Benefits of Investing in Water and Sanitation

AN OECD PERSPECTIVE

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Foreword

An adequate and dependable source of water is needed to sustain human life, future economic development, and the integrity of ecosystems. About 884 million people lack access to safe water supplies (although the number of people without access to water in their homes is considerably higher) and 2.6 billion are without access to basic sanitation (JMP, 2010). Approximately 10% of the global burden of disease worldwide could be prevented with improvements to water, sanitation and hygiene and better water resource management worldwide. The burden of water-related diseases falls disproportionately on developing countries and particularly on children under five, with 30% of deaths of these children attributable to inadequate access to water and sanitation. Wastewater from industrial and domestic uses often reach the environment untreated or insufficiently treated, resulting in major impacts on surface waters and associated ecosystems.

Investment in water supply and sanitation services (WSS) typically generates a number of economic, environmental and social benefits. Access to clean drinking water and sanitation reduces health risks and frees-up time for education and other productive activities, as well as increasing the productivity of the labour force. Safe disposal of wastewaters helps to improve the quality of surface waters with benefits for the environment (*e.g.* functioning of ecosystems; biodiversity), as well as for other economic sectors (*e.g.* fishing, agriculture, tourism).

However, the benefits of water and sanitation remain insufficiently documented, resulting in low political priority for water issues, and most likely, in sub-optimal levels of investment in water infrastructure. Where numbers are available (*e.g.* for health benefits), their reliability is a matter of debate between experts. More generally, information about the benefits of water and sanitation are usually hidden in various technical documents, where they remain invisible to key decision-makers in Ministries of Finance and Economy.

The purpose of the present report is therefore to draw together and summarise existing information on the benefits of investing in water and sanitation services and to present this information in a format that is informative for policy makers.

The report highlights that overall benefits from investing in water and sanitation are likely to be large, but that there are wide variations depending on the type of investments made along the water and sanitation services "value chain" and the local conditions (*i.e.* depending on the existing level of development of water and sanitation infrastructure, the prevalence of water-related diseases, availability of water resources, etc). The report throws light on the relative magnitude of the benefits emerging from various types of investment in water and sanitation. This should ultimately help with identifying areas of needed investment in the water and sanitation sector and with the prioritisation and sequencing of such investments.

The readers targeted by this report are policy makers in both OECD and non-OECD countries concerned with water, environmental policy, finance and development. The Report addresses specialists, but is also intended to be accessible to non-specialist readers. With this in mind, it tries to be jargon-free and sparing in its use of technical vocabulary.

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Abbreviations and acronyms

3Ts	Tariffs, Taxes, Transfers
ACP	Africa, the Caribbean and the Pacific
BCR	Benefit-Cost Ratio
BOD	Biochemical Oxygen Demand
CBA	Cost-Benefit Analysis
CEA	Cost-Effectiveness Analysis
CVM	Contingent Valuation Method
DAC	Development Assistance Committee (OECD)
DALY	Disability-Adjusted Life Year
DFID	Department for International Development (United Kingdom)
ECAs	Export Credit Agencies
ELL	Economic Level of Leakage
EPA	United States Environmental Protection Agency
ESI	Economics of Sanitation Initiative
EU	European Union
IWRM	Integrated Water Resources Management
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JMP	Joint Monitoring Programme (WHO-UNICEF)
MDGs	Millennium Development Goals
NGO	Non-Governmental Organisation

O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
USD	United States Dollars
WFD	Water Framework Directive
WHO	World Health Organisation
WSP	Water and Sanitation Program
WSS	Water and Sanitation Services
WTP	Willingness-to-Pay

Executive Summary

Key messages

The provision of water supply, sanitation and wastewater services generates substantial benefits for public health, the economy and the environment.

Benefits from the provision of basic water supply and sanitation services such as those implied by the Millennium Development Goals are massive and far outstrip costs. Benefit-to-cost ratios have been reported to be as high as 7 to 1 for basic water and sanitation services in developing countries.

Wastewater treatment interventions can generate significant benefits for public health, the environment and for certain economic sectors such as fisheries, tourism and property markets, although these benefits may be less obvious to individuals and more difficult to assess in monetary terms.

Finally, protecting water resources from pollution and managing water supply and demand in a sustainable manner can deliver clear and sizeable benefits for both investors in the services and end water users. Investments in managing water resources are going to be increasingly needed in the context of increasing water scarcity at the global level.

The full magnitude of the benefits of water services is seldom considered for a number of reasons. Non-economic benefits that are difficult to quantify but that are of high value to the concerned individuals and society, *i.e.* non-use values, dignity, social status, cleanliness and overall well-being are frequently under-estimated. In addition, benefit values are highly location-specific (depending on the prevalence of water-related diseases or the condition of receiving water bodies, for example) and cannot be easily aggregated.

Background

An adequate and dependable source of water is needed to sustain human life, future economic development, and the integrity of ecosystems. Around 884 million people lack access to safe water supplies and 2.6 billion are without access to basic sanitation. Approximately 10% of the global burden of disease worldwide could be prevented with improvements to water, sanitation and hygiene and better water resource management worldwide. The burden of water-related diseases falls disproportionately on developing countries and particularly on children under five, with 30% of deaths of these children attributable to inadequate access to water and sanitation. Wastewater from domestic and industrial uses often reaches the environment untreated or insufficiently treated, resulting in major impacts on surface waters and associated ecosystems as well as economic activity that uses these resources.

Investment in water supply and sanitation services (WSS) typically generates a number of economic, environmental and social benefits. Access to clean drinking water and sanitation reduces health risks and frees-up time for education and other productive activities, as well as increases the productivity of the labour force. Safe disposal of wastewaters helps to improve the quality of surface waters with benefits for the environment (*e.g.* functioning of ecosystems; biodiversity), as well as for economic sectors that depend on water as a resource (*e.g.* fishing, agriculture, tourism).

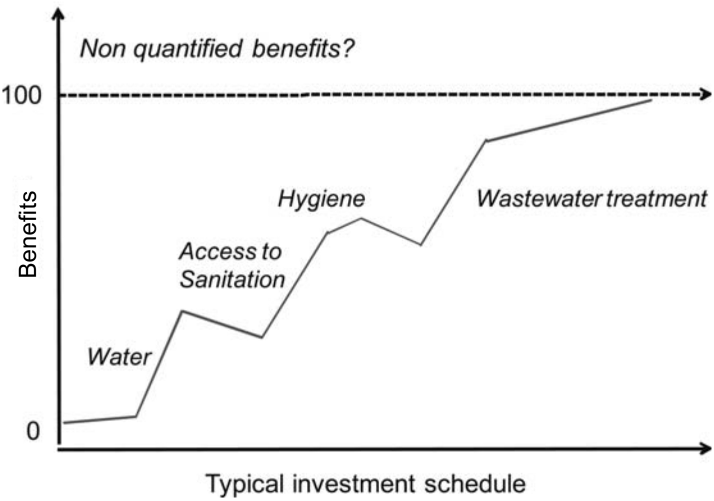
The benefits of water and sanitation remain insufficiently documented, however, resulting in low political priority for water issues and in sub-optimal levels of investment in water infrastructure. Where numbers are available (*e.g.* for health benefits), their reliability can be a matter of debate between experts. More generally, information about the benefits of water and sanitation are usually hidden in various technical documents, where they remain invisible to key decision makers in Ministries of Finance and Economy. This report draws together and summarises existing information on the benefits of investing in water and sanitation services and presents this information in a format that is informative for policy makers.

Key findings

Formulating a coherent message on the benefits of water services is difficult due to the fact that countries are at very different stages of developing their infrastructure, as shown on the WSS benefit curve in Figure 0.1. Whereas the least developed countries still need to make substantial investments in order to improve access to water, sanitation and hygiene, most developed countries are much further down the curve and are investing in wastewater treatment, usually to comply with regulations. Figure 0.1. shows a number of important points.

Firstly, whilst substantial benefits can be realised from providing access to water, sanitation and hygiene, there may also be some "disbenefits" along the way, depending on the sequencing of investments (for example, if access to water is provided without simultaneous access to sanitation). Secondly,

Figure 0.1. **The water and sanitation benefits curve**



wastewater treatment, which is usually provided last, can generate substantial benefits but those benefits are likely to tail away as there tends to be diminishing returns from further investments in improving quality. Lastly, measured benefits are usually under-estimated given that some significant benefits (such as pride and dignity with respect to access or amenity value with respect to wastewater treatment) are more difficult to quantify in monetary terms.

Benefits from access to basic water supply and sanitation

Benefits from the provision of basic water supply and sanitation services such as those implied by the Millennium Development Goals (MDGs) are massive and far outstrip costs. For example the achievement of the MDGs for water and sanitation would generate benefits of USD 84 billion per year with a benefit to cost ratio of 7 to 1. Three quarters of these benefits stem from time gains, *i.e.* time that is gained by not having to walk long distances to fetch water or to queue at the source. Most other benefits are linked to a reduction of water-borne diseases such as reduced incidence of diarrhoea, malaria or dengue fever. Almost ten per cent of the global burden of disease could be prevented through water, sanitation and hygiene interventions. Children are most affected, with 20% of disability adjusted life-years (DALYs)[1] in children under 14 attributable to inadequate water, sanitation and hygiene and 30% of deaths of children under 5.

In most OECD countries, these benefits have been reaped in the late 19th or early 20th century when basic water and sanitation infrastructure was extended to reach large parts of the population. For instance, the introduction of water chlorination and filtration in 13 major US cities during the early 20th century led to significant reductions in mortality with a calculated social rate of return of 23 to 1 and a cost per person per year saved by clean water of about USD 500 in 2003.

OECD experience shows, however, that the marginal rate of return of water and sanitation interventions diminishes with the increasing sophistication of measures. For instance, in the US experts estimate that the average cost per cancer case avoided due to tighter drinking water standards on certain pesticide and herbicide concentrations has been assessed between USD 500 million to USD 4 billion.

Benefits are probably systematically under-estimated due to a number of non-economic benefits that are difficult to quantify but that are of high value to the concerned individuals in terms of dignity, social status, cleanliness and overall well-being. A number of studies show that it is the non-health, non-economic issues that usually drive the intention to build a household latrine, such as having facilities for sick or old relatives, safety at night, convenience or because it is easier to keep the facility clean.

More broadly, adequate water and sanitation services appear to be a key driver for economic growth (including investments by firms that are reliant on sustainable water and sanitation services for their production processes and their workers). However, such links have yet to be adequately tracked and measured and are therefore not evaluated in detail in the body of the report.

Wastewater treatment

In contrast to water supply and sanitation services, the benefits of wastewater treatment are less obvious to individuals and more difficult to assess in monetary terms. The consensus on the need for increased urban wastewater treatment as well as safe disposal of its residues has therefore developed more slowly, probably also due to the relatively high costs of such interventions. In the United States, the 1972 Clean Water Act built an important legal basis for expanding wastewater treatment facilities. In Europe, the European Union Urban Waste Water Treatment Directive adopted in 1991 represented the policy response to the growing problem of untreated sewage disposed into the aquatic environment.

All benefits from wastewater treatment are linked to an improvement in water quality through the removal of different polluting substances, generating withdrawal benefits (*e.g.* for municipal water supply as well as irrigated agriculture, livestock watering and industrial processes) and in-stream benefits (benefits that arise from the water left "in the stream" such as swimming, boating, fishing). This can have a substantial impact on the economy as a whole. In South East Asia, for example, the Water and Sanitation Program estimated that due to poor sanitation, Cambodia, Indonesia, the Philippines and Vietnam lose an aggregated USD 2 billion a year in financial costs (equivalent to 0.44% of their GDP) and USD 9 billion a year in economic losses (equivalent to 2% of their combined GDP).

For instance, the health benefits of quality improvements of recreational waters in south-west Scotland have been calculated at GBP 1.3 billion per year. In the Black Sea, the degradation of water quality due to an enrichment in nutrients led to an important increase in algal mass affecting aquatic life. The mass of dead fish was estimated at around 5 million tons between 1973 and 1990, corresponding to a loss of approximately USD 2 billion.

Water quality is also an essential factor for certain tourism activities and sewage treatment leads to enhanced tourist attraction. In most countries, non-compliance with certain norms for bathing water leads to the closure of beaches and lakes for recreational purposes and therefore influences strongly the local tourism economy.

In Normandy (France), it has been estimated that closing 40% of the coastal beaches would lead to a sudden drop of 14% of all visits, corresponding to a loss of EUR 350 million per year and the potential loss of 2 000 local jobs.

Benefits for property have also been shown to be significant. People living in the surroundings of water bodies benefit from increased stream-side property values when wastewater treatment measures ensure a certain quality of water bodies. Several studies show that in proximity of areas that benefited from improved water quality, property values were found to be 11 to 18 per cent higher than properties next to water bodies with low quality.

More aggregated, economy-wide assessments of benefits of water quality improvements are very few and far between. The US Environmental Protection Agency estimates the net benefits of water pollution legislation in the last 30 years in the United States at about USD 11bn annually, or about USD 109 per household. In the UK, several studies estimating benefits and costs of measures to implement the EU Water Framework Directive have been showing a net benefit in England and Wales of USD 10 million. In the Netherlands, similar cost-benefit analyses showed that monetisable benefits were significantly less than estimated costs (but an important range of benefits could not be monetised) and that costs increase disproportionately with growing environmental ambition, suggesting decreasing marginal net benefits.

Protecting the quality of the resource and balancing supply and demand

For water services to be provided sustainably over time, it is critical to ensure that the raw material, clean water, is adequately protected and managed. This will become increasingly relevant with increasing pressures on the resource exerted by economic and demographic growth as well as the potential impacts of climate change on the water cycle.

Protecting water catchments and reducing pollution to water resources result in similar benefits to end-customers as those described from access to safe water. Protecting water resources directly at the source by limiting pollution from catchments also generates indirect benefits, such as avoided (investment and treatment) costs and can be overall more cost-effective. Increasingly, countries are recognising the benefits of managing water resources using a whole of basin or river basin approach, given that reducing pollution at the source tends to be a cheaper option than treating water before supplying it to consumers.

In order to ensure a reliable water supply there is a need to balance water supply and demand. The degree of certainty with which water is supplied is an important factor in determining the benefit that water users derive from the service and strongly influences their willingness-to-pay. Increased reliability of water supplies avoids the need for households to store water for shortage situations and therefore induces cost savings. Water reliability is also an important parameter for economic activities (industries, but also agriculture and services) which use water in their processes or as a non-substitutable input.

Using benefit values to allocate funds to the sector

There is a clear demand from policy makers for information on the benefits of investing in water resource management in general and in water and sanitation services in particular. Reliable benefit information could be used to support critical policy and investment decisions, such as:

- ***To define investment strategies and prioritise investments,*** so that funds can be better targeted where net benefits are likely to emerge for the largest group or the low-income or both.
- ***To evaluate how benefits are shared between users and inform tariff-setting policies.*** Benefits from WSS investments are not equally shared amongst users, whereas benefits from water services are usually experienced at household level, benefits from sewerage services are shared by a community as a whole. Benefit information can provide information on willingness-to-pay for given service

improvements and allows allocating additional charges to those who are explicitly benefiting from these service improvements, as they are more likely to be willing to pay for them.

- ***To formulate decisions with respect to the organisation of WSS.*** The lack of a coherent analysis on the benefits of investing across the entire value chain of WSS partly stems from a fragmented market structure for service delivery. Although Ministries are in charge of setting overall policy direction, it is usually the main utility service provider which takes investment decisions, when it may be serving only a small percentage of the population. As a result, such utility seldom considers the benefits (or the disbenefits, in the case of inadequate services) of other types of investments, such as on-site sanitation or water delivery by small-scale water service providers. Information on benefits (or on the costs of inadequate services) could support market structure reforms or better investment coordination between stakeholders in order to take account of the entire value chain of WSS.
- ***To articulate messages towards users of the service on the private and public benefits from the services.*** Some users are simply not aware of key benefits from water and sanitation. For example, the lack of understanding of the health impact of poor sanitation is often a factor of under-investment in on-site sanitation at household level. Estimating such benefits and organising media and promotion campaigns to disseminate these messages could act as a powerful driver for investment.

Note

1. The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

Introduction

Overview

This report synthesises available information about the benefits of investing in drinking water supply and sanitation services (WSS), with the goal of making this information more widely available to policy makers in both OECD and non-OECD countries.

Key policy questions explored in this report include:

- What do we know about the benefits that are generated by the delivery of WSS?
- Do current levels of investment appear to be sufficient with regard to the potential benefits?
- Should WSS receive higher priority in the allocations of public budgets than at present?

For the purpose of this study, water and sanitation services (WSS) are defined as the services provided through man-made capital for supplying drinking water and sanitation services. WSS customers may include households but also commercial and industrial users. In some cases, industrial users may invest in their own water supply or wastewater treatment capacities: this means that they are effectively providing such services to themselves.

The study examines the investments needed to ensure sustainable provision of WSS services alongside the WSS "value chain". Although providing access to water and sanitation services is usually considered a priority (as reflected by the focus on access placed via the Millennium Development Goals), adequate investments are needed both downstream and upstream from providing access in order to ensure sustainable services. The report examines whether or not it makes sense to allocate funds to the sector as a whole and which elements of the WSS "value chain" are likely to yield most benefits from investment.

Downstream from providing access, adequate investment in wastewater collection, safe storage or treatment and disposal is necessary so as to ensure that the impact of wastewater being released in the environment is adequately controlled and good quality of the water resources is maintained. This is linked to the fact that water resources are for the most part renewable resources, which can be recycled as long as they are adequately maintained and not degraded. Recycling and reuse of treated wastewater can reduce the amounts of water consumed and generate by-products that can be used for agriculture or energy production.

Investing in water resource management up-stream, so that sufficient water resources of adequate quality are available over time with limited negative impact on other alternative uses of water is also critical and will become even more so as competition for the resource rises. Balancing supply and demand can be done via protecting and augmenting water resources available for supply, but also through managing water demand (*e.g.* by investing in leakage reduction programmes or water-saving technologies at household level).

In addition, the study points to the importance of coherent investment along the value chain. Indeed, if investments are limited to providing adequate water supply and sewage collection, without proper treatment prior discharging effluent water to the aquatic environment, some of the benefits presented here may not materialise.

The study considers investments in a relatively broad manner, including infrastructure investments (the "hardware") as well as accompanying measures (the "software"). Although the report is more focused on the investments in hardware that can be made alongside the WSS value chain (such as water connections, water treatment plants, wastewater treatment plants, transport networks, etc.), the benefits of investing in the software that is necessary to get the overall sector to operate sustainably, such as to plan and implement institutional and tariff reforms, to promote demand management, to conduct hygiene education or manage ecosystems effectively also need to be taken into account, although they are usually more difficult to quantify.

For the benefits of initial investments to be sustained, investment into adequate maintenance must be carried out, in order to ensure the long-term sustainability of such assets. Indeed, WSS investment will only yield benefits if they are adequately operated, maintained and renewed. Too frequently, such investments are not adequately maintained, with close to half of manual handpumps for water abstraction being out of order in Sub-Saharan Africa for example. Evidence of deteriorating wastewater treatment standards has recently emerged in the United States which could be partly caused by insufficient investment in maintaining the assets. The investments needed in adequate maintenance are therefore also considered in this report.

The benefits of such "investments" are considered overall, without seeking to evaluate benefits from public or private investments separately. Other OECD reports have identified the potential sources of funds for the water sector, including tariffs, taxes and transfers to fill the financing gap, and market-based repayable finance to bridge the financing gap (OCDE, 2009a; OCDE, 2009b). Public budgets would typically be used only to partially fill the financing gap or as a lever to attract financial resources to the sector. Private funds would usually be allocated either to pre-finance shared infrastructure or to build private infrastructure (such as in-door plumbing, household latrines or networks used by industrial users or a group of households). The present study does not examine what the best possible combination of public and private funds would be in order to meet the costs of such investments.

The benefits from drinking water and sanitation services are by and large considered from the point of view of household customers. However, it is important to recognise that substantial benefits are also generated for other types of users, such as commercial and industrial users, with subsequent impacts on economic growth, particularly in urban and peri-urban areas. Agricultural users may also be significant beneficiaries, particularly in multi-usage schemes in rural areas.

Why is it important to assess benefits from investing in water and sanitation?

The nature of the benefits stemming from investments and the distribution of these benefits between groups of stakeholders can form the basis for allocating public funds to the sector. Public financing is particularly required where investment can have external effects over a broad range of beneficiaries, if it can reduce the risk of epidemics for example. A better understanding of benefits is therefore critical to define policies for the water sector.

There is a clear demand from policy makers for information on the benefits of investing in water resource management in general and in water and sanitation services in particular. For example, with respect to water resource management in the European context, carrying out economic analysis and gathering data on economic benefits (and costs) is clearly mentioned as an objective in the European Water Framework Directive. For the first time, data on the costs and benefits of investing in WSS in developing countries was presented to senior decision-makers within Ministries of Water and Ministries of Finance at the High-Level Meeting on water, sanitation and hygiene held in Washington, DC in April 2010.

Reliable benefit information can be used to support policy and investment decisions, such as:

- ***To define investment strategies and prioritise investments,*** so that funds can be targeted where net benefits are likely to emerge for the largest group or low-income people (or both, depending on the context and on overall priorities).
- ***To evaluate how benefits are shared between users and inform tariff-setting policies***. Benefits from WSS investments are not equally shared amongst users: whereas benefits from water services are usually experienced at household level, benefits from sewerage services are shared by a community as a whole. Benefit information can provide information on willingness-to-pay for given service improvements and allows allocating additional charges to those who are explicitly benefiting from these service improvements, as they are more likely to be willing to pay for them.
- ***To formulate decisions with respect to the organisation of WSS***. The lack of a coherent analysis on the benefits of investing across the entire value chain of WSS partly stems from a fragmented market structure for service delivery. Although Ministries are in charge of setting overall policy direction, it is usually the local authority and/or the main utility service provider which takes investment decisions, when it may be serving only a small percentage of the population (this is the case in many large cities in developing countries where the main utility provider has failed to keep up with population growth and a large proportion of the population is served by small-scale independent providers). As a result, such a utility seldom considers the benefits (or the disbenefits, in the case of inadequate services) of other types of investments, such as on-site sanitation or water delivery by small-scale water service providers. Information on benefits (or on the costs of inadequate services) could support market structure reforms or better investment coordination between stakeholders in order to take account of the entire value chain of WSS.
- ***To articulate messages towards users of the service on the private and public benefits from the services.*** Some users are simply not aware of key benefits from water and sanitation. For example, the lack of understanding of the health impact of poor sanitation is often a factor of under-investment in on-site sanitation at household level. Estimating such benefits and organising media and promotion campaigns to disseminate these messages can act as a powerful driver for investment.

There is often a disconnect between the perceived benefits from investing in WSS and the actual drivers for those investments. For example, in developing countries, investments in WSS are often justified in public health terms, when in fact the bulk of the benefits come from time gains and households themselves may be incentivised to invest through a mix of other intangible drivers, such as prestige, shame or general quality of life improvements. Conducting more systematic reviews of benefits (and costs) and understanding better actual investment drivers would allow improving the quality of decision-making.

