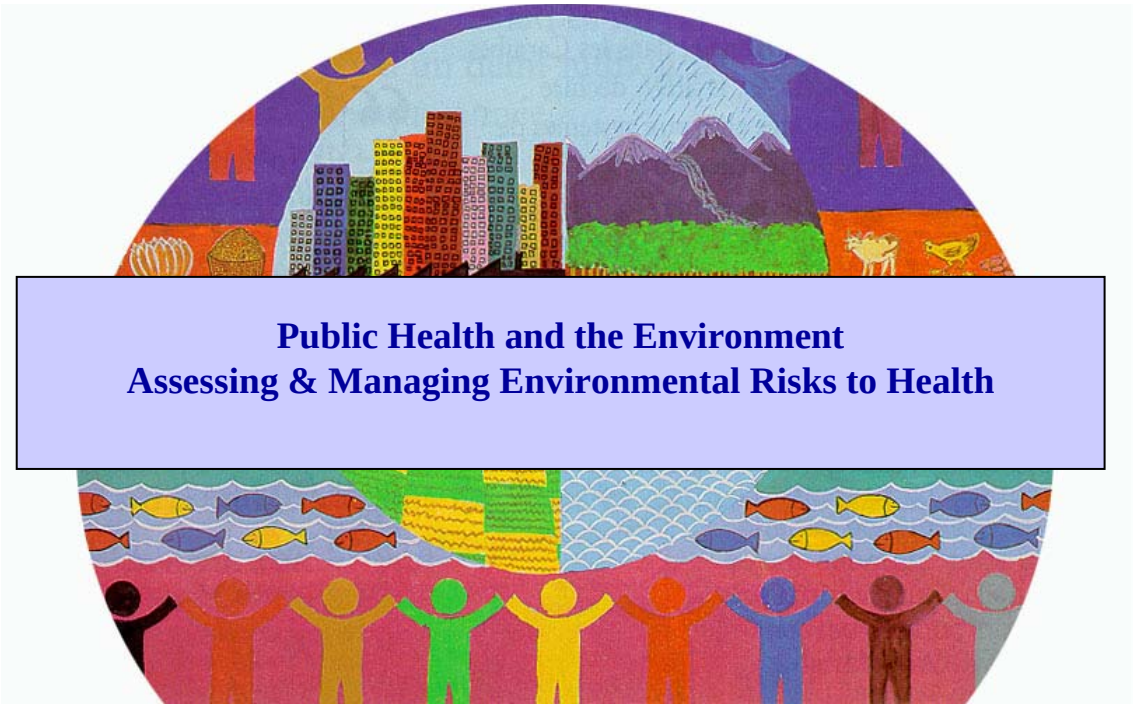
World Health Organization

Regional and Global Costs of Attaining the Water Supply and Sanitation Target (Target 10) of the Millennium Development Goals

Guy Hutton
Jamie Bartram



WHO/HSE/AMR/08/01

Regional and Global Costs of Attaining the Water Supply and Sanitation Target (Target 10) of the Millennium Development Goals

Prepared by:

Guy Hutton, Water and Sanitation Program – East Asia & Pacific Region, World Bank (work conducted while at DSI Development Solutions International, Basel, Switzerland)
Jamie Bartram, World Health Organization, Geneva, Switzerland

Public Health and the Environment
World Health Organization
Geneva 2008

Regional and Global Costs of Attaining the Water Supply and Sanitation Target (Target 10) of the Millennium Development Goals

Printed by the WHO Document Production Services, Geneva, Switzerland

CONTENTS

Summary

Target 10 of the Millennium Development Goals (MDGs) is to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation". This study presents regional and global estimates of the cost of attaining the water and sanitation MDG target.

Improved water and sanitation coverage data for 1990 and 2004 are used to estimate the population to be covered to attain the MDG target, taking into account population growth until 2015. The targeted population is assumed to receive improved water and sanitation in equal annual increments from the beginning of 2005 (the base year) until the end of 2014. Investment and recurrent costs per capita are applied to the target population. Country data are aggregated to 11 World Health Organization (WHO) developing country subregions and globally.

Estimated spending required in developing countries to provide new coverage to meet the MDG target is 42 billion United States dollars (US$) for water and US$ 142 billion for sanitation, or a combined annual equivalent of US$ 18 billion. The cost of maintaining existing services totals an additional US$ 322 billion for water supply and US$216 for sanitation, or a combined annual equivalent of US$ 54 billion. Spending for new coverage is focused mainly on rural areas (64%), whereas spending for maintaining existing coverage is focused mainly on urban areas (73%). Additional programme costs – incurred administratively outside the point of delivery of interventions – of between 10% and 30% are required for effective implementation.

In assessing financing requirements, estimates of cost should include the operation, maintenance and replacement of existing coverage as well as costs of new services and programme costs. Country-level costing studies are needed to guide financing.

This report is an expanded version of the paper "Global Costs of Attaining the Water and Sanitation MDG Target", incorporating additional data and presentational detail, and is published in response to requests for this additional information.

Acknowledgements

WHO wishes to express its appreciation to all those whose efforts made this study possible, in particular Guy Hutton, DSI Development Solutions International, Basel, Switzerland, Jamie Bartram, World Health Organization, Geneva, Switzerland, and Tessa Tan-Torres, World Health Organization, Geneva, Switzerland. WHO also thanks the anonymous peer reviewers for their comments on the shorter form of this paper published in the *Bulletin of the World Health Organization* 2008;86:13–19.

Acronyms and abbreviations

AFR	WHO African Region (see Annex A)
AMR	WHO Region of the Americas (see Annex A)
EMR	WHO Eastern Mediterranean Region (see Annex A)
EUR	WHO European Region (see Annex A)
GDP	gross domestic product
HC	household connection
JMP	Joint Monitoring Programme for Water Supply and Sanitation (run by WHO and UNICEF)
LAC	Latin America and the Caribbean
MDG	Millennium Development Goal
OECD	Organisation for Economic Co-operation and Development
SEAR	WHO South-East Asia Region (see Annex A)
UNICEF	United Nations Children's Fund
US$	United States dollars
VIP	ventilated improved pit-latrine
WHO	World Health Organization
WPR	WHO Western Pacific Region (see Annex A)

Introduction

Goal 7 of the Millennium Development Goals (MDGs) addresses environmental sustainability, with a target (target 10) to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation" (*1*). The attainment of target 10 also contributes to the reduction of child mortality (target 5), a decrease in the incidence of major infectious diseases (target 8), improvement of maternal health (target 6) and improvement of the quality of life of slum populations (target 11). Improved water and sanitation also contribute to gender equality and empower women (goal 3), being linked to school enrolment and attendance, especially of girls. Meeting the target would deliver further development benefits and contribute to poverty reduction (target 1) and hunger reduction (target 2) through use of water supply for industry and agriculture, saving productive time in accessing closer water sources and sanitation facilities, and contributing to workforce health. Importantly, improved water supply and sanitation promote economic equity, since the unserved tend to be the poorer, more vulnerable members of society.

In working towards the MDG target for water and sanitation, it is critical to understand what resources are required, where they need to be deployed and whether there are financing gaps. Corresponding assessments need to be based on reasonable estimates at global, regional and country levels (*2*). Furthermore, comparing estimated costs required with existing funding levels helps to mobilize resources and to direct efforts to specific contexts (e.g. rural or urban) and to countries that are "off-track" (*3*).

Since 2000, several studies have estimated the cost of attaining one or both of the components of the target for water and sanitation at the global (*4–8*) and regional (*2, 9, 10*) levels. Reviews have compared these costs, which are in the range of 9 billion to 30 billion United States dollars (US$) per year at the global level (*11, 12*). This wide range is largely explained by the different methodologies and unit cost assumptions. Different approaches to incremental improvement and definitions of adequate service levels also contribute to the differences.

