# WATER QUALITY ISSUES IN DEVELOPING COUNTRIES[1]

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# 1. Introduction

*The Millennium Development Goals*

Of all the environmental concerns that developing countries face, the lack of adequate water of good quality is probably the most serious. When the United Nations agreed at the Johannesburg Earth Summit on the set of the 8 Millennium Development Goals, Goal 7 was 'to ensure environmental sustainability'. This has three targets and a number of indicators (Table 1). It is noteworthy that water is so prominent; it is the only environmental media that has a target of its own as well as being an indicator for the 'improving slum dwellers' target. One can debate whether this priority is justified on social and economic grounds and we intend to do that in this chapter. However, there is no doubting the importance that national governments and international financing agencies place on addressing the water problem.

**Table 1: The 'Environmental' MDG**

| **Goal 7: Ensure environmental sustainability** | |
|---|---|
| **Targets** | **Indicators** |
| **Target 9**: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources | 1. Proportion of land area covered by forest<br>2. Ratio of area protected to maintain biological diversity to surface area<br>3. Energy use (kg oil equivalent) per $1 GDP (PPP)<br>4. Carbon dioxide emissions (per capita) and consumption of ozone-depleting CFCs (ODP tons)<br>5. Proportion of population using solid fuels (WHO) |
| **Target 10**: Halve, by 2015, the proportion of people without sustainable access to safe drinking water | 6. Proportion of population with sustainable access to an improved water source, urban and rural |
| **Target 11**: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers | 7. Proportion of urban population with access to improved sanitation<br>8. Proportion of households with access to secure tenure |

Source: United Nations (2003)

This chapter looks at the current status of water access for households in developing countries, the consequences of the poor condition of the water they receive and the way they dispose of water effluent. It also looks at other uses of water, which are not picked up in the MDGs, but which may, nevertheless, be important to local communities in developing countries. These include inland rivers and lakes, as well as some coastal zones.

For this brief description, it is clear that the chapter does not cover all water issues. Primary among those not addressed are the questions relating to *quantity* (e.g., do we have enough water to meet our needs?). Other major issues outside the scope of this chapter are the irrigation uses of water and the management of water flows for flood control, etc. Finally, the chapter does not address issues relating to the management of groundwater. All these important aspects of water use are addressed in other chapters in this volume.

## 2. The Use of Water in the Household

*Numbers Without Safe Water*

The reason for water being so predominant among the MDGs is the view that poor quality drinking water and improper disposal of wastewater have serious impacts on human health. Most work on this has been done by the World Health Organization (WHO). It defines 'safe water' and estimates the physical impacts of the lack of such water in terms of premature mortality and diarrhea. In 2000, the global population without access to safe water was estimated at about 1.2 billion, or 19 percent (World Bank, 2003a). This has come down from about 26 percent in 1990, showing that significant progress has been made in that decade. The majority of those without access are in Asia and Sub-Saharan Africa (Table 2). There is, however, some dispute about the accuracy of the estimates. The definition of "safe water" is oriented towards reasonable access and convenience and not towards quality of supply; although in most cases the two are highly correlated[2] this is not always the case. In Eastern Europe, for example, this is not the case; water is supplied to the households, but the quality is declining and is not picked up in the WHO data (World Bank, 2003b). If the MDG target is met, the proportion falls to around 9.5 percent by 2015. Given the growth in population, that would leave around 675 million people without this essential commodity.

**Table 2: Population without access to safe water, by region**

| Regions | Total Population (Mn.) | | Population without access (Mn.) | |
|---|---|---|---|---|
| | 1990 | 2000 | 1990 | 2000 |
| EAP | 1,597 | 1,806 | 460 | 435 |
| ECA | 466 | 476 | n.a. | 43 |
| LAC | 434 | 511 | 77 | 69 |
| MNA | 237 | 294 | n.a. | 35 |
| SAS | 1,120 | 1,354 | 313 | 211 |
| SSA | 509 | 658 | 238 | 275 |
| World | 5,251 | 6,053 | 1,354 | 1,165 |

Source: World Bank (2003a)

Note: The regional population does not add up to the world total population because aggregate data include economies for which component population data are not available.

Legends: EAP – East Asia and the Pacific; ECA – Europe and Central Asia; LAC – Latin America and the Caribbean; MNA – Middle East and North Africa; SAS – South Asia; SSA – Sub-Saharan Africa.

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[2] "Improved" water supply technologies are: household connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection. Also, "improved water supply" refers to the availability of at least 20 liters per person per day from a source within one kilometer of the user's dwelling. "Not improved" are: unprotected well, unprotected spring, vendor-provided water, bottled water (based on concerns about the quantity of supplied water, not concerns over the water quality), tanker truck-provided water (WHO, 2002). Unprotected water sources are vulnerable to elements that may contaminate the water.

The access to improved water supply and sanitation are also summarized in Figure 1, which shows the level of access in each region in 1990 and 2000, along with the trend in *per capita* GDP from 1980 to 2002. The figures show an increase in access going along with an increase in *per capita* GDP in all regions except for sub-Saharan Africa, where access also improved from 1990 to 2000, but *per capita* income actually declined. It may be useful to empirically examine whether there is a significant correlation between income and progress in access but it is not possible with the current available data.[3]

*Environmental Health Risks*

In the 2002 World Health Report, seven groups of risk factors to health are identified, one of which is related to the environment. The environmental risk factors are: unsafe water, sanitation and hygiene; urban air pollution; indoor smoke from solid fuels; lead exposure; and climate change. Table 3 shows how the environmental risk factors are assessed. Among the environmental risk factors, *unsafe water, sanitation and hygiene* is the leading cause of mortality and morbidity in high-mortality developing countries; and is among the top five of all risk factors (environmental and non-environmental) in the same countries. However, it is second to *indoor air pollution* as an environmental risk factor in the low-mortality developing countries[4]. The measured outcome of the ingestion of unsafe water, lack of sanitation facilities and poor hygiene practices is in terms of diarrheal disease and other illnesses related to the risk factor of interest (e.g., schistosomiasis, ascariasis, trachoma, trichuriasis and hookworm disease).

**Table 3: Environmental risk factors to health**

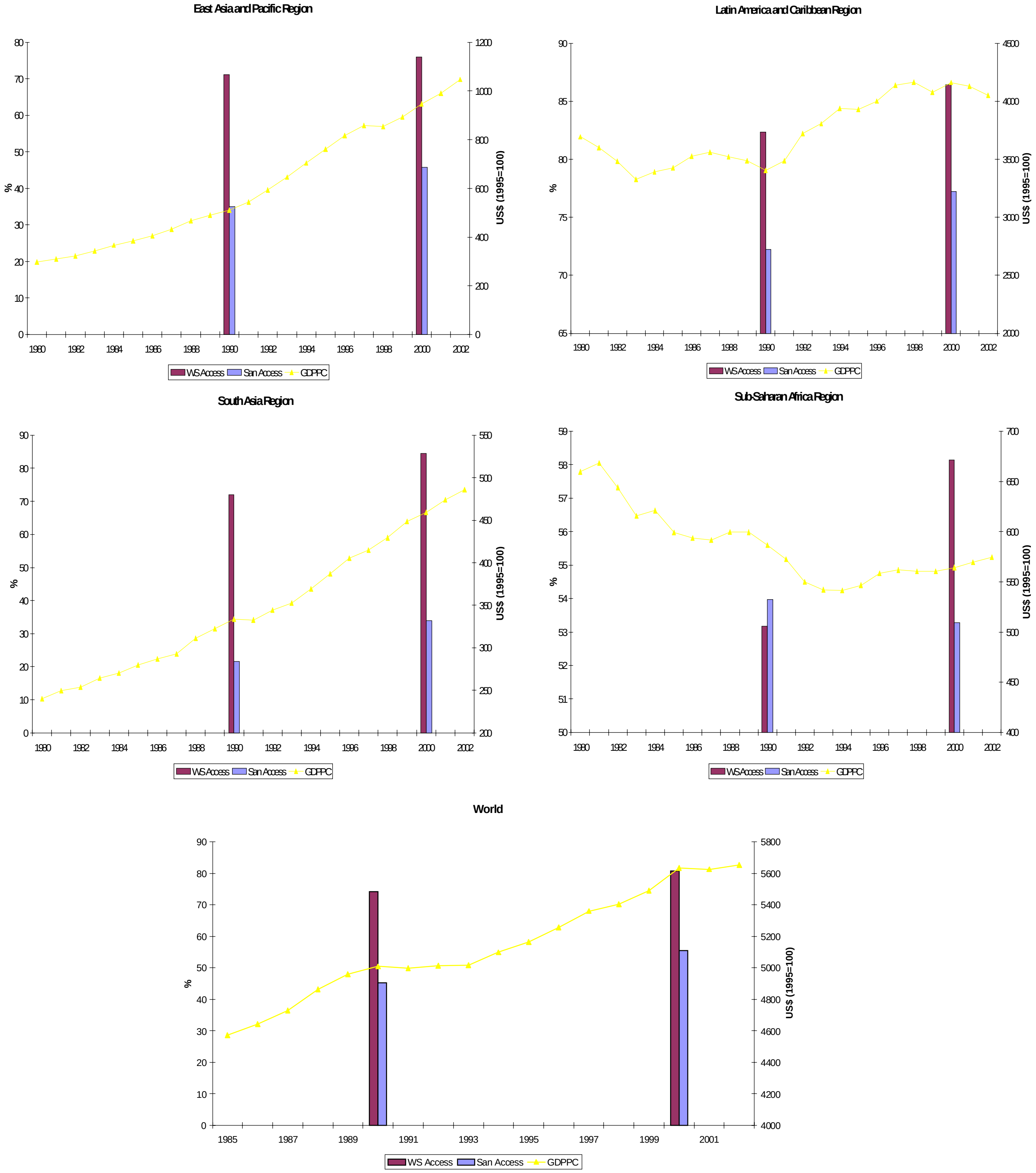
| **Risk factor** | **Theoretical minimum exposure** | **Measured adverse outcomes of exposure** |
|---|---|---|
| Unsafe water, sanitation and hygiene | Absence of transmission of diarrheal disease through water, sanitation and hygiene practices | Diarrhea and other illnesses related to the risk factor |
| Urban air pollution | 7.5 $\mu g/m^3$ for $PM_{2.5}$ | Cardiovascular mortality, respiratory mortality, lung cancer, mortality from acute respiratory infections in children |
| Indoor smoke from solid fuels | No solid fuel use | Acute respiratory infections in children, chronic obstructive pulmonary disease, lung cancer |
| Lead exposure | 0.016 $\mu g/dl$ blood lead levels | Cardiovascular disease, mild mental retardation |

Source: Adopted from WHO (2002).