Structure of the report

The report has six chapters, as follows:

Chapter 1 sets the stage for the rest of the report, giving some background on the size of the investment challenge for water and sanitation and identifying where benefits are likely to emerge from investment along the value chain of water and sanitation services.

Chapter 2 examines the benefits that stem from providing access to water and sanitation services, which is the main focus for attaining the Millennium Development Goals in developing countries. Where historical information is available, benefits from service extension in developed countries are also reviewed in this chapter.

Chapter 3 investigates the benefits of investing downstream in wastewater treatment and safe disposal, in order to minimise the potentially negative impacts of discharging untreated sewage in the environment.

Chapter 4 looks at the benefits of investing in water resource management so as to guarantee sustainable water supply of adequate quality and minimise the potentially negative impacts on other competing demands – including environmental – for water resources. Furthermore, it investigates the benefits of investing in measures to reduce the gap between available supply and demand. On the demand side, it focuses in priority on the benefits arising from the implementation of technical measures (such as leakage reduction, water-saving devices at household level, etc.) but also discusses measures to modify behaviour (including pricing or awareness raising campaigns).

Chapter 5 brings together these different strands of analysis in order to identify where the most significant benefits from investing in water and sanitation stem from. This forms the basis for drawing policy implications, in terms of justifying investments in WSS and prioritising investments along the WSS value chain.

Finally, ***Annex A*** outlines various methodological approaches for measuring benefits and ***Annex B*** contains a list of the key references for this report.

Chapter 1

Setting the stage

This Chapter provides some background on the size of the investment challenge for water and sanitation and identifies where benefits are likely to emerge from investment along the value chain of water and sanitation services. Potential types of benefits include health, environmental and economic benefits, as well as benefits that are more difficult to quantify, such as dignity and well-being. Annex A provides an overall methodological framework for evaluating such benefits.

1.1. Evaluating the size of the investment challenge

The needs for investment in water and sanitation are enormous and are driven by a number of factors, including the backlog due to past under-investment in the sector, population growth, changes in expectations, tightening of environmental standards and climate uncertainty. The OECD conducted an evaluation of future infrastructure investment needs up to 2030 in telecommunications, land transport, water and electricity. This initiative found that required investments in water and sanitation services dwarfed investment needs in other sectors. As reported in OECD (2006a), the average investment requirements in OECD countries and a number of other large countries (including Russia, India, China and Brazil) were projected to be around USD 780 billion per year by 2015 and USD 1 037 billion by 2025, up from a current estimated expenditure on water infrastructure of USD 576 billion annually. According to OECD (2007a), this was far higher than comparable estimates for roads (USD 160 billion per year by 2020) or electricity transmission and distribution (around USD 80 billion per year by 2025).

OECD (2006a) highlighted that there is a wide range of estimates of required annual expenditures in the water sector, however, this depends on the methods used for evaluation. The report stressed the wide variations from region to region reflecting very different levels of infrastructure coverage and economic ability (or political will) to take account of environmental pressures. The headline figures were estimated based on the review of investment needs in a number of OECD and non-OECD countries, which concluded that going forward, the levels of expenditure on water services for high income countries should be of the order of 0.75% of GDP (ranging between 0.35% and 1.2%) and could go up to 6% for some low-income countries which need to cover previous investment deficits in the sector. Finally, it noted that most estimates tend to focus on investments and ignore the need to cover the costs of operations and maintenance.

With respect to developing countries, Hutton and Bartram (2008) estimated spending required to meet the MDG target at USD 42 billion for water and USD 142 billion for sanitation, a combined annual equivalent of USD 18 billion. The cost of maintaining existing services totals an additional USD 322 billion for water supply and USD 216 billion for sanitation, a combined annual equivalent of USD 54 billion. In addition, administrative costs, incurred outside the point of delivery of interventions, of between 10% and 30% were estimated necessary for effective implementation.

Recent estimates across a large number of countries, including developed and developing countries were compiled by Lloyd Owen (2009). This report identified seven main drivers for investments in water and sanitation services in the coming two decades, including extending access to water and sanitation services to fulfil the Millennium Development Goals by 2015, addressing the challenges of population growth and urbanisation, providing industrial water and wastewater services in the context of global economic growth, meeting WHO drinking water guidelines, complying with national and international environmental standards, securing water supplies and dealing with exceptional rainfall in the context of climate change and rehabilitating existing assets. Lloyd-Owen (2009) estimated that meeting these challenges would call for around USD 2 880 billion in investments over the next two decades (or about USD 144 billion per year) in the 67 countries covered, with associated operating costs which can be twice as high as capital investment costs, as shown in Table 1.1. This report also identified a substantial financing gap, given that only USD 631 to 1 381 billion could be generated from existing sources of revenues (including tariffs), leaving a gap of between USD 1 049 to 2 297 billion.

OECD (2006a) concluded on a cautionary note, by stating that: “Although the benefits are likely to outweigh the costs, it does not follow that these projected expenditures will be realised. Indeed, if past experience is any guide, it is certain that they will not be achieved”.

Indeed, in the context of a global economic crisis and constrained public budgets, financing for water and sanitation services is often insufficient, which means that critical investments are delayed, leading to deferred benefits and higher investment costs in future. This highlights the need for re-emphasising the benefits from investing in water and sanitation services but also for identifying areas for priority investment, depending on where the

Table 1.1. **Forecast operating and capital spending in countries covered, 2010–29 (USD bn)**

	Operating costs	Capital spending (capex)			% capex by region
		Low	Medium	High	
North America	1 821	525	630	940	23%
Europe	2 133	642	838	991	28%
Developed Asia	1 018	461	550	640	19%
Latin America	796	119	164	194	5%
Rest of World	992	472	713	1 027	24%
Overall	6 760	2 213	2 880	3 792	100%

Source: Thomson Reuters in Lloyd-Owen (2009).

highest benefits are likely to stem from and where the most cost-effective interventions can be identified.

1.2 The value chain of water and sanitation services

As with any other production process, it is possible to draw out a "value chain" for water and sanitation services, starting with protecting, collecting and abstracting water (groundwater or surface water), bringing it to its point of consumption (households, industrial or institutional customers in the case of water and sanitation services) and taking it away, for treatment and safe disposal.[1] Water is an unusual good, however, as it is naturally "recycled", as shown in Box 1.1.

For water and sanitation services to be provided sustainably, a number of investments must be undertaken, operated and maintained over time at each step of the WSS value chain. Given that the natural water cycle has become affected through man-made activity, it has become much more critical to invest in securing adequate supply of water resources and treating wastewater to sufficient standards so that it can be discharged back into the environment with minimum negative impact.

The chain of investments and activities that need to take place in order to provide sustainable water and sanitation services is shown in Figure 1.3. Although the main focus is usually placed on providing access to water and sanitation services (as reflected in the Millennium Development Goals, for example), that figure shows that additional investments need to take place up-stream and down-stream of providing access in order to ensure sustainable services.

Box 1.1. **The natural and the engineered water cycles**

The ***natural water cycle*** is depicted in Figure 1.1 below. Water reaches the earth's surface as precipitation in the form of rain or snow. Some of the precipitation runs off to enter streams quickly as storm flow. Some is stored in depressions, and a significant fraction infiltrates into the ground and is stored in the soil for plant growth. Some water percolates below the plant's roots and recharges underground storage called groundwater. Stored groundwater feeds streams with a slow supply of water called baseflow. Storm flow and base flow comprise the streamflow that makes its way downstream to the nearest ocean. Transpiration from plants and evaporation from soil, water bodies, and the oceans returns water to the atmosphere and cools the earth.

The engineered water cycle is shown on Figure 1.2**.** Over the last two centuries, the natural water cycle has been modified considerably by human activity, with a dramatic impact over the water environment. Large areas of land have been built on, converted to agriculture, and significantly altered. In metropolitan areas, soils have been compacted and paved over. Large volumes of ocean and fresh water are used for cooling in power plants. Water suppliers withdraw fresh water from surface and ground sources for residential and commercial use. Wastewater is then discharged back into the environment, generally far from where the water was obtained. Water distribution systems distribute water to facilitate its use, but move the water many miles from its source. Water is also lost to the atmosphere from agricultural or lawn irrigation and evaporation.

Figure 1.1. **The natural water cycle**

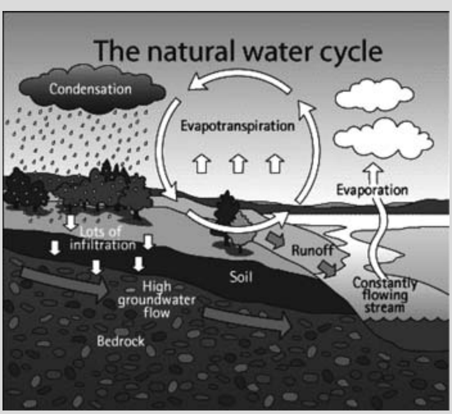
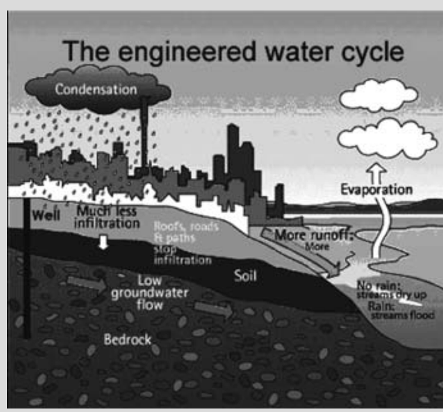


Figure 1.2. **The engineered water cycle**

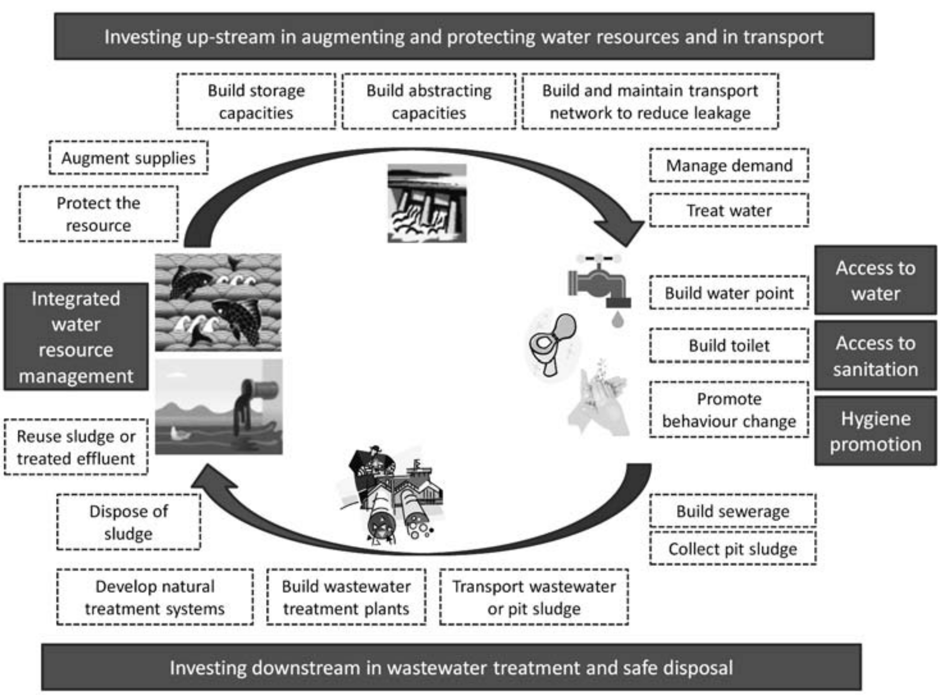


Source: Pickering, N (undated).

Up-stream from providing access, managing water resources is an integral part of providing sustainable WSS. Given that water resources have multiple uses (including for domestic consumption but also for agriculture, industry or the environment), "Integrated Water Resources Management" (IWRM) goes beyond the investments and activities that are carried out for the sole purpose of providing water and sanitation services.[2] If IWRM activities are not conducted adequately, this can affect the WSS provider through higher costs. For example, deforestation may reduce water capture and create the need to invest in additional water storage capacities.

Down-stream, dealing with stormwater and wastewater in a sustainable manner is critical to ensure health (with an emphasis placed on separating humans from their excreta) and protecting the environment. Such outcomes can be achieved in many different ways, depending on the technical solutions used. On-site sanitation solutions tend to collect and store the waste stream on the premises. The waste is isolated and stored permanently on-site when sufficient land is available or transported and treated somewhere else before being discharged into the environment. Off-site solutions take the waste away

Figure 1.1. **The value chain of sustainable water and sanitation services**



via sewerage networks and may or may not entail treatment before disposal. Although treatment reduces the negative impact on the environment, it is not always carried out. The last step consists of reusing the sludge or treated effluent for productive uses, such as agriculture or energy production.

1.3 Potential benefits along the WSS value chain: an overview

A variety of benefits can be generated from carrying out the investments and activities necessary to provide safe and sustainable services at each step of the value chain, including health, environmental, economic and intangible benefits as shown in Table 1.2.

The next four chapters present in more detail the types of investment and activities that need to be carried out to provide sustainable WSS, as well as the categories of benefits stemming from these investments. In each case, we present how the benefits are generated and any available estimates to quantify them, drawing from an extensive review of the literature on the subject (Annex B provides a full list of references). We present the results from a number of expert studies: wherever possible, the report also seeks to evaluate how such studies have been used in the policy-making process, in order to demonstrate how facts and figures can support the development of water sector policy.

Table 1.2. **Typology of benefits alongside the water and sanitation value chain**

Types of investment	Types of benefits
Chapter 2 – Providing access to safe water and sanitation	
Access to safe water near/in the home • Build water access points • Build and extend networks (water and sewers) • Build and operate water treatment plants • Provide point-of-use water treatment methods **Access to sanitation and hygiene** • Build sanitation and hygiene facilities • Promote adoption of hygienic practices **Wastewater collection and transport** • Collect wastewater via sewerage networks • Collect and transport pit sludge outside the home	**Health benefits** • Reduced incidence of diseases, especially waterborne and water-washed diseases **Economic benefits** • Time saved for productive activities • Increase in productivity • Reduced coping costs • Use of urine and faeces as economic input • Impact on tourism from improved amenity **Other benefits** • Increase in cleanliness, dignity and pride • Increased school attendance (especially for girls)

Table 1.2. **Typology of benefits alongside the water and sanitation value chain**
(continued)

Types of investment	Types of benefits
Chapter 3 – Investing downstream in wastewater treatment for safe disposal and reuse	
Wastewater treatment • Build and operate wastewater treatment plants • Rely on natural treatment processes • Safe disposal of residual sludge	**Health benefits** • Additional health benefits, such as those from improved quality of recreational waters **Environmental benefits** • Reduced eutrophication **Economic benefits** • Reduced pre-treatment costs downstream (for drinking water and industrial purposes) • Protection of commercial fish stocks and aquaculture • Enhanced tourism activities • Increased water supply for irrigation • Saving of fertilisers through use of sludge **Other benefits** • Improved amenity • Increased property values
Chapter 4 – Investing upstream in managing the supply/demand balance sustainably	
Protecting water resources • Establish catchment protection zones • Establish voluntary agreements • Establish regulations **Augmenting and ensuring supply** • Build storage capacity • Build abstraction capacity • Develop alternative sources, such as aquifer recharge, desalination, re-use of treated effluent • Adopt drought and flood management plans **Managing demand** • Reduce leakage (on the network and within customers' premises) • Introduce incentive pricing • Install water saving devices • Raise awareness, educate the public	**Environmental benefits** • Reduced pressure on available resources and improved river flows • Economic impact on use of water for economic activities (agriculture, hydropower) **Economic benefits** • Reduced in-water pre-treatment costs • Uninterrupted supply for production processes • Reduced coping costs from unreliable water supplies • Downsizing of facilities • Reduced need for desalination **Other benefits** • Increased quality of life due to reliable water supply • Indirect benefits: recreational activities on dams or reservoirs

Note: investments in Table 1.2. are presented in the order of the Chapters in this report rather than sequentially along the WSS value chain.

Methodologies for evaluating such benefits are discussed in more detail in Annex A. This Annex also points to the limitations of conducting such analysis, as summarised below:

- ***Measuring benefits from WSS investments is highly location-specific.*** On the one hand, estimates of benefit values fluctuate depending on a number of local factors, such as the prevalence of water-related diseases (for access to the services), the quality of the receiving waters (for wastewater treatment) or the level of development of existing water resources (for augmenting and protecting water supplies). On the other hand, benefit values are highly influenced by overall income levels and by other macro-economic factors, such as exchange rates, which means that transferring benefit values across countries with varying development status can be misleading (see Annex A on how the type of issues that arise with transferring benefit values).
- ***Sequencing matters.*** Because of the cyclical nature of water as a resource and the inter-linkages between various water sector interventions, there may be disbenefits along the way depending on the sequencing of investments. A common example of this is that investments in providing access to water can potentially generate disbenefits in terms of health impact if not coupled with adequate investment in removing and treating wastewater.
- ***Benefits from water and sanitation investments are not always measured in monetary terms, which can make comparisons difficult.*** Given the multi-dimensional nature of the benefits generated by investment in water and sanitation, it has not been possible so far to define a common metric for comparing benefits across different interventions (in the same way that DALYs, or Disability-Adjusted Life Years, is used to compare the effectiveness of a broad range of health interventions). Many benefit studies have not necessarily sought to monetise such benefits. When benefits have been monetised, an indicator of the scale for such benefits is often missing (a straightforward way to indicate scale would be to quote benefits as USD /beneficiary household or as USD /household in the area (even if all households do not benefit directly).
- ***Defining the appropriate discount rate is not straightforward.*** As noted by Whittington *et al.* (2009), the present value of the benefit stream is very sensitive to the discount rate chosen because of the large up-front capital costs and the unusually long economic life of the assets.[3] Given that water and sanitation are primarily seen as social investments with benefits for the wider economy and the environment, the discount rate used would need to be the discount rate used for public and social projects as defined by the Government.

- ***Potential benefits do not always materialise.*** As a result, it is important to be conservative about estimating benefits in monetary terms. For example, time released from not having to walk long distances to fetch water or wait in line at the nearest water point would not always be used productively when in fact, most methodologies would estimate the value of time based on earning potential. Similarly, although it is well established that poor water and sanitation has a significant impact on health, improving access to those services may not be sufficient to realise all health benefits as there may be other counteracting factors, such as air pollution or a lack of hygienic practices.
- ***The distribution of benefits may be as important as the size of such benefits.*** Benefits from investing in water and sanitation are not equally distributed. Whereas benefits from water services tend to accrue to the household that receives the service, benefits from sanitation would spread to the entire community and beyond. For example, installing improved latrines in an urban setting can improve general health and reduce the risk of epidemics but also boost tourism and reduce the water treatment costs. These overall economic benefits would need to be valued in order to define the most appropriate financing strategy for the initial investments. Some of these benefits would have a direct impact on public finances (through a reduction in healthcare budgets for example), whereas others may be more difficult to quantify (for example, increased dignity and pride).

Notes

1. On the wastewater side, excreta or sullage can also be stored on-site without treatment.
2. Integrated water resources management can be defined as the practice of making decisions and taking actions while considering multiple viewpoints of how water should be managed. These decisions and actions relate to situations such as river basin planning, organization of task forces, planning of new capital facilities, controlling reservoir releases, regulating floodplains, and developing new laws and regulations. The benefits stemming from these broader activities are not specifically reviewed in this report but they are considered in a companion OECD report.
3. For example, the water pipes installed by the Victorians in the late 19th century in London are being replaced only now.

Chapter 2

Providing access to services

Access to water and sanitation has contributed to major improvements in living conditions, with corresponding reductions in mortality and morbidity, historically in the developed world and presently in the developing world. Providing access is often perceived as the core function of water and sanitation services and therefore considered to be the area where most benefits materialise. Partly as a result, access to water and sanitation services is the focus of Target 3 of the Millennium Development Goals 7, set out as follows: "To halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation".[1]

Accumulating evidence has demonstrated that improving access to safe water and sanitation facilities associated with better hygiene behaviour results in significant positive health impact. In addition, access to those services can confer many additional benefits, ranging from the easily identifiable and quantifiable – such as time saved from collecting water closer to home or from defecating in a household latrine rather than in the open– to the intangible and difficult to measure – such as convenience and well-being. The latter are collectively referred to as "non-health" benefits.

In monetary terms, non-health benefits are estimated to be more significant than health benefits. This is partly due to the fact that measuring the impact of water, sanitation and hygiene interventions on health is difficult and highly location-specific. The World Health Organisation estimates that the total economic benefits stemming from achieving the sanitation MDG for the most off-track countries would amount to USD 35 billion, out of which 90% would be generated from time saved from not having to travel long distances and queue for obtaining water or defecating (Hutton and Haller, 2004).

This chapter starts by setting out the investments required to provide access to water and sanitation services, as well as associated hygiene measures (although the latter are not the focus of this report). Second, the various types of benefits resulting from these investments are reviewed, pointing to the areas of consensus as well as areas that are still debated. For example, whereas experts agree on the significant benefits stemming from providing access to water and sanitation, the issue of whether it is water quantity or water quality that matters more for health improvements is still acutely debated within the community of experts.

2.1 Types of investment

Providing sustainable access to safe water and sanitation requires investments in water and sanitation as well as associated interventions to promote hygiene.

Providing access to water and sanitation can be done in many different ways, reflecting great variations in the level of service provided. As stated by Cairncross and Valdamenis (2006), "what constitutes a perfectly acceptable water supply to some consumers leaves others considering themselves unserved: in much of rural Africa, a hand pump 500m from the household is a luxury, but most residents in urban Latin America would expect a minimum of a house connection".

To some extent, each of these services can be "self-provided". People can collect water themselves, through digging a well, going to the nearby river or harvesting rainwater. They can also dig a hole at the back of their garden for defecating, which they can move periodically when it fills up. However, such "self-provision" is mostly available to those in rural areas that are relatively water-rich or where availability of land is not a constraint. With an overall increase in population, accelerating urbanisation and mounting pressure on water resources, the provision of dedicated services (with their associated investment and operating costs) is going to be more and more necessary.

Access to water refers to the supply of water for domestic purposes (thereby excluding its provision for irrigation or livestock). Access can either be provided in the community via a well or a handpump or via a reticulated network system. When water is provided via a network, this can be done via a household connection (within the house or in the yard) or a public connection, referred to as standpipes or tap stands. Investments required can range from digging a well and maintaining it in good working order to building water transport and distribution networks with associated water treatment facilities.[2]

To ensure that water is provided to the right standard (defined based on WHO guidelines on drinking water quality), water treatment is necessary to remove suspended solids, bacteria, algae, viruses, fungi, minerals and man-made chemical pollutants including fertilisers. Treatment is usually carried out off-site at the point of source, although it may also be required at point-of-use (*i.e.* at household level), as water may be contaminated during transport or storage. Examples of water treatment technologies include filtration, chlorination, flocculation, solar disinfection, boiling and pasteurising.