Most studies have ignored the costs of maintaining existing coverage levels (the costs of operating, maintaining, monitoring and replacing existing infrastructure and facilities) – especially important as the global stock of assets increases and in light of reports indicating wide variability in effective "working life". Toubkiss (*12*) concludes, based on global cost studies, that "approximately US$ 10 billion per year would be required to supply low cost water and sanitation services to people who are not currently supplied, and a further US$ 15 to 20 billion a year to provide them with a higher level of service *and to maintain current levels of service to people who are already supplied*" (our emphasis). Future financing studies should consider costs of operation, maintenance and replacement of existing as well as new water and sanitation infrastructure and facilities (*12*). A major component of variability for sanitation is technology choice: a low-cost household "improved latrine" can provide both safety and privacy, yet the cost of waterborne sewerage systems must also include the cost of treatment to reduce health and environmental risks from the discharged wastewater. Thus, Toubkiss (*12*) concludes that in addition to the above costs, "up to US$ 80 billion is projected solely for collecting and treating household wastewater…" (page 7).

The divergence of previous global cost studies of water and sanitation is partially explained by differences in methodology, leading to some convergence in estimates when these are taken into account (*11*, *12*). Nevertheless, previous studies suffer methodological weaknesses or simplifying assumptions that make the cost estimates difficult to interpret; hence, the crude figures presented above are still incomplete.

While water and sanitation coverage has been advancing in many countries, recent estimates consistently show the sanitation component of the target to be significantly off track, with a projected shortfall of 550 million people in 2015 compared with what target achievement would require (*3*). The drinking-water component, while formally "on track" (within 5% of target), is at the bottom limit of that range and has deteriorating prospects (*13*). A factor cited as contributing to this low level of achievement is population growth. Uneven progress between rural and urban populations is also often cited, and the lower baseline in rural compared with urban areas is well documented (*14*). The importance of this is reflected in the fact that, uniquely among MDG indicators, rural–urban disaggregation is specified in the indicator definition, although there is no clear agreement that the target *itself* applies separately to rural and urban areas. Since costs, feasible technologies and population growth differ between rural and urban areas, these factors have a significant impact on cost estimates. Finally, costs and benefits depend on technology choice, from the high-technology, high-cost option (e.g. piped household connection) to the low-technology, low-cost choice (e.g. water hauled, pit latrine). However, the base case analysis should use a realistic assumption for what proportion of new population covered receives which improvements.

This paper presents new regional and global estimates of the cost of attaining MDG target 10, using updated data inputs and showing the range of costs based on different assumptions. It also provides policy-relevant cost disaggregations, including breakdowns between water and sanitation, rural and urban, capital and recurrent, and existing and new coverage. This paper builds on the lessons learned from the review conducted by the World Water Council (*12*) and uses the same general methodology of the World Health Organization (WHO) global cost–benefit analysis on attaining MDG target 10 and universal coverage (*5*). Two separate papers on cost-effectiveness analysis (*15*) and cost–benefit analysis (*16*) based on the WHO study have been published.

Methods

Water and sanitation coverage

Improved and unimproved water and sanitation coverage estimates are obtained from the Joint Monitoring Programme for Water Supply and Sanitation (JMP), run jointly by WHO and the United Nations Children's Fund (UNICEF) since 1990. Coverage estimates are based on the current JMP classifications, shown in Table 1 (*14*). JMP classifies the following as "improved" water supply: piped water into dwelling, plot or yard; public tap; tubewell or borehole; protected dug well or spring; and collected rainwater. To be classified as improved, the water supply must provide at least 20 litres per capita per day from a protected source within 1 km of the user's dwelling. "Improved" sanitation consists of flush or pour-flush toilet to piped sewer system, septic tank or pit latrine; a ventilated improved pit-latrine (VIP); pit latrine with slab;

or composting toilet. Estimates are based on household surveys of actual use, and resulting figures therefore reasonably reflect true "access".

Table 1
Definition of "improved" and "unimproved" water supply and sanitation

Intervention	Improved	Unimproved[a]
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)

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

[a] Defined as being unimproved as a result of being unsafe or costly.
Source: JMP report (*14*).

This study includes all countries for which coverage estimates are available for both 1990 and 2004 (http://www.wssinfo.org). Summary water supply and coverage data for the year 2004 are provided in Table 2, by world region, but reflecting only those countries included in the current analysis. The 1990 coverage level is necessary because it allows estimation of the target coverage in 2015. The 2004 coverage level is necessary because it allows the estimation of remaining population to be covered in order to meet the MDG target in 2015. For some countries, only overall coverage is available. For these, assumptions were made based on regional averages for the distribution of populations between piped household connection and other improvements. This study presents the costs of attaining the MDG target in rural and urban areas separately and together, based on application of the target separately to rural and urban populations.

Table 2
Proportion of population covered with improved water and sanitation, 2004[a]

WHO subregion[b]	Population with improved water (%)				Population with improved sanitation (%)			
	Rural		Urban		Rural		Urban	
	HC	Other	HC	Other	HC	Other	HC	Other
AFR-D	7	36	31	45	6	23	26	32
AFR-E	5	37	49	39	1	29	23	32
AMR-B	45	28	92	6	11	36	65	23
AMR-D	39	35	80	10	8	39	55	20
EMR-B	67	18	96	3	35	43	84	13
EMR-D	25	52	68	25	6	35	45	38
EUR-B	55	28	93	5	16	54	80	13
EUR-C	48	37	93	7	26	41	84	8
SEAR-B	6	64	30	57	0	59	2	76
SEAR-D	7	75	44	50	2	24	23	37
WPR-B	51	19	84	9	4	27	45	26
All	**26**	**45**	**70**	**22**	**4**	**30**	**43**	**30**

HC, household connection

[a] Countries included in this analysis only.

[b] AFR = WHO African Region; AMR = WHO Region of the Americas; EMR = WHO Eastern Mediterranean Region; EUR = WHO European Region; SEAR = WHO South-East Asia Region; WPR = WHO Western Pacific Region. The letters B, C, D and E refer to the WHO mortality strata (see Annex A).

The analysis assumes an intervention period of 10 years, bridging the last available year of JMP statistics (assumed end of 2004) to the start of the MDG target year (2015). In other words, the analysis assumes that new coverage starts to be delivered at the start of 2005 and is completed by the end of 2014. Hence, to meet the MDG target, 1/10th of the population to be covered is assumed to receive improved water or sanitation each year from 2005 to 2014 inclusive. This assumption of gradual constant scaling up is the most operationally feasible.

The focus of the study is on developing countries, which WHO summarizes in 11 developing country subregions (see Annex A). A few small countries that have already reached 98% coverage or more in both rural and urban areas (such as advanced Caribbean islands) were excluded. Developing countries that have already achieved progress equivalent to MDG target 10 at the national level but are still below 98% coverage are included because of the significant costs associated with continuing to sustain the existing coverage levels. Given the different completeness of water and sanitation data and the different coverage levels achieved so far, slight variance existed between the countries included for water and those included for sanitation. The estimate of costs of achieving the water component of the MDG target is based on 91 countries, with a combined population of 5.84 million in 2015 (93% of the projected population of 6.25 billion for non-Organisation for Economic Co-operation and Development [OECD] regions). The costs of achieving the sanitation component of the MDG target are based on 94 countries, with a combined population of 5.68 billion in 2015 (91% of the projected population of 6.25 billion for non-OECD regions).

Increases in the population between 1990 and 2015 must also be covered to meet the MDG target. However, not all population increments are unserved, especially for non-

piped water interventions where new houses may have access to community sources. Therefore, population growth between 2004 and 2015 is allocated to improved and unimproved based on the distribution between improved and unimproved coverage in the year 2004. This represents a slightly optimistic assumption, given global trends towards decreasing household size and hence decreasing numbers of new facilities and connections that would need to be made available for new housing developments, especially in countries where the population is still growing. Table 3 shows the total population in 2015 according to coverage status used for the analysis: those already covered in 2004 (including the adjustment for population growth); those needing to be covered between 2005 and 2014; and those still uncovered in 2015 if the MDG target is met. The table shows that, globally, 420 million people need to be covered with improved water and 1052 million need to be covered with improved sanitation between the years 2005 and 2014 to meet the MDG target 10.