[3] Access data are only available for 1990 and 2000. Also, 1990 data may not always be available, especially at the country-level.

[4] See Annex 1 for the list of high and low mortality countries.

**Figure 1. Per Capita GDP and % Population with Access to Improved Water Source and Sanitation, by Region.**



*The Disability Adjusted Life Year (DALY)*
The WHO has estimated the impacts of the lack of access in health conditions by estimating the burden of disease in terms of the number of disability adjusted life years lost (DALYs), attributable to this factor. DALYs combine impacts of mortality and morbidity attributed to a risk factor into a single measure.[5] The DALY has been used as a measure of the burden of disease and it is an indicator of the time lost due to premature mortality and time lived with a disability (mental or physical). It is beyond the scope of this paper to discuss the DALYs in detail but there are various literatures that show different ways of calculating the DALYs (Homedes, 1996; Anand and Johnson, 1995; Pruss-Ustun, *et al*, 2003). Table 4 gives the burden of disease attributed to environmental risk factors for the high mortality developing countries in terms of annual DALYs per 1,000 people. These countries account for 29 percent of the world's population but nearly two-thirds of DALYs lost due to unsafe water.

**Table 4: Attributable DALYs per 1,000 people due to environmental risk factors, High Mortality Countries, 2000.**

| Countries | Unsafe water, sanitation and hygiene | Urban air pollution | Indoor smoke from solid fuels | Lead exposure | Total |
|---|---|---|---|---|---|
| | | | | | |
| All Countries | 9.0 | 1.3 | 6.4 | 2.1 | 18.9 |
| High Mortality Countries | 18.9 | 1.4 | 12.9 | 2.8 | 35.9 |
| *Of which* | | | | | |
| Africa | 22.6 | 1.0 | 17.6 | 3.3 | 44.5 |
| The Americas | 11.4 | 0.8 | 5.0 | 4.0 | 21.2 |
| Eastern Mediterranean | 29.7 | 2.3 | 12.5 | 4.0 | 48.4 |
| Southeast Asia | 15.8 | 1.3 | 12.2 | 2.3 | 31.5 |

Sources: WHO (2002)
Note: See Annex 1 for the list of high mortality countries.

Table 4 shows that these high mortality countries face a significant burden from 'unsafe water, hygiene and sanitation'. Overall, it accounts for about half the total environmental health burden, being a slightly smaller share in South East Asia and a higher share in the Eastern Mediterranean and the Americas. Compared to urban air pollution, unsafe water is responsible for thirteen times as many DALYs; and compared to lead exposure, it is responsible for nearly seven times as many. The only environmental risk that comes close is indoor air pollution, which accounts for about 70 percent of the unsafe water burden. Looking at the DALYs across regions, Eastern Mediterranean suffers the most, with attributable DALYs of nearly 30 per thousand people due to unsafe water. The region is followed by Africa with about 23 DALYs per thousand people.

These calculations are of course subject to substantial uncertainties and based on many simplifying assumptions. It is not possible to carry out a thorough assessment of the

[5] See Anand and Johnson, 1995 for details of how DALYs are calculated and their limitations.

methodology here but it is important to note some of the major problems in making such estimates. One is the state of impact assessment that is undergoing substantial changes in the area of air pollution (see Chapter X in this volume). Some of the developments there indicate that the long term impacts of exposure to small particles may be underestimated.

*Valuing DALYs*

These issues are clearly important and the numbers should be examined more carefully. Nevertheless, even if it is assumed that they are of the right order of magnitude, the WHO study points to unsafe water and sanitation as a major issue to be addressed in terms of development. To put the costs in economic terms, we need to value a DALY in monetary terms. Values for DALYs are hard to come by, but there are two sources from which estimates can be made. One is based on the 'output' approach, which takes the per capita GDP as a lower bound (World Bank, 2003c). This derives its justification from the use of the human capital approach in the valuation of mortality in developing countries (Cropper, *et al*, 1997). Another is to take the recent willingness-to-pay values for a reduction in the risk of death, derived from contingent valuation studies of risks in developed countries (Alberini, *et al*, 2001; Markandya, *et al*, 2003). From these studies, the value of the loss of life expectancy of one year can be obtained and the most recent work indicates that the median value for the European Union is around €50,000, which is about 2.5 times GDP per capita. If we apply a range of values to the countries in question, where *GDP per capita* is the lower bound and *2.5 times GDP per capita* is the upper bound, we obtain the estimates of damages in Table 5.[6]

**Table 5: Estimated Value of Health Costs of DALYs Attributable to Environmental Risks**

| Countries | ('000) DALYs attributable to | | GDPPC (current US$) | Damage Cost to Health | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | ALL Environmental Risks | | | Unsafe water, sanitation and hygiene | |
| | Unsafe water, sanitation & hygiene | All Env. Risk Factors | | Low (Bn $) | High (Bn $) | Ave. as % of GDP | Ave. for Unsafe Water (Bn $) | As % of GDP |
| High Mortality Countries | 34,462 | 65,513 | 645 | 42 | 106 | 6.3% | 39 | 3.3% |
| *Of which* | | | | | | | | |
| Africa | 6,916 | 13,629 | 490 | 7 | 17 | 7.8% | 6 | 4.0% |
| The Americas | 756 | 1,403 | 4,464 | 6 | 16 | 3.7% | 5 | 1.9% |
| Eastern Mediterranean | 8,303 | 13,557 | 729 | 10 | 25 | 8.5% | 10 | 4.6% |
| Southeast Asia | 18,487 | 36,924 | 449 | 17 | 41 | 5.5% | 18 | 3.4% |

Source: WHO (2002) and own calculations.

[6] There is an underlying assumption that the 'elasticity' of WTP with respect to GDP is one. Krupnick, *et al* (1996) have argued for an elasticity of 0.35, based on the work of Carson and Mitchell (1993). Yaping (1999), on the other hand suggests a value of one. Here we take a unit elasticity as providing a lower bound to the costs. Most of the high-mortality countries have a relatively low income, where the gross national income per capita ranges from $140 to $700. Between 1990 and 2002, the average annual GDP growth of this group of countries is about 3.6%.

The estimated annual cost of all environmental risks averages $74 billion, with water-related costs being around $39 billion. For the high mortality country group as a whole, the costs are relatively small in percentage terms – around 3.3 percent. One might think that this figure would be greater if we looked at the people most affected, as the loss of DALYs is surely concentrated among them. This does not, however, appear to be the case. WHO estimates indicate that if the risk to individuals with less than $2 a day were to be the same as that for people with more than $2 a day, the 'risk factor' from unsafe water would decline by 51 percent. Given that the population with less than $2 of expenditure per person per day in these high mortality countries is between 15 percent (Algeria) and 83 percent (Madagascar), the costs to them, as a percentage of *their* income ranges from 2.0 to 4.0 percent with the low value of a DALY and 5.0 to 10.0 percent with a high value of the DALY.[7] Although the DALYs are concentrated among the poor, their value per DALY is also lower, with the two factors pulling in different directions. Even this calculation, however, has an averaging aspect to it and misses the impact on those in the vulnerable groups who *actually bear* the costs of unsafe water and sanitation, the consequences can be disastrous. Hence, although the share of income represented by these losses is moderate, there is a real distributional and poverty issue to be tackled. Protecting the very vulnerable from unsafe water and sanitation can yield social benefits that are greater than the private benefits estimated above. One way of picking this up would be to use 'equity weights, so a poor person's benefits were given a weight of more than one. This has been used in some analysis by economists, but is criticized on the grounds that there is an element of arbitrariness in selecting the weights. Another way is simply to report the benefits to these groups and leave the judgment as to the value to be attached to them to the decision-maker.

*How Much Are Safe Water and Sanitation A Priority?*

While the discussion so far provides useful information on deciding priorities for action, it does not directly tell us whether it is justified to spend scarce resources on tackling the unsafe water issue. That depends on what options are available to reduce the number who do not have safe water, what these options would achieve in terms of reducing the numbers (the 'avoidable' risk) and what value we attach to that reduction. To see how the benefits and costs stack up, we look at the MDG for water supply and sanitation (Table 7). If the water supply target were to be met *and* the sanitation improvements were to meet a similar target, we can estimate the costs of each target independently, as well as the benefits of both targets. The cost figures are based on an internal World Bank study on the costs of meeting all the MDGs (World Bank, 2003d,e). Table 6 and Figure 2 summarize the findings. Details of the calculations are given in Annex 3.

The figures indicate that both sanitation and safe water targets of a 50 percent reduction are marginally justifiable. For Africa and Southeast Asia, the costs are above the upper bound of the benefits of the reduced DALYs. For the Americas, they are below the lower bound thus justifying the targets, and in the Eastern Mediterranean they lie in between. The 'critical' values of DALYs as a percentage of GDP (i.e., the values at which the MDG program just become viable) are: 3.1 times GDP for Africa, 0.4 times GDP for the Americas, 1.2 times GDP for the Eastern Mediterranean and 2.8 times GDP for South East Asia.

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[7] The calculations are detailed in Annex 2 to this chapter.