Sanitation is defined by the JMP as the "methods for the safe and sustainable management of human excreta, including the collection, storage, treatment and disposal of faeces and urine".[3] This definition excludes other environmental health interventions such as solid waste management and surface water drainage. There are two main types of facilities for collecting human excreta: on-site sanitation systems (such as dry-pit latrines, ventilated improved pit latrines or pour-flush latrines) and network-based sanitation solutions, with or without treatment of the sewage collected. On-site sanitation solutions are often built and managed by households themselves, with some limited support from governments. Policies that consist of using public funds to build latrines have often failed when they had neglected to generate demand for the facilities.[4]

Hygiene promotion is a key intervention to ensure that access to water and sanitation services can deliver benefits. They include provision of hand washing points, hygiene and health education and the encouragement of specific behaviors such as hand washing at critical times, keeping animals out of the kitchen, proper management of child excreta and proper storage of household drinking water. If such activities are not properly conducted, sanitation facilities may end up not being used and public money wasted.

Different service levels can be offered for each of these services and activities. The choice of interventions is usually driven by local factors, including the socio-economic context and availability of options. The Joint Monitoring Programme (JMP), which is run jointly by WHO and UNICEF, gathers comparable information that is used for comparing data on access to water and sanitation services in developing countries.[5] The JMP distinguishes between "improved" and "unimproved" sanitation solutions. An improved drinking-water source is protected from outside contamination, in particular from faecal matter, and includes piped water into dwelling plot or yard, public tap/standpipe, tubewell/borehole, protected dug well, protected spring and rainwater. An improved sanitation facility is defined as a facility constructed in such a way that it hygienically separates human excreta from human contact. It includes flush/pour-flush facilities to piped sewer system, septic tank or pit latrine, ventilated improved pit latrine, pit latrine with slab and composting toilets. According to the JMP, all other options are "unimproved", which means that they would not deliver the anticipated benefits, are costly or not sustainable (such as bottled water or water delivered by tanker trucks). As a result, these solutions would not be counted when measuring progress with meeting the MDGs in JMP statistics.

The JMP definitions have been criticised as they sometimes do not reflect the realities of access on the ground. For example, in slums where space, land tenure and affordability are significant constraints, shared or public latrines may be the only level of service that can be provided.

According to the JMP, these solutions are not improved even though well-managed paying toilet blocks can offer a very good service at an affordable cost (the "Sulabh toilets" in India, for example, provide a good example of well-managed and hygienic public latrines).[6] The JMP is in the process of revising those definitions, partly in response to such criticisms.

Although, in theory, access to water and sanitation services should be provided in conjunction in order to deliver maximum benefits, this is by no means the case in practice given that such services are often provided by different service providers. This is partly due to the fact that water and sanitation services are not always provided by the same entity, typically with sanitation services being the responsibility of local governments with little financing available to actually provide such services. If water services are provided without corresponding sanitation and adequate drainage, this can generate disbenefits as more dirty water becomes available in a compound with no outlet for this water, resulting in pools of dirty water lying about.

2.2 Health benefits from improving access to services

2.2.1 How do health benefits materialise: the links between water, sanitation and health

Inadequate water, sanitation and hygiene (WASH) are known to cause a large number of preventable diseases, examples of which are discussed below. These diseases are typically classified in four categories, including: waterborne (the pathogen is ingested by drinking water, such as diarrhoea), water-washed (*i.e.* due to inadequate hygiene practices, such as trachoma), water-based (referring to transmission by means of an aquatic invertebrate, such as schistosomiasis) and water-related insect vector routes (when an insect vector breeds in or near to water, such as for malaria or dengue fever).[7]

Diarrhoea itself is a symptom that can be associated with a variety of diseases, including cholera, typhoid or dysentery. Diarrhoea is caused mainly by the ingestion of pathogens, especially in unsafe drinking water, in contaminated food or from unclean hands. Inadequate sanitation and insufficient hygiene promote transmission of these pathogens. A typical water-washed disease is trachoma, a contagious eye disease that can lead to blindness. It results from water scarcity and is spread, especially among young children, by flies, fingers and clothing coming into contact with infected eyes, spreading the infection to other people's eyes. Trachoma can be reduced by facial cleanliness, access to safe water and adequate sanitation facilities.

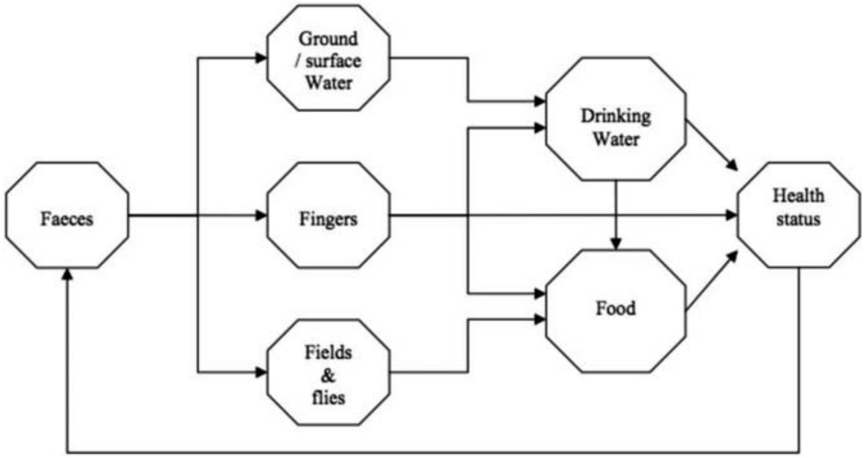
Additional water-related diseases are caused by helminths (worms), which are parasites that lay eggs under the skin. Such diseases emerge after drinking contaminated water or having been in contact with soil contaminated with faeces. They are entirely preventable by adequate sanitation, and the outcomes of sanitation interventions are reinforced by good hygiene. The transmission of malaria by mosquitoes can be interrupted by reducing vector habitats, which requires eliminating stagnant water bodies, modifying the contour of reservoirs, introducing drainage and improving the management of irrigation schemes. Many respiratory diseases can be associated with poor sanitation, including more recent disease such as SARS, although research is still ongoing on this. Finally, childhood malnutrition can be linked to repeated episodes of diarrhoea which can affect a child's ability to retain nutrients.

Although most of these diseases have been eliminated in developed countries, other problems may occur due to cryptosporidia, endocrine descriptors, heavy metals and pollution from persistent organic compounds.

Isolating the respective impacts of water, sanitation and hygiene on health can be difficult, as these risk factors comprise a number of interrelated pathways. As discussed by Prüss *et al.* (2002), pathogens can be transmitted through *(i)* poor quality drinking water (which causes diseases from faecal-oral pathogens or diseases from toxic chemicals, such as arsenic); *(ii)* the lack of water linked to inadequate personal hygiene (causing diseases such as trachoma), *(iii)* poor personal, domestic or agricultural hygiene (with the use of contaminated water for irrigation and cleaning, causing person-to-person transmission of faecal-oral pathogens or food-borne transmission of faecal-oral pathogens); and *(iv)* contact with water through bathing containing organisms such as schistosoma and vectors proliferating in water reservoirs or other stagnant water (which can cause malaria or lymphatic filariasis). Water, sanitation and hygiene interventions can provide barriers to transmission from the environment to the human body as they can stop transmission through fingers, food, flies and fluid collectively referred to as the four "Fs"). Figure 2.1 shows how pathogens and contaminants contained in faeces and drinking water can affect health status.

Inadequate water, sanitation and hygiene can have long-lasting impacts beyond specific cases of illness, particularly on children. As stated in Hutton *et al.* (2008), the downward cycle linked to poor sanitation starts from an early age: "early childhood infections contribute to malnutrition, poor rate of child growth, later childhood diseases, lower energy/activity levels, poorer schooling outcomes, and lower work productivity". The World Bank (2008) provides a comprehensive analysis of the impact of environmental factors on child health and highlights the critical importance of adequate water and

Figure 2.1. **Potential transmission routes for faecal-oral contamination**



Source: Waddington *et al.*, 2009. Arrows represent transmission routes for pathogens.

sanitation to improve the likelihood of child survival. It notes that out of the 2 million premature child deaths every year, a vast majority can be attributed to inadequate water and sanitation provision.

Although each of these interventions generate distinct benefits, such benefits can be difficult to measure independently for a number of reasons. WASH interventions are often carried out in conjunction and, as a result, there is no attempt to measure the results of these different interventions independently from each other. In addition, health benefits from water and sanitation interventions are relatively difficult to measure in a scientifically robust manner, although a number of recent methodological developments have developed ways of dealing with these issues. As Cairncross and Valdmanis (2006) indicate, "it is almost impossible, ethically and politically, to randomise the intervention. For example, when the intervention is an improvement in the level of access to water, it cannot be blinded, there is no placebo for a standpost".

As a result, according to Garandeau (2009), modern evaluation techniques, such as Randomised Controlled Trials, which are increasingly used to support policy-making in health or education, have not been used to the same degree to evaluate WASH interventions so far. According to Peterson Zwane and Kremer (2007), whereas there is a growing body of evidence to demonstrate the impact of handwashing or point of use water treatment, evidence is scarcer for community water supply or latrines. For example, they state that randomised impact evaluations of point-of-use water treatment systems (disinfection of water in the home, for example) suggest that these technologies can reduce diarrhea incidence some 20–30 percent.[8]

2.2.2 Evaluating the health impact of water, sanitation and hygiene interventions

In developed countries, access to WASH has allowed significant improvements in public health over the years. The sanitary revolution gained momentum in Europe and the USA towards the end of the 19th century, driven by public health concerns over infectious diseases such as cholera, typhoid, yellow fever and reactions to filth and poverty in rapidly growing cities. Efforts reflected local government initiatives with construction of city sewers and the enforcement of numerous sanitary regulations (Jenkins *et al.*, 2009). Such "revolution" was partly driven by misconstrued ideas about disease transmission, given that the "odours" or miasmas were initially thought to be a vector of disease themselves. As a result, it is only when the "stench" near the Houses of Parliament[9] became unbearable that the British Parliament adopted legislation and allocated necessary funding to remediate the fact that the Thames had been turned into an open sewer during the Victorian era.[10] The hygiene revolution was a much more gradual and long-winded process, reflecting difficulties in changing personal behaviours.

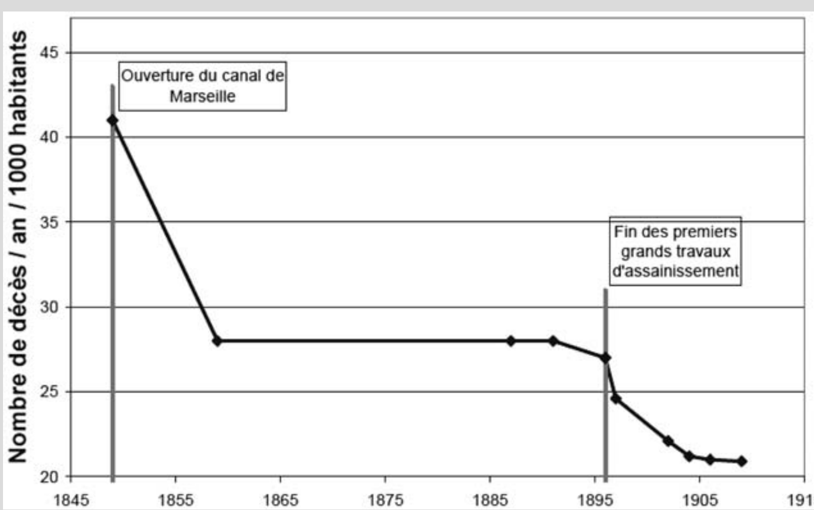
Such investments and public health campaigns led to substantial reductions in mortality rates. This has been well-documented in the case of Marseilles in the South of France (see Box 2.1). Similarly, a study by Cutler and Miller (2005) examined the impact of introducing drinking water chlorination and filtration in 13 major American cities during the early 20th century. They showed that these interventions led to large reductions in mortality, with a social rate of return on investment of 23 to 1 and a cost per person-year saved by clean water of about USD 500 in 2003.

Following these advances, diseases related to poor water and sanitation are no longer a significant cause of mortality or morbidity in developed countries, except in the case of a few isolated disease outbreaks linked to problems in water or wastewater treatment plants (see Box 3.1.). Access to water and sanitation services is now almost universal in developed countries except in deprived areas, where access is limited or affordability concerns limit consumption volumes. There are also issues of declining reliability of water supplies in regions of the world that had previously enjoyed good standards, such as in the ex-Soviet Union for example. Declining standards may be a reflection of a lack of investment in adequate maintenance, amongst other factors.

By contrast, in the developing world, diseases associated with poor water and sanitation have considerable public health significance. In 2002, the World Health Organisation (WHO) published the first scientifically substantiated estimate of the global burden of disease related to WASH[11] as a risk factor and has continued to develop the evidence base for policy and good practice since then. At the time, the World Health Report 2002 estimated that achieving the millennium goal of “halving by the year 2015 the proportion of people who are unable to reach or to afford safe drinking water” would yield a gain of approximately 30 million DALYs worldwide. Achieving universal access (evaluated at 98% coverage) of improved water supply and basic sanitation plus disinfection at point of use would result in an additional 553 million DALYs.

Box 2.1. **Falling mortality rates following water and sanitation investments in Marseille (France)**

In Marseille (France), water supply was a significant constraint on the city’s growth during the early nineteenth century. A catastrophic drought in 1834 meant that water availability dropped from 75 litres per capita per day to 1 litre per capita per day and triggered a cholera epidemic. This in turn led to the construction of a canal to bring water, which allowed augmenting water supply to 370 litres a day after its completion in 1848. Increased water availability helped bring down mortality significantly, although it remained at much higher levels than in other French cities at the time (28 deaths/1000 inhabitants as opposed to 9/1000 in Paris at the same time). Higher water supply also meant more dirty water lying about: it is not until ambitious sewerage works were completed and households were connected to the sewers that mortality rates dropped significantly. Although attributing causality is always a perilous exercise, the Figure below shows a clear correlation between a reduction in mortality and the timing of water and sanitation investments.



Source: AESN (2007).

More recently, Prüss-Üstün *et al.* (2008) concluded that 9.1% of the global burden of disease worldwide, leading to an estimated 3.6 million lives and 136 million DALYs lost per year, could be prevented by improvements related to drinking water, sanitation and hygiene. This figure is higher than previously quoted figures as it includes all water and sanitation related diseases as well as the lasting impact on children, via malnutrition and being underweight (which causes 35% of all deaths of children under 5 years old worldwide). For example, Prüss *et al.* (2002) had reported that 4% of the global burden of disease and 1.6 million deaths per year were attributable to poor water and sanitation. Yet, Prüss-Üstün *et al.* (2008) emphasise that this figure may still be an underestimate as the links between WASH and health are more extensive and complex than the more direct causes of pathogens: the role of inadequate water for food for instance is likely to be important as is the impact of unquantifiable infectious diseases (such as respiratory infections related to hygiene, injuries related to recreational water use or adverse effects due to high concentrations of certain chemicals).

Children suffer a disproportionate share of this burden, as the fraction of total deaths or DALYs attributable to unsafe water inadequate sanitation or insufficient hygiene is more than 20% in children up to 14 years old (Prüss-Üstün *et al.*, 2008). This percentage goes up to nearly 30% deaths of children under 5 years old (WaterAid, 2009). Given the relationship identified by demographers between a decline in a country's infant mortality and the population rate of growth,[12] investing in water and sanitation could therefore act as significant driver for reducing population pressures worldwide, with associated indirect benefits on reducing competition for natural resources and curbing climate change.

Although the range of results is wide, overall estimates drawn from existing studies suggest that water, sanitation and hygiene play an important role in reducing the prevalence of such diseases. A large number of studies have been conducted that seek to measure the impact of water, sanitation and hygiene on health. Most of these studies have focused on the impact on diarrheal diseases, as they are the most prevalent and comparatively easier to track. The results of these studies have been combined in a number of "meta-analysis", which seek to draw "median" values for the estimates (see for example, Esrey *et al.*, 1991; Fewtrell *et al.*, 2005). These results are generally in line with those of other reviews (Esrey *et al.*, 1991; Prüss *et al.*, 2002; Curtis and Cairncross, 2003; Cairncross and Valdmanis, 2006 and Haller *et al.*, 2007), with some key differences, as shown in Table 2.1. The most recent study was conducted by Waddington in 2009 and seeks to synthesise and update all previous studies in this area.

Health benefits from improved access to water supply are lower than for sanitation and hygiene but vary substantially depending on the level of

Table 2.1. **Impact of WASH on diarrhoea: results of comparative reviews and surveys**

Study authors	Study scope	Study conclusions
Esrey *et al.* (1991)	Survey of 144 studies. Calculate the median percentage reductions in diarrhoea morbidity across studies of water supply, water quality, sanitation and hygiene interventions.	• Water supply: -27% in diarrhoea morbidity. • Sanitation: -22% in diarrhoea morbidity. • Hygiene: -33% • Water quality (treatment at source): -17%
Prüss *et al.* (2002).	For estimating the disease burden from infectious diarrhea, exposure scenarios were established based on the state of water supply and sanitation infrastructure (according to the Global Water and Sanitation Assessment 2000[13]), the level of faecal-oral pathogens in the environment and populations assigned to these scenarios. They calculate risk transition between the scenarios based on the literature, including Mead *et al.* (1999), Esrey (1996), Quick *et al.* (1999)	Refers to Esrey *et al.* (1996): • Water supply: -21% in diarrheal diseases • Sanitation: -37.5% in diarrheal diseases • Water supply & sanitation: -37.5% • POU disinfection: -45% in total population and -55% for children (Quick et al) • Hand washing: -35% (Huttly) The study also points out that no existing study attempts to measure the benefits of continuous water supply versus intermittent supply.
Fewtrell *et al.* (2005)	Meta-analysis of 60 studies on impacts of water quality and hygiene	Hygiene education and water quality interventions (POU treatment) reduce diarrhoea risk by 40% each, while sanitation provision and water supply reduce the risk by only 20%.
Waddington (2009)	Meta-analysis of 71 studies (assessing 130 000 children in 35 countries)	• Hygiene interventions lead to an estimate 31% reduction in child diarrhoea morbidity. • Sanitation hardware interventions are as effective as hygiene software and water quality, leading to a 37 per cent relative reduction in diarrhoea morbidity.

service provided. In particular, health experts have been debating on whether it is water quantity or quality that matters most in terms of driving health benefits.

Increased water quantity is a critical factor for the adoption of hygienic practices. Cairncross and Valdmanis (2006) estimate that most of the benefits from water supply are attributable to improved convenience of access to water in terms of quantity. In their evaluation, they differentiate between access via a household connection (with a 63% impact on diarrhoea) and access via a public source (with only a 17% impact). This supports their argument that the impact of water provision is highly dependent on the distance between the house and the water point, as this determines the total amount of water that can be used: they estimate that acquiring a household connection (in the house or in the yard) can double or even triple the volume of water consumed, from an average of 20 litres per capita per day to 60 litres. Water quantity is indeed critical for hygiene, as individuals are more likely to wash their hands at critical time if water is plentiful and accessible. Cairncross and Feachem (1993) showed that water consumption almost triples when house connections are provided and there are strong reasons to believe that much of the additional consumption is used for hygiene purposes.

Other experts argue that water quality is a critical determinant driving health benefits. Waddington (2009)[14] points out that while water supply interventions appear ineffective – averaging a negligible and insignificant impact on diarrhoea morbidity compared to controls – water quality interventions on average lead to a 42% relative reduction in child diarrhoea morbidity (with a 95% confidence interval). Prüss *et al.* (2002) states that point-of-use (POU) treatment solutions can significantly improve the impact of water supply interventions, with an estimated 45% reduction in diarrhoea rates. Such authors argue that treatment at point of use is more efficient than treatment at the point of source (via a community water treatment plant, for example) given that there are many opportunities for treated water to become unsafe alongside the transportation process (Waddington, 2009; Wright *et al.*, 2004). Clasen *et al.* (2006) and Fewtrell *et al.* (2005) confirmed this finding, as they found that household water-quality interventions can reduce diarrhoea morbidity by more than 40 percent in both rural and urban settings. These interventions can include ceramic water purifiers, SODIS, sand biofilters, etc. An example of efficient water treatment interventions at household level is described in Box 2.2.

The problem of arsenic in Bangladesh is also an emblematic example of the necessity of water treatment (WaterAid, 2003).[15] In the 1990s, an alarming discovery confirmed widespread arsenic contamination in groundwater, which provides drinking water to 97% of the population of the country. Only certain areas are affected by high arsenic levels, but tens of thousands of people have already been showing skin discoloration and other more serious manifestation of chronic poisoning, including neurologic, vascular and carcinogenic effects.

However, while point-of-use water quality interventions appear to be highly effective (IEG, 2008), some experts argue that widespread promotion of household water treatments is still premature given the uncertainty about their sustainability (Waddington, 2009; Schmidt and Cairncross, 2008). Water quality interventions conducted over longer periods tend to show smaller effectiveness, while impact appears to fall markedly over time. For example, Cairncross points out that it may be cheaper to invest in treatment facilities at source rather than to conduct social marketing of POU treatment facilities.[16]

Box 2.2. **Reaching the poor ("bottom of the pyramid") with Safe Water Systems**

The World Health Organisation (WHO), UNICEF, and others have a strong commitment to the MDGs, and to supporting incremental improvements in water supplies via alternative approaches targeting the provision of safe drinking water among vulnerable populations. Among those alternatives are decentralised safe water models, including point-of-use (POU) treatment. An estimated 3 billion people lack consistent household access to clean and safe piped water, and could benefit from these solutions through health impacts or reductions in coping costs, such as the costs of boiling water used for drinking (JMP, 2008). However, despite growing international attention to the need for improving water quality, investments in adequate safe-water products and services in developing countries remain low and mostly concern middle and upper income markets. Suppliers have few obvious incentives to target poor customers (or Base of the Pyramid (BOP) markets), which are usually considered to be riskier and more challenging. In report published in 2009, the International Finance Corporation identified a number of challenges for expanding coverage of safe-water technologies, including the lack of awareness about water-quality issues, the lack of sustainable financing and the need to understand the target population behavioural attitudes.

Pioneering work by the Centers for Disease Control and Prevention (CDC) has responded to these challenges with a simple low-cost approach to prevent waterborne diseases at household level. The Safe Water Systems incorporate three elements: *(i)* point-of-use water treatment by consumers with a locally manufactured dilute sodium hypochlorite solution; *(ii)* safe storage of treated water in containers designed to prevent recontamination and *(iii)* behavioural change techniques, including social marketing, community mobilisation, motivational interviewing, communication and education to improve water and food handling, sanitation and hygiene practices in the home and in the community. Along the way, program delivery shifted almost entirely from governments and NGOs to a single social-marketing organisation, Population Services International.

According to CDC, no single approach has been more extensively tested and none has been distributed at the same scale, despite some resistance in uptake due to objections to taste and smell. In 2007, more than 7.6 million bottles of SWS product – enough to treat 7.8 billion litres of drinking water and supply 10.6 million users – were sold for routine (non-emergency, non-outbreak) use in 20 countries. Nearly 60 percent of these sales were in just three countries, Zambia, Madagascar, and Malawi, which means that these countries have achieved scale in terms of coverage for household water treatment and safe storage. In a series of published randomised intervention trials conducted by CDC in three continents, the Safe Water Systems have shown to reduce the diarrheal disease incidence by 25-84%, with an average of 50%.