Table 3
Population covered and uncovered with improved water and sanitation by the year 2015[a]

	Population (million)							
	Water				Sanitation			
WHO subregion	Total	Covered with existing	Covered with new (MDG[b])	Uncovered	Total	Covered with existing	Covered with new (MDG[b])	Uncovered
AFR-D	412	242	83	87	412	175	110	126
AFR-E	480	280	91	109	482	184	138	160
AMR-B	484	453	9	21	480	389	32	59
AMR-D	90	76	5	9	90	60	11	19
EMR-B	122	115	2	4	42	38	1	4
EMR-D	469	392	25	52	433	252	58	123
EUR-B	154	141	7	7	141	118	9	14
EUR-C	152	145	3	3	152	130	11	11
SEAR-B	269	214	27	28	338	234	43	61
SEAR-D	1517	1294	22	200	1516	549	352	615
WPR-B	1694	1380	145	169	1594	809	287	497
All	**5842**	**4732**	**420**	**690**	**5679**	**2938**	**1052**	**1689**

[a] Countries included in this analysis only. Totals may not add up as a result of rounding.[b] According to MDG target 10 on water and sanitation.

Interventions

For each country, and for rural and urban areas separately, populations were assumed to receive household connections and "other improvements" based on the distribution of populations between these two categories in the year 2004 (see Table 2). Given that "other improvements" can be of several types and that preferences and available options vary, those receiving other improvements were divided equally among four major non-household connection options: for water, standpost, borehole, dug well and rainwater; and for sanitation, septic tank, pour-flush, VIP and simple pit latrine.

In order to take into account the costs of operating, maintaining and replacing existing water and sanitation facilities, this study assumes a length of life of household connections (both piped water and sewerage) of 40 years and a length of life of "other improvements" of 20 years. For the estimation of investment costs, 1/40th of those with household connections and 1/20th of those with other improvements are assumed to incur investment costs per capita every year from 2005 to 2014 (see Table 4).

Recurrent costs of existing facilities are estimated on the same basis as new coverage (see below) on an annual per capita basis.

Table 4
Per capita costs of water and sanitation improvements, excluding programme costs

	Per capita costs (US$ year 2005[a])					
	Initial investment cost			Annual recurrent cost		
Improvement type	Africa	Asia	LAC	Africa	Asia	LAC
Water improvement						
Household connection (treated)	164	148	232	13.4	9.6	14.6
Standpost	50	103	66	0.5	1.0	0.7
Borehole	37	27	89	0.2	0.2	0.6
Dug well	34	35	77	0.2	0.2	0.5
Rainwater	79	55	58	0.5	0.4	0.4
Average of non-household connection options	50	55	72	0.4	0.5	0.5
Sanitation improvement						
Household connection (partial treatment)	193	248	258	8.2	9.1	11.0
Septic tank	185	167	258	6.2	6.1	6.8
Pour-flush	147	81	97	6.1	5.5	5.7
VIP	92	81	84	3.8	3.8	3.8
Simple pit latrine	63	42	97	3.6	3.5	3.9
Average of non-household connection options	122	93	134	4.9	4.7	5.0

LAC, Latin America and the Caribbean

[a] Data from 2000 adjusted to 2005 prices using an average annual gross domestic product (GDP) deflator of 10%.

Costs

Unit costs of water and sanitation improvement are applied to the population to be covered under the MDG target in order to estimate total costs at country, regional and global levels. All costs are updated to the year 2005 and presented in US$ using an average gross domestic product (GDP) deflator of 10% per annum. Unit costs for capital investments are available per person covered (for the length of life of the selected technology), whereas recurrent costs are estimated on a cost per person per year basis. Recurrent costs apply to both the increments in population coverage each year from 2005 to 2014 and those already covered with improved water or sanitation. In all cases, there is an underlying assumption that per capita costs can be related to coverage that is assessed on a household basis. Since household size changes slowly over time, this is likely to be a reasonable assumption; however, as noted elsewhere, there is a trend towards decreasing household size, and this is therefore a slightly optimistic assumption.

Unit capital (investment) costs are sourced from the latest available cost survey, reported in the 2000 Global Water Supply and Sanitation Assessment Report of the JMP (*17*). While weaknesses are recognized in the country estimates, the average regional estimates for three world regions (Asia, Africa, Latin America and the Caribbean) are thought to be indicative of the costs of each technology and have been used widely. The unit costs are updated to 2005 prices and presented in Table 4.

Recurrent costs comprise operation and maintenance, surveillance and education. Previous costing studies were found to make similar assumptions for annual recurrent cost as a percentage of capital cost (*12*), and hence assumptions similar to those used

in the previous WHO study (*5*, *15*, *16*) were used: annual operation and maintenance costs 5–10% of capital cost for low-technology options, water source protection an additional 5–10% of capital cost per year, and education for sanitation interventions 5% of capital cost per year. Costs of household piped water were based on regional average treatment and distribution cost of between US$ 0.20 and US$ 0.30 per cubic metre (*17*) and average per capita consumption per year (*5*). Costs of sewerage were based on regional average treatment costs of between US$ 0.15 and US$ 0.20 per cubic metre (*17*) and average discharge per capita per year (*5*). Annual recurrent costs of household piped water vary by region between US$ 9.6 and US$ 14.6 per capita, while for sewerage these costs range from US$ 8.2 to US$ 11.0. Annual recurrent costs of non-piped water improvement options are considerably less and vary between regional averages US$ 0.4 and US$ 0.5 per capita, while for sanitation these costs range from US$ 4.7 to US$ 5.0. These recurrent costs were applied to the total populations covered with each improvement option in each year from 2004 to 2015.

An exhaustive costing of water and sanitation interventions takes into account "programme" costs, which are costs incurred at a level other than the delivery point of an intervention to beneficiaries and include costs incurred at the district, provincial or central administrative level (*18*). For health interventions, programme costs have been shown to vary considerably between different types of intervention and different WHO subregions, between just a few per cent and 100% (*18*). In the published economic literature on water and sanitation, no estimates have been presented on programme costs or their per cent contribution to total intervention costs. JMP estimates of unit investment costs of water and sanitation interventions do not include programme costs (*17*). Donors in the sector typically allow between 10% and 20% of project budget for "management" costs, but this may not reflect the programme costs of delivery of services. Hence, owing to the high degree of uncertainty of the actual size of programme costs, results are presented without programme costs in the base case and with different assumptions on programme costs in scenario analysis.

Alternative scenarios

Given the uncertainty in some assumptions in the analysis, different scenarios are presented that indicate the likely range on the costs of meeting the water and sanitation MDG target. Three high-cost scenarios were run:

- *Scenario 1* assumes that the entire population to be covered to meet the water and sanitation MDG target receives a household connection.
- *Scenario 2* assumes a high range of unit costs of improvement options, sourced from previous cost studies (*4*, *6–8*): US$ 322 capital cost per capita for household piped water; US$ 81 capital cost per capita for other water improvements; US$ 483 capital cost per capita for sewerage; and US$ 161 capital cost per capita for other sanitation improvements. Recurrent costs of all options are increased by 50% in Scenario 2.
- *Scenario 3* combines scenarios 1 and 2 to give a likely upper bound on the costs of meeting the water and sanitation MDG target.

Three low-cost scenarios were also run:

- *Scenario 4* assumes that the entire population to be covered to meet the water and sanitation MDG target receives a low-technology and low-cost improvement option.