The estimates are crude; they underestimate the benefits for two reasons. First, the value of DALYs will increase over the fifteen-year period due to economic growth and this has not been allowed for (growth rate projections are difficult to make with any accuracy over the period). Nevertheless, with a reasonable assumption of per capita growth of around 3 percent per annum, the critical value of the DALYs is reduced by a third and all regions expenditures are justifiable with the upper bound value of the DALYs. The second factor is the non-health benefits of improved water supply and sanitation. Savings in time for collection in the case of the former, and in comfort and ease of use in both cases have not been included. The willingness to pay for these benefits varies widely and depends very much on the nature of the improvement (e.g., public stand posts versus private connection; see Whittington et al, 1990, 2002; Boadu, 1992; McPhail, 1994). It is problematic, however, to add the benefits measured in such studies to the health benefits taken here as the WTP studies also include some element of health benefits.

**Table 6: Estimated Benefits and Costs of Meeting the MDG Targets for Water and Sanitation in High Mortality Countries ($US Bn.)**

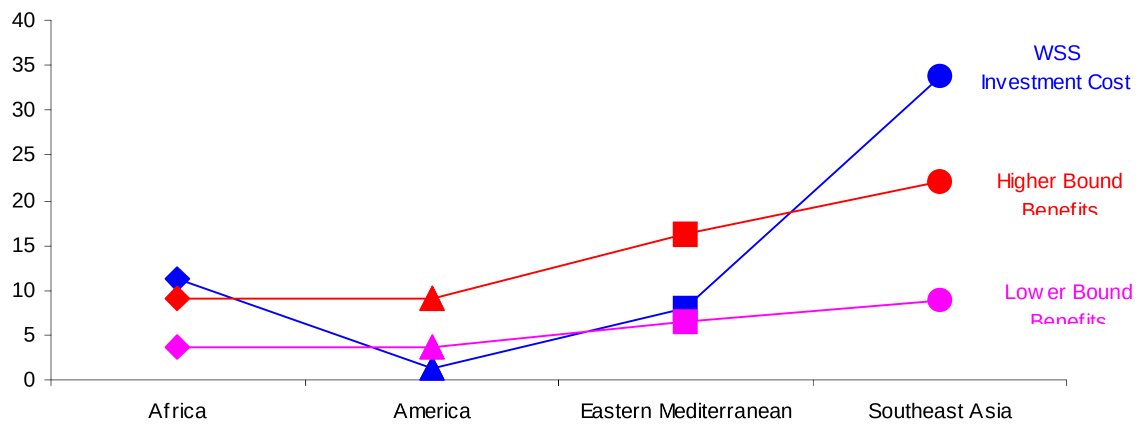
| Region | Cost of Water Supply | Cost of Sanitation | Total Cost | Benefits of reduced DALYS | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Africa | 4.1 | 7.2 | 11.3 | 3.6 | 9.0 |
| The Americas | 0.5 | 0.9 | 1.1 | 3.6 | 9.0 |
| Eastern Med. | 2.2 | 5.8 | 8.0 | 6.4 | 16.1 |
| S.E. Asia | 8.1 | 25.6 | 33.7 | 8.8 | 22.1 |
| **Total** | **14.9** | **39.4** | **54.3** | **23.7** | **59.2** |

Source: Own calculations

Notes:

1. Costs are sum of capital and operating costs.
2. Costs for water and sanitation goals will be mostly for capital costs, which is about 85% of the cost.
3. Capital costs based on a 'levelized' capital cost calculated at a 10 percent discount rate with a 15-year life of the equipment.
4. The annual operating costs are taken as 15 percent of the total investment costs.

**Figure 2: Water supply and sanitation (WSS) annual investment cost and benefits by region, US$ Bn.**



*Separating improved water supply and sanitation*

The assessment provided above is for both water supply and sanitation taken together. The cost justification side of the calculations shows that the sanitation target costs about three times as much as the water supply target. Hence a separate valuation of the two is merited and is provided in Table 7. The table shows that while water supply targets are justifiable for all regions (i.e., the costs lie between the lower and upper bounds), the sanitation targets are only justifiable for the Americas. This does not mean, of course, that **no** programs for improved sanitation are justified in the high mortality countries. Unfortunately we cannot answer the question: if a 50% cut is too big, what does pass a cost-benefit test? There are no data on how the marginal costs of the programs change with the target, nor on how the marginal benefits vary. Doubtless, some of the programs will have greater benefits and some will have lower costs. What the analysis does therefore is to draw attention to the need to look more carefully at the individual programs and select those locations and communities where the benefits will be greatest; or scale reductions differently; and/or look at cheaper options. For water supply, on the other hand, a more general commitment to meeting the MDG target is warranted.

**Table 7: Estimated Benefits and Costs of Meeting the MDG Targets for Water and Sanitation Individually in High Mortality Countries ($US Bn.)**

| Region | Cost of Water Supply | Benefits of reduced DALYS | | Cost of Sanitation | Benefits of reduced DALYS | |
|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | | Lower Bound | Upper Bound |
| Africa | 4.1 | 2.3 | 5.8 | 7.2 | 1.3 | 3.3 |
| The Americas | 0.5 | 2.3 | 5.7 | 0.9 | 1.3 | 3.2 |
| Eastern Med. | 2.2 | 4.1 | 10.3 | 5.8 | 2.3 | 5.8 |
| S.E. Asia | 8.1 | 5.6 | 14.1 | 25.6 | 3.2 | 8.0 |
| **Total** | **14.9** | **15.1** | **37.8** | **39.4** | **8.5** | **21.3** |

Source: Own calculations

*Complementary Activities*

The prioritizing of water supply and sanitation programs to fund as part of the MDG targets is a reasonable objective. But it is only part of the whole issue of designing such programs and the implementation of complementary activities is critical. In this regard, the role of education for sanitation is paramount. There are several World Bank and other documents that attest to the substantial benefits of careful, well designed education programs covering basic hygiene practices, such as hand washing. Not only do these activities pay dividends on their own, they also complement the benefits of improvements in sanitation services. Other areas where the investment and education programs complement each otherinclude: educating people about the use of water filtration and other water quality improvement measures (where necessary), impacts of sanitary landfills on ground water, etc.

*Sustaining Water Supply and Sanitation Services*

The comparison of costs and benefits presented above is, of course, only one part of designing and providing systems of water supply and sanitation. Equally important is to ensure that the institutions can provide these services in a sustainable manner. As the 'Camdessus' Report notes, it is critical for the host government to take real political ownership of the targets and to be clear on their strategies and priorities for the water sector. They need to prepare the strategies and action programs for 2015 and to include them in their short to medium-term development plans (Winpenny, 2003).

The most difficult problem that the program will face is to put in place suitable mechanisms for continued coverage of the costs of provision of improved water supply and sanitation. Typically, water supply and sanitation services in developing countries do not cover the costs – the average level of cost recovery for them is around 25 percent, compared to over 50 percent for power and over 100 percent for telecommunications (Saghir, 2003). This makes private investment in the water sector much less attractive than the other sectors and, furthermore, results in a system that deteriorates over time (capital expenditures are deferred due to lack of funds). That, in turn, makes people less willing to pay for the service and the situation get progressively worse.

If, therefore, the MDG target of increasing provision of water supply and sanitation is to be met, the issue of cost recovery has to be addressed head on. There are, broadly, only two sources of financing the system: the consumers and the government (local or central). Consumer willingness to pay varies with income (the richer are generally willing to pay more), with quality of service and with their present status as consumers (those already connected to the system may pay less than those who are not). A number of recent studies have shown that the WTP **for an improved water supply** is considerably higher than current tariffs (Whittington *et al*, *20*02; Brocklehurst, 2003), both for current consumers as well as for those who are not connected. Thus the case for an improved service can be made on grounds of WTP, but exactly **what** is affordable will depend on the level of income of the population and the distribution of that income. The more costly and sophisticated the system the greater will be the number who cannot afford it. This implies either that they are not connected or that they receive some kind of subsidy. Even with the most basic systems, however, supply will be unaffordable to some households and some form of subsidy will be needed for them. It is key, therefore to carry out careful research on what design is desired by the community and what it will pay for.

What form should the subsidy take? Again recent work at the World Bank has come up with some useful findings. First, 'cross subsidization', where the 'poor' are subsidized by the 'rich' who pay more than the cost of supply is hard to achieve. The mechanism typically used for this is the increasing block tariff, where the first X cubic meters are charged at a low rate and subsequent amounts charged at increasing rates. Apart from the difficulties in installing meters and monitoring water use, the problem with this method is that consumption is not that strongly related to income. From studies in Bangalore and Kathmandu, it was found that non-poor households consume only about 20 percent more than poor households (Brocklehurst, 2003). Hence a significant part of the benefit of the lower block rate goes to non-poor households and using cross subsidization to cover the full cost becomes virtually impossible. Furthermore a tariff of this kind makes it unattractive for any utility to take on more customers.

The second finding is that a more appropriate form of subsidy may be for connections. Poor households often cannot afford the one-time up front cost and paying for this can be much better targeted than a consumption subsidy. The data referred to above for Bangalore and Kathmandu was analyzed to show that replacing the consumption subsidy with a subsidy to connections allowed universal coverage to be achieved within a decade.

More generally, subsidizing part of the capital cost and requiring the utility to cover operating and maintenance (O&M) costs, rather than subsidizing the latter is attractive because it provides the utility with an incentive for cost efficiency on the O&M side. On the capital side, a problem that has been encountered, particularly in Eastern Europe, is over estimating the capacity required for an improved system. When tariffs increase as a result of such a change, consumption can fall quite sharply. Utility reform and metering has brought about some astonishing declines in consumption. In Gdansk, Poland, for example higher tariffs led to a fall in domestic consumption of 33 percent; in Bydgozcz consumption fell from 213 l/c/d to 147 l/c/d (a 30 percent decline). In Rostock, Germany, the French company Lyonnaise des Eaux managed to cut consumption by 67 percent and in the Baltic states higher tariffs led to reductions of around 50 percent (Stottmann, 1999). If such a decline is not planned for, the system will be too large and cost recovery will become even more difficult. Indeed it can be shown that if the demand is elastic enough, cost recovery may be impossible, i.e., raising the tariff results in even more cuts and even lower revenues (Markandya, 2004a).