Source: IFC (2009) and *www.cdc.gov/safewater.*

Estimating the impact of providing access to sanitation is complicated by the fact that there are significant externalities attached to sanitation. Whereas unsafe or insufficient water affects primarily the individuals concerned, inadequate sanitation can have significant external effects through the spread of epidemics. It is only if the entire community adopts sanitation simultaneously (as opposed to individual households adopting) that full health benefits can materialise and that the spread of epidemics (such as cholera) can be stopped. As a result, it is often assumed that significant reductions in the prevalence of diarrhoea can only be achieved when an entire community gains access to sanitation rather than isolated individuals. This observation underlies community-led approaches to sanitation, such as the Community-Led Total Sanitation (CLTS) campaigns, which rely on eliminating open-defecation in a particular area.[17] Barreto *et al.* conducted the first comprehensive study that strived to analyse the impact of a city-wide sanitation program on reduction in rate of childhood diarrhoea in northeast Brazil (see Box 2.3).

Box 2.3. **Effect of a city-wide sanitation programme on reduction of childhood diarrhoea in northeast Brazil**

Study context. The study was developed in the context of a city-wide programme (*Bahia Azul*) to increase sanitation coverage. When the programme started in 1995, only 26% of the population of Salvador (2.5 million inhabitants) was connected to the sewerage system. When the program officially ended in 2004, coverage had increased to 70% and it has since risen to almost 90% in the city itself. The programme included laying 2 000 km of sewer pipes, building 86 pumping stations and connecting more than 300 000 households to the sewerage network over 8 years. In addition, 1% of the budget was spent on public education campaigns to promote sewerage connections.

Overview of the epidemiological study. A monitoring study was conducted by the Institute of Collective Health of the Federal University of Bahia to assess the impact of the intervention. The aim of the Barreto study was to investigate the epidemiological effect of the sanitation programme throughout the city on diarrhoea morbidity in children less than three years old. The investigation was composed of two studies, including one before the sanitation programme was launched and another after the intervention had been completed. The pre-intervention study was based on a sample of 841 children aged 0 to 36 months that were randomly selected to represent a range of environmental conditions. The post-intervention study took into account 1 007 children from the same areas. Each study was based on household interviews by trained fieldworkers and on environmental surveys that assessed the basic neighbourhood and household sanitation conditions. Daily diarrhoea data were obtained during home visits twice per week over a maximum of 8 months. The effect of the intervention was estimated by a hierarchical modelling approach fitting a sequence of multivariate regression models.

Box 2.3. **Effect of a city-wide sanitation programme on reduction of childhood diarrhoea in northeast Brazil** *(continued)*

Results. After adjustment for baseline sewerage coverage and other confounding variables (such as education and type of housing), it was found that diarrhoea prevalence fell on average by 22% (from 9.2 days per child-year before the intervention to 7.3 afterwards) and by 42% in areas with high prevalence of diarrhoea prior to the intervention. Most of this reduction was explained by the increased coverage of the sewerage system that has been constructed during the intervention. The intervention had an even bigger impact on other diseases, According Shankland *et al.,* however, "although the publication of the study findings in respected Brazilian and international medical journals significantly enhanced the credibility of the claims for positive health impacts made by the Bahia state government, the study came too late to influence the political and policy debate during the programme".

Sources: Barreto *et al.* (2007), Shankland *et al.* (forthcoming).

Although there is no consensus over which intervention is the most effective to reduce diarrheal diseases, experts seem to agree on the importance of hygiene interventions and behaviour change. Hygiene interventions act by reducing contamination of hands, food, and water, and seem to be highly effective: a systematic review of the effect of hand washing with soap has shown that this simple measure is associated with a reduction of 43% in diarrheal disease (Curtis and Cairncross, 2003). However, the effectiveness of such interventions particularly depends on sustained behaviour change (van der Knapp, 2006; Waddington, 2009).

The impact of each intervention is likely to vary widely according to local circumstances, including the prevalence of diseases in the particular location, and the scale of intervention. Prioritising should therefore be based on local conditions and evidence from implementation rather than from pooled data (WHO, 2008). Besides, interventions cannot be seen as independent events, as potential disbenefits may emerge from investing in one area without commensurate investment in the other. For example, inadequate water quality at the point of consumption may undermine the benefits from water supply improvement (Fewtrell, 2005), and sanitation facilities without hygiene promotion may end up not being used (Trémolet *et al.*, 2010). However, a few studies show that multiple interventions do not necessarily bolster the impact on health. For instance, Fewtrell *et al.* (2005) show that providing both improved water supply and basic sanitation facilities does not yield greater impact on reduction of diarrhoeal diseases than sanitation alone (32% for sanitation only vs. 33% for a combined intervention). Independent Evaluation Group (2008) suggest that "while complementary interventions are not necessary to have a positive impact, they may be necessary for those benefits to be sustained".

Different service levels may have varying benefits (and costs). For rational decision-making, it is crucial to carry out a sound economic evaluation of the various options available (Haller *et al.*, 2007). For water supply, several reviews (Esrey *et al.*, 1991; Emerson *et al.*, 2000; Cairncross and Valdmanis, 2006) have shown that the level of service is likely to have an effect on diarrheal diseases, *i.e.* that an increased quantity of water available at household level leads to a substantial decrease of water and sanitation related diseases, mostly by contributing to hygiene behaviour change. Whether the different types of latrines might confer different health benefits is less clear. Some simple latrines can be very effective, whilst sewage captured via sewers and released untreated in the environment can spread pathogens and be the source of disease.

2.2.3 Evaluating health benefits in monetary terms

Health benefits from water, sanitation and hygiene interventions are significant in value terms, although they are not high enough to justify the investments in and of themselves. The costs of treating diarrhoeal diseases drain both national budgets and family finances on medicines or lost earnings due to the incapacity to work. Minimising the prevalence of such diseases therefore frees up resources for other development objectives. Hutton and Haller (2004) estimate that the direct benefits of avoiding diarrhoeal diseases include: *(i)* the costs saved in health care related to the reduced number of treatments of diarrhoeal cases, which is between USD 10 and USD 23 per case of diarrhoea treated; and *(ii)* the costs of non-health nature, such as transport costs to the health facility, opportunity costs (time that could have been spent more productively), estimated at USD 0.50-USD 2 per patient visit. Finally, particularly severe cases of diarrhoea or epidemics such as cholera can be a cause of premature deaths, particularly for children under 5 years old. Valuing the impact on reduced mortality requires attributing a value to human life saved or death avoided. This raises important methodological issues, as discussed in Annex A. Additional figures by Bartram for Sub-Saharan Africa show that treating preventable infectious diarrhoea consumes 12% of the total health budget (Bartram, 2008). At global level, WHO estimate the amount of health-care savings from improved water and sanitation of USD 7 billion a year for health agencies and USD 340 million for individuals (Hutton and Haller, 2004).

Avoided health costs alone do not provide a sufficient justification for improving water and sanitation if compared with the costs. An empirical study by Whittington *et al.* (2009) estimates that the avoided cost of illness would amount to USD 1 per month per household, which is much less than the costs of improved water and sanitation services as estimated by Pattanayak *et al.* (2005),[18] *i.e.* approximately USD 4 per month. Other, non-health benefits must therefore be taken into consideration to account for the full benefits stemming from improved access to water and sanitation.

2.3 Non-health benefits

Non-health benefits include both economic benefits (such as time saving or productivity increases) and additional social benefits such as enhanced dignity and well-being. Although the latter are more difficult to quantify given that they are more intangible and qualitative in nature, they would often act as powerful determinants of the demand for services, over and above the potential health benefits that can be extracted (Hutton and Haller, 2004).

2.3.1 Economic benefits

Health benefits appear relatively marginal when put in a framework evaluating the overall economic benefits from providing access to water and sanitation. Hutton and Haller (2004) estimated the overall benefits that would stem from attaining the Millennium Development Goals targets with respect to water and sanitation, as shown in Table 2.2. Overall, they estimated that reaching the targets would generate a total payback of USD 84 billion per year, to be compared with an estimated USD 11.3 billion per year investment needed to meet the targets. In other words, each USD 1 invested in drinking water and sanitation would yield a potential economic return of USD 7.4.

Table 2.2. **Overall benefits from meeting the MDGs for water and sanitation**

Type of benefits	Breakdown	Monetised benefits (in USD)
Time savings from improved water and sanitation services	• 20 billion working days a year	USD 63 billion a year
Productivity savings	• 320 million productive days gained in the 15-59 age group • 272 million school attendance days a year • 1.5 billion healthy days for children under 5	USD 9.9 billion a year
Health-care savings		• USD 7 billion a year for health agencies • USD 340 million for individuals
Value of deaths averted, based on discounted future earnings		USD 3.6 billion a year
Total benefits		**USD 84 billion a year**

Source: Prüss-Üstün *et al.* (2008), based on an evaluation by Hutton and Haller (2004).

As shown in Table 2.3, the bulk of economic benefits come from time-savings associated with improved access to water and sanitation. Benefits from time savings (as opposed to time saved associated with illness) are substantial, even though they are rarely factored into project impact evaluations (Hutton *et al*., 2006; IEG, 2008; Pattanayak *et al*., 2007). Time savings can translate into increased production, improved education levels or more leisure time.

Time saved through improved water supply stems from the time gained from not collecting water from far away and/or queuing at the source or from improved reliability of supplies. Intermittent supplies can cause considerable inconvenience. For example, in the Kathmandu valley where water is available for only a few hours every couple of days at low pressure, users have to wake up in the middle of the night to manually pump water out of the system. It can also lead to serious reductions in the quality of water distributed by causing polluted groundwater to enter leaking pipe systems.

There are wide variations for time saving estimates quoted in the literature, driven by various assumptions made about the different methods of delivery, the mix of rural/urban locations and the dearth of data on time savings in the literature. For example, Hutton and Haller (2004) assumed that, on average, a household gaining access to improved water supply would save 30 minutes per day (within a range of 15 to 60 minutes) and households receiving piped water would save 90 minutes per day (within a range of 60 to 120 minutes). Time savings are usually valued at the minimum wage (with GNP per capita used as the low value) and could justify investing in improved water supply in and of itself. However, one difficulty with monetising time savings is that all the time that is made available from improved access to water and sanitation may not be used for productive purposes, either because of unemployment or under-employment or an increase in leisure time or household duties. Monetising the value of time based on wage estimates is therefore likely to lead to an over-estimate.

Cairncross and Valdmanis (2006) used another method to evaluate money spent on water collection. They observe that households often pay others to collect their water or pay to collect water from a nearby source rather than from a more distant, but free source. In a survey of 12 sites in 10 countries, Zaroff and Okun (1984) found that households were spending a median of over 20 percent of their income on the purchase of water from vendors.

Time saved from improved sanitation is linked to the fact that people without a toilet in their house spend a great deal of time each day queuing for public toilets or seeking secluded spots to defecate. In a recent study to calculate the benefits of sanitation investments, the World Health Organisation made a conservative estimate of 30 minutes per person per day, amounting to 21 unproductive hours a week for a household of six people. Improved sanitation would give every such household an additional 1 000 hours a year to work, study, care for children, engage in collective efforts, and rest. Hutton and Haller (2004) estimated the economic value of these time savings at well over USD 100 billion per year. A WSSCC report (2006) describes the potential for women's income generation that sanitation can bring through significant time savings: in Tanzania, women devoted time saved from improved sanitation to economic activities such as working in shops and tea rooms, and selling what they produce.

Hutton *et al.* (2007a) estimated that the benefits of attaining the sanitation MDG in off-track countries confirmed the importance of time savings as a key driver for economic benefits. This study found that sanitation investments in such countries had an even higher benefit/cost ratio, with USD 9 of benefits for USD 1 invested (total economic benefit estimates for achieving the MDG were estimated at USD 35 billion per year and the annual costs at USD 3.8 billion. The breakdown of those benefits is shown in Table 2.3.

Table 2.3. **Benefits from attaining sanitation MDGs in off-track countries**

Health-related benefits (1.8%)	Health sector benefits due to avoided illness (1.6%) Patient expenses due to avoided illness (0.2%)
Non-health benefits (98.1%)	Time savings due to access to improved sanitation (90%) Deaths averted (5%) Other benefits (3.1%) • Productive work days gained through avoided illness (older than 15) • Days of school attendance through avoided illness (5-15 years old) • Days of life gained for a baby through avoided illness (0-4 years old)

Source: Hutton *et al.* (2007a).

Investments in sanitation can yield substantial economic benefits as set out below.

Increased school attendance. The condition or absence of latrines in schools contributes in part to a student's decision to enrol, to attend or to drop out, especially for menstruating girls and children affected with diarrhoeal diseases. The reduction in diarrhoea from meeting the sanitation MDG target would add more than 200 million days of school attendance per year (see Table 2.3), which in turn would mean higher rates of female literacy. According to UNICEF, in a typical developing country, each 1% increase in female secondary schooling results in a 0.3% increase in economic growth (Bartram, 2008). Besides, there is a significant negative effect of soil-transmitted helminths (*i.e.* worms) on education, by affecting learning and cognitive development among children (Bhargava *et al.*, 2005). The spread of such worms can be stopped through avoiding contact with human excreta.

Improved productivity. Many workplaces also lack adequate sanitation facilities, affecting time use, productivity, and employment decisions, especially of women. A myriad of workdays are lost to diarrhoeal diseases – days lost or where productivity is reduced when the worker is ill as well as when she or he is caring for a sick child. When work places have no toilets, women may lose workdays during menstruation. Meeting the sanitation MDG target would add more than three billion working days a year worldwide and universal coverage would add more than four times as many (Hutton and Haller, 2004).

Boosted tourism revenue. Tourism is an important source of income, employment and foreign currency in many developing countries, accounting for 10% of global GDP and almost 9% of total global employment (Bartram, 2008). Few studies have examined the link between tourism and sanitation conditions, although the popularity of tourist destinations is partially related to a country's sanitary conditions. A WSP-led study (Hutton *et al.*, 2008) sought to evaluate the impact of sanitation on the economy of five South-East Asian countries, including Cambodia, Lao PDR, Vietnam, Indonesia and the Philippines (see Box 6.1). This study estimated that in all countries, poor sanitation accounts for 5 to 10% of tourism losses.

Environmental benefits. One of the key drivers for sanitation adoption among end users is the improvement in their local environment (Cairncross, 1999). It is fairly obvious that the absence of open defecation can greatly enhance the local environment. This in turn can attract business to the region and benefit the local economy.

Economic benefits from reusing faeces and urine. Both faeces and urine can be used as potent fertilisers for agriculture, as well as biogas. The supporters of ecological sanitation (EcoSan) have developed different solutions for allowing such reuse, such as the twin-pit urine-diverting latrines (which separate urine from faeces in order to facilitate excreta reuse and promote recycling of nutrients) or the Arborloo. The latter are constructed with simple, often unlined pits. When the latrine is full, the superstructure is moved and the site of the pit is used to plant a crop-bearing tree so as to make use, at least in part, of the nutrients available in the pit waste. EcoSan can sometimes save water and can potentially increase crop yields (Manandhar *et al.*, 2004), as was the case in China and Malawi. A recent study led by WSP evaluated the financial and economic benefits of ecological sanitation in Sub-Saharan Africa.[19] The study found that the benefits from crop production could offset the higher capital and operating costs but that these benefits were not sufficiently high to cover additional software costs to implement EcoSan, which implies that these solutions are not ready or economical to be scaled up as yet.

Biogas plants can also be built to use animal and human waste to produce a colourless clean gas similar to liquefied petroleum gas (LPG), which can be used for cooking and lighting with virtually smoke-free combustion. A study by Winrock International evaluated an integrated household-level biogas, latrine and hygiene education programme in Sub-Saharan Africa and found that the programme's economic rate of return was 178%, with a 7.5% financial rate of return.[20]

2.3.2 Substantial additional benefits may be more difficult to quantify

Improved water and sanitation generate a number of non-economic benefits that may be difficult to quantify but that are of very high value to the concerned individuals, in terms of dignity, social status, cleanliness and overall well-being.

Hutton *et al.* (2008) quoted the results of a WSP study that surveyed the perceived importance of an improved latrine to households in rural and urban areas of Cambodia. Among the sampled households, more than 80% of urban and 70% of rural households recognised an improved latrine would provide better hygiene and a generally clean living environment. Comfort, health improvement, safety, convenience, privacy, improved family status and prestige were cited as other advantages of having an improved latrine at home.

For women and girls, a private sanitary latrine with running water is particularly important, and has considerable impact on their quality of life. There can be physical dangers for women of using distant toilets or open spaces, especially at night. Also, menstruation may impact on bodily discomfort in class or at work, cause anxiety, affect concentration and productivity and cause girls to miss classes and women to miss work. Cultural and religious constraints in Muslim cultures particularly make menstruation a taboo (Water Aid/UNICEF, 2005).

Vulnerable groups tend to be more affected by poor sanitation, due to frailty (senior or disabled people) or dangers (*e.g.* children) of poorly functioning latrines and open defecation. Besides, sanitation-related diseases also impact quality of life, causing pain, discomfort, reduced capacity to socialise and undertake normal activities, and grief, all of which are hard to value in monetary terms. All these motivations are often quoted as important factors for people's willingness-to-pay for improved services and should not be underestimated as trigger of demand (Pearson *et al.*, 2007).

Work carried out by Jenkins *et al.* (2007) in rural Benin showed that it is the non-health issues that usually drive the desire for a household latrine, such as having facilities for sick or old relatives, to offer safety at night, for convenience and because it is easier to keep the facility clean. It would therefore be essential to take account of the non-health benefits of sanitation in order to successfully design and implement sanitation programs.

Notes

1. See *www.un.org/millenniumgoals/environ.shtml.*
2. Investments in obtaining access to the resource in a sustainable manner are reviewed in Chapter 3.
3. Joint Monitoring Program on progress towards achieving the water and sanitation Millennium Development Goals.
4. Trémolet, S. *et al.* (2010).
5. Countries usually have their own methodologies for tracking access to water and sanitation services, which can result in discrepancies between national statistics and JMP data. As a result, JMP figures are not always accepter at national level.
6. SDC (2004).
7. See Cairncross, S. and V. Valdmanis (2006).
8. Large research programs with funding from the Bill and Melinda Gates Foundation have recently been initiated in order to evaluate the benefits of a range of water and sanitation interventions in a more rigorous manner.
9. The building where British parliamentary life takes place, which sits right on the Thames.
10. See Black, M. and B. Fawcett (2008).
11. Prüss *et al.*, 2002.
12. Such relationships can be explained in causality terms, as parents with old-age security concerns tend to have more children when the latter have a higher risk of dying young. See Eswaran, M. (2006).
13. The assessment is a synthesis of major international surveys and national census reports covering 89% of the global population. The parameters included access to improve water sources and improved sanitation facilities. Here, the six scenarios are associated with different faecal-oral pathogen loads in the environment, influencing the risk of contracting faecal-oral infections.
14. This is a meta-analysis based on 71 interventions in 35 countries across Africa, Asia and Latin America.
15. The full report on arsenic contamination and mitigation measures, including arsenic removal technologies can be found on-line at the WaterAid website under "Research and campaigns" and the Arsenic Crisis Information Centre site (*http://bicn.com/acic/*).
16. Personal communication with Professor Sandy Cairncross, LSHTM, 7 December 2009.

17. See *www.communityledtotalsanitation.org/page/about-site* and Trémolet *et al.*, 2010.
18. Pattanayak, S. *et al.* (2005).
19. See Schuen, R. *et al.* (2009).
20. Renwick, M. *et al.* (2007).

Chapter 3

Investing downstream in wastewater treatment and safe disposal

Providing safe access to water and sanitation generates significant benefits, as shown in Chapter 2. However, discharging untreated wastewater into the environment can affect users downstream (including population settlements, industry, agriculture etc.) and cause environmental damages. Collecting and treating wastewater and stormwater is required to ensure the long-term availability of water in a convenient quality for human use and environmental demands.[1] Despite its importance, it appears that investments in wastewater treatment are often below the required levels to generate sustained benefits.

In contrast to water supply and sanitation services, the benefits of wastewater treatment are less obvious to individuals (Wolff, 2003). The consensus on the need for increased urban wastewater treatment as well as safe disposal of its residues has therefore developed slowly (Rodriguez, 2009), probably also due to the relatively high costs of the proposed technologies (Jouravlev, 2004). In the United States, the 1972 Clean Water Act (CWA) built an important legal basis for expanding wastewater treatment facilities. In Europe, the European Union (EU) Urban Waste Water Treatment Directive (UWWTD) adopted in 1991 represented the policy response to the growing problem of untreated sewage disposed into the aquatic environment. The latter sets minimum standards for the collection, treatment and disposal of wastewater while considering the size of the discharge and the type and sensitivity of the receiving waters (Crouzet *et al.*, 1999). Despite these policy initiatives, the US still need major investments in wastewater treatment, to increase coverage and to maintain the performance of existing facilities. For example, the rating attributed to wastewater infrastructure by the US American Society of Civil Engineers (ASCE) had fallen from D+ in 1998 to D- by 2009, reflecting chronic under-investment.[2]

Wastewater treatment coverage is still limited in most parts of the world. In Latin America and the Caribbean, for example, it was estimated that only 13.7% of wastewaters discharged by the 241 million people connected to the sewerage network received some degree of treatment in 2004 (Jouravlev, 2004). This situation is common in many other developing countries, with even much lower levels of wastewater treatment or none at all: in Dar Es Salaam (Tanzania), for example, it is estimated that only 3% of wastewater is treated before being discharged into surface waters and the nearby sea.[3] The People's Republic of China has been investing massively in recent years to increase wastewater treatment coverage, going from 52% of wastewaters treated with secondary and tertiary treatment in 2005 to an estimated 60-65% in 2011 and projected to reach 70 to 80% in 2016.[4] In the following sections, the different types of wastewater treatment investments as well as technologies to safely dispose of the residual sludge are briefly described, before setting out the benefits of both in more detail.

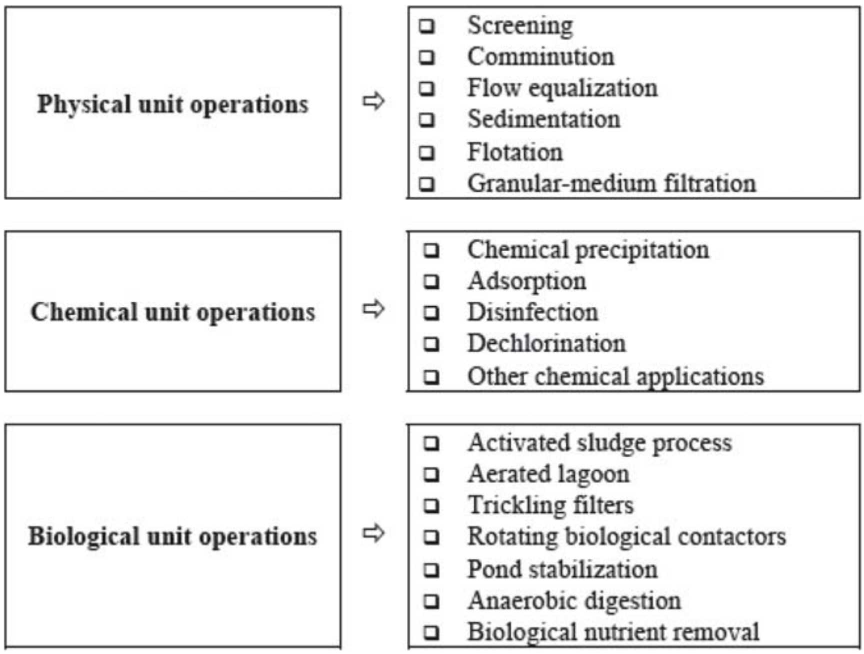
3.1 Investments in wastewater treatment

Untreated urban wastewater usually shows high content levels of organic material, various pathogenic micro-organisms, as well as nutrients and toxic compounds. The characteristics of sewage can be defined using physical, chemical and biological parameters (UN, 2003). Common indicators to describe the organic content of wastewater include for example the biochemical oxygen demand (BOD) which is a measure of the oxygen used for sewage decomposition (and which implies a reduction in the availability of oxygen for aquatic life) (Wilson, 2000). Furthermore, inorganic chemical parameters (*e.g.* concentrations of nitrates, phosphates or salinity) as well as bacteriological parameters can be used. However, all constituents and concentrations can vary with time and local conditions (UN, 2003). More or less complex treatment processes are applied to remove the different polluting substances from the water.