- *Scenario 5* assumes a low range on unit costs of improvement options: US$ 161 capital cost per capita for household piped water; US$ 32 capital cost per capita for other water improvements; US$ 161 capital cost per capita for sewerage; and US$ 24 capital cost per capita for other sanitation improvements. Recurrent costs of all options are halved in Scenario 5.
- *Scenario 6* combines scenarios 4 and 5 to give a likely lower bound on the costs of meeting the target.

Scenario 7 models the attainment of the water and sanitation MDG target as a whole, with no distinction between rural and urban achievement. Scenario 7 assumes that populations in rural and urban areas receive improvements to reach the target according to existing distribution of improved facilities between rural and urban areas. This would reinforce existing unequal distribution between rural and urban areas, but may be the most likely scenario, given current resource allocation patterns.

Scenario 8 assumes that all the population growth between 2005 and 2014 falls into the unimproved water and sanitation category, thus increasing the population to be covered.

Scenarios 9, 10 and 11 show the total costs of attaining the water and sanitation MDG target with additional programme costs (on top of the base case results) of 10%, 20% and 30%, respectively.

Results

Tables 5–7 and Figures 1–4 present the results of the base case analysis, whereas Table 8 and Figures 5–6 present summary results of the scenario analysis, where the impact of different assumptions on the base case results is assessed.

Table 5 shows that the estimated spending required in developing countries to increase coverage to meet the water component of the MDG target is US$ 42 billion, whereas for sanitation it is US$ 142 billion. This equals per capita spending of US$ 8 for water and US$ 28 for sanitation in the more than 90 developing countries included in the analysis. Annually, this translates to roughly US$ 4 billion for water supply and US$ 14 billion for sanitation (annual combined total of US$ 18 billion).

Table 5

Estimated spending required in developing countries to increase coverage to meet the water and sanitation MDG target, by region, excluding programme costs

WHO subregion	Spending (US$)[a]						Percentage of total	
	Water		Sanitation		Water and sanitation			
	Total (US$ million)	Per capita (US$)	Total (US$ million)	Per capita (US$)	Total (US$ million)	Per capita (US$)	Sanitation	Rural
AFR-D	5 952	18	15 544	48	21 496	67	72	60
AFR-E	5 724	15	18 335	48	24 059	63	76	70
AMR-B	1 537	4	6 351	15	7 888	19	81	49
AMR-D	786	10	2 082	28	2 868	38	73	40
EMR-B	292	3	119	1	411	4	29	68
EMR-D	2 324	6	7 125	19	9 449	25	75	79
EUR-B	680	5	1 398	10	2 079	15	67	70
EUR-C	406	3	2 239	14	2 645	17	85	60
SEAR-B	2 080	9	4 270	18	6 350	26	67	60
SEAR-D	1 446	1	41 980	32	43 427	33	97	74
WPR-B	20 634	13	42 494	27	63 128	40	67	57
All	**41 862**	**8**	**141 937**	**28**	**183 799**	**36**	**77**	**64**

[a] Totals may not add up as a result of rounding.

Figure 1 shows that developing countries in the WHO Western Pacific Region need 48% of the global resources to increase coverage to meet the MDG target for water, followed by 28% for the WHO African Region (strata D plus E). For sanitation, the picture is different (Figure 2), with the WHO Western Pacific Region and stratum D of the WHO South-East Asia Region requiring 30% of global resources each, followed by the WHO African Region, which requires 24%.

Figure 1

Regional share of spending on increasing coverage to meet the MDG water target

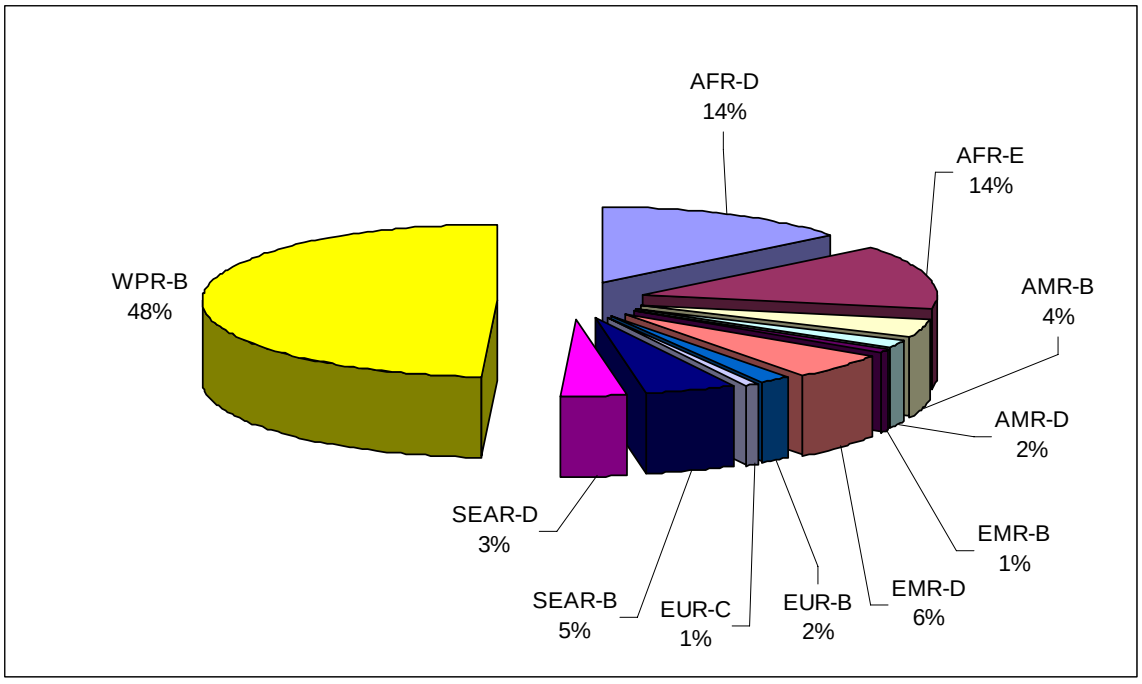
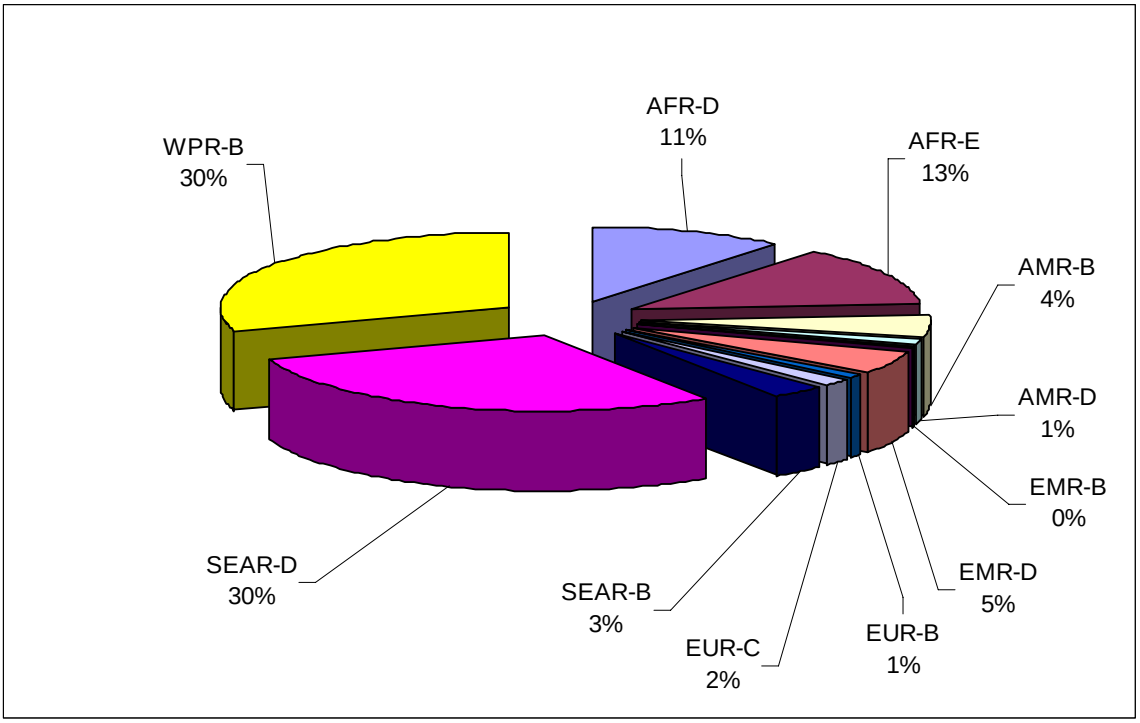