The capital financing for water supply and sanitation can come from either the private or public sectors. Given the problems of cost recovery, and the risks associated with obtaining tariff levels that yield a sufficient return on capital, private finance in this sector has been relatively limited. In 2000, for example, just under $60 billion was invested by the public sector in water supply and sanitation and just under $20 billion by the private sector (Saghir, 2003). Moreover the usual private sector interest in investing has declined and the supply of ‘bankable projects’ is declining. This trend will only be reversed through reduced risks in investment in developing countries in general, and through credible legal and regulatory reforms, especially in the regions with the greatest opportunities (e.g., the FSU, Central Asia and Mekong region and Africa).

To conclude, once investments have been made to provide improved water supply and sanitation services, they have to be sustained. This has not been easy in the past and will continue to be a challenge. It is critical to design systems that meet the affordable needs of the population being served and to design effective systems of subsidy that target those who most need assistance and that ensure adequate funds to the utility, public or private, so it can meet its costs and make a reasonable return on the capital invested.

## 3. The Quality of Inland Water

*Water Quality and the Environmental Kuznets Curve*

Before we look in detail at the issues arising with respect to water quality in rivers and lakes it is interesting to examine the evidence on the relationship between economic development, as measured by *per capita* GDP and the quality of water in developing countries (i.e., whether the data support the so-called Kuznets curve). In Figure 3, the relationship between real *per capita* GDP and per capita emissions of BOD are shown for selected ‘high mortality’ countries from 1980 to 2002, as defined by the World Health Organization (see Annex 1 for a list of these countries). For both series, a five-year moving average has been taken to smooth out year on year cyclical fluctuations. As the graphs show, there is no clear evidence of the Kuznets hypothesis. Some countries show the 'inverted 'U' shape (Mauritius and India, to some extent); some show a 'U' shape, which is the opposite of the Kuznets hypothesis (Bangladesh and Morocco). Others demonstrate no clear pattern.

If, however, the panel data are taken for these countries and some others in the high mortality group[8], the relationship between water quality and income can be estimated using the simple model of environmental Kuznets curve, as below:

$$BODPC = Intercept + \beta GDPPC + \delta GDPPC^2 + error\ term$$

where BODPC is BOD emissions per capita, and GDPPC is real per capita GDP. The following results are obtained:

**Table 8: Regression results using OLS**

| Variable | Parameter estimate | Standard error | t-Value | Prob |
|---|---|---|---|---|
| Intercept | 0.58745 | 0.12884 | 4.56 | <.0001 |
| GDPPC | -0.00052 | 0.00020 | -2.53 | 0.0120 |
| GDPPC^2 | 5.37245E-7 | 6.257041E-8 | 8.59 | <.0001 |

| | |
|---|---|
| Turning point | 0.46 kg (BOD emission), US$ 481.32 |
| R-square | 0.6003 |
| Adj R-square | 0.5970 |

Water quality is represented by the variable, *biochemical oxygen demand* or *BOD*, which is the primary indicator of pollution in wastewater. The regression results show that there is a statistically significant relationship between income and an environmental degradation indicator (e.g., BOD emissions), but the relationship does not support the hypothesis of the environmental Kuznets curve. Rather the results suggest that, initially, water quality improves as incomes increase; but when per capita GDP reaches about US$480, the quality of water begins to deteriorate and continues to do so at an increasing rate as incomes increase (Figure 4).

These results are similar to those obtained recently by Hettige, Mani and Wheeler (2000), who rejected the EKC hypothesis for industrial water pollution. They found that water pollution increases rapidly through middle income status and remains roughly constant thereafter. On the other hand, the results from the study by Grossman and Krueger (1995) support the EKC hypothesis but the turning point reaches a per capita income more than US$7500 (i.e., dependent variable: annual mean concentration of BOD). We should note, however, that the data sets between these studies are not the same. Specifically, we look at high mortality countries only,

[8] Fifteen high mortality countries were considered for the estimation because they have relatively more time series data available compared to the others. These countries are: Algeria, Bangladesh, Bolivia, Cameroon, Ecuador, Egypt, India, Mauritius, Morocco, Nepal, Nigeria, Pakistan, Peru, Senegal and Yemen. The periods covered are from 1980 to 2002, and the data were obtained from the World Bank (2003f). He regression also looked for fixed effects but none were found.

going up to $5000 per capita income whereas Grossman and Krueger look at a mixed group of countries with a higher upper income range and for different years.

**Figure 3. Relationship between BOD emissions and GDP, Selected High Mortality Countries (5-year Moving Average).**

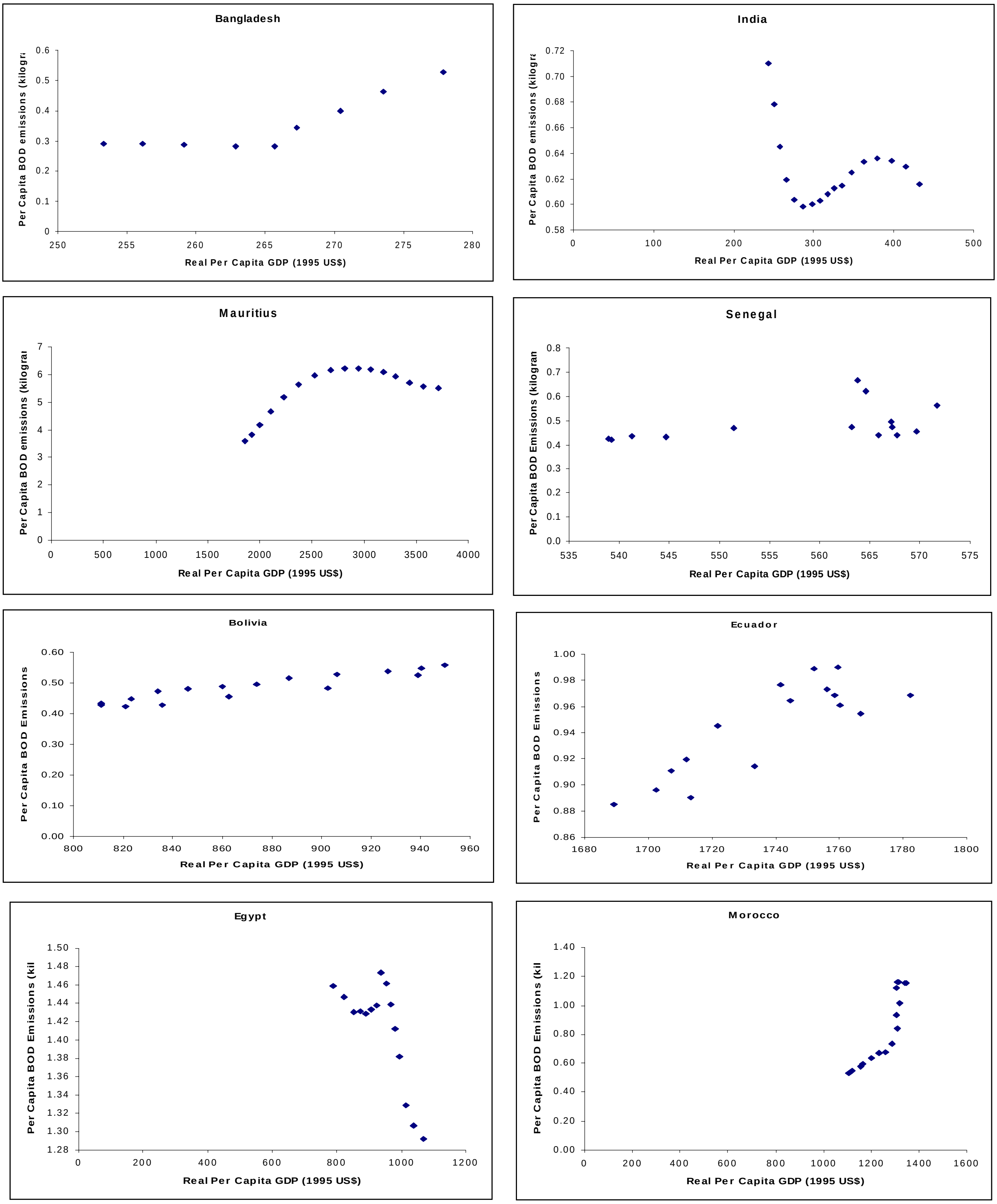
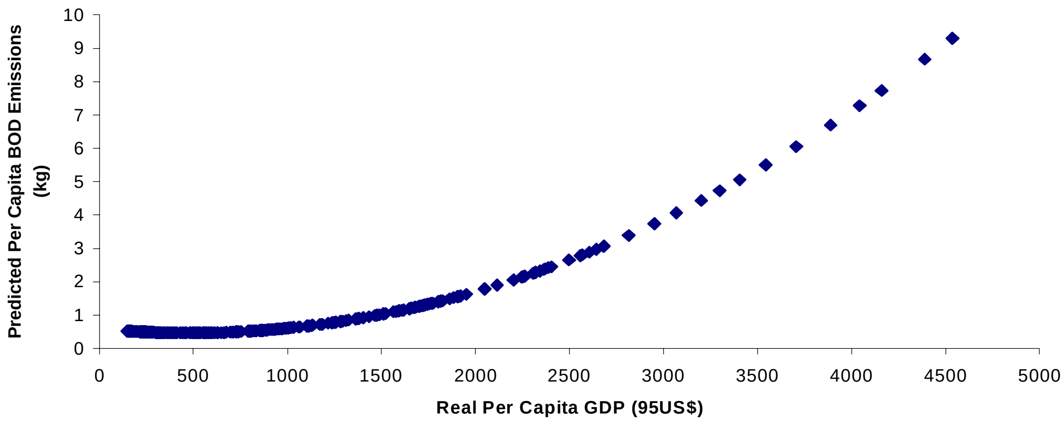


**Figure 4. Relationship between Per Capita GDP and Predicted Per Capita BOD Emissions.**




This result, which is contrary to the Kuznets hypothesis suggests that water quality is a growing problem with development. Of course, the countries looked at are all relatively poor (the highest per capita income here is for Mauritius at $4,500), and there may well be another turning point at much higher per capita incomes (e.g., Egypt). Even assuming this to be the case, however, the evidence does not support a simple Kuznets hypothesis but rather a more complex phenomenon, with multiple turning points, which need further investigation.