Depending on the level of treatment provided by the wastewater treatment plants, contaminants are removed through physical, chemical and biological processes (see Figure 3.1). The individual processes are grouped together in a variety of configurations for producing different levels of treatment. Based on this, wastewater treatment plants can be classified based on whether they provide preliminary, primary, secondary, tertiary and/or advanced treatment (UN, 2003).

Preliminary treatment removes bigger objects in order to prepare water for the actual treatment process. In the primary treatment process, mainly physical operations are used to remove a first part of the pollutants. Secondary treatment eliminates soluble organics and suspended solids with

Figure 3.1. **Wastewater treatment operations and processes**



Source: United Nations (2003).

biological processes. In a last step, tertiary or advanced wastewater treatment removes significant amounts of nitrogen, phosphorus, heavy metals, bacteria and viruses, beyond the level of conventional secondary treatment (United Nations, 2003 or Wilson, 2000).

Comprehensive handling of wastewater does not stop with the treatment process alone, but has to ensure the safe disposal of residual sludge. As the residue of the wastewater treatment process, sewage sludge is rich in organic material, but potentially includes also hazardous substances like heavy metals, bacteria, viruses and different types of chemicals. Poor sewage sludge management practices can therefore result in risks to human health, water, air, soil quality and biodiversity. Different treatment processes affecting sludge composition can be applied prior to its disposal or recycling and thus reduce risks. The potential impact of sewage sludge depends furthermore on the way it is used afterwards. Whereas it is usually applied to agricultural land, some countries (*e.g.* UK) use increasing amounts in the forestry sector, and in former opencast coal sites for the purpose of land restoration (Ayres *et al.*, 2008).

In addition, natural systems can provide wastewater treatment services. In particular, those systems include land treatment and constructed wetlands (UN, 2003; EPA, 2000), of which the self-purification capacity reduces pollution. Reed *et al.* (1988, in: UN, 2003) emphasises that they can be the most cost-effective option in terms of construction and operation, in cases where sufficient suitable land is available. Constructed wetlands are often well suited for small communities and rural areas. For municipal and industrial wastewater, land treatment consists predominantly in the controlled application of wastewater to vegetated land. Natural treatment processes occur either when the water percolates through the soil profile or when it flows down a network of vegetated sloping terraces. Constructed wetlands, on the other hand, dispose of vegetation that "provides surfaces for the attachment of bacteria films, aids in the filtration and absorption of waste-water constituents, transfers oxygen into the water column, and controls the growth of algae by restricting the penetration of sunlight" (UN, 2003).

Wetland services can also be linked to a wastewater treatment plant. If so, they are particularly effective in taking over tertiary treatment processes. Kazmierczak (2000) mentions for example the importance of coastal wetlands for the mitigation of degraded water flowing south through the coastal Louisiana and the Northern Gulf of Mexico.

3.2 Benefits from wastewater treatment

Discharging untreated wastewater into the environment has manifold effects which depend on the types and concentrations of pollutants and the receiving environment (UN, 2003). To the same extent, the benefits of treating wastewater vary. Table 3.1 lists important contaminants in wastewater, their potential effects on receiving waters and treatment needs.

All benefits from wastewater treatment are linked to an improvement in water quality through the removal of different polluting substances. Different ways of classifying water quality benefits can be found in the literature (see also Atkins & Burdon, 2006). Dumas and Schuhmann (2004) are falling back on Feenberg & Mills (1980) when differentiating predominantly between withdrawal benefits and in-stream benefits. Whereas the former includes municipal water supply and domestic use benefits as well as benefits linked to irrigated agriculture, livestock watering and industrial processes, in-stream benefits arise from the water left "in the stream". The latter can furthermore be differentiated between use benefits (*e.g.* swimming, boating, fishing, but also stream-side trail hikers) and non-use benefits of water quality (including option value, bequest value and existence value).[5]

In the following paragraphs, the different types of benefits are presented, differentiating between: *(1)* health benefits; *(2)* environmental benefits;

(3) benefits for economic sectors; and *(4)* other benefits (*e.g.* recreational or aesthetic benefits as well as the impact on land and property values).

Quantifying benefits resulting from wastewater treatment is a challenging task. Firstly, the literature usually aggregates benefits from water quality improvements resulting from wastewater treatment plants and from other measures, such as enhanced agricultural practices. In a study undertaken by the US Environmental Protection Agency (Bingham *et al.*, 2000) the benefits of the water pollution control legislation in the last 30 years have been estimated to about USD 11 billion annually (about USD 109 per household). Those benefits include the impacts of the use of wastewater treatment plants; however, they cannot be singled out. Thus, it is rarely possible to assess the marginal benefits of wastewater treatment. Secondly, whereas improvements in water quality can take place continuously, this is not directly translated into continuously increasing non-use benefits. The water quality amelioration has to exceed a certain threshold (*e.g.* disappearance of unpleasant odours) before it can be recognised and valued by citizens. Furthermore, some improvements in water quality might not be perceived at all by individuals (*e.g.* linked to changes in dissolved oxygen content).

Table 3.1. **Main contaminants in wastewater and impact on receiving waters**

Contaminants	Effects on receiving waters and treatment needs
Suspended solids	Can lead to development of sludge deposits and anaerobic conditions when untreated wastewater is discharged to the environment.
Biodegradable organics	Are principally made up of proteins, carbohydrates and fats. They are commonly measured in terms of BOD and COD. If discharged into inland rivers, streams or lakes, their biological stabilisation can deplete natural oxygen resources and cause septic conditions that are detrimental to aquatic species.
Pathogenic organisms	Can cause infectious diseases.
Priority pollutants (including organic and inorganic compounds)	May be highly toxic and/or provoke cancer, cause genetic damage or malformations.
Refractory organics	Tend to resist conventional wastewater treatment including surfactants, phenols and agricultural pesticides.
Heavy metals	Usually added by commercial and industrial activities. Must be removed when wastewater is reused.
Dissolved inorganic constituents	Such as calcium, sodium and sulphate, which are often initially added to domestic water supplies, and may have to be removed for wastewater reuse.

Source: Adapted from Metcalf and Eddy, Inc., *Wastewater Engineering*, 3rd edition; in United Nations (2003).

Hence, the estimation of benefits arising from wastewater treatment is often biased, given that "the existence of a positive willingness to pay for water quality improvement depends upon the ability of people to perceive water quality changes when such changes do in fact occur" (Rodriguez, 2009; see also Poulos *et al.*, 2006). Thirdly, current valuation studies estimate willingness-to-pay (WTP) for a given improvement in water quality. However, it is difficult to estimate a general relationship between a reduction in pollutants and a change in water quality since this highly depends on the receiving aquatic environment (Howarth *et al.*, 2001). It has also to be taken into account that an aggregation of values stemming from WTP studies for water improvement is not possible, as they are depending on the availability of substitutes. The quantified results can therefore not be applied to all water bodies at the same time (Howarth *et al.* 2001).

3.2.1 Health benefits

Treating wastewater before discharging it into the environment delivers health benefits to those connected to receiving waters further downstream. This applies in particular to those which withdraw water for consumption without prior pre-treatment. While benefits from safe access to drinking water have been discussed in Chapter 2, additional health benefits resulting from wastewater treatment are presented here. Box 3.1 illustrates the potential negative impacts of malfunctioning treatment plants.

Box 3.1. **Epidemics in France due to malfunctioning treatment plants**

In the last 30 years, several episodes of epidemics have been linked to problems of sanitation and to poor operation and maintenance of sewage systems (*e.g.* leaks, connection problems or contamination of seafood through effluents insufficiently treated). Between 1974 and 1979, for example, about 15 epidemics were reported in France. As an illustration, strong rains on the 14th, 15th and 16th of November 2002 led to an epidemic of gastroenteritis in four local communities in the Isère Region connected to the same water network. The capacity of the wastewater treatment plant had been exceeded so non-treated effluent was discharged directly into the river, upstream of a drinking water abstraction zone. The drinking water protection zone was flooded and the drinking water network contaminated by parasites coming from the river. As a result, 300 cases of gastroenteritis (or nearly 10% of the total population) had to be treated in the four local communities in the days following the flood event.

Source: Beaudeau 2006, in AESN (2007).

In the OECD report on the "Costs of inaction of selected environmental policy challenges" (OECD, 2008) health benefits of reducing water pollution linked to recreational activities are presented. The results of some of those studies are presented in Table 3.2.

Table 3.2. **Valuation of health benefits of quality improvements of recreational waters**

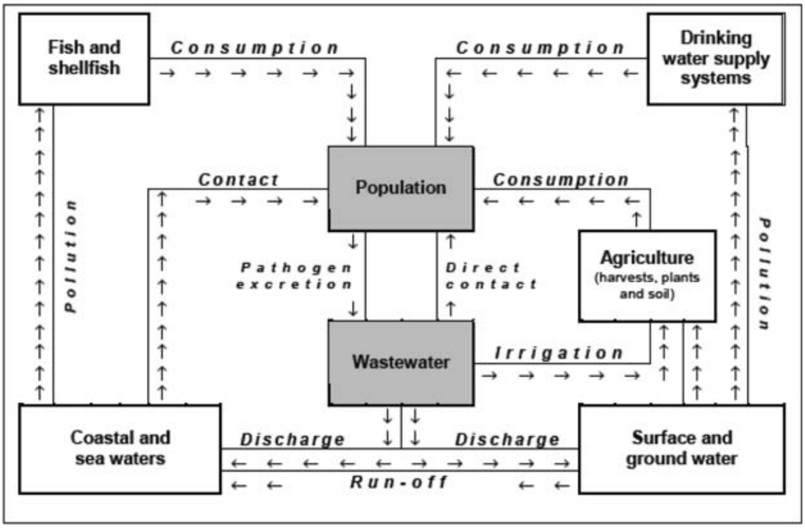
Scenario assessed	Studies	Benefits of Policy Intervention/ Costs of Inaction
Health benefits of quality improvement of recreational waters in south-west Scotland (UK)	Hanley *et al.* (2003)	GBP 1.3 million per year
Health benefits of improving the quality of recreational waters in Brest harbour (France)	Le Goffe (1995)	EUR 33.23 per household per year
Improving the quality of recreational waters in the UK	Georgiou *et al.* (2005)	25% reduction of illness: GBP 11.9 billion/100% reduction: GBP 22.8 billion for a 25-years period
Improving the quality of recreational waters in the Netherlands	Brouwer and Bronda (2005)	EUR 2.4 billion for a 20-year period

Source: OECD (2008): selected examples.

Untreated wastewater can affect human health via different pathways not limited to drinking water consumption. Figure 3.2 illustrates the possible forms of human exposure to pollution caused by wastewater discharges. Jouravlev (2004) summarises health risks of untreated wastewater discharges to the following exposure mechanisms: *(i)* consumption of untreated water; *(ii)* consumption of foods produced with contaminated irrigation water or from livestock farms that use such water; *(iii)* direct physical contact in recreational, bathing or work activities; and *(iv)* the fact that wastewaters are an ideal breeding ground for flies and mosquitoes, which when coming into contact with utensils, food or persons who live or work in areas close to the river, can contaminate them with pathogenic micro-organisms.

Furthermore, adequate management techniques of sewage sludge disposal can provide health benefits linked to reducing the pollutant content in the sludge. This concerns different types of exposures to sewage sludge, including employees in sewage works, recreational users of areas where sewage has been applied or crops grown on land fertilised with sewage sludge (Ayres *et al.*, 2008).

Figure 3.2. **Main forms of human exposure to pollution caused by wastewater discharges**



Source: adapted from Bosch *et al.*, 2000, in: Jouravlev, 2004.

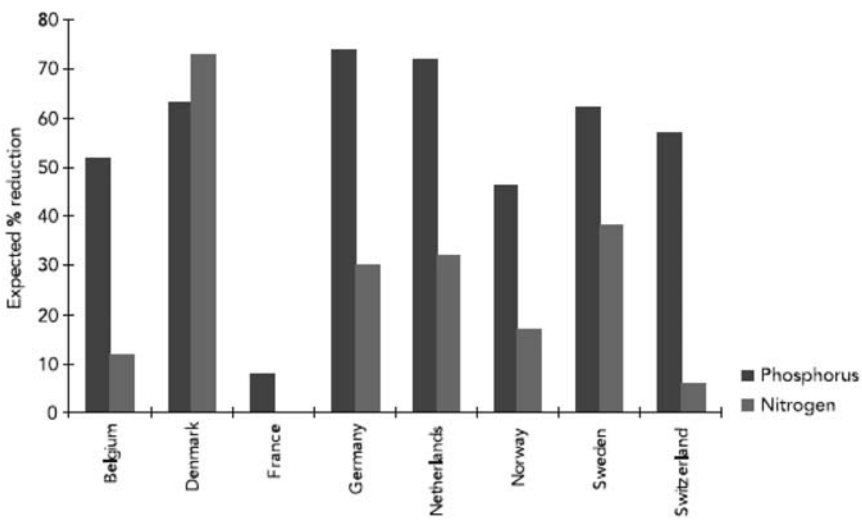
3.2.2 Environmental benefits

In Europe, natural waters were long supposed to be self-purifying, independent of the load of nutrients they receive. As a consequence, very large quantities of nutrients – phosphorous and nitrogen in particular – were released into rivers and lakes through untreated wastewater discharges. This contributed to a significant reduction in nutrient-poor surface water bodies and related flora and fauna (Crouzet *et al.*, 1999).

One important benefit of treating wastewater before discharging it to the environment is that the amount of nutrients is significantly reduced and that eutrophication, with all its negative impacts, can be avoided (AESN, 2007; Howarth *et al.*, 2001). Increased amounts of nutrients released into water bodies can lead to eutrophication. This involves the development of phytoplankton (algal bloom) with a significant impact on the aquatic environment. In particular, related fluctuations in the oxygen concentration can lead to the disappearance of fauna (*e.g.* certain fish species) and flora (AESN, 2007; Howarth *et al.*, 2001). A surplus of nutrients provokes rigorous changes in the aquatic ecosystems and is generally accompanied by a significant reduction in biodiversity (Crouzet *et al.*, 1999).

This requires a given treatment level as pre-condition, however. The first European wastewater treatment plants were concentrating on the removal of organic matter. Additional biological treatment and precipitation mechanisms that effectively remove phosphorous from wastewater were built in Europe only over the last 40 years and treatment plants with corresponding processes for nitrogen removal have been constructed over the last 25 years. Hence, the environmental degradation which took place in Europe up to the 1970s was turned to improvement during the 1980s and 1990s, mainly as a result of improved urban wastewater treatment. Figure 3.3 shows the estimated reduction of nitrogen and phosphorous from municipal treatment plants between 1985 and 1995 in different countries (Crouzet *et al.*, 1999).

Figure 3.3. **Estimated reduction of nitrogen and phosphorous**
from municipal treatment plants between 1985-1995



Source: OSPAR 1995, in Crouzet *et al.*, 1999.

For the environment, not only nutrient reduction, but also the amount of suspended solids discharged into water bodies is important. If they are in large quantities, suspended solids can prevent sunlight reaching underwater plant life. This affects aquatic growth and productivity and can result in food shortages for other living organisms (Wilson, 2000). Furthermore, the aquatic environment can be affected by stream sedimentation[6] or toxic chemicals related to untreated wastewater. This can equally lead to reductions in aquatic species populations or in diversity and negatively influences stewardship, altruistic, bequest and existence values given to the specific ecosystem (Dumas & Schuhmann, 2004).

A positive impact on the ecology of the aquatic environment can therefore be assigned to wastewater treatment.[7] In Paris, for example, additional efforts to increase the wastewater treatment capacity from 1997 to 2000 had clear impacts on water quality. Analyses made since 2000 showed good or very good water quality in 80% of the cases. Furthermore, a considerable improvement of the ecological quality and the fish fauna was recorded (AESN, 2007).

Many studies worldwide have sought to translate environmental benefits into monetary values. Atkins and Burdon (2006) found that people in the Århus County (Denmark) were willing to pay € 12.02 (USD 16.39) per month and per person over a 10 year period for improving the water quality of the Randers Fjord by reducing eutrophication.

General income levels clearly affect willingness-to-pay, however. Ready *et al.* (1998) found in a contingent valuation study widespread support for improvement of river quality through investments in sewage treatment among Latvian residents. The stated willingness-to-pay was limited to 0.13 Lats per month (0.26 USD), representing a 7% percent increase on the current tariff level. Birol *et al.* (2009) investigated the WTP of the population in the Chandemagore Municipality, India, for an improved wastewater treatment of discharges to the river Ganga. Their study revealed an average willingness-to-pay of Rs 16.46 (USD 0.35) per month per household (equivalent to USD 4.25 per year) for additional municipal taxes spent on improving wastewater treatment (volumes treated and treatment level) and reducing environmental and health risks related to polluting discharges to the river Ganga.[8]

3.2.3 Benefits for the economy

Wastewater treatment provides not only health and environmental benefits, but also influences the quality of water resources available for different economic sectors downstream in the same river basin (Jouravlev, 2004). The benefits of wastewater treatment for different economic sectors and activities requiring good water quality are described below.

Benefits for the water supply sector

Wastewater treatment results in lower pre-treatment costs for downstream users. The quality of the water resources determines the possibility to use it for producing drinking water (AESN, 2007). In densely populated river basins, the wastewater discharge point for one urban centre is often located just a few kilometres upstream of the water intake area of another city, so that the time the pollutants remain in the environment before the water is used again is not enough for sufficient natural decomposition and dispersion processes. The content of organic material, chemicals and other pollutants leads to higher pre-treatment costs for drinking water. If no pre-treatment takes place, damages to public health can occur as well as higher costs for supply from more distant sources or from rationing (Jouravlev, 2004). Some additional costs have been quantified for the Sebou basin, in the region of Fès, Morocco (see Box 3.2).

Box 3.2. **Water quality degradation in the Sebou river basin (Morocco)**

Water quality in the Sebou basin (Morocco) has been considerably affected by local industry growth, the development of the agricultural sector, progressive urbanisation and the lack of control over the discharges from these different sectors. A net degradation has been observed on the major part of the watercourse, including at the drinking water abstraction point. Water quality in the Sebou river basin drops in particular during the period in which olive mills are working, as they generate an important pollution charge. In addition to the costs from additional treatment needs, the olive mills also cause a seasonal doubling in energy prices. As a consequence, the institution in charge of the drinking water production in the region (ONEP) has serious problems producing drinking water with a satisfying quality at an acceptable price.

For example, in the city of Fès, water is sold for 1.76 dirham/m^3 (about USD 0.21). According to ONEP, the additional costs for water production reach 6 dirhams/m^3 (USD 0.73), representing 340% of the selling price. Due to the seasonality of the phenomenon (olive mills operate mainly from November to February), the influence of the olive mills resulting from the lack of available treatment for their discharges can easily be identified. However, it has to be kept in mind that domestic pollution is the most important pressure in the basin, with the city of Fès causing 95% of discharges. Challenges in the Sebou basin are therefore manifold.

Source: AESN, 2007.

Eutrophication can also affect the use of water from lakes and reservoirs for the purpose of water production. According to Meybeck *et al.* (1987) and Crouzet *et al.* (1999), the following problems related to eutrophication can influence public water supply and pre-treatment activities: clogging of filters in water pre-treatment plants; undesirable tastes, odours and colour caused by algae; presence of toxins liberated by certain cyanobacteria; etc.

In the Paldang reservoir in Korea for example, which supplies drinking water to 5.8 million households in the Seoul metropolitan area, water quality has become so bad that it was no longer suitable for drinking water purposes due to liquid waste from the manufacturing industry and wastewater from livestock farming. As a solution, stricter regulations for both the agricultural sector and wastewater treatment for factories discharging effluent were applied. As those measures have significant economic costs, Cho and Kim (2004) determined the willingness-to-pay of the population supplied by the Paldang reservoir, which turned out to be an average of about USD 1.30 per household per month for the 5.8 million households concerned. This was deemed sufficient to pay for the full cost of providing improved water quality. Although one of the study's objective was "to help policy makers find the socially optimal level of abatement for water contamination in Korea", it is to be noted that the investment plan had already started when the cost-benefit analysis was carried out, pointing to the fact that the study was partly used as an ex-post justification rather than an ex-ante evaluation of options.

Benefits for industry

Water is used for many industrial purposes, as it can be incorporated into the finished product or used for intermediary purposes such as dilution, cooling or washing. The sectors with the highest water consumption are thermal plants and nuclear power plants (cooling water) as well as papermaking industries (AESN, 2007). Depending on the type of industry (*e.g.* paper and food processing), high-quality water is needed for the production process (Bingham *et al.*, 2000). Accordingly, if water quality is low due to untreated wastewater discharges, water must be treated before it can be used and pre-treatment costs lower the net economic benefits associated with using this water (Dumas & Schuhmann, 2004).

However, the benefits of treated wastewater for the industrial sector are not very easy to identify and value, as industries often attempt to take water from less polluted water bodies upstream. If this generates additional costs, benefits from wastewater treatment can be measured in the form of avoided costs. Whenever or not these additional costs can be evaluated will depend on the local situation. Furthermore, industrial reuse of water and internal recycling can reach up to 85% of the total consumption for certain countries and types of industries, limiting therefore the impact of the quality of incoming water (AESN, 2007).

Benefits on fishing and angling activities

Clean water provides life support to fish species. As the success of commercial fishing activities is directly related to the health of the stock of commercially exploitable fish species, poor water quality – *e.g.* leading to reductions in dissolved oxygen – can result in increased fishing costs and prices for fish (Bingham *et al.*, 2000; Dumas & Schuhmann, 2004). Church *et al.* (2008) state in their study on the benefits of improving water quality for recreational activities that very good water quality is essential for fish populations and therefore also for angling and fishing activities.[9] Foster Ingeneria Limitada (2001, in Jouravlev, 2004) indicates that there is an annual loss of about USD 1 million linked to the disappearance of fish from the middle and lower courses of the Bogota river, Colombia, due to increased water pollution (following discharges of untreated wastewater).