Figure 2
Regional share of spending on increasing coverage to meet the MDG sanitation target



Tables 6 and 7 show the estimated total spending required, including maintaining and replacing existing infrastructure and facilities and extending coverage to existing and future increases in population to meet the MDG target. These tables also disaggregate the shares for rural/urban, capital/recurrent and new/existing coverage. Interestingly, the spending on water and the spending on sanitation are roughly equal, at US$ 360 billion each, or US$ 36 billion annually from 2005 to 2014. Distribution between the regions is more equal than the regional distribution for new coverage only (see Table 5), given the spending of high-coverage countries on existing coverage, with the WHO Western Pacific Region still dominating the other regions with about one third of the global costs.

Table 6

Total spending on new and existing water coverage to meet MDG target 10[a], excluding programme costs

WHO subregion	Total spending (US$ million)[a]	Context (%)		Cost item (%)		Coverage type (%)	
		Rural	Urban	Capital	Recurrent	New	Existing
AFR-D	17 296	32	68	37	63	34	66
AFR-E	19 852	34	66	32	68	29	71
AMR-B	64 042	11	89	6	94	2	98
AMR-D	10 034	22	78	11	89	8	92
EMR-B	10 960	25	75	6	94	3	97
EMR-D	28 087	37	63	13	87	8	92
EUR-B	13 640	31	69	9	91	5	95
EUR-C	18 685	19	81	6	94	2	98
SEAR-B	8 397	26	74	32	68	25	75
SEAR-D	37 013	37	63	14	86	4	96
WPR-B	135 440	42	58	18	82	15	85
All	**363 447**	**32**	**68**	**16**	**84**	**12**	**88**

[a] Total spending includes operation and maintenance of existing supply; periodic replacement of existing infrastructure; and the costs of increasing coverage to existing and increased future populations so as to meet the MDG target. Totals may not add up as a result of rounding.

Table 7

Total spending on new and existing sanitation coverage to meet MDG target 10[a], excluding programme costs

WHO subregion	Total spending (US$ million)[a]	Context (%)		Cost item (%)		Coverage type (%)	
		Rural	Urban	Capital	Recurrent	New	Existing
AFR-D	27 272	48	52	58	42	57	43
AFR-E	29 700	58	42	63	37	62	38
AMR-B	44 303	12	88	19	81	14	86
AMR-D	7 575	25	75	32	68	27	73
EMR-B	3 300	29	71	10	90	4	96
EMR-D	24 124	50	50	34	66	30	70
EUR-B	11 242	29	71	18	82	12	88
EUR-C	15 622	22	78	19	81	14	86
SEAR-B	16 550	49	51	31	69	26	74
SEAR-D	76 141	60	40	56	44	55	45
WPR-B	101 656	37	63	44	56	42	58
All	**357 485**	**41**	**59**	**43**	**57**	**40**	**60**

[a] Total spending includes operation and maintenance of existing supply; periodic replacement of existing infrastructure; and the costs of increasing coverage to existing and increased future populations so as to meet the MDG target. Totals may not add up as a result of rounding.

These results suggest that total spending on water to increase and maintain coverage to meet the MDG target should be distributed as follows: urban (68%) and rural areas (32%); recurrent costs (84%) and investment costs (16%); and population already covered (88%) and new coverage (12%). For sanitation, these figures are lower – urban areas take 59% of the share, recurrent costs 57%, and population already covered 60%. This is largely because present levels of sanitation coverage are lower than for water. Some inter-regional variation exists in these shares.

Figures 3 and 4 indicate the total spending requirements from 2005 to 2015, by year. Overall spending on water and sanitation should increase over this period only marginally, from about US$ 72 billion to US$ 80 billion annually, to account for the increase in recurrent costs of the new coverage achieved year on year. For water

supply, over three quarters of the overall spending is accounted for by operating, maintaining and replacing existing facilities. For sanitation, this figure is roughly one half. By 2015, half of the spending on sanitation will be for new coverage achieved between 2005 and 2014. This difference between water supply and sanitation is largely explained by the lower baseline and therefore larger number of persons or households to achieve coverage for sanitation as opposed to water. Figures 3 and 4 also illustrate that for new water and sanitation coverage, the larger share of costs is for capital items, whereas for existing water and sanitation coverage, the larger share of costs is for recurrent items. This is because the new coverage focuses on investment in new facilities, whereas existing coverage focuses on running the infrastructure in place.

Figure 3

Spending required on new and existing water facilities from 2005 until 2015 to meet MDG target 10, excluding programme costs

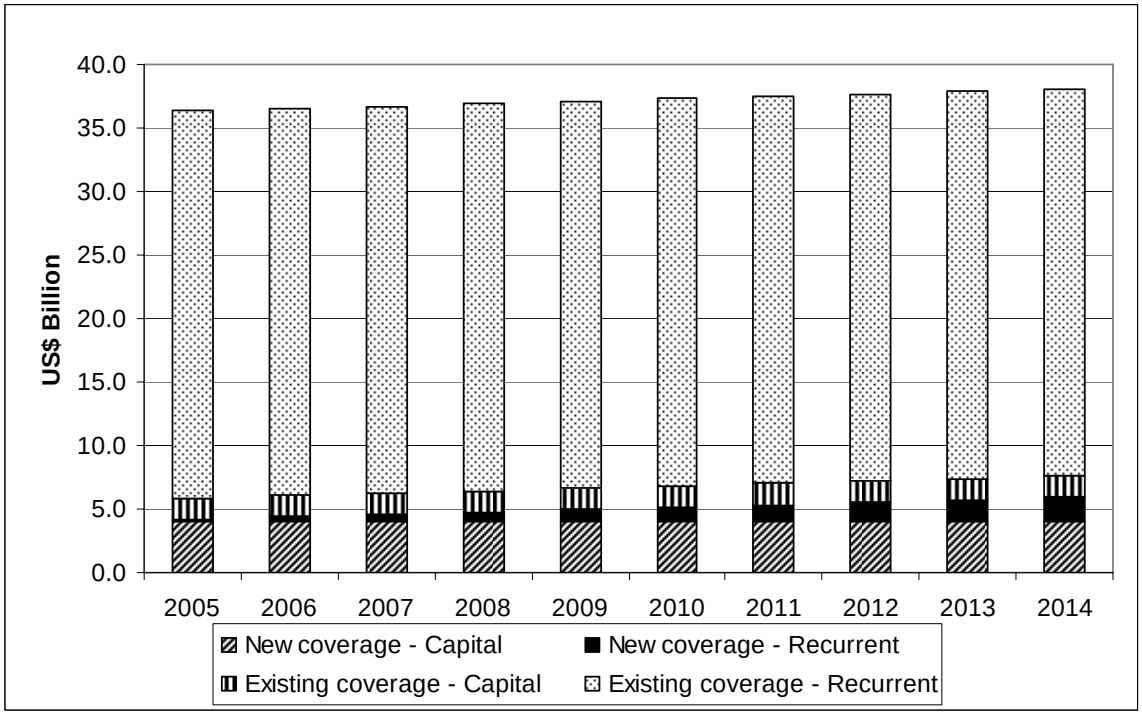


Figure 4

Spending required on new and existing sanitation facilities from 2005 until 2015 to meet MDG target 10, excluding programme costs