*Indicators of water quality in developing countries*

In this section, we look at the quality concerns arising with regard to inland water. Frequently, the quality of such water is poor in developing countries. Primarily, as a result of the increased demand on freshwater resources, high environmental costs have been paid. Some rivers no longer reach the sea; 50 percent of the world's wetlands have disappeared in the past century; 20 percent of freshwater fish are endangered or extinct; many of the most important groundwater aquifers are being mined, with water tables already deep and dropping by meters every year, and some are damaged permanently by salinization. Most of the collected wastewater in developing countries is discharged directly to surface waters without treatment. In addressing these problems, however, the focus is on the management of quantity of water, including investment in storage, flood control, and watershed management more generally; and promotion of policies that do not waste scarce water resources. Little reference is to be found in the development literature on improving the quality of freshwater directly. The Water Resources Strategy (World Bank, 2002), for example, discusses various interventions along the lines mentioned above, but has virtually nothing to say about directly improving the quality of the water.

This emphasis on the quantity side may well be justified, given the high costs of ensuring that rivers, lakes and ground water sources are clean. Moreover, the benefits of such investments are probably smaller in developing countries, given that a part of them are derived from recreational uses, for which poorer people are willing to pay less than richer people. Not all benefits, however, are of this kind, and at least some water quality projects include benefits of lower costs of water treatment and use of treated water for irrigation.

There are, broadly, three types of benefits from cleaner water. The first is the *amenity benefit*, which refers to the use of water for recreational purposes and the value attached to it looking and smelling cleaner. The second is the *benefit of lower costs of treatment of the water source* before drinking and the possible benefits to those who use it without treatment. The last are the *benefits attached to cultural and religious values* of some rivers. These may be partly *use values* but also *non-use values*; and even for a poor country, these values may be significant enough to warrant investment in clean up. Unfortunately, there is no comprehensive review of projects generating each type of benefit, but there are useful and (probably) representative case studies of each. These are examined below.

*Measures to Improve Inland Water Quality*

Although the most important contribution to improving water quality is to treat discharges in municipal or industrial effluent treatment plants, there are other measures that can be taken and the combination of measures chosen can make a big difference to the total cost of achieving a given improvement in quality. The general propositions that water quality is a broader management issue than just wastewater treatment, and that quality and quantity are related, are certainly correct and should be borne in mind when designing a control strategy for quality.

Other factors that are relevant include amounts of water abstracted, and discharges from non-point sources, notably agriculture. It is easy to construct examples of situations in which: (a) better management practices or pre-treatment of waste from single industrial or agro-industrial sources would be cheaper than taking the waste to a common treatment plant; (b) policies to reduce agricultural run-off through extension services and/or fiscal incentives such as taxes on pesticides and fertilizers can be a less expensive way of getting a better quality than higher levels of treatment; and (c) prohibiting abstraction in critical low flow periods can make a big difference to water quality during those periods at a relatively low cost.

Notwithstanding these observations, wastewater treatment remains the most important source of achieving improved water quality. Hence the section below looks at the potential benefits of such improvements and compares them to the costs of wastewater treatment. This is not to give such treatment an exclusive role relative to other methods, but to have a benchmark cost with which to compare the benefits.

*Arithmetic of the Costs and Benefits of Improvements in Water Quality for Recreation*

Before reviewing a number of case studies, it is quite informative to look at the costs and potential benefits of river and lake clean up in simple, ‘back of the envelope’ terms. The numbers are as follows:

> Costs: The capital cost of providing secondary treatment in accordance with the urban wastewater directive of the EU ranges from €89 to €405 per person, depending on the population that is being served. The smaller the population, the higher the unit costs – the

lower figure applies to a city of 236,000, while the higher figure applies to a village of 2000. The operational costs have to be added to the capital cost, and the two can be combined by taking the levelized equivalent of the capital cost. In this example we have calculated the levelized capital cost taking a 25-year life for the plant and a 10 percent discount rate. The combined annual costs range from €13.9 to €72.6 per person. Data are taken from the Compliance Cost Study for Bulgaria (World Bank, 2003g).

Benefits: The total benefits will depend on the number of persons who make use of the recreational facilities. In Table 9, the total number of such beneficiaries is assumed to range from 10,000 to 150,000 per year. This number may also depend, of course, on the improvements generated in terms of water quality. The costs given in the previous paragraph refer to achieving standard in terms of BOD, COD, suspended solids, phosphorous and nitrogen that would, in most cases, represent a very significant improvement in water quality and allow most recreational uses, including game fishing where this was relevant.

Net Benefits: These will depend on how many urban areas there are that need the treatment facilities. In the calculations in Table 9, we allow this figure to range from one town of about 100,000, to ten such towns.

The figures in Table 9 give the breakeven benefit values for different combinations of users and polluters whose discharges have to be treated.

**Table 9: Breakeven Values of Benefits for Improved Inland Water Quality With Different Combinations of Number of Users and Polluters (€/Person)**

| | **No. of Beneficiaries** | | | | | |
|---|---|---|---|---|---|---|
| | **10000** | **25000** | **50000** | **75000** | **100000** | **150000** |
| Pop. ('000) | | | | | | |
| 100 | 246 | 98 | 49 | 33 | 25 | 16 |
| 200 | 492 | 197 | 98 | 66 | 49 | 33 |
| 300 | 738 | 295 | 148 | 98 | 74 | 49 |
| 400 | 983 | 393 | 197 | 131 | 98 | 66 |
| 500 | 1,229 | 492 | 246 | 164 | 123 | 82 |
| 600 | 1,475 | 590 | 295 | 197 | 148 | 98 |
| 700 | 1,721 | 688 | 344 | 229 | 172 | 115 |
| 800 | 1,967 | 787 | 393 | 262 | 197 | 131 |
| 900 | 2,213 | 885 | 443 | 295 | 221 | 148 |
| 1000 | 2,459 | 983 | 492 | 328 | 246 | 164 |

Source: Own calculations.
Note: The population of users is assumed to be located in identical towns of 100,000 each.

As there are very few studies of the benefits of recreational and other use in developing countries, these break-even values have to be interpreted in the light of benefit studies in developed countries plus a few in developing countries. In the **US**, values for improved fishery benefits range between €60 and €380 per househo ld per annum, depending on the exact improvement, the location, etc. (Olsen, *et al*, 1994; Sanders, *et al*, 1991; Hanemann, 1991). In the **UK**, Willis and Garrod (1995) estimated the benefits from improved flow rates on a 130 km stretch of river as between €18 and €23 per household per year [9]. In developing and transition countries, the figures are generally somewhat lower. In the **Philippines**, the benefits of improving river surface water so that it is fit for swimming ranged from €11.1 to €18.9 per user per year (Choe, *et al*, 1996). In **Latvia**, the benefits from making the Gauja River suitable for swimming and fishing were estimated at €5.7 per person per year (Ready, *et al*, 2002). In **Thailand**, the benefits of improving water quality so that it moved from 'boatable' to 'fishable' were €28.8 per household per year; and further improvements from 'fishable' to 'swimmable' were €33.2 per household per year (Tapvong, *et al*, 1999). In **China** values for water quality for East Lake close to the town of Wuhan were made using CV and travel cost methods (Yaping, 2003). He found that improving quality from 'existing to 'boatable' gave a per capita benefit of €1.2 and €1.8. Going from 'boatable' to 'swimmable' gave a benefit of between €2.2 and €4.7 per person.[10] Finally, we have a study from **Hungary** where a clean up program was valued in terms of willingness to pay to prevent further deterioration of water quality. The estimate was a WTP of €22.5 per person per year for this benefit[11] (Mourato, *et al*, 1999).

The message from Table 9 and these studies is that clean up projects for rivers and other inland water bodies are unlikely to be justifiable unless the number of beneficiaries is large relative to the number of polluters whose waste has to be removed, or unless there are significant non-recreational benefits to improving inland water quality. Just looking at amenity benefits to start with, we can see that, for example, with 150,000 users and only 100,000 polluters, the break-even value is around €16, which might be feasible from some locations in Asia and Eastern Europe. On the other hand, with the number of polluters well in excess of the number of users (which is typically the case), the break-even values are much too high.

*Evidence on the Non-amenity Benefits of Cleaner Inland Waters*

What evidence do we have on non-amenity benefits of cleaner inland waters? From the ecological perspective, the case has been made for significant impacts of deteriorating water quality on fisheries, health and eco-systems. The valuation of these in economic terms, however, is much more difficult. We consider here the experience of two seas (the Black and Caspian), a river (the Ganges in India) and a lake (Lake Mariut in Egypt).[12]

For the Black and Caspian Seas, for example, fish catches have been declining, and part of the decline is attributable to the impacts of eutrophication, industrial pollution, overfishing and the introduction of exotic species. Quantifying these impacts separately, however, has not been done

[9] All benefits figures are in 1999 Euros. Original studies have been converted to Euros to make them comparable with the cost estimates.

[10] CVM values were the higher of the range of value; travel cost estimates were the lower.

[11] All values have been converted to Euros, at the prevailing exchange rates of the year in which the studies were carried out.

[12] Another interesting study on the non-amenity value is that by Emerton, *et al* (1999) for Nakivubo wetlands in Uganda. It does not value the quality of water in wetlands as such but rather the value of wetlands in purification of sewage loads from Kampala. The savings in sewage treatment account for most of the economic value of the wetlands. As the authors note, however, important non-amenity values, such as non-use values, and the impact of the sewage loads on wetland crops have not been valued and need further research.

for the Caspian Sea. One cannot say how much of the loss of the sturgeon is due to the damming of the major rivers flowing into the Sea, how much to illegal fishing and how much to the increasing loads of industrial pollution, including the oil spills that occur there regularly (Markandya, 2004a). For the Black Sea an estimate was made (Knowler, *et al*, 1997) of the increase in profits from fisheries that would arise from investments in eutrophication. The numbers are somewhat speculative, but even if we accept them, they explain between 14 and 21 percent of all identified benefits of the program (Arin, 2001). Of the remaining benefits amenity dominates (60 to 63 percent), followed by health (7 to 14 percent) and agriculture (9 to 12 percent). The resulting calculations marginally 'justify' the World Bank/GEF Strategic Partnership's investment program, although the benefit estimates must be treated with some caution, especially those relating to fisheries and agriculture[13].