In the Black Sea, the degradation of water quality due to an enrichment in nutrients led to an important increase in the algal mass. After a larger imbalance of the ecosystem in the 1970s and 1980s, the mass of dead fish was estimated at around five million tons between 1973 and 1990, corresponding to a loss of approximately USD 2 billion (AESN 2007). Hutton *et al.* (2008), which looked at the impact of poor sanitation in Southeast Asia, also quantified the negative effect of the release of untreated sewage into the aquatic environment on fish production.

Table 3.3 indicates the economic losses linked to the reduction in fish catch in four Southeast Asian countries.

Table 3.3. **Economic losses for fish production due to poor sanitation**

	Total value (million USD)	Per capita (USD)
Cambodia	10.9	0.8
Indonesia	92.0	0.4
Philippines	9.6	0.1
Vietnam	27.4	0.3

Source: Hutton *et al.* (2008).

Note: The figures are based on the value of lost sales.

Benefits for aquaculture

Aquaculture depends on good water quality, independent of the species chosen. Fish or shellfish all depend on water to live, eat and grow. The success of aquaculture relies greatly on its ability to manage water quality (Buttner *et al.*, 1993). For example, oyster production needs to take place in areas where the contamination risk through coliform bacteria is reduced (see Box 3.3).

In the case of the Halifax Harbour, it has been estimated that sewage treatment would lead to economic benefits between USD 230 000/year and USD 380 000/year from reopened shellfisheries (Wilson, 2000).

Box 3.3. **Aquaculture in Morlaix (France)**

To protect its oyster production, the city of Morlaix (France) undertook efforts against the detrimental effects of diffuse and non-controlled emissions from the agglomerations and tourism activities. Until 1992, efforts to reduce diffuse emissions coming from wastewater not discharged into the sewerage network were undertaken. As a result, infectious periods with concentrations above 10 000 coliform bacteria/100g nearly disappeared. A further improvement of the water quality took place in 1996 through the augmentation of the capacity of the wastewater treatment plant. Thereafter, the concentrations of coliform bacteria have been found to be limited to 1 000/100g, which reduces strongly the time needed until the oysters are suitable for human consumption.

Source: AESN, 2007.

Economic impacts on tourism

Water quality is an essential factor for certain tourism activities and sewage treatment leads to enhanced tourist attraction (Wilson, 2000). In several countries, non-compliance with certain norms for bathing water leads to the closure of beaches and lakes for recreational purposes and therefore influences strongly the local tourism economy. This can be avoided through wastewater treatment that reduces bacterial and other contamination (AESN, 2007; Wilson, 2000).

In Normandy (France), it has been estimated that closing 40% of the coastal beaches would lead to a sudden drop of 14% of all visits, corresponding to a loss of EUR 350 million per year and the potential loss of 2 000 local jobs (AESN, 2007). In the Black Sea, it has been reported that a significant surplus of nutrients led to a reduced number of visits by tourists and a shortfall for the tourism industry. It has been estimated that, in 1995, the annual economic loss linked to the disaffection of tourists for this region was about 360 million dollar for each 10% reduction in the quality of the local aquatic environment (Roger Aertgaerts, in AESN, 2007).

Benefits for agriculture

Water which has been polluted by human activities can potentially become inappropriate for animal consumption and/or irrigation. This applies to both water extracted from polluted water bodies and the direct reuse of wastewater. Whereas irrigation with raw wastewater increases the risk factors for the population’s health (*e.g.* potentially favouring the spread of diarrhoea, cholera, parasitism and other diseases) (Jouravlev, 2004), treating wastewater enhances the possibilities of using water for agriculture. This applies both to treated wastewater, which can be directly used for irrigation, and to surface water, which is of better quality as a result of sewage treatment. This can lead to increases in area under irrigation, lead to improved crop yields (due to the remaining nutrients) and provide enhanced marketing opportunities (if compared to agricultural products which have been irrigated with untreated wastewater) (Jouravlev, 2004, see also El Madani & Strosser, 2008). The residual sludge can also be used in the agricultural sector, if it is adequately handled (see chapter 5.1). Benefits can be measured in terms of the reduced need to use fertilisers (Andersen, 2001).[10]

In the Mediterranean region, reuse of treated wastewater is done for around 30% of the wastewater discharged.[11] It is mainly applied as irrigation water for agricultural land and green spaces. At a global scale, wastewater reuse offers a promising solution in the short-term, as it allows reacting efficiently to the needs of different water scarce areas (AESN, 2007). For the Sebou basin in Morocco, for example, it has been estimated that the bad water quality of surface water bodies is limiting the irrigated area by about 44 400 ha, which represents a production loss of about 378.6 million DH (USD 47.3 million) (El Madani & Strosser, 2008).

Recycling of some of the nutrients contained in wastewater (such as phosphorus, used in fertilisers) can also play a key role, particularly in the context of declining phosphorus availability across the world (see http://phosphorus.global-connections.nl).

(Indirect) Benefits for energy production

Wastewater treatment processes can also indirectly be used to produce energy. Organic solids which result from the wastewater treatment process produce biogas during anaerobic digestion. This can be used to generate on-site electrical power (see also Section 0 on the use of biogas for household energy production in developing countries). However, the technology is still innovative. Further developments are ongoing to refine the biogas to a quality which for example can be fed into the natural gas grid (Peng and Peng, 2008). In Sweden, a pilot project for producing biogas in wastewater treatment processes for use in vehicles has already started in 1996 (Energie-Cités 1999). A second energy source related to wastewater is its average temperature, which lies around 15°C. Cost-effective heat-exchange technologies allow to extract a part of the heat and to use it as a supplementary heat source in a centralised community heating system.

Benefits for the national economy

Apart from economic benefits which occur either to individual companies or sectors, Jouravlev (2004) states that water pollution linked to untreated wastewater discharges affects also national competitiveness, as the access to external markets is increasingly linked to environmental standards applied in the country of origin of the respective product. Those standards are increasingly causing disputes as non-tariff barriers in international trade. Jouravlev cites the example of Peru, which experienced losses in fish product exports exceeding USD 700 million, due to a cholera epidemic in 1991 (WHO 1999, in Jouravlev, 2004).

Restrictions on its access to external markets was one factor which led Chile to initiate an ambitious investment programme for wastewater treatment, as irrigation with untreated wastewater was estimated to hinder exports of Chilean agricultural products. The required investments of about USD 2 billion were financed through a combination of public and private funds, as the water companies were privatised via a sale of assets. By 2004, all water and sewerage companies in the country had been privatised and the coverage with wastewater treatment grew from 8% in 1989 to 71% in 2003, with the forecast to exceed 98% in 2010. In Santiago de Chile, tariffs increased by 25% due to the investments (different sources, in Jouravlev, 2004).

3.2.4 Other benefits

Wastewater treatment does not only provide benefits for health, the environment and different economic sectors, but also some benefits which are more difficult to capture.

Aquatic environments have an aesthetic value which can be affected by water quantity and quality changes. The enjoyment which humans receive when viewing water resources and the surrounding environment can be compromised through chemicals that harm aquatic organisms but also through eutrophication which changes the whole aquatic ecosystem (Bingham *et al.*, 2000). Aesthetic benefits are therefore directly linked to benefits from recreation activities near water bodies, like hiking, picnicking or photography (Carson & Mitchell, 1993), but also for example bird watching – both due to aesthetic reasons and to the fact that improved water quality might increase bird populations (Church *et al.*, 2008).

Different recreational activities are linked to water and are influenced by water pollution. This includes for example in-stream uses like swimming, boating, fishing (see above), hunting, and plant gathering. Wastewater treatment can for example eliminate infestations by pathogens (*e.g.* toxic cyanobacteria) which could otherwise impede swimming and other forms of recreation with direct water contact (Bingham *et al.*, 2000; Crouzet *et al.*, 1999).

Bingham *et al.* (2000; see also Chapter 3.2 for the total benefits) estimated the value of different recreational benefits across the United States due to an improved control of point-source water pollution, including through wastewater treatment. The study found that the additional benefits due to an improved water quality lay between USD 3.4 million and USD 9.8 million per year for boat cruising, between USD 0.4 million and USD 1.4 million per year for sailing and between USD 9.1 million and USD 46.5 million per year for wildlife viewing.

However, not all water pollutants affect participation in water-related recreation to the same extent. Mainly water clarity is used as a criterion for recreational users, but also odour or algal masses (Church *et al.*, 2008; Crouzet *et al.*, 1999). All factors are clearly influenced by wastewater treatment that reduces sediment loads to the aquatic ecosystems and reduces eutrophication risk.

Benefits for property owners. People living in the surroundings of water bodies benefit from increased stream-side property values as wastewater treatment ensures a certain quality of the water bodies (Dumas & Schuhmann, 2004). It also reduces bad smells and improves the quality of groundwater (Jouravlev, 2004). Wilson (2000) cites several studies which demonstrated that housing prices rise with better water quality. In the proximity of the area which benefited from improved water quality, property values were found to be between 11% and 18% higher as compared to properties next to water of low quality.

Specific benefits of constructed wetlands. Next to the benefits linked to its wastewater treatment function, some specific benefits are attributable to constructed wetlands. These particularly include habitat provision and related biodiversity. Kazmierczak (2001) looked at the economic value of water quality services provided by 12 different wetlands. The values he found ranged between USD 2.85/acre/year and USD 5 673.80/acre/year (with a mean and median of USD 825.04/acre/year and USD 210.93/acre/year, respectively).[12] The geographic location and the specific demand of users for water quality are the most important factors explaining the high differences in value. In general, it has to be kept in mind that values regarding the treatment function can only be attributed to wetlands if they are built near urban areas or industrial discharge areas.

3.2.5 Aggregated benefit values

Studies providing aggregated values for the benefits of wastewater treatment are rare. One example of such aggregated study looked at the quantified negative impacts of untreated wastewater discharges into the Bogota River, Colombia (see Table 3.4). The total annual value of costs linked to the lack of wastewater treatment was estimated at about USD 110 million, including considerable economic damages in different sectors.

Table 3.4. **Economic impacts of pollution of the Bogota River caused by untreated wastewater discharges**

Type of impact	Size of impact	Percentage
Impact on land value. This is the increased value of the land linked to a reduction in bad smells, improvement in groundwater quality and other effects connected with water pollution control.	USD 61 million/year	54%
Impacts on agricultural production. The use of contaminated water from the river and its tributaries for irrigation has significant negative impacts on the quality of the food produced. If water of acceptable quality was available, the irrigation coverage could be extended, and the quality of the agricultural products would be improved.	USD 35 million/year	32%
Impacts on municipal public services. Improvement of the river water quality could allow some communities to use the river as a water source for their water supply systems. The benefit would then be equivalent to the reduction in the costs of obtaining water for the water supply system, and the reduction in rationing and treatment costs incurred by communities which have no alternative sources.	USD 9 million/year	8%
Impacts on the health of the population directly exposed. Persons living close to the river and to the lower part of its urban tributaries are exposed to water pollutants through several mechanisms: *(i)* consumption of untreated water; *(ii)* consumption of foods produced with contaminated irrigation water or from livestock farms that use such water; *(iii)* direct physical contact in recreational, bathing or work activities; and *(iv)* flies and mosquitoes breeding in the polluted water and transferring pathogenic micro-organisms to settlements.	USD 4 million/year	4%
Impacts on sedimentation of river and lake beds. The discharge of residual waters generates sedimentation, owing to the solids present in the waters. This increases the costs of dredging the river and the Muña reservoir and also impedes the natural drainage of waters to the river, whenever the level of the bed has been raised by this gradual sedimentation. The latter created also the need to construct dikes along the length of the river.	USD 1 million/year	1%
Impacts on fishing. In the past, the course of the river Bogotá and its tributaries were rich in fish. With the increasing pollution, the fish have disappeared from the middle and lower courses of the river, and are now found only in the high and turbulent sectors, which are pollution-free, and in some reservoirs and lagoons.	just under USD 1 million/ year	1%
Total	**~ USD 111 million/year**	**100%**

Source: Adapted from Foster Ingenieria Limitada (2001), in Jouravlev (2004).

Note: The total value does not include all of the damages caused by pollution: *(i)* health impacts on the population indirectly exposed; *(ii)* impacts on the operation and maintenance costs of the hydroelectric plants of the river; *(iii)* impacts on the benthic and avifauna biodiversity; and (iv) impacts on the landscape and odours in the vicinity of the river.

Notes

1. This section is focused on wastewater treatment, as methods for collecting and storing human excreta through on-site sanitation solutions are dealt with in Section 2 focused on providing access to sanitation services.
2. David Lloyd-Owen, presentation at the OECD Expert Meeting on Water Economics and Financing, 15 March 2010, Paris.
3. WaterAid (forthcoming).
4. David Lloyd-Owen, *ibid*.
5. Non-use benefits accrue to individuals regardless of whether or not they have direct interaction with water.
6. Wastewater treatment and its reduction of sedimentation reduces also the costs of dredging rivers and reservoirs and assures natural drainage (which is impeded if the river bed becomes too high due to sedimentation (Jouravlev 2004).
7. In general, it has to be taken into account that less than half of the nitrogen loads to surface waters are stemming from wastewater. However, sewage effluents contain nitrogen also in its ammonium form, which is especially harmful to the aquatic environment (Crouzet *et al.* 1999).
8. However, the aggregated amount is not enough to allow for investments to treat 100% of the wastewater generated by the municipality. Budget constraints mean that it is necessary to search for additional financing sources (Birol *et al.* 2009).
9. Hutton *et al.* (2008) also mentions that the high nutrient content of wastewater can also be good for fish and crop production. This requires careful dosing, however and limiting other harmful pollutants, including pathogens.
10. Untreated wastewater has a certain value due to its nutrient content and the reduction of fertiliser needs. However, the supply of nutrients needs to be limited and the content of other harmful pollutants, including pathogens, heavy metals etc., may limit this direct use of wastewater (Silva-Ochoa and Scott, *after* 2001).
11. This is also the case with very arid countries, such as Qatar (AESN, 2007).
12. All values are in 2000 dollars.

Chapter 4

Managing water supply and demand in a sustainable manner

For water services to be provided sustainably over time, it is critical to ensure that the raw material, clean water, is adequately protected and managed. This will become increasingly relevant with the threat of climate change, in both developed and developing countries, even though the latter are likely to be more exposed to variations in rainfall and overall scarcity. According to forecasts presented in the Stern report (Stern, 2007), a 2°C rise in global temperature will lead to between 1 and 4 billion people experiencing growing water shortages, mainly in Africa, the Middle East, Southern Europe, and parts of South and Central America. In South and East Asia, by contrast, between 1 and 5 billion people may receive more water. But as much of the additional water will be available during wet seasons, sufficient storage capacity will be needed if shortages during dry seasons are to be alleviated.

Even though water consumed for municipal use represents only a small portion of the total (with agriculture taking the lion's share) and human consumption is usually prioritised by law over other less essential uses, sustained demographic and economic growth, increasing water scarcity and rising unpredictability about rainfall patterns will increase competition over the resource.

Given the priority given to drinking water in the pecking order of water uses, WSS providers are usually in a strong position to influence decisions over water resource management. In addition, in countries or river-basins with severe water scarcity, water abstractions for municipal purposes have been a primary driver for investment in schemes to divert water from distant sources. The State Water Project in California, for example, is a water storage and delivery system which provides water for 23 million Californians (Californian Government, 2010). The main conveyance takes place on a length of 715 km, from the Northern Sacramento River to water scarce areas in the Central and Southern regions of the State (Frederiksen, n/a). In the city of Amman, Jordan, extreme water scarcity led to a strict water rationing programme, supplying water to households only one or two times a week (Denny *et al.*, 2008).

This chapter reviews the benefits from investments in order to achieve two main objectives:

- ***To protect the quality of the resource***. This is linked to the investments related to wastewater treatment discussed in Chapter 3, since benefits from both water source protection and wastewater treatment are felt in terms of reduced water pre-treatment costs at water intake.
- ***To manage water supply and demand in a reliable manner and at least cost***, so as to be able to provide users with reliable continuous water supply and minimise negative impacts on other types of water use (such as agriculture or the environment). Investments reviewed in this section include investments to augment supplies as well as to manage demand and reduce system losses.

4.1 Protecting the quality of the resource

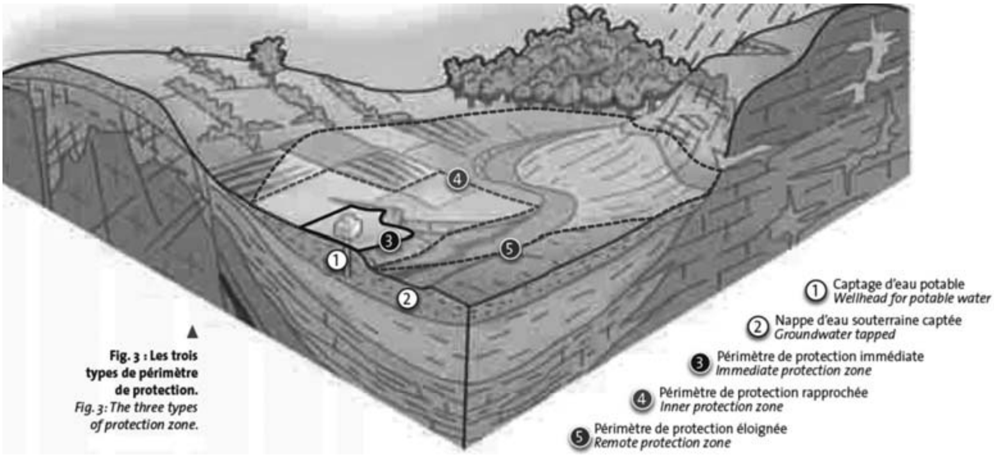
The following section focuses on water catchment protection and its role to secure an adequate water quality. The interventions described include water catchment protection zones, voluntary agreements and regulations. Resulting benefits comprise, for example, the reduced need (and costs) for downstream treatment.

4.1.1 Investments to protect water resources

Water catchment protection zones. Water catchment protection includes precautionary actions, procedures or installations to prevent or reduce harm to the environmental integrity of drainage areas used to catch water, such as reservoirs or basins. In some cases, this implies banning any economic activity to avoid pollution risks. In other cases, it involves adapting practices of economic operators (*e.g.* shifting farm practices to biological farming with zero use of pesticides). Depending on the degree of protection, different zones requiring different adaptation can be defined or specified by law. For example, in France, three protection zones around each water abstraction point are legally specified, each zone having a different level of protection (see Figure 4.1).

The concept of protection zones is included in European legislation (*i.e.* in the Drinking Water Directive and the Water Framework Directive) and promoted by the WHO in the context of water safety planning. Although protecting water resources generates benefits, it also has a cost, which depends on the local hydrological conditions, and on economic activities in the protection zone.

Figure 4.1. **The three types of protection zones (France)**



Source: BRGM (after 2006).

Establishing voluntary agreements. Recent studies and research have highlighted the diversity of institutional arrangements for managing water protection zones. In particular, they stress experiences where contractual voluntary agreements have been established between (mainly domestic) water users/utilities and farmers who agree to adapt their farming practices to limit diffuse pollution to high value water resources.

In the UK, for example, a water catchment project was launched to investigate how to communicate with farmers on the environmental impact of pesticide application and support them by identifying the best practical methods to reduce pesticide levels in water. Six catchments were chosen for a trial, according to hydrological and agricultural criteria. Each catchment had its own management team, led by a farmer and including all local stakeholders. Water quality was regularly tested to check the impact of the applied measures. Initial results show that in some catchments up to 60% reductions in pesticide levels were achieved. Among the key messages identified to guarantee the success of such an experience were (The Voluntary Initiative, 2005):

- Adopting a "farmer-led" approach and working at a local catchment basis, is a fundamental condition to obtain appropriate results;
- Implementing a parallel program with non-agricultural users, *e.g.* local authorities, as well as government support is essential;
- A voluntary program should be placed within a broader strategy, including a right mix of regulatory and financial incentives;

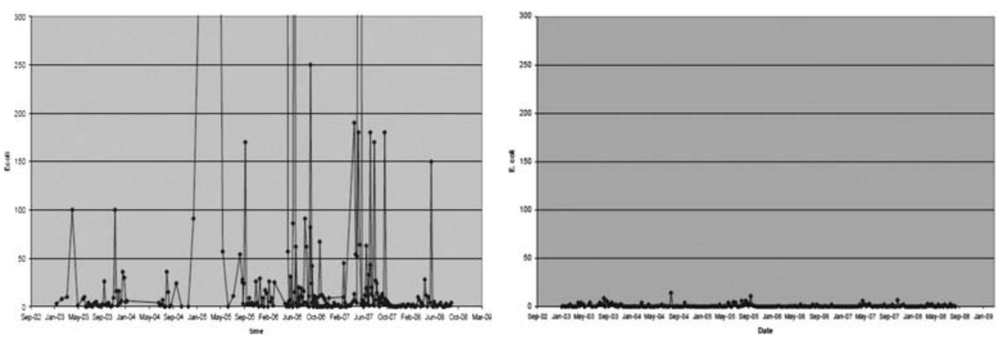
- A clear explanation of the problem and its link to agriculture use of phytosanitary products, as well as positive messages conveying the existence of simple solutions which can be inexpensive combined with practical advice and help, are more effective than negative messages such as the threat of a pesticide tax.

Regulations. Water catchment protection can also be done through the adoption of regulations. These do not only concern agriculture, but also urbanisation or leisure activities.

Figure 4.2 illustrates how recreational activities within catchment areas can influence water quality and microbiological activities.

Figure 4.2. ***E coli***[1] **rates in dams in Western Australia**

Logue Brook Dam **Canning Dam**



Source: Government of Western Australia (2009).

The Logue Brook Dam (on the left), where recreational activities are allowed, has significantly higher *E coli* rates than the Canning Dam (on the right), where recreation is prohibited. Such legal provisions can not only concern the authorisation or interdiction of certain activities, but can also consist for example in the specification of maximal allowed concentrations of certain substances in the different water bodies.

4.1.2 Benefits of protecting water resources

Protecting water catchments and reducing pollution to water resources result in similar benefits to end-customers as those described from access to safe water in Chapter 2, *e.g.* reducing or avoiding costs resulting from health problems and diseases.

Protecting water resources directly at the source by limiting pollution from catchments can also generate indirect benefits, such as avoided (investment and treatment) costs. Increasingly, countries are recognising the benefits of managing water resources using a whole basin or river basin approach, given that reducing pollution at the source tends to be a cheaper option than treating water before supplying it to consumers.

Box 4.1. **Water catchment protection in New York (United States)**

The most famous case of benefits linked to water catchment protection is reported in New York. A new drinking water regulation, required water suppliers to filter their surface water supplies, unless they could demonstrate that they had taken other steps – including watershed protection measures – to avoid harmful water pollution. Confronted with the choice between the provision of clean water through a newly built filtration plant or managing water sheds, New York City concluded that the latter was more cost-effective. Whereas the costs of the filtration plant have been estimated at between USD 6 to USD 8 billion, watershed protection efforts, including the acquisition of critical watershed lands and a variety of other actions designed to reduce contamination sources in the watershed, were estimated to cost only around USD 1.5 billion – thus four to five times less! As a consequence, New York City chose the second solution that favored investing in natural rather than built capital.