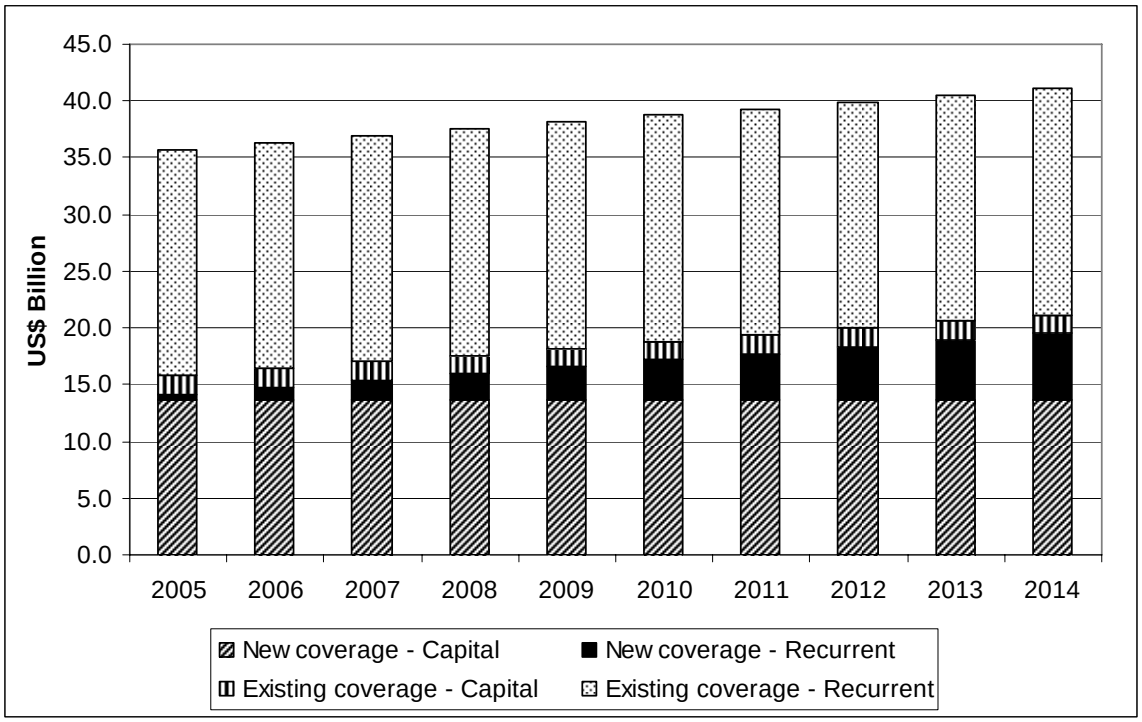


Table 8 summarizes the results for different scenarios. When high-technology options are compared with low-technology options, total costs of attaining the water and sanitation target range from US$ 135 billion (Scenario 4: all receive low-technology, low-cost improvement option) to US$ 327 billion (Scenario 1: all receive household connection), compared with the base case result of US$ 184 billion. This translates to an average annual spending ranging from US$ 14 billion to US$ 33 billion. Clearly, opportunities exist to reduce the cost to the lower end of this range. However, in the case of drinking-water, lower-technology alternatives (protected community sources from which water is carried to the home) yield significantly fewer health and economic benefits when compared with piped supply. For sanitation, technology choice may be significantly restricted by the setting, although the benefits of higher- over lower-technology options may be negligible.

Table 8
Summary of spending on water and sanitation to meet MDG target 10 under different scenarios

	Spending (US$ billion)[b]					
	Water		Sanitation		Water and sanitation	
Scenario[a]	New	Total[c]	New	Total[d]	New	Total[e]
Base case	42	364	142	358	184	722
1: All HC	71	393	256	472	327	865
2: High unit costs	79	401	245	461	324	862
3: All HC & high unit costs	142	464	522	738	665	1203
4: All non-HC	23	345	113	329	135	673
5: Low unit costs	37	359	57	273	94	632
6: All non-HC & low unit costs	20	342	68	284	88	626
7: No rural/urban MDG target	46	368	162	378	208	746
8: All population increments categorized as "unimproved"	121	397	220	401	341	799
9: Programme costs, add 10%	46	400	156	394	202	794
10: Programme costs, add 20%	50	437	170	430	221	866
11: Programme costs, add 30%	54	473	185	465	239	938

HC, household connection (water and/or sanitation); non-HC, other improvements outlined in Methods "Interventions" section

[a] Scenarios are described more fully in Methods "Alternative scenarios" section.

[b] Totals may not add up as a result of rounding.

[c] This column is the sum of "new" coverage column plus US$ 322 billion for existing facilities.

[d] This column is the sum of "new" coverage column plus US$ 216 billion for existing facilities.

[e] This column is the sum of "new" coverage column plus US$ 538 billion for existing facilities.

Using high unit cost assumptions in Scenario 2 gives a high value similar to that for Scenario 1, whereas the low unit cost assumptions in Scenario 5 give a lower value of US$ 94 billion, or US$ 9 billion per year. Combining the two high-cost (Scenarios 1 and 2) and two low-cost (Scenarios 4 and 5) scenarios (as in Scenarios 3 and 6, respectively) leads to estimated global cost bounds ranging from US$ 88 billion to US$ 665 billion, or annually US$ 9 billion to US$ 67 billion.

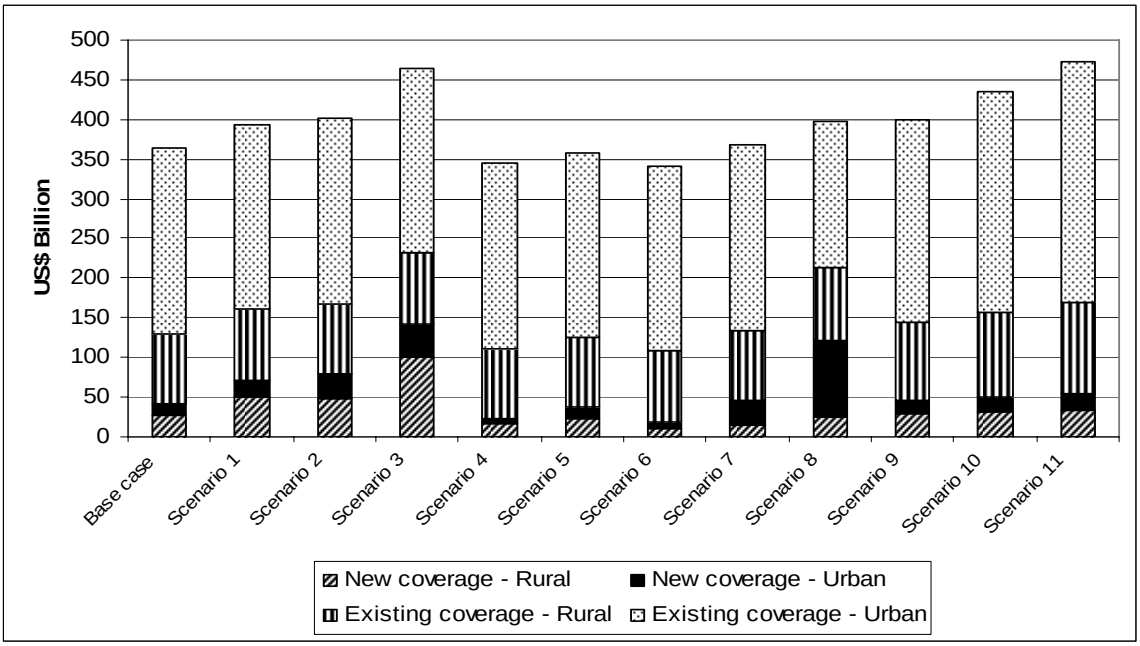
Assuming new coverage distribution to rural/urban areas occurs along historical lines (Scenario 7) increases costs 13% to US$ 208 billion. This is largely due to the higher costs of extending coverage to urban areas, where more households receive piped connections. Scenario 8, which assumes that the increments in population between 2005 and 2014 are all allocated to unimproved water and sanitation, shows a considerable increase in costs for new coverage to US$ 341 billion, but a smaller increase in combined costs of new and existing coverage of US$ 799 billion, compared with US$ 722 billion in the base case.