Another case where non-amenity benefits were examined with some care was the Ganges Clean Up Plan. In this study, it was concluded that (a) fisheries benefits could not be quantified, (b) direct health benefits were small and, (c) if biodiversity benefits existed, they could not be valued in money terms. More details of this study are given in the next section.

In the case of Lake Mariut, which is immediately South of the coastal city of Alexandria, the authorities decided to divert the city's sewage from the sea to the lake, to reduce pollution on Alexandria's beaches. As a result the value of its fisheries declined from $8 million in 1950 to 0.5 million in 1985. With the growth in industry the level of sewage increased to such an extent that the water from the lake, which flows into the sea, is now so polluted that the original objective of the diversion has been lost (World Bank, 2003h).

There are many other studies where non-amenity benefits of better quality water have been cited to a lesser or greater degree but not fully quantified in physical terms and hardly at all in money terms. Examples include the following river, lake and coastal zone projects supported by the GEF: (a) in Africa: Algeria (El Kala National Park and wetlands), Guinea and Guinea-Bissau (coastal zone management), Kenya (Tana River and Lake Victoria), Malawi (Lake Malawi), Mozambique and Namibia (coastal biodiversity), Niger (Niger River), Senegal (Senegal River Basin), South Africa (Cape Peninsula), and the Nile River; (b) in South America: Chile; (c) in Asia: China (Hai River), Philippines (River Basin Management, Mekong River; and (d) in Europe: Croatia (Karst eco-systems), Georgia (Kolkheti wetlands), Russia (Lake Baikal), Ukraine (Azov-Black Sea), Lake Orhid and River Danube.

*Non-use Benefits of Cleaner Water*

In the case of exceptional water bodies, there could be non-use benefits that justify clean-up. Some of these have been quantified, and a good example is the Ganges study, which is cited below. Other cases where non-use values have been estimated and related to water quality, however, are hard to find. In fact the only studies we could find that cameunder this category

[13] The agriculture benefits arise from the improved yields that would result when nutrient applications are **reduced** as a result of demonstrating to farmers that environmentally friendly practices are actually commercially beneficial as well. Typically, such an assumption turns out to optimistic about the rate of adoption of the new methods. The other problems with estimating non-amenity benefits arise from predicting the impacts of marginal changes in nutrients when the limited evidence available refers to the impacts of the total loadings that currently exist.

were for the US (see Bergstrom, *et al*, 2001). Hence it is difficult to make a case for clean-up on these grounds[14] in developing countries.

*Case Studies of Surface Water Quality Improvements*
*(1) The Clean Up of the Ganges in India*
The Ganges is one of the most important river systems in the world, 2,510 kilometers (km) long and with a basin covering 861,404 square km. Currently, half a billion people, almost one-tenth of the world's population, live within the river basin at an average density of over 500 per square km. The local population is projected to increase to over one billion people by the year 2030. There are about 52 cities, 48 towns, and thousands of villages in its basin. Nearly all the sewerage from these populations goes directly into the river, totaling over 1.3 billion liters per day, along with a further 260 million liters of industrial waste, runoff from the 6 million tons of fertilizers and 9,000 tons of pesticides used in agriculture within the basin, large quantities of solid waste and, thousands of animal carcasses and several hundred human corpses released into the river every day for spiritual rebirth. The inevitable result of this onslaught onto the river's capacity to receive and assimilate waste has been an erosion of river water quality, to the extent that, by the 1970s, large stretches (over 600 km) of the river were effectively dead from an ecological point of view.

The “Ganga Action Plan (GAP)”, an important environmental project to clean the Ganges, originated from the personal intervention and interest of the late Indira Gandhi. The GAP was launched in February 1985 and was largely completed in 1998. The final cost of the GAP is estimated at Rs. 11.2 billion ($318 million) in 1995 prices. The operating costs of the program run at around Rs356 million ($10 million).

The GAP has been, perhaps, the largest single attempt to clean up a polluted river anywhere in the world. Although a number of other international scale river basin clean-up programs have been effectively implemented in other countries, none has the full spectrum of geographical, ecological and socio-cultural complexities that faced the Indian Government during the GAP’s implementation. The sums of money referred to above are large by any standards, and were committed with the main objective of raising the river water quality to bathing standard. As a result of GAP, the quality of water in the Ganges has shown varying improvements in absolute terms since 1985. The dissolved oxygen levels have been improving in some areas but in others, particularly the lower stretches, they have continued to decline. Similar improvements in phosphate and nitrate concentrations have been observed since the early 1990s. However, a proper comparison of the water quality “with” and “without” the project requires the use of a sophisticated water quality model to account for what quality would have been in later years without the project. The results of such a model in the case of the Ganges show that some improvements in water quality (measured in terms of dissolved oxygen and biochemical oxygen demand (BOD)) were observed everywhere, albeit quite small ones in some places. It is also worth noting that a total stretch of about 437 km still violates the permissible level of 3.0 mg/l of BOD. In terms of dissolved oxygen, the level throughout the river is now more than 5.0 mg/l.

[14] Indirectly, one could argue, however, that support for GEF projects that involve reduced pollution loads in ecologically important water bodies is a reflection of the international non-use WTP. But if the purpose of this kind of assessment is to inform that decision the argument becomes circular and cannot be used.

Without the GAP, more than 740 km would have violated the BOD limit, with about 1000 km having BOD levels in excess of 10 mg/l. So, in summary, some improvements in water quality have been achieved. The important question is, what are these worth in money terms, taking account of the broadest set of values placed on cleaner water?

There are multiple benefits from cleaning the Ganges. There are user benefits accruing to people who stay near the river or visit the river for pilgrimages or tourism. These will be in the form of recreation and health benefits from direct and indirect exposure, and are called user benefits. They will also include benefits to fishermen, farmers and those for whom employment is created as a result of the project. Fishermen get benefits of improved fish production. Farmers get some type of irrigation and fertilizer benefits by using treated water and sludge from the sewage treatment plants of GAP.

The other category of benefits is non-user benefits, accruing to the people who are not staying near the river but gain welfare from knowing that the river is clean. Especially important in this regard is the religious significance of the river to Hindus but also relevant are the biodiversity benefits – the Ganges supports 25,000 or more of species of biodiversity ranging from microorganisms to mammals. There are a number of international species comprising of mammals, reptiles and birds supported by the Ganges ecosystem.

Also, the investment projects for cleaning Ganges provide employment to unemployed or underemployed unskilled labor in India, and contribute benefits in the form of cost savings to water supply undertakings along the river. Hence, the beneficiaries from cleaning Ganges can be classified as users, non-users, health beneficiaries, farmers, unskilled labor, and fishermen. Finally, there are the biodiversity benefits not captured in the program.

In a post-project evaluation, an estimation was made of several categories of benefit and these were compared to the costs (for details see Markandya and Murty, 2001) as presented in Table 10 below.

The table shows that overall the project is viable at a 10 percent discount rate (the official rate used by the Government of India) and yields a rate of return of around 14 percent. It is important to note, however, that the bulk of the benefits come from the non-users (67.2%), principally those who have a religious value for the river, and from the employment creation as a result of the project (18.8%). Without these, the project would never have been viable and indeed the direct benefits are quite small.[15] The study was also instructive in showing that positive net benefits would not guarantee successful implementation of the project. That would require the operational and maintenance costs to be sustainably financed from one or more sources: the polluters, via a wastewater charge; the beneficiaries, via a charge on non-users and users; or a subsidy from the central government. Unfortunately, this issue has not been resolved and the ongoing operations from the project are in some difficulty as a result.

[15] There is a issue about whether or not the benefits of lower treatment costs should be included in the above. The authors of the study took the view that they should not, because one has already accounted for the improvements in health and other benefits and to include the savings in treatment costs would be double counting.

**Table 10: Benefits and Costs of Ganga Action Plan ($Mn.)**

| Category | Benefits/Costs | | Description |
|---|---|---|---|
| | $Mn. | As % | |
| Users | 0.8 | 0.3 | CV survey of residents within 0.5 km of bank and visitors |
| Non-users | 195.2 | 67.2 | CV survey of literate urban residents in 4 Indian cities |
| Farmers | 16.3 | 5.6 | Estimated benefits of fertilizer value of sludge |
| Health | 23.5 | 8.1 | Epidemiological study of villages near river before and after the program, compared to control group far from the river |
| Unskilled labor | 54.5 | 18.8 | Benefits of job creation reflected in a shadow price of labor of 0.5 |
| Fishermen | N.A | N.A. | It was not possible to estimate these benefits, despite considerable efforts to collect the data. |
| Biodiversity | N.A. | N.A. | The program did improve natural habitats but a value for these improvements could not be elicited. |
| | | | |
| **Total Benefits** | **290.4** | **100.0** | |
| Industry Costs | 42.7 | 24.8 | Industry is required to take an number of measures to treat effluent before release |
| Public Sector Costs | 129.8 | 72.5 | |
| **Total Costs** | **172.5** | **100.0** | |
| **Net Benefits** | **117.8** | | |

Source: Markandya and Murty (2001)
Note: All costs and benefits are in present value terms, discounted at 10 percent. Note: still marginally have MB>MC even if cut non-use benefit estimate by 50%.

*(2) The Nura River Clean Up*

The Nura River in the Republic of Kazakhstan has been the recipient of a significant amount of mercury (about 3,000 tons) from a synthetic rubber factory nearby, which is no longer operating. This has consequences not only for the quality of the water *per se*, but also on the well being of the direct water users (World Bank, 2003). Over the operating lifetime of the factory, mercury was discharged from industrial processes and has accumulated at the plant site and in the topsoil of the flood plain, riverbed and banks. The Nura River project has the following components: (a) clean-up of the Nura River Basin; (b) rehabilitation of the Intumak Dam and Reservoir; (c) capacity building of Basin authorities; and (d) project management and monitoring. The targets of these four components are to reduce the large concentrations of mercury that poses health risks to the local population both through direct exposure and contamination of the Basin's water supply, and to improve flow control within the Basin[16]. These targets translate to security of water supply in terms of it being safe for direct consumption and accessibility (guaranteed delivery supply at a regular basis). The project is specifically noted in Kazakhstan's Country Assistance Strategy, and meets the Millennium Development Goal on providing access to clean water.