Source: Salzman (2005).

In Germany and in the Netherlands, farmers are compensated by law for meeting more stringent rules in water catchment areas. However, it seems that the effectiveness in terms of preventing water pollution has been limited (Heinz *et al.*, 2002). Voluntary agreements, on the other hand, are judged to be more effective in reducing agricultural pollution. Even though, in many cases, it will take many years to observe actual improvements in water quality because of the geological conditions.

Co-operative agreements are effective at minimising the overall cost of meeting drinking water quality standards as they are targeted to a specific catchment (Heinz *et al.*, 2002). In Portland Oregon, Portland Maine and Seattle Washington, for example, it has been estimated that every USD 1 invested in watershed protection can save anywhere from USD 7.50 to nearly USD 200 in costs for new water treatment and filtration facilities (Emerton and Bos, 2004).

4.2 Balancing water supply and demand

In order to ensure a reliable water supply at any time, there is a need to balance water supply and water demand. This requires investments on both sides over the long-term and the short term, especially during shortfall events. Rather than being viewed as substitutes, investments in these different aspects need to be part of an efficient package of options (Griffin, 2000). In particular, investments to adjust the long-run water supply (*e.g.* investments in water abstraction), as well as proposing alternative water supply options to tackle short-term water shortages, are key to providing reliable access to water.

On the demand side, reducing leakages, introducing incentive pricing and water saving appliances as well as educational campaigns are useful tools. To give an idea of the potential effect of managing water demand, a report prepared for the European Commission (Dworak *et al.*, 2007) indicated that, with regards to public water supply (including households, public sector and small businesses), the reduction of leakage in water supply networks, water saving devices and more efficient household appliances have the potential for up to 50% water savings. These water saving technologies are not only easy to introduce and to implement, but have also short payback periods, further enhancing their uptake possibilities. Applying the above mentioned measures would allow for a reduction in water consumption from 150 litres/person/day (average in the EU) to a low of 80 litres/person/day. A similar reduction could be applied to public water supply, leading to an estimate of potential savings up to 33% of current abstractions.

Benefits linked to the reliability of supply involve, for instance, an increase in the standard of living, a reduced need for storage capacity at household level and the possibility to ensure continuous industrial production processes. While the benefits of improving and varying water abstraction and storage technologies are recognised, their potential social and environmental negative impacts must not be minimised. In many cases, negative impacts of alternative water supply options could be avoided by better management of water demand and water resources.

The remainder of this section first examines the investments and benefits linked to water supply before turning to the investments and benefits of water demand management.

4.2.1 Investments for ensuring reliable water supply

As mentioned above, water reliability depends on the water source (*i.e.* surface water abstraction versus groundwater extraction) as well as on storage capacity. If water is structurally lacking (for example, in areas suffering from drought), alternative water supply options such as desalination, can also be considered. In addition, drought management plans can be developed and implemented as one way to balance water supply and demand.

Water abstraction. Depending on the water source, water is abstracted either from surface water bodies or groundwater, using river intakes or wells, respectively. While surface water can be classified as a renewable resource, groundwater has a more ambiguous status. Some groundwater bodies are replenished very quickly, in other cases, recharge can only take place over millennia, which means that this type of groundwater is analogous to mineral deposits or fossils fuels.

Water storage to counter natural variability. Variability in river flows, both within and between years, is a limiting factor to water use. If water is over-abstracted, variability in river flows can be exacerbated and ecosystems affected. To stabilise water supply over time, water storage is thus necessary. Depending on the time scale, volumes concerned and goals, water storage can be done through water towers or reservoirs/dams.

Groundwater recharge is an alternative to surface water storage. Intentional aquifer recharge[2] (Dillon, 2004) can result from different techniques (Tuinhof and Heederik, 2003) among which aquifer storage and recovery (injection of water into a well for storage and recovery in the same well) or infiltration ponds (ponds constructed off-stream where surface water is diverted and allowed to infiltrate to the underlying unconfined aquifer). For small volumes of water, aquifer recharge can be more economical than building storage dams that might lead to significant evaporation losses in arid countries.

Alternative water supply options. Many alternative water supply options have been developed in different parts of the world. These include:

- Desalination, *i.e.* the specialised treatment method used to remove dissolved minerals and mineral salts (demineralisation) from the feed-water (*e.g.* brackish or saline water, but mainly sea water) and thus convert it to fresh water for domestic, irrigation or industrial use.
- Re-use of treated effluent implies that treated wastewater is supplied to water users via a water distribution system without first being incorporated in a natural stream or lake or in groundwater. Indirect wastewater re-use involves the mixing of reclaimed wastewater with another water supply source before re-use.
- Rainwater harvesting is the process of collecting, diverting and storing rainwater from an area (usually roofs or another surface catchment area) for direct or future use.

Drought management plans. Drought management plans aim at using the water infrastructures described above (wells, dams, etc.) in an optimal and effective manner during droughts.[3] Drought management plans allow drought forecasting and aim to cope with gaps between water demand and supply by using water rationing measures. They respond to droughts through:

- Managing emergency situations (crisis), which require the use of extraordinary resources;
- A general planning framework taking the existing risk into account and inserting drought management in a long term approach.

Drought management plans are not common, as countries affected by droughts often limit their reactions to emergency actions. Furthermore, drought events are rarely integrated into the general planning and strategies as a means of minimising environmental, economic and social impacts of droughts.

Box 4.2. **The drought management plan of the City of Louisville, Colorado (United States)**

The City of Louisville, Colorado, experiences varying degrees of drought during the normal weather variations. As a guide in those situations, the city has developed a drought management plan which predetermines the general responses to the given level of drought. Four drought stages from moderate to extreme have been identified with different water use reduction targets being assigned to each category (varying from 0-10% to 50%). Depending on the severity of the drought conditions, different steps to reduce water usage are foreseen. They are ranging from mainly voluntary recommendations to the prohibition of all outdoor water usage. The latter goes along with the application of a drought surcharge on water prices.

Source: City of Louisville (2004).

4.2.2 Benefits from improving the reliability of water supply

The degree of certainty with which water is supplied is an important factor influencing the willingness-to-pay for water supply (Young, 1996). Reliability of supply may vary on a daily or weekly basis, as well as on a seasonal basis. Increased reliability avoids first of all the need for households to store water for shortage situations and induces therewith cost savings, as space and material is economized. Furthermore, people might benefit from a feeling of confidence in water supply and from increased comfort.

Contingent valuations can be a useful tool to estimate how the reliability is valued by individuals. In particular, Baraket and Chamberlin (1994) showed that consumers are more likely to pay higher amounts to avoid larger, infrequent shortages than small, frequent shortages. They found that the mean monthly household willingness-to-pay ranged from USD 11.63 to avoid a year-long 10 percent reduction in water supply with an expected frequency of one in ten years, to a monthly value of USD 16.92 to avoid a year-long 50 percent reduction in service with an expected frequency of one in ten years.

But, as pointed out by Brozovic *et al.* (2007), taken together, contingent valuation studies suggest that consumers are fairly insensitive in their valuation of the severity, duration, and frequency of water supply shortfall. The construction of residential demand functions for water also allows estimating the willingness-to-pay. Using this principle, Brozovic *et al.* (2007) estimated that a magnitude 7.9 earthquake on the San Andreas Fault could lead to 279 million dollars in residential welfare losses due to water supply disruption over a sixty day period before the resumption of normal water services. If this amount seems to be very large, it has to be placed in the context of the estimated 14.4 billion dollars in overall business interruption losses. Indeed, water reliability is also an important parameter for economic activities (industries, but also agriculture and services) which use water in their process (chilled water for example) or as a non-substitutable (or substitutable with important costs) input.

In addition to storing water for drinking needs, dams are often used for other purposes such as irrigation, leisure or hydroelectricity power and provide respective additional, but indirect, benefits. In particular, hydroelectricity leads to substantial benefits for society since it produces a renewable energy which meets peak-demand. However, dams and reservoirs are often denounced for their negative impact on river flows. If sustainably managed, however, they may enhance baseflow in streams that support downstream aquatic ecosystems and connected water uses.

4.2.3 Investments to manage water demand

Water demand needs to be actively managed not only in contexts where high current water usage needs to be reduced, but also where there is current unmet demand, and therefore there is likely to be further stress on the resource in future. Managing water demand can be achieved via different measures such as:

- Technical measures – water saving devices, water metering, water reuse systems…;
- Economic instruments – pricing, abstraction charges and taxes, new allocation mechanisms;
- Institutional changes – new water rights, organisational setups;
- Information measures – in particular public awareness campaigns or information to schools;
- Regulatory changes – specifying new abstraction limits or river water flow thresholds.

The focus of the following sub-sections is on reducing water leakages and water saving devices (two technical measures), raising public awareness (information measure) and introducing pricing reforms (economic measure).

Leakage control

Leakage in the water distribution network, either due to the poor condition of pipes, or to illegal siphoning off of water, is a growing concern in developed and developing countries. For example, it has remained at very high levels in all EECCA (Eastern Europe/Central Asia) countries and has even increased in some cases in recent years. Leakage rates rose from about 30% to 45% in Georgia and Moldova from 1998 to 2003, and remained at high levels of 50% to 70% in Armenia and Kyrgyzstan. The international benchmark figure considered as "good practice" for leakage rates in water distribution networks is around 20% (OECD, 2006). However, it is not reached in all developed countries. If average leakage rates are relatively low in Germany (7%), they remain quite high in England & Wales (19%), in France (26%) or in Italy (29%) (VEWA, 2006).

In cases where leakage occurs due to poor pipe condition, measures applied include monitoring leakage, detecting and locating leaks and their reparation. Some of the costs and benefits of leakage control can be external

Box 4.3. **Economic level of leakage (ELL) calculation in England and Wales**

In 1997, following a drought in the UK in 1995 and rising awareness of leakage problems, the British Government required Ofwat, the Water Services Regulation Authority, to set mandatory leakage targets for all water companies. Those targets were defined in the same year and were based on the analysis of the Economic Levels of Leakage (ELL). The ELL balances the costs and benefits of leakage management and can be defined in two ways (Stephens, 2003):

- "The level of leakage at which it would cost more to make further reductions than to produce the water from another source";
- "The level of leakage at which the total cost to the customer of supplying water is minimised and companies are operating efficiently".

In 2001, a Tripartite group comprising Ofwat, the Environment Agency and the Department for Environment, Food & Rural Affairs (DEFRA) launched a large process which aimed at defining and communicating the current best practice for leakage targets. The analysis focused on estimating the economic level of leakage (ELL), based on economic analysis, including consideration of social and environmental costs. The water companies were asked to provide information about their current practices to calculate the ELL, which includes external costs and benefits (as shown in Table 4.1).

to the water company (as shown in Table 4.1), hence the need to calculate an economic level of leakage (ELL), which may be different from the optimal leakage rate that may be estimated by the water company based on considerations solely of financial costs and revenues.

Table 4.1. **External costs and benefits of leakage control**

Impact/Consequence of Leakage Control Activity	External Cost	External Benefit
Increased travel times through higher road congestion and road diversions	Cost of delays	Reduction in frequency of mains bursts leading to disruptions (for example, associated with programmes of mains replacement)
Pedestrian Disruption through footpath restriction/closure	Cost of pedestrian delay and nuisance value	
Domestic Disruption through planned or unplanned interruptions	Costs of Disruption net of any compensation payments (*e.g.* under Guaranteed Standards Scheme)	
Reduced River Abstractions		Use (*e.g.* recreation, angling) and Non-use (*e.g.* conservation value) benefits of improved river flows
Reduced Groundwater abstractions		Use and non-use of benefits of improved wetlands and river flows
Deferred reservoir construction	Avoided benefits of water based recreation (*e.g.* angling, water sports)	Avoided costs of landscape disamenity and construction

In 2002, the Tripartite Group published a document on best practise which provides guidelines for the calculation of the ELL. However, it recognises that several approaches exist, and that regional differences should be taken into account (Tripartite Group, 2002). In 2008, Ofwat conducted further work to revise leakage based on a frontier approach to leakage target setting (WRc, 2008).

Sources: Stephens (2003); Tripartite Group (2002), WRc (2008).

Incentive pricing

Economists often promote incentive pricing as a way to reduce water demand. In particular in Europe, water pricing has been promoted as one important instrument for water management aimed at achieving several goals at the same time. It provides incentives for the efficient use of water and thus reduces the pressure on water resources and the environment. Furthermore, it contributes to the efficient allocation of water between users and mobilises financial resources to ensure the financial sustainability of water infrastructure (European Commission, 2000; see also Berbel, 2009). Whereas the tariff level provides an answer to the question "How much should we pay?" the tariff structure indicates "Who should pay for what?" (Scatasta, 2008).

The effectiveness of incentive-based pricing depends on its design, however. Seasonal tariffs can be very effective in providing higher incentives for saving water in periods with high scarcity. Increasing-block tariffs, on the other hand, which foresee elevated charges above a certain level can be an effective way of reducing consumption from users with very high demand (WATECO, 2003). In any case, price structures need to be volumetric, with low fixed charges, in order to provide incentives for reducing water consumption. Water metering is usually a precondition for effective pricing systems (Roth, 2001; Lallana *et al.*, 2001).

Currently, water services are provided in many countries at prices well below long-run financial and environmental costs, resulting in water overuse and wastage. As a consequence, European legislation such as the Water Framework Directive promotes the concept of cost-recovery, *i.e.* policies to recover the full costs of water provision, taking into account private costs (costs endorsed by water suppliers such as abstraction, storage and treatment costs) as well as social costs (costs endorsed by the society as a whole, including environmental costs).

The actual impact of incentive pricing depends on how consumers respond to price signals. This reaction is measured by elasticities, which are often quite low (see Box 4.4), reflecting small effects of pricing.

Box 4.4. **Examples of water price elasticities**

In a meta-analysis, Espey *et al.* (1997) found that 90 percent of reported residential price elasticities of demand for water ranges between -0.75 and 0. This is influenced by income levels and pricing structure. Dalhuisen *et al.* (2003) report a mean price elasticity of -0.41, suggesting that, in general, residential demand for water is price inelastic. Another, empirical study using monthly time-series observations from Sevilla (Spain) estimated price-elasticity of demand at around -0.1 in the short run and -0.5 in the long run (Martins and Fortunato, 2005).

These examples show elasticities that are lying between -1 and 0, indicating that water demand is price inelastic (*i.e.* decreases in demand are less than increases in price in percentage terms). However, it is only when price elasticity is equal to zero that prices have no impact on demand at all.

Sources: Espey *et al.* (1997); Dalhuisen *et al.* (2003); Martins and Fortunato (2005).

Table 4.2. **Potential savings from water efficient appliances**

	Standard equipment (range)		Water efficient equipment (range)		
	litre/use	litre/household/ day [a]	litre/use	litre/household/ day [a]	% reduction
Toilet flush	9	87 [b]	4	39 [b]	55
	6	57 [b]			32
Shower	54 [c, d]	77 [f1]	30 [g]	43 [f1]	44
	45 [c, e]	64 [f1]			33
Bath	88	71 [f2]	65 [h]	53 [f2]	26
Taps	0.6 [i]	10 [j]	0.5 [k]	8.5	15
Washing machine	60	26 [l]	40	17.4	33
			45	19.6	25
Dish washer	20	8.7 [l]	12	5.2 [l]	40
			14	6.1 [l]	30
Total		**237-280**		**167-169**	**29-41**

Note: *(a)* Assuming 2.38 persons/household; *(b)* Assuming 4 full flushes per person per day; *(c)* Assuming 5 minute shower; *(d)* Assuming 10.8 lt/min; *(e)* Assuming 9 lt/min (use of restrictor); *(f1)* Assuming 1.43 showers per household per day; *(f2)* Assuming 0.34 bath per person per day; *(g)* Assuming a 6 lt/min "water saver" showerhead; *(h)* Assuming an undersized or corner bath; *(i)* Assuming 6.5 lt/min and an average 6 sec use; *(j)* Assuming 7.1 tap uses/day/person; *(k)* Assuming 5 lt/min flow; *(l)* Assuming 1 full load per day.

Source: Dworak *et al.* (2007).

If the price elasticity of water demand is usually moderate, it increases as water prices increase. To enhance the effect of water pricing policies, they must be combined with other water saving measures and awareness raising. Moreover, many studies stress that price elasticity increases in the long term – possibly because consumers replace inefficient fixtures and modify habits gradually rather than instantly (see for example Dandy *et al.*, 1997; Renzetti, 2002). In Hungary, for example, price increases from HUF 0.6/m^3 (1980) to HUF 70/m^3 (1998) (USD 0.003 to 0.36, respectively) led to a decrease in water supply by 30%, from 3 300 million m^3 to 2 300 m^3/year (Lallana *et al.,* 2001).

Water saving devices and equipment

Water saving devices and equipment can contribute to a recognisable part of domestic water saving efforts. The following table presents some potential savings from different household technologies (*e.g.* through taps with air devices, double-command toilets, water efficient washing machines etc.). According to this, up to 41% savings can be obtained by improving the technological performance of household devices.

Since investing in such devices might be costly, some local authorities provide financial support to buyers. In New York for instance, water-guzzling toilets (up to 19 litres per flush) were replaced with high-efficiency toilets (6 litres per flush). The city offered landowners 290 million USD worth of grants as an incentive to update plumbing systems with low-flow toilets, shower heads and faucets. Between 1994 and 1997, the city of New York replaced 1.3 million inefficient toilets, saving an estimated 265 to 303 million litres of water per day. In some of the participating buildings, water use decreased by up to 37 percent (EPA, 2002).

Raising awareness and educating the public

Rebates when buying high efficiency devices are a good tool to **raise awareness and educate the public** and make incentive pricing and water saving devices efficient. Another tool that plays to the strength of both approaches is the labeling of water efficient products (see Box 4.5). It works by labeling certain products like washing machines or toilets according to their water efficiency. The advantages of water efficiency labeling are:

- It informs the customer about the water consumption level of the product and enables him to make a deliberate decision. If domestic water consumption is metered and paid for by volume, the incentive to purchase a product with higher water efficiency is increased;
- Water efficiency labels create a pressure on the producers of the labeled products to incorporate available water saving techniques into the design of their products and to develop them further. This can only work if labeling for certain products is mandatory. If the system is voluntary, producers will for obvious reasons only label their better products.

Box 4.5. **Water efficiency labelling in Australia**

In Australia, the "Water Efficiency Labelling and Standards" scheme became mandatory from 1 July 2006. A research study estimated that labelling shower heads, toilets, clothes washers and dishwashers (accounting for over 80% of indoor water use in the domestic sector) would reduce the total national water consumption of these products by about 63 710 million litres per year below the business-as-usual trend line by 2016. This would represent a water use saving of about 5.2% in total household indoor water consumption.

Source: GWA (2003).

Public authorities are also organising **ad campaigns** aimed at building public support and encouraging residents to conserve water. For instance, in Atlanta, messages such as "We need to start looking at the glass as half empty," and "Don't wait until the tap runs dry" are spread in a video public service announcement. Beside rebates for two types of water-efficient purchases, the Metropolitan Water District of Southern California also proposes a webpage (*www.bewaterwise.com*) with water saving tips, information on public education program designed to educate Californians on the state's water challenges or technical information (with visual support) on the water reserve levels.

4.2.4 Benefits of managing water demand

Implementing measures and actions aimed at reducing water demand and managing drought situations deliver a range of potential benefits. Even if consumption and abstraction are closely interrelated, these benefits can be classified into:

- Benefits linked to reduced abstraction from the ecosystem, which can in turn enhance river flows and wetlands functionalities and prevent the depletion of the water table.
- Benefits directly linked to a reduced consumption, which can translate into delayed investments in the water sector or savings in water bills for consumers.

Benefits of reducing abstraction

Over-abstraction[4] of water has negative impacts both on the natural and man-made environment. These impacts differ depending on the water source (groundwater or surface water).

Unsustainable management of groundwater resources can lead to the ***overexploitation*** of aquifers. However, ***if managed in a sustainable way, groundwater extraction can continue to aid regional economic development,*** in particular in many arid or semi-arid parts of the world. The benefits of managing water demand are thus linked with limiting the negative effects of overexploitation.[5] Such benefits develop over several dimensions:

- Water stock: each unit which is not pumped today remains for future users;
- Water table level: managing water demand (partly) avoids lowering the water table, and thus limits increases in pumping costs (see Box 4.6.).

- Management of risk: an aquifer provides an insurance against variability in rainfall lowering water user's exposure to production risk, which is increasingly relevant with climate change;
- Land subsidence: damage to surface and subsurface structures due to groundwater withdrawal may be (partly) avoided with water management respecting sustainable withdrawal levels;
- Groundwater quality: reduction in water abstraction could avoid aquifer contamination (due for example to agriculture, industrial or municipal runoff) or saltwater intrusion in coastal aquifers. In Italy, for example, the latter has taken place due to excessive abstraction (Massarutto, 1999).
- Ecological impacts: because of the interconnection between groundwater and surface water, managing water abstraction avoids negative effects such as drying up wetlands, disappearing riparian vegetation or alteration of natural hydraulic river regimes.

Box 4.6. **Impact from the over-exploitation of groundwater resources in Tunisia**

In Tunisia, overexploitation is resulting in an annual lowering of underground water of almost 0.4 meters and of deep underground water of more than 0.7 meters. The additional pumping costs necessary to extract water from a deeper level is around USD 23 million. In addition, the costs of digging new wells to replace those abandoned because of pollution are USD 12.5 million. Overall, the costs of a declining water table can be estimated at USD 35.5 million (equivalent to 0.13% of GDP).

Source: World Bank, 2007.

These ecological impacts are also observed when surface water abstraction is reduced. Improving river flows leads to benefits related to landscape amenities, recreational activities and ecological services provided by the river (*e.g. *fish species diversity). In the context of the WFD, many studies have valued these benefits, by deriving use and non-use values. Indeed, the WFD sets an objective of "Good Ecological Status" by 2015 for water bodies across the EU. European countries can only request derogation from meeting these objectives based on technical or economical criteria, which need to be substantiated with a cost-benefit analysis.

To estimate benefits, contingent valuation and choice experiment valuation have been widely used. For example, Hanley *et al.* (2006) estimate through a choice experiment valuation that households are willing to pay between EUR 4 and 5.7 per household per reduced month of low-flow conditions and between EUR 31 and 47 per household per year for improvements in river ecology. In the Walloon region, a contingent valuation study was undertaken and willingness-to-pay to reach the good ecological status were found to be comprised between EUR 27/household/year and EUR 44/household/year, depending on the scale at which people accept to pay (for the Walloon region as a whole or only for their river basin) (Bouscasse *et al.*, 2008). Ojeda *et al.* (2008) estimates the economic value of environmental services which would be provided by restored in-stream flows in the Yaqui River Delta in Mexico. This includes healthy riverside vegetation, wetlands and estuaries, fish and wildlife habitats, non-use values, and recreation. A contingent valuation study revealed that households are willing to pay an average of 73 pesos (USD 6.83) every month through higher water bills for purchasing water for environmental flows.[6]

More generally, services supplied by wetlands, rivers and aquifers are preserved if water abstraction is sustainably managed. Recent studies, such as the Millennium Ecosystem Assessment,[7] describe and classify the different functions, services and goods provided by ecosystems before monetising them. This assessment looked at ecosystems as infrastructures and estimated the values of these infrastructures. With respect to wetlands, they estimated that the global economic importance of wetlands was highly variable, with an upper value of USD 15 trillion (although the report also noted that such figures are strongly disputed on methodological grounds by many economists).[8]

Box 4.7. **Services provided by aquatic infrastructures**

In the Indus river basin in Pakistan, extensive water abstraction upstream for irrigation purposes leaves only inadequate downstream flow to maintain the natural ecosystems of the Delta area. The resulting ecosystem degradation has devastating economic impacts. A wide range of land and resource opportunities have diminished or disappeared altogether in the Indus Delta area, including arable and livestock production, fisheries and forest products collection. This has impacted annual catches from mangrove-dependent fish species worth more than USD 20 million a year, fuelwood to a value of more than USD 0.5 million, fodder and pasture of almost USD 1.5 million and crop production worth hundreds of thousands of dollars. As more than three quarters of the local population depend on these products for their livelihoods, this has resulted in mass migration out of the area.