Including programme costs increases total costs to US$ 794 billion (assuming that they contribute an additional 10%), US$ 866 billion (at 20%) and US$ 938 billion (at 30%). Actual programme costs are highly uncertain.

Figures 5 and 6 show that the focus of spending on extending coverage is disproportionately in rural areas, whereas the focus of spending on maintaining and replacing existing infrastructure is in urban areas. The exception is Scenario 7, which appears to represent the most realistic future expectation, in which new coverage resource allocation patterns follow the historical spending patterns.

Figure 5

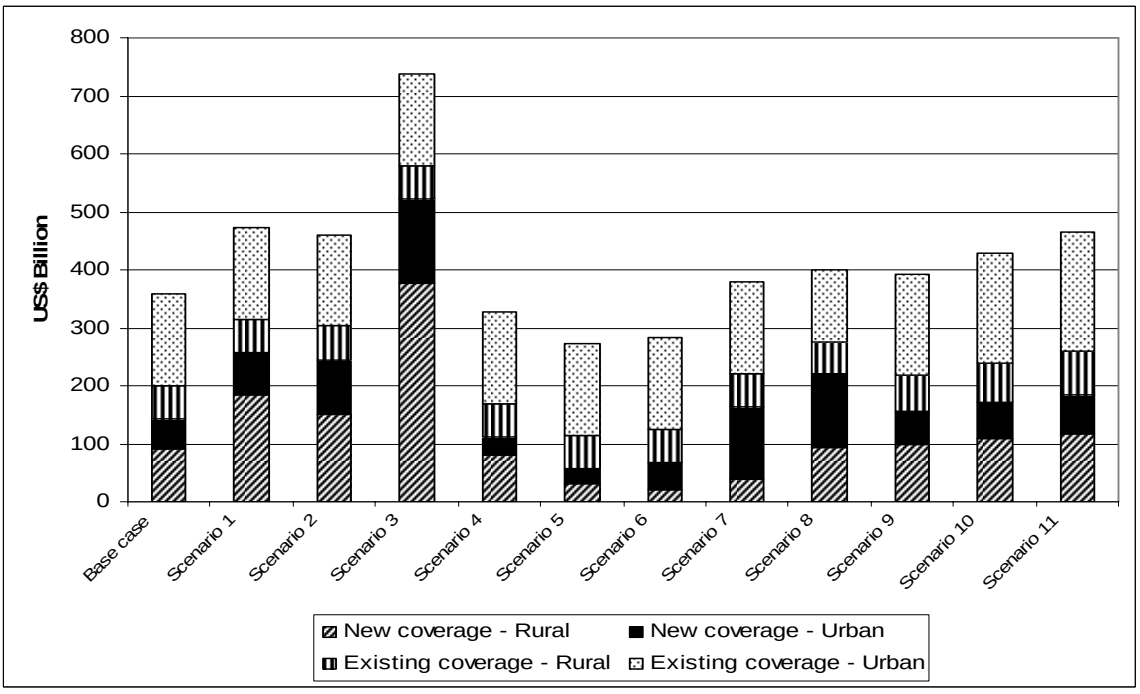
Total spending on new and existing water coverage for different scenarios[a], by rural/urban location



[a] Key for scenarios: see column 1 of Table 8. Scenarios 1–8 exclude programme costs.

Figure 6

Total spending on new and existing sanitation coverage for different scenarios[a], by rural/urban location



[a] Key for scenarios: see column 1 of Table 8. Scenarios 1–8 exclude programme costs.

Discussion

This study provides more updated and comprehensive figures than have been previously available on the costs of attaining the MDG target for water and sanitation.

From 2005 until 2014 inclusive, US$ 72 billion needs to be spent on water and sanitation annually in the countries included in this analysis, of which US$ 18 billion is on increasing coverage to the currently unserved population and US$ 54 billion is on maintaining and renewing existing facilities for populations already with water supply or sanitation coverage. These results highlight an important policy issue regarding the investment required to prevent the existing covered population from falling back into "unimproved" coverage category and to ensure the ongoing maintenance of these improved facilities to get maximum value from them. This US$ 72 billion price tag translates to a developing region average per capita spending requirement of US$ 120 over a 10-year period (2005–2015), or US$ 12 per capita annually. Given the lack of up-to-date data on actual combined spending by governments and households on water supply and sanitation in developing countries, it is not possible to estimate the current financing gap at the global level.

These results are not inconsistent with previous global cost estimates for meeting the water and sanitation MDG target. Annual investment costs previously estimated for increasing coverage to meet the water and sanitation MDG target range from US$ 9 billion (*8*) to US$ 11.3 billion (*5*) to US$ 18 billion (*6*) to US$ 30 billion (*4*, *7*). The annual global cost estimate of the present study of US$ 18 billion is roughly 50% higher than the US$ 11.3 billion of the previous WHO study (*5*) for two main reasons. First, the previous WHO study used annualized costs for capital costs, whereas the present study estimates the actual payments needed, which includes capital items that have a longer life period than the time horizon of the MDG target in 2015. Hence, the investments made in this period will last beyond 2015. Second, the assumption in the present study is that the proportion of households receiving a household connection is in line with current distribution, which in developing regions is about 55% for water and 40% for sanitation. These proportions are at least twice the assumptions used in the previous WHO study.

Focusing future programmes on low-technology, low-cost options could reduce costs considerably. On the other hand, low-cost options may not yield comparable benefits and may not be in demand from users. Furthermore, household piped water is justified for the additional time savings from water haulage and the benefits of increased water availability for productive domestic or small-scale commercial uses, and for which many populations are able and willing to pay. On the other hand, low-cost and low-technology options also bring some time savings and health, environmental and economic benefits (*5*, *15*, *16*); hence, decisions should be based not on the costs alone, but on the comparative costs and benefits of the different options (*19–21*).

Cost estimates presented in this study should still be interpreted with caution. The cost results are only as good as the information feeding into the quantitative model as well as the assumptions of the model. Major uncertainties still exist, such as the lack of representative unit costs of diverse water and sanitation improvements for different regions; the lack of distinction in unit costs between rural and urban areas; the lack of globally compiled data on which water and sanitation improvement options are

promoted by governments and chosen by households; and the inconsistency in coverage rates revealed by different household surveys applied at the country level. More detailed studies are required to produce more precise estimates to feed into national decisions on financing and intervention selection, using local unit cost data. To this end, a new set of water and sanitation costing tools is available from WHO (http://www.who.int/water_sanitation_health/economic/en/).

Furthermore, this study has excluded integrated water resource management, water storage and conveyance infrastructure, transportation costs (particularly to isolated communities) and financing costs. As Toubkiss (*12*) notes, with the demographic shift towards larger urban centres and climate change, investment in large, upstream infrastructure might grow in the future in order to make more water available. Furthermore, global climate change appears likely to reduce the reliability of water resources and is therefore likely to lead to increased costs. Finally, this study does not account for the costs of upgrading the significant fraction of waterborne sewerage that carries untreated or inadequately treated sewage.

However, this study has consistently used the best available evidence and most realistic assumptions in formulating the model. Changes in key assumptions were tested under different scenarios, which revealed the ranges in the global costs. Furthermore, unit costs are known to be highly variable between locations and depend on wage rates, programme scale, the type and quality of the technology, geophysical features (terrain, water availability), local traditions and culture (specific features of the options) and the potential involvement of local human resources and skills.

This analysis has revealed where increased financing of water and sanitation interventions should be focused. First, it appears as if there is an enormous overall financing gap at the global level, given that spending is nowhere near the cost estimates presented here. Recent comprehensive data on expenditure at the global level are lacking and are especially weak for spending by households and nongovernmental organizations in comparison with that by government and international assistance. Nevertheless, reported estimates of total expenditure in the 1990s appear remarkably consistent. Thus, the JMP estimates that in the 1990s, water received US$ 12.6 billion annually and sanitation US$ 3.1 billion annually from government and external support agencies (*17*). The Global Water Partnership estimates global spending of US$ 14 billion annually for drinking-water and sanitation combined (*4*). These estimates are far short of the annual US$ 72 billion or more that is estimated to be required at the global level, although this figure includes household spending. Estimates of household spending on water and sanitation in non-OECD countries are unavailable.

Second, new financing should be targeted to where there is the greatest shortfall. A significant proportion of the funding for *increased* coverage is required for investment purposes in rural areas in the WHO South-East Asia and African regions, owing to slower progress towards the MDG target in rural areas and the larger rural populations, especially in WHO African Region stratum E and WHO South-East Asia Region stratum D. Combined water and sanitation per capita spending for *increased* coverage over the years 2005–2015 is highest in WHO African Region stratum D (US$ 67), followed by WHO African Region stratum E (US$ 63), WHO Western Pacific Region stratum B (US$ 40), WHO Region of the Americas stratum D (US$

38), WHO South-East Asia Region stratum D (US$ 33) and WHO South-East Asia Region stratum B (US$ 26); the developing region average is US$ 36 per capita. Hence, in order to reach the MDG target for water supply and sanitation, focus is needed on the WHO African Region in terms of per capita investment, whereas the WHO South-East Asia Region would require higher overall spending because of its larger population size. Conversely to spending required on *increased* coverage, increased funding made available for *existing* coverage is needed in urban areas, but with a more balanced regional distribution (i.e. higher contribution from the WHO Region of the Americas and the WHO Eastern Mediterranean Region).

The actual funding gap eventually depends on which improvement options are selected and whether costs can be reduced through technological innovation or economies of scale. It is also influenced by the likely pressure on costs arising from water scarcity and the "law of diminishing returns", as the simplest and lower-cost challenges tend to be addressed first.

The discussion presented here on the absolute spending required and the overall shortfall in estimated current spending should be contrasted with previous work comparing these costs with the estimated value of the associated benefits (*5*, *16*). In that work, it was estimated that the value of benefits associated with improved drinking-water and sanitation was of the order of US$ 3–34 per dollar invested.

The present study has focused on the MDG target for water and sanitation, which would bring improvements in quality of life to a further 420 million people for water supply and 1052 million for sanitation. However, even if MDG target 10 were met, there would still be 690 million people without improved water supply and 1689 million without improved sanitation in 2015: 10% of the projected 7.2 billion world population without improved water supply, and 23% without improved sanitation. As we approach 2015, it will be essential to focus on new targets both to address this deficit and to ensure that the benefits of higher levels of service are extended to larger populations.

References

1. Lenton R, Wright A, Lewis K. *Health, dignity, and development: what will it take?* United Nations Millennium Project, Task Force on Water and Sanitation. London and Sterling, VA, Earthscan, 2005.
2. Mehta M, Fugelsnes T, Virjee K. Financing the Millennium Development Goals for water and sanitation: what will it take? *World Resources Development*, 2005, 21(2):239–252.
3. Hutton G, Haller L, Bartram J. *Economic and health effects of increasing coverage of low cost household drinking water supply and sanitation interventions.* Geneva and New York: World Health Organization and United Nations Development Programme, in press.
4. *Towards water security: a framework for action.* Global Water Partnership, 2000.
5. Hutton G, Haller L. *Evaluation of the non-health costs and benefits of water and sanitation improvements at global level.* Geneva, World Health Organization, 2004 (WHO/SDE/WSH/04.04).
6. Smets H. *The cost of meeting the Johannesburg targets for drinking water: A review of various estimates and a discussion of the feasibility of burden sharing.* Nanterre Cedex, Water Academy, 2004.
7. *Water supply and sanitation and the Millennium Development Goals Addendum 3.* Washington, DC, World Bank, 2003.
8. *Vision 21: A shared vision for hygiene, sanitation and water supply, and a framework for action.* Water Supply & Sanitation Collaborative Council, 2000.
9. *Asia Water Watch 2015: Are countries in Asia on track to meet target 10 of the Millennium Development Goals?* Manila, Asian Development Bank, 2005.
10. *Financial needs of achieving the Millennium Development Goals for water and sanitation in the EECCA region.* Copenhagen, Danish Ministry of Environment, 2004 (study undertaken by COWI Ltd.; summary report available at http://www.ecoaccord.org/english/wi/2004/MDG-En.pdf).
11. Fonseca C, Cardone R. *Analysis of cost estimates and funding available for achieving the Millennium Development Goals targets for water and sanitation.* Leicestershire, Loughborough University, WELL Resource Centre for Water, Sanitation and Environmental Health, 2004 (WELL Briefing Note; http://www.irc.nl/content/download/15378/202251/file/Overview_Cost_Estimates_MDG.pdf).
12. Toubkiss J. *Costing MDG target 10 on water supply and sanitation: Comparative analysis, obstacles and recommendations.* World Water Council, 2006 (http://www.financingwaterforall.org/fileadmin/Financing_water_for_all/Reports/FullTextCover_MDG.pdf).
13. Joint Monitoring Programme. *Meeting the MDG drinking water and sanitation target: a mid-term assessment of progress.* Geneva and New York, World Health Organization and United Nations Children's Fund, 2004 (http://www.wssinfo.org/pdf/JMP_04_text.pdf).
14. Joint Monitoring Programme. *Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade.* Geneva and New York, World Health Organization and United Nations Children's Fund, 2006 (http://www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf).

15. Haller L, Hutton G, Bartram J. Estimating the costs and health benefits of water and sanitation improvements at global level. *Journal of Water and Health*, 2007, 5(4):467–480.
16. Hutton G, Haller L, Bartram J. Global cost–benefit analysis of water supply and sanitation interventions. *Journal of Water and Health*, 2007, 5(4):481–502.
17. Joint Monitoring Programme. *Global water supply and sanitation assessment report*. Geneva and New York, World Health Organization and United Nations Children's Fund, 2000 (http://www.who.int/docstore/water_sanitation_health/Globassessment/GlobalTOC.htm).
18. Johns B, Baltussen R, Hutubessy R. Programme costs in the economic evaluation of health interventions. *Cost Effectiveness and Resource Allocation*, 2003, 1(1) (doi:10.1186/1478-7547-1-1; http://www.resource-allocation.com/content/1/1/1).
19. Drummond MF et al. *Methods for the economic evaluation of health care programmes*, 2nd ed. Oxford, Oxford University Press, 1997.
20. Gold MR et al. *Cost-effectiveness in health and medicine*. Oxford, Oxford University Press, 1996.
21. Tan-Torres Edejer T et al. *Making choices in health: WHO guide to cost-effectiveness analysis*. Geneva, World Health Organization, 2003.

Annex A : WHO epidemiological subregions

Region[a]	Mortality stratum[b]	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
	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
	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
	D	Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, Yemen
EUR	B	Albania, Armenia, Azerbaijan, Bosnia and Herzegovina, Bulgaria, Georgia, Kyrgyzstan, Poland, Romania, Serbia, Slovakia, Tajikistan, The former Yugoslav Republic of Macedonia, Montenegro, Turkey, Turkmenistan, Uzbekistan
	C	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
SEAR	B	Indonesia, Sri Lanka, Thailand
	D	Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, Nepal
WPR	B	Cambodia, China, Cook Islands, Fiji, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia (Federated States of), Mongolia, Nauru, Niue, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu, Viet Nam

[a] AFR = WHO African Region; AMR = WHO Region of the Americas; EMR = WHO Eastern Mediterranean Region; EUR = WHO European Region; SEAR = WHO South-East Asia Region; WPR = WHO Western Pacific Region.

[b] 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.