Multiple parties are expected to benefit from the project, such as: the *water suppliers* (in the cities of Astana, Temirtau and Karaganda), through incurred savings from drawing water from

[16] e.g., for flood management and protection of downstream wetlands

the Nura River instead of the Irtysh-Karaganda Canal, as well as an improvement in the regularity of supply as a result of the project; *local water users*, through reduced health risks and more regular water supply; *recreational visitors* (hunters, fishers and tourists), through more and cleaner water in the Nura River and Kurgalzhino Wetlands Protected Area; and *other community members*, through improvement in biodiversity levels (i.e., non-use values). Table 11 shows the total project costs and the estimated benefits. The positive value of net benefits infers that the project is viable at a 12% discount rate. Most importantly, however, the majority of the benefits (95%) are from the savings to water suppliers. Although health issues feature largely in the public discussion about the plant, the direct health benefits of the clean up of the mercury do not appear to be very large. This may partly be the result of problems in identifying the impacts of mercury pollution on the population, and partly the consequence of the fact that people, knowing of the dangers of such pollution, have taken effective avertive action (savings on avertive action are of course a benefit).

**Table 11: Benefits and costs from the Nura River Project**

| | **Cost (US$ Mn.)** | **Description** |
|---|---|---|
| *Project Cost* | 54.1 | Components: Nura Valley Mercury Clean Up; Intumak reservoir rehabilitation; Nura-Sarysu River Basin Authority Strengthening; Project Management and Monitoring |
| **Beneficiaries** | **Benefits (US$)** | |
| Water suppliers | 76.9 | Savings in costs of water from a more expensive source |
| Local water users | 2.8 | Reduction in health risks from direct consumption of water; Regular source of water |
| Recreational visitors | 1.2 | Fishermen, hunters, and tourists, who exploits the recreational services of the Nura River banks and the buffer zone of the Kurgalszhino Wetlands Protected Area, based on interviews of the use of the facilities. |
| Other community members | 0.5 | Those who value biodiversity protection by improving the water quality based on a CV study. |
| **Net Benefits** | **80.9** | |

Source: World Bank (2003i). Project Appraisal Document for the Nura River Clean Up Project and background studies.
Notes: All figures are discounted at 12%.

*(3) The Davao River and Times Beach in the Philippines*

Choe, *et al* (1996) conducted a study in Davao City, Philippines where they attempted to estimate the economic value that people place to improve the water quality of the rivers and sea near their community. Although the majority of the households have their own water-sealed toilets that drain into large septic tanks, effluent from the tanks reaches the surface waters of the province. The most popular beach in the area is Times Beach, whose quality has deteriorated due to nearby discharge of the Davao River, such as silt, household waste and industrial waste. Due to high levels of pathogens and fecal coliforms found in the water, the city's Health Department issued warnings about the health risks of swimming at the beach. Furthermore, the deterioration of the beach discouraged other recreational activities, such as picnics.

For the study, surveys were conducted through the Contingent Valuation Method (CVM) and the Travel Cost Method (TCM), which intend to capture the respondents' stated preferences and revealed preferences, respectively. The hypothetical scenario is as follows: *There is a city-wide plan to clean up the river and sea (by waste treatment), and make Times Beach safe again for swimming and other recreation activities. The implementation of the Plan would require a monthly fee at a continuing basis to maintain the cleanliness of the surface water body. Assume that other households and industries will do their fair share and other actions would be taken to ensure the accomplishment of the Plan.* The estimated cost of this Clean-Up Plan ranges from $5 to $15 per household per month, but this cost was not revealed to the respondents during the survey.

From CVM, the estimated average willingness-to-pay values of the users of Times Beach for water quality improvement ranges from $1.2 to $2.04 per month. There were also people who were interviewed but were non-users of the beach. The mean WTP of these people for an improvement of the water body's quality ranges from $0.04 to $1.4 per month. These values capture the non-use values for cleaning up the beach, such as significance regarded on enhanced aquatic life and aesthetics. On the other hand, the estimated monthly WTP from TCM ranges from $1.44 to $2.04 per user. Notice that the estimates from both valuation approaches are close to each other. Considering that the average household monthly income is about $204, the WTP estimates are low both in absolute terms and as a percentage of household income. Moreover, since the population of users and non-users is the same as that of the polluters (totaling about 100,000 households), the results do not justify the project at the present time.

Aside from looking at the values people place on improving surface water quality, the study also examined the *relationship between income and demand for water quality*. Externalities due to lack of wastewater treatment fall largely on the residents of Davao themselves, but their WTP values are low. A closer investigation showed that although people are aware of the poor water quality status, they do not place a high priority on it since there are more urgent environmental issues in the area such as deforestation and, poor collection and disposal of solid waste. The policy message of the study is to wait until incomes and WTP are higher before engaging on large investments (e.g., waste treatment infrastructures).

*(4) The Gauja River in Latvia*

Ready, *et al* (2002) conducted a similar study in Sigulda, Latvia. Latvia attempts to implement Program 800+, which is a package of infrastructure investments in over 800 small and medium-sized towns. Part of the Program is a project on the modernization of sewage facilities. The present water and sewerage service charge is $3.6 per month. The annualized cost of the upgrading the sewage treatment plants, under Program 800+, is $1.8 per person per month.

The study employed the CVM approach to elicit the values people place on the improvement of surface water quality. The hypothetical scenario in Sigulda is where the investments on upgrading the sewage facilities would yield an improvement in the water quality of the Gauja River (e.g., reduction in nutrient loads) so that it would be suitable for fishing and swimming, but not for drinking. The payment vehicle used is an increase in the monthly fees for water and sewerage service. Results of the study showed that for an average person, the WTP is about

$0.54 per month. However, this is far below the local financing monthly requirement for Program 800+ (i.e., $1.8 per person) and is only 0.7% of the average household monthly income.[17]

A similar message was given of delaying the investment emerges from this study as from the Philippines study. Latvia has to meet the environmental requirements for admission to the EU over a period of time, depending on the particular directives. For the directives related to inland water quality, the time period is 10-15 years after accession – i.e., to 2014-2019. The authors state that the economic growth of the country will reach its full potential when it integrates with Western Europe. From the study, the calculated income elasticity of demand for water quality was 0.56 for an average person. Further examination of the relationship through econometric analysis showed that the income elasticity will increase as incomes increase, reaching 0.9 at an income level that is twice the current average of $77 per month. Thus, depending on the underlying growth rate in the economy, the programs will be justified at some date in the future. If we take the above elasticities (0.56, rising to 0.9), and assume a 5 percent *per capita* income growth rate and no changes in populations of users or polluters, the project will only be viable in 2032! With a growth rate of 7 percent, however, it will be viable in 2023 and with a rate of 10 percent it will be viable in 2016.

## 4. Conclusions

This chapter has looked at two issues arising from poor water quality: the impact it has on households through their use of such water for drinking and other domestic purposes, and through the facilities they employ for the disposal of household waste; and the consequence of poor water quality in inland rivers and lakes on other water uses (recreation, abstraction for domestic use, etc.).

Regarding the first issue, we have focused on the targets under the Millennium Development Goals, and looked in some detail at developing countries with high mortality rates. According to the WHO, the lack of access to safe water and sanitation is responsible for more than half the DALYs lost due to all environmental factors. The other important one is indoor smoke from solid fuels. Data from 1980 onwards does show access to improved water and sanitation has been increasing worldwide – even in those regions such as Africa, where real *per capita* income has fallen over this period. There is, thus, not a strong link between increased access and increased living standards over the recent past, although it is undoubtedly true that the countries with higher living standards do have higher levels of access.

In order to see whether the targets under the MDGs are justified in economic terms, it is necessary to compare the costs of meeting those targets with the benefits. For the latter, a value has to be placed on the DALY. We take a range from *per capita* GDP to 2.5 times *per capita* GDP, basing this on some of the recent literature that has valued lost life years. On this basis, the costs of achieving the targets by 2015 exceed the benefits for some of the regions (Africa and Asia). For the high mortality countries of America, the costs are less than the lower bound of the

[17] As in the Philippines study, the polluters and the users are the same population. Hence a simple comparison of the per household costs and benefits gives the answer to the question of project viability.

benefits; and for similar countries in the Eastern Mediterranean, the costs lie between the lower and the upper bounds.

The above calculations are reported for both the safe water and the sanitation goals. If we separate the costs of each goals and make an estimate of the benefits, we would find that the water supply targets are justified for all regions, but the sanitation targets are only unambiguously justified for the Americas. This is the result of two factors: the costs of sanitation connections are about three times those of water supply and the benefits per connection are somewhat lower.

A comparison of costs and benefits is, of course, only one part of designing and providing systems of water supply and sanitation. Equally important is to ensure financial sustainability and here ensuring sustained cost recovery remains one of the most serious problems that need to be addressed. Typical levels of cost recovery are low and utilities find it difficult to operate in an effective manner. A number of recent studies have shown that the WTP **for an improved water supply** is considerably higher than current tariffs both for current consumers as well as for those who are not connected. Thus the case for an improved service can be made on grounds of WTP, but care is needed to design the system to recognize the WTP limitations. Furthermore, some subsidy will generally be needed, if the MDG goal is to be met – the poorest parts of the population, who will largely be the focus of the program, often will not be able to afford the services.

Where subsidies have to be provided, recent work has come up with some useful findings. The use of an increasing block tariff is difficult to achieve and not that effective. There are problems in doing the metering and there are not big differences in consumption between the rich and the poor households. It also appears that a connection subsidy is more effective than a consumption subsidy.

Another issue that has to be guarded against is designing systems that are too large. When tariffs increase as a result of such a change, consumption can fall quite sharply and if this not accounted for, the system will be more costly than necessary and have greater difficulty achieving cost recovery.

The overall implications of the analysis therefore are that the water supply targets need careful cost benefit appraisal before they are implemented. In addition, they need a careful analysis of financial sustainability and in this regard affordability is a critical element. The same remarks apply to sanitation programs, but here the cost and benefit comparison is less clearly in favor of the program as a whole. Even if we remain committed to the MDG targets as a whole, the phasing of the investment can still benefit from a careful comparison of costs and benefits. Furthermore complementary activities such as education about hygienic practices have to play an important part.

The second set of concerns relate to the quality of water in rivers, lakes, etc. We looked at an indicator of water quality (BOD), and how it relates to development – à la the Kuznets curve. The time series analysis of selected countries for which data are available do not generally support the usual inverted ‘U’ shape, with quality decreasing in the early stages of development and improving after a certain point. The panel data for 15 high mortality countries in fact come up with a statistically significant 'U' – quality improves up to an income level of $480 and then deteriorate up to an income of $4000 or thereabouts. Beyond that, it may improve again, but this would not represent the usual Kuznets relation.

To ensure that water is clean enough for recreational uses would require significant investments in the treatment of household and industrial effluent and, possibly, some controls on non-point pollution from agriculture. The simple arithmetic of sewerage treatment shows that the justification of high level wastewater treatment depends on the: (a) per person WTP for the improvement; (b) number of beneficiaries of the improvement; (c) cost per household of the investment in treatment; and (d) number of households whose waste has to be treated. With plausible values of (b) to (d), we find that the WTP per person has to be quite high compared to the kind of estimates that have been made of this figure in developing countries. Treatment projects are not ruled out in all cases, but their success depends on having a large number of beneficiaries relative to polluters whose waste has to be treated. We also note that most of the data available on benefits of clean water relate to amenity benefits – recreational use and the like. There may also be special cases where non-amenity benefits justify clean-up, but the information on that is very limited – there are hardly any non-use benefit studies and studies of agricultural and fisheries benefits are few and far between.

Hence the viability of cleaning up water bodies in developing countries cannot be analyzed statistically, as the projects are highly individual and depend a lot on local conditions. Instead, we have looked in detail at four case studies from: India, Kazakhstan, Philippines and Latvia. These studies lead to the following conclusions:

i. In general, water treatment in pursuit of recreational benefits is not justified in developing countries. The benefits rarely exceed the costs and often fall far short of them;

ii. An exception is when the water body has special religious or cultural significance, as in the case of the Ganges. Here, an extremely ambitious project was found to be justified largely on the grounds of non-users benefits. Individuals not visiting the river and living quite far away expressed a significant WTP for the clean up on the grounds that the river held important religious values;

iii. Another exception is when the water body is a source of water supply and there are gains to be made from using it as opposed to a more expensive source. This was the case for the Nura River project in Kazakhstan;

iv. Finally, clean up may be justified when biodiversity of international significance is threatened. It is not always possible to value the protection of such natural assets in money terms, but this does not mean that a special case cannot be made for them.

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**Annex 1: WHO member states grouped by mortality strata, high mortality and low mortality (both child and adult), 1999**

| High Mortality Countries | | Low Mortality Countries | |
|---|---|---|---|
| Africa | Eastern Mediterranean | The Americas | Southeast Asia |
| Algeria | Afghanistan* | Antigua and Barbuda | Indonesia |
| Angola | Djibouti | Argentina | Sri Lanka |
| Benin | Egypt | Bahamas | Thailand |
| Burkina Faso | Iraq* | Barbados | |
| Cameroon | Morocco | Belize | Western Pacific |
| Cape Verde | Pakistan | Brazil | Cambodia |
| Chad | Somalia* | Chile | China |
| Comoros | Sudan | Colombia | Cook Islands |
| Equatorial Guinea | Yemen | Costa Rica | Fiji |
| Gabon | | Dominica | Kiribati |
| Gambia | Southeast Asia | Dominican Republic | Lao People's Democratic Republic |
| Ghana | Bangladesh | El Salvador | |
| Guinea | Bhutan | Grenada | Malaysia |
| Guinea-Bissau | India | Guyana | Marshall Islands |
| Liberia | Korea, Dem. Rep.* | Honduras | Micronesia (Federated States of) |
| Madagascar | Maldives | Jamaica | Mongolia |
| Mali | Myanmar* | Mexico | Nauru |
| Mauritania | Nepal | Panama | Niue |
| Mauritius | Timor-Leste* | Paraguay | Palau |
| Niger | | Saint Kitts and Nevis | Papua New Guinea |
| Nigeria | | Saint Lucia | Philippines |
| Sao Tome and Principe | | Saint Vincent and the Grenadines | Republic of Korea |
| Senegal | | | Samoa |
| Seychelles | | Suriname | Solomon Islands |
| Sierra Leone | | Trinidad and Tobago | Tonga |
| Togo | | Uruguay | Tuvalu |
| | | Venezuela | Vanuatu |
| The Americas | | | Viet Nam |
| Bolivia | | Eastern Mediterranean | |
| Ecuador | | Bahrain | |
| Guatemala | | Cyprus | |
| Haiti | | Iran (Islamic Republic of) | |
| Nicaragua* | | Jordan | |
| Peru | | Kuwait | |
| | | Lebanon | |
| | | Libyan Arab Jamahiriya | |
| | | Oman | |
| | | Qatar | |
| | | Saudi Arabia | |
| | | Syrian Arab Republic | |
| | | United Arab Emirates | |

Source: World Health Organization:
http://www3.who.int/whosis/member_states/member_states_stratum.cfm?path=evidence,cea,cea_regions,member_states_stratum
http://www.who.int/whr/2003/en/member_states_182-184_en.pdf

The 192 Member States of the World Health Organization have been divided into five mortality strata *on the basis of their levels of mortality in children under 5 years old (5q0) and in males 15–59 years old (45q15)*. This classification was carried out using: UN population estimates, and estimates of 5q0 and 45q15 based on WHO analyses of mortality rates for 1999. In this study, High Mortality refers to Stratum E (high adult mortality and high child mortality). Please see the provided Internet links for more details about the WHO's mortality strata.

**Annex 2: Estimating the Cost of DALYS on the Poor**

Let

$r_p$ = risks of disease to the poor
$r_r$ = risks of disease to the rich
$T$ = total number of DALYs
$T_1$ = total number of DALYs if risks for rich and poor were equal
$P$ = population that is poor
$R$ = population that is rich
$\alpha = T_1/T$ (the reduction in risk factor if the poor had the same risk as the rich)
$V_p$ = Unit value of DALY to a poor person
$VD_p$ = Total value of DALYs to the poor
$Y_p$ = Average income of the poor
**$\beta$ =** share of income of the poor that the DALY loss represents.

The relationship between the risks and the number of DALYs is given by

$$r_p P + r_r R = T$$

Suppose that the poor had the same risk as the rich, then, $r_p = r_r = \bar{r}$. The number of cases would be $\alpha T$, where

$$\bar{r}(P+R) = \alpha T$$

or

$$\bar{r} = \alpha T/(P+R)$$

and

$$r_p\ P = T - \bar{r}\,R$$

The left hand side of the last equation is simply the number of DALYs borne by the poor. The value of these DALYs is $VD_p$ where

$$VD_p = r_p P.V_p$$

And the share of their income the loss represents is **$\beta$**

$$\beta = {r_p V_p}\big/{Y_p}$$

For the estimates made in the paper, the following values have been taken

- $T$ = 34.4 million
- $P$ = 15% to 85% of total
- $R$ = 85% to 15% of total
- Total Population is taken as 1.8 billion
- $\alpha$ = 0.49 (WHO estimate)
- $V_p$ = \$548 lower bound to \$1369 upper bound
  Based on average daily income of \$1.5 per day and a value equal to annual income or 2.5 times annual income.
- $Y_p$ = \$548
  Based on an average income of \$1.5 per day for a group whose income is less that \$2 per day.

**Annex 3: Estimating the Change in DALYs as a Result of Meeting the MDGs**

Since the DALYs in the WHO tables are for both water supply and sanitation, and since the MDG targets involve different additions in the numbers provided with these services, it is necessary to estimate the change in DALYs due to each factor. To do this, the following assumptions have been made:

1. The DALYs lost due to poor water supply are between 1.5 and 3 times those from sanitation. This is based on estimates made by Shi (2000) and Larsen (2003). We take the average of these two, which gives a factor of 2.25.
2. Worldwide, the DALYs lost due to both factors are 0.0542 billion in 2000.
3. The number of people in year 2000 without adequate water supply and sanitation are 1.16 billion and 2.7 billion respectively (World Bank, 2003a).
4. As a result of the MDG target being met, the number of people who will get improved water are 131 percent of the present number without water. Likewise the number of people who will get improved sanitation are 80 percent of the present number without these facilities. Although the target requires a <u>halving</u> of the percentage without these services, the greater increases reflect the increase in population between 2000 and 2015.

The calculation is made as follows:

1. Let $\alpha$ be the number of DALYs lost per person per year from a lack of sanitation.
2. Then the total number of DALYs lost are calculated as follows:

$$0.0542 = (2.25).\ \alpha.\ (1.16) + \alpha.\ (2.70) \qquad (1)$$

**which gives a value of $\alpha$ = 0.01017.**

From equation (1) it also follows that the share of all DALYs due to lack of improved water supply are about 52 percent of the total, while those due to a lack of sanitation are about 48 percent.

Let

$X_1$ be the number of DALYs lost due to improved water supply in 2000
$X_2$ be the number of DALYs lost due to improved sanitation in 2000
$X_T$ be the total number of DALYs lost due to both factors in 2000.
$X_S$ be the total number of DALYs saved due to the MDG program by 2015

Then

$$(1.31)\bullet X_1 + (0.8) \bullet X_2 = X_S$$

Or

$$(1.31)\bullet(0.52)X_T + (0.8)\bullet(0.48)\ X_T = X_S;\ \text{or}\ (1.06537)X_T = X_S$$

The factor of 1.06637 has been used calculating the total benefits based on the present DALYs. Of this, the share of water supply is 64 percent and that of sanitation is 36 percent.