Work carried out in the Zambezi Basin in Southern Africa shows that natural wetlands have a net present value of more than USD 3 million in reducing flood-related damage costs, are worth some USD 16 million in terms of groundwater recharge, and generate water purification and treatment services to an estimated USD 45 million.

Source: Emerton and Bos (2004).

This is also what the IUCN did in its report "Counting ecosystem as infrastructures" (Emerton and Bos, 2004). Two examples extracted from this report are proposed in Box 4.7.

Benefits from reduced consumption

On the consumption side, managing water demand and promoting an efficient use of water leads to short-run and long-run benefits. Short-run benefits include, amongst others, money saved on water bills and on the costs of producing water (with avoided electricity costs when leakage is reduced for example. For example, data analysed for the Aquitaine region (Talpaert, 2005) show that water savings of 45 m^3 per year could be achieved for a 2 member household. Multiplied by the water price, this would mean a reduction in the water bill of EUR 122 per year. At the same time, reductions in household energy consumption would be expected at around 1 013 kWh per year, equivalent to a reduction in the electricity bill of EUR 70 per year. In total, cost savings of nearly EUR 200 per year can be expected for a two member household.[9]

In the longer run, social benefits can also be obtained, in particular for quantitative restrictions that give priority to health or social users as compared to water use in economic activities. Also, reductions in water supply uncertainty might provide opportunities for setting up industries and economic activities supporting rural and urban development. ***Demand reduction may also allow either the deferral and/or downsizing of planned facilities or network expansion to meet unmet demand*** (see Box 4.8).

Box 4.8. **Introducing total water cycle management in Sydney (Australia)**

With the intention to turn away from the traditional supply option of building dams and its associated environmental problems, the Kogarah council – the local government of an area close to Sydney – stressed the need to adopt new supply options that can be incorporated into urban development and at household-level, including rainwater harvesting and wastewater reclamation. In partnership with the Sydney Water Corporation and the Institute of Sustainable Futures, the Kogarah Council developed a total water cycle management strategy for the Beverley Park catchment to identify priority projects that produce the most cost-effective water savings. It was projected that by 2005/06, the implementation of these projects will have saved up to 150 million litres of drinking water every year in the Kogarah local government area.

Source: Chanan and Woods, 2005.

A sustainable use of water may also ***reduce the need for alternative supply options and hence lower their negative effects***. The benefits linked include (see Campling *et al.*, 2008):

- Financial gains: infrastructures for alternative water supply options are not built and do not need to be maintained;
- Environmental benefits: no energy consumption due to desalination, no brine discharges into the sea;
- Economic benefits: no land use by building a wastewater re-use installation;
- Social benefits: avoidance of health problems related to wastewater re-use.

In coastal areas of Spain or on islands such as Malta or Cyprus, where desalination is used for drinking water production, saving water can reduce the operation of desalination plants and/or avoid the building of new plants. In Malta, for example, where the costs per unit of drinking water produced are about EUR 0.4/m^3, every cubic meter of water saved leads to a potential saving of EUR 0.4. However, the costs per cubic meter of drinking water produced can vary significantly. For instance, USD 2.50/m^3 is reported for desalination plants in Australia. As desalination is very energy demanding, saving water in areas where the technology is used directly translates into energy savings. With an energy demand for seawater desalination ranging from 3 to 5 kWh/m^3, avoiding the production of one cubic meter of desalinised water implies saving between 1 to 5 kg of CO_2 per m^3 (depending on the energy mix for producing electricity) (Dworak *et al.*, 2007).

The benefits of saving water have hence to be determined case by case, as they depend on the costs linked to the different (alternative) water sources available.

Notes

1. *E coli* is a specific indicator of faecal contamination and hence the safety of water for drinking.
2. Managed recharge is intentional as opposed to the effects of land clearing, irrigation, and installing water mains where recharge increases are incidental. It is also called enhanced recharge, water banking and sustainable underground storage.

3. Drought is defined as a recurrent climate feature and characterized by temporary water shortages relative to normal supply over an extended period of time, ranging from one season to several years. The term is relative, since droughts differ in extent, duration, and intensity.

4. "Over-abstraction" refers to an abstraction rate above the natural resource recharge rate.

5. For more information, see the OECD report on costs of inaction (OECD 2008).

6. A summary of further studies valuing reduced water abstraction can be found in Olmstead (2009).

7. Millennium Ecosystem Assessment (2005), *www.millenniumassessment.org/en/About.aspx*.

8. Understanding the goods and services provided by ecosystems is a developing field. Before the value of these services can be adequately assessed, appropriate scientific evidence is needed.

9. However, the impact on water companies can be negative, at least in the short-run. Indeed, the great majority of tariff-setting regimes give an incentive to water companies to sell *more* water, rather than less, as they would get remunerated based on the volumes of water sold. A similar issue emerges in the energy sector, where utilities do not have an incentive to promote conservation even for resources that are projected to get scarcer and more expensive in the future.

Chapter 5

Policy implications

This Chapter brings together data and analysis from the previous chapters in order to identify where the most significant benefits from investing in water and sanitation stem from. The chapter starts by identifying what we currently know about the overall benefits of investing in WSS (Section 5.1.). Second, we examine how such information can be used to support policy-making for identifying priority investments in WSS so as to allocate scarce financial resources to the areas that generate most benefits (Section 5.2). Finally, the chapter explores needs for additional research, at both the local and global levels in order to gather additional evidence for sound policy-making and investment in WSS (Section 5.3.).

5.1 Benefits from investing in WSS: key findings

This section summarises the report's main findings on the benefits of investing in WSS, starting with the identification of the main benefits alongside the WSS value chain. The review found that benefits have been measured at various scales, with no attempt at evaluating overall benefits except in the case of meeting the MDGs. As a result, characterising the main areas where benefits are generated is a difficult exercise, which can only provide indicative figures rather than global evaluations. In addition, to derive meaningful lessons for policy makers, benefits should always be compared to costs, either through cost-benefit (CBA) or cost-effectiveness analysis (CEA) exercises. As a result, we provide indicative references for circumstances where such CBA and CEA have been conducted, which enable comparisons with investment in other sectors as well.

5.1.1 Valuing benefits alongside the WSS value chain

Chapter 2 has shown that providing access to water, sanitation and hygiene to those who are currently not served would generate significant benefits, in health terms and through time gained for productive activities as well as other intangible benefits.

In developed countries, most of these benefits were reaped in the 19th and 20th centuries, when the "sanitary" revolution, followed by the "hygiene" revolution led to almost universal water and sanitation coverage and sharp drops in mortality and morbidity. Some disadvantaged groups remain excluded, which raises equity issues, but these are usually fairly isolated and localised cases.

The "access gap" remains significant in developing countries, however, where about 884 million and 2.6 billion people do not have access to safe water and sanitation respectively (JMP, 2010). In 2008, WHO estimated that 9% of the global burden of disease worldwide could be prevented through improvements related to water, sanitation and hygiene. They estimated that 30% of total deaths of children under 5 years old can be attributed to inadequate water and sanitation. Experts are divided on the magnitude of health impacts and on the nature of the interventions that are most effective to generate such benefits, however. This said, broad consensus has emerged that hygiene education is a very cost-effective way to improve health.

Hutton and Haller (2004) estimated the total benefits from meeting the MDGs at USD 84 billion a year. Despite their significance, direct health benefits accounted for only 8% of that total, to which gains in productivity from not having to care for sick children or to take time off work when sick must be added. This assessment found that three quarters of the total benefits would be generated from time gains, from not having to walk to or queue in line at the water point or to find a secluded spot to defecate. Therefore, even if health benefits alone may not be sufficient to justify investments in water and sanitation from a cost-benefit analysis standpoint, associated time gains mean that these investments can be massively beneficial to society, with about USD 7 economic returns generated for each USD worth of investment.

Other associated benefits include increased school attendance, boosted tourism revenues, environmental improvements from a decrease in open defecation, economic benefits from reusing faeces and urine, cost savings due to less water treatment or better (closer) access to clean water sources and benefits to individuals in terms of improved status and dignity. Studies tend to concord in stating that the latter benefits are key drivers of demand (particularly for sanitation) rather than the health benefits, which are often insufficiently known by the populations.

Chapter 3 stresses that treating wastewater for safe disposal delivers benefits for other types of water uses, for both withdrawal and in-stream uses. Whereas the former includes municipal water supply and domestic use as well as irrigated agriculture, livestock watering and industrial processes, benefits from in-stream uses arise from the water left "in the stream". These include benefits for swimming, boating, fishing and non-use benefits of water quality (including stewardship value, altruistic value, bequest value and existence value). At present, the "foregone benefits" from a lack of wastewater treatment are substantial, particularly in developing countries. For example, only 13% of wastewater is treated before disposal in Latin America and equivalent figures are well below 10% in Sub-Saharan Africa.

In some cases, treating wastewater at health-based water quality standard might not be sufficient to fully capture all "instream" benefits. Experience with the implementation of the WFD in Europe shows, for example, that tertiary treatment is not always sufficient for achieving good ecological status as required under the WFD. Reducing diffuse pollution from agriculture in parallel to treated wastewater would then be necessary for capturing all environmental benefits presented above.

All benefits identified can become costs if adequate wastewater treatment facilities are not provided in parallel to drinking water and sewerage services. Indeed, investing in sewerage networks would result in diffuse household pollution becoming point source pollution which, if not adequately treated, can lead to significant negative impacts on downstream water users (*e.g.* households, irrigated agriculture, fisheries) and on the aquatic ecosystem.

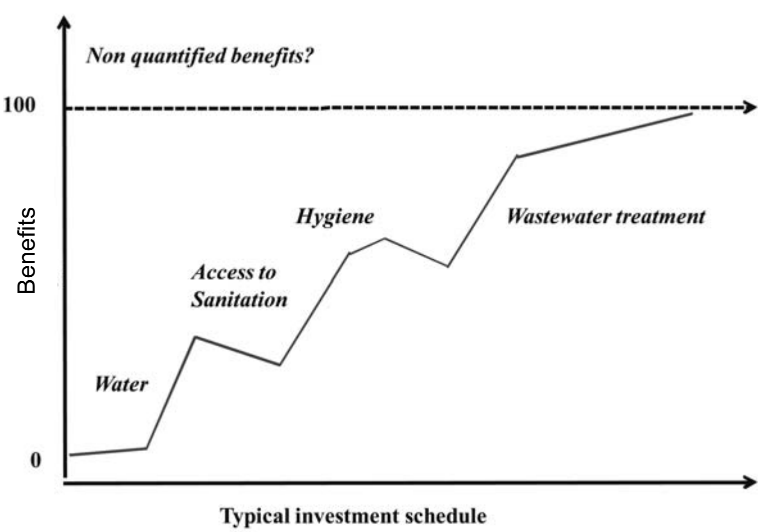
Chapter 4 sets out that protecting water resources from pollution and managing water supply and demand in a sustainable manner can deliver clear and sizeable benefits for both investors in the services and end water users. Investments in managing supply and demand are going to be increasingly needed in the context of increasing water scarcity at the global level: whereas it was estimated that 2.8 billion people lived in areas of high water stress in 2009, this number is projected to rise to 3.9 billion by 2030.[1] McKinsey & Company (2009), in a report for the Water Resources Group 2030 which comprises of international institutions such as the IFC and large industrial corporations, evaluated that the "water gap" would be in the range of 40% by 2030, *i.e.* the difference between current accessible, reliable supply (including return flows, and taking into account that a portion of supply should be reserved for environmental requirements) and projected water needs. They highlighted that this global figure is an average, hiding the fact that in some regions of the world, the situation could be much worse, particularly in developing countries where the deficit could be as high as 50 percent.[2]

Investments in managing the water supply and demand balance can ensure that infrastructure is not over-sized compared to "optimal needs" and can help reduce water resource pollution at source, which is cheaper than investing in additional treatment. This clearly allows avoiding unnecessary expenses, which is essential in the current situation where financial and budgetary resources are scarce. Overall, this ensures that WSS can be provided to a larger population leading to larger benefits. In the medium and longer term, this would also mean that O&M and replacement costs would be kept lower, which strengthens the long-term sustainability of WSS.

Overall, the analysis developed in the report stresses the need to conduct a systematic integrated planning of investments in WSS that combines the different components of the value chain. Investments in drinking water and sewage cannot be considered in isolation of (upstream) resource protection and (downstream) wastewater treatment. Their integration allows avoiding unnecessary costs and maximising benefits along the value chain, whilst avoiding potential "disbenefits" from inadequately timed or sequenced investments.

The magnitude of benefits can vary substantially depending on the level of sector development. Figure 5.1 represents the streams of benefits coming from a typical investment schedule. In most countries where the "access gap" is still large, providing access to water services is seen as a priority and it

Figure 5.1. **The water and sanitation benefits curve**



can indeed deliver substantial benefits. If access to water is provided without corresponding investments in sanitation, this can generate temporary disbenefits, however, as abundant water supply can create pools of stagnant waters mixing with excreta and other types of waste (such as grey waters). Hygiene education can significantly enhance the realisation of benefits alongside the first part of the curve. Sanitation without wastewater treatment can itself generate disbenefits if it transforms diffuse pollution into point-source pollution. Wastewater treatment would eliminate all residual risks. However, benefits start tailing off once a high degree of wastewater treatment is reached (although this would clearly depend on maintain existing installations, so that they can continue to deliver benefits). In addition, there may be some additional benefits (such as from an improved living environment or benefits for future generations) which may be harder to quantify but that could nevertheless justify investments in WSS beyond the level at which quantifiable benefits overtake costs.

5.1.2 Estimating benefits at different scales

Most benefit estimates focus on fairly small study areas, in the context of a specific investment. Results from such studies are difficult to compare and cannot be meaningfully aggregated. An abundance of studies have sought to value the various types of benefits generated from WSS investments at the level of a river basin or a given population settlement. As a result, there are a wide range of results, depending on the circumstances at the local level. Synthesising results is complicated by the fact that such studies have been carried out at various scales and in countries with very different characteristics, including in terms of prevalence of water-related diseases, pollution of the water bodies or even population's income or levels of economic development.

Few studies estimate benefits at the national level. Only a few studies have estimated the overall benefits from WSS investments at the level of a given country on the economy as a whole (using economic indicators such as percentage of GDP). Taking a comprehensive view of benefits is important as certain economic sectors can benefit from combined actions at different steps of the WSS value chain. For example, the agricultural or the tourism sectors can benefit from investment in both up-stream and down-stream activities of the value chain.

Economy-wide studies have been conducted in developing countries rather than in developed countries (where studies have more frequently been carried out at the local level). For example, the Water and Sanitation Programme (WSP) launched the Economics of Sanitation Initiative (ESI) in 2006, to address the lack of response to sanitation as a health issue by high level decision makers in South East Asia and to raise the profile of sanitation in those countries. In a first phase, the ESI carried out comprehensive assessment of the impact of poor sanitation on the economies of five South East Asian countries (see Box 5.1). This initiative has since been extended to 3 countries of South Asia and is in the planning phase in three countries in Africa.

The estimated losses from poor sanitation alone (ignoring inadequate access to water) are of comparable magnitude today than the predicted (and therefore highly uncertain) losses due to climate change far in the future. These findings are very substantial when compared to interventions in other sectors. For example, the Stern Review on climate change found that the impact of climate change on economic output for a baseline-climate-change scenario would be around 2.5% loss in GDP for India and South East Asia and 1.9% loss in GDP for Africa and the Middle East by 2100, compared to what could have been achieved in a world without climate change (Stern, 2007).[3]

No global estimates of the benefits of investing in WSS have been compiled. Benefit valuations at the global level have been carried out with the objective of generating political momentum (and associated financing) for meeting the water and sanitation MDGs. However, these studies are focused on providing access to the services and do not cover the entire WSS value chain (which would include the benefits from wastewater treatment for example). It is beyond the scope of this study to provide an estimate of the global benefits of investing in WSS, as this raises complex methodological challenges, but such analysis may need to be conducted in future (see Section 5.3 on additional research needs).

5.1.3 Comparing benefits and costs

Most studies identified and reviewed in this report have not systematically sought to compare benefits with costs. The present study has reviewed available information and existing studies on benefits from investing in WSS. It is only when cost information has been gathered alongside information on benefits that those have been presented. There are several problems with this lack of cost information. As mentioned above (Section 1.3), benefit information cannot easily be compared or transferred across countries or even across localities (the benefits of investing in aquifer recharge or wastewater treatment can vary significantly from one river basin to the next).

Information on benefits alone is not sufficient to convince policy makers that investing in WSS is a good use of public money. There are two main ways of carrying out this type of evaluation: through cost-benefit analysis (CBA) or through cost-effectiveness analysis (CEA). The main difference is that CBA requires valuing both costs and benefits in monetary terms whereas CEA only needs to express costs in monetary units and can rely on various metrics for measuring effectiveness. Carrying out sound cost-benefit analysis

Box 5.1. **The Economics of Sanitation Initiative: evaluating the impact of poor sanitation**

Phase 1 of the ESI study consisted of evaluating the impacts of inadequate sanitation on the economy of five countries in Southeast Asia, including Cambodia, Indonesia, Lao PDR, the Philippines and Vietnam. The stated goal of the study was to provide decision-makers at country and regional levels with better evidence on the negative economic impact of poor sanitation, and to provide estimates of those negative impacts that can be mitigated by investing in improved sanitation. The study showed that, due to poor sanitation, these countries (except Lao, which was not included in the total estimate) lose an aggregated USD 2 billion a year in financial costs (equivalent to 0.44% of their GDP) and USD 9 billion a year in economic losses (equivalent to 2% of their combined GDP). This was equivalent to annual financial losses of USD 5 per capita and USD 22 per capita of economic losses at current exchange rates, although these values could reach close to 200 international dollars (*i.e.* expressed on a PPP basis) on a purchasing-power parity basis in the case of Cambodia.

The study also sought to estimate the economic gains that could be achieved from adopting improved sanitation, which are summarised below for the four countries combined. Given the difficulties of attributing health impacts to sanitation, it was estimated that only 45% of the health losses could be reverted through improved sanitation, which means that the total benefits from improvement are lower than the estimated losses. This estimation shows that the protection of water resources (through preventing leakage of contaminated wastewater into surface and groundwater resources) is the most significant component of total benefits.

Economic benefits from improved sanitation	Estimated total (bn USD)	% of total gains
Time gained from latrine access	1.4	21%
Health gains from latrine access and hygiene	2.2	33%
Water resource protection (reduced contamination)	2.3	35%
Increase in tourism activity	0.4	6%
Benefits from waste re-use (Ecosan)	0.271	4%
Estimated total economic benefits	6.571	100%

In Phase 2 of the study, which began in 2008, cost-benefit analysis studies of a range of sanitation options were conducted for both rural and urban areas in the East Asia Pacific region as well as the Yunnan Province in the South of China. In all study sites, the study found that benefit-cost ratios for investments in various sanitation options (including both on-site and off-site) were all above one, reaching as high as 10. The economic rate of return on initial investment ranged from 30% to 200% per year and was highest in rural areas.

Sources: Hutton *et al.* (2008, 2009); personal communication with Guy Hutton (2010).

allows evaluating whether the benefits of a proposed investment outweigh the costs or setting standards and targets at a welfare-maximising level.

In the developed world, the majority of health benefits from WSS have already been generated, with water being provided on a continuous basis at drinking water standards, almost universal sanitation coverage and high degrees of wastewater treatment. OECD experience suggests that the marginal rate of return of water and sanitation interventions diminishes with the increasing sophistication of measures. For instance, in the US, the average cost per cancer case avoided due to tighter drinking water standards on certain pesticide and herbicide concentrations has been assessed between USD 500 million to 4 billion (Olmstead, 2010). It is important to note, however, that this has happened even though some rivers remain at sometimes poor chemical status, which leads to additional (costly) treatment for ensuring drinking water standards or investments to access alternative (potentially more expensive) water sources. There is no available evidence on the magnitude of these potential "additional costs", although recent cost-effectiveness studies (carried out in the context of the WFD implementation) stress that they could be significant.

However, even in developed countries, there are some areas where the benefits from new investments are likely to be significantly above costs. This might be the case when policy choices have led to building "non cost-effective" measures in the past. This might also arise when some benefits are difficult to capture and translate into monetary terms, as illustrated by the recent experiences with cost-benefit assessment carried out in the European Union in support to the implementation of the WFD in a few countries only (see Box 5.2). Although the WFD relates to the broader field of water resource management, these examples are relevant as they show the ways in which information on costs and benefits of water investments can feed into the policy-making process. In the case of the WFD, however, the main areas of benefits relate to environmental benefits associated with reaching Good Ecological Status, which are particularly difficult to quantify as these are linked largely to non-use values.

In developing countries, investments in WSS usually have a high benefit-cost ratio and compare favourably to other development interventions. Cost benefit analysis of WSS investment projects are carried out in the context of project appraisal to compare alternative investment options, especially by some bilateral donors.[4] However, they are rarely compared to alternative development interventions in other sectors.

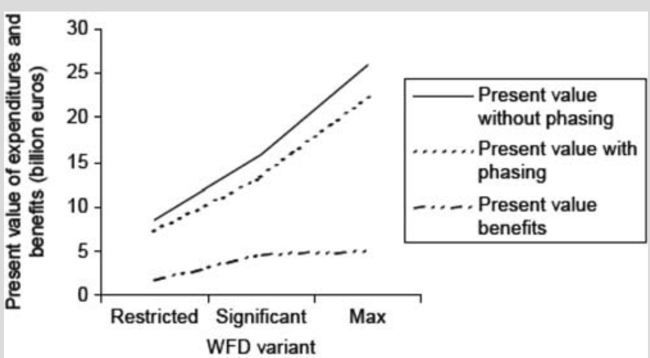
The Copenhagen Consensus project sought to compare the costs and benefits of a broad range of development interventions in order to help define international priorities: it did so by evaluating benefit-cost ratios (BCR) using standardised methodologies across sectors.

Box 5.2. **Comparing benefits and costs of the European Water Framework Directive**

In Europe, a limited number of countries have sought to compare the costs and benefits of introducing the WFD at the national level. In the UK, several studies estimating benefits and costs have been carried out, fulfilling the requirement to conduct a regