4.1**	**189.5**

Table 3. Diarrheal cases (millions) averted by age group from achieving intervention 3 (water and sanitation MDG target)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	35.3	48.1	23.6	14.9	1.4	123.3
Arab States	3.4	4.7	2.1	1.5	0.1	11.8
East Asia & Pacific	5.2	7.5	4.8	17.5	2.7	37.7
South Asia	8.7	12.7	5.2	6.6	0.8	34.0
Latin America & Caribb.	1.9	2.8	2.7	1.8	0.2	9.4
Eastern Europe & CIS	0.4	0.7	0.3	0.4	0.1	1.9
Non-OECD	**54.9**	**76.4**	**38.8**	**42.8**	**5.3**	**218.1**

Table 4. Diarrheal cases (millions) averted by age group from achieving intervention 4 (water universal coverage)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	32.2	43.9	21.6	13.6	1.3	112.5
Arab States	2.7	3.7	1.6	1.2	0.1	9.4
East Asia & Pacific	8.7	12.5	9.0	34.7	5.3	70.2
South Asia	4.3	6.3	2.6	3.3	0.4	16.8
Latin America & Caribb.	1.4	2.0	2.0	1.3	0.2	6.9
Eastern Europe & CIS	0.3	0.5	0.2	0.3	0.1	1.4
Non-OECD	**49.6**	**68.9**	**36.9**	**54.5**	**7.4**	**217.3**

Table 5. Diarrheal cases (millions) averted by age group from achieving intervention 5 (sanitation universal coverage)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	70.8	96.5	47.4	29.9	2.8	247.4
Arab States	7.4	10.1	4.4	3.4	0.3	25.6
East Asia & Pacific	24.1	34.7	24.9	96.2	14.8	194.7
South Asia	44.6	65.4	27.0	34.1	4.2	175.1
Latin America & Caribb.	5.2	7.7	7.5	5.2	0.7	26.2
Eastern Europe & CIS	1.0	1.5	0.5	0.9	0.2	4.1
Non-OECD	**153.1**	**215.9**	**111.7**	**169.6**	**22.9**	**673.1**

Table 6. Diarrheal cases (millions) averted by age group from achieving intervention 6 (water and sanitation universal coverage)

World Region	*0 to 1*	*1 to 4*	*5 to 14*	*15 to 59*	*60 plus*	*Total*
Sub-Saharan Africa	70.8	96.5	47.4	29.9	2.8	247.4
Arab States	7.4	10.1	4.4	3.4	0.3	25.6
East Asia & Pacific	24.1	34.7	24.9	96.2	14.8	194.7
South Asia	44.6	65.4	27.0	34.1	4.2	175.1
Latin America & Caribb.	5.2	7.7	7.5	5.2	0.7	26.2
Eastern Europe & CIS	1.0	1.5	0.5	0.9	0.2	4.1
Non-OECD	**153.1**	**215.9**	**111.7**	**169.6**	**22.9**	**673.1**

Table 7. Deaths averted due to diarrhea by age group from achieving intervention 1 (water MDG target)

World Region	*0 to 4*	*5 to 14*	*15 to 59*	*Total*
Sub-Saharan Africa	37'464	3'519	1'976	42'958
Arab States	3'984	331	224	4'539
East Asia & Pacific	8'282	1'008	3'185	12'475
South Asia	3'465	282	317	4'064
Latin America & Caribbean	538	101	58	697
Eastern Europe & CIS	963	92	80	1'135
Non-OECD	**54'696**	**5'333**	**5'840**	**65'870**

Table 8. Deaths averted due to diarrhea by age group from achieving intervention 2 (sanitation MDG target)

World Region	*0 to 4*	*5 to 14*	*15 to 59*	*Total*
Sub-Saharan Africa	99'300	9'331	5'234	113'865
Arab States	8'916	795	486	10'197
East Asia & Pacific	11'390	1'322	4'045	16'757
South Asia	26'565	2'162	2'430	31'157
Latin America & Caribbean	5'792	1'109	682	7'582
Eastern Europe & CIS	525	20	79	624
Non-OECD	**152'488**	**14'739**	**12'956**	**180'182**

Table 9. Deaths averted due to diarrhea by age group from achieving intervention 3 (water and sanitation MDG target)

World Region	*0 to 4*	*5 to 14*	*15 to 59*	*Total*
Sub-Saharan Africa	108'349	10'180	5'711	124'240
Arab States	10'476	920	575	11'972
East Asia & Pacific	16'511	2'076	6'703	25'290
South Asia	27'743	2'258	2'538	32'539
Latin America & Caribbean	5'997	1'149	709	7'855
Eastern Europe & CIS	1'472	112	157	1'741
Non-OECD	**170'548**	**16'696**	**16'393**	**203'637**

Table 10. Deaths averted due to diarrhea by age group from achieving intervention 4 (water universal coverage)

World Region	***0 to 4***	***5 to 14***	***15 to 59***	***Total***
Sub-Saharan Africa	98'837	9'287	5'210	113'334
Arab States	8'401	701	472	9'573
East Asia & Pacific	27'460	3'868	13'322	44'650
South Asia	13'721	1'117	1'255	16'093
Latin America & Caribbean	4'450	848	513	5'811
Eastern Europe & CIS	1'146	99	108	1'353
Non-OECD	**154'014**	**15'919**	**20'880**	**190'814**

Table 11. Deaths averted due to diarrhea by age group from achieving intervention 5 (sanitation universal coverage)

World Region	***0 to 4***	***5 to 14***	***15 to 59***	***Total***
Sub-Saharan Africa	217'336	20'423	11'455	249'213
Arab States	22'714	1'883	1'294	25'891
East Asia & Pacific	76'449	10'743	36'871	124'063
South Asia	142'786	11'622	13'063	167'471
Latin America & Caribbean	16'763	3'216	1'991	21'970
Eastern Europe & CIS	3'162	220	350	3'732
Non-OECD	**479'210**	**48'107**	**65'022**	**592'339**

Table 12. Deaths averted due to diarrhea cases averted by age group from achieving intervention 6 (water and sanitation universal coverage)

World Region	***0 to 4***	***5 to 14***	***15 to 59***	***Total***
Sub-Saharan Africa	217'336	20'423	11'455	249'213
Arab States	22'714	1'883	1'294	25'891
East Asia & Pacific	76'449	10'743	36'871	124'063
South Asia	142'786	11'622	13'063	167'471
Latin America & Caribbean	16'763	3'216	1'991	21'970
Eastern Europe & CIS	3'162	220	350	3'732
Non-OECD	**479'210**	**48'107**	**65'022**	**592'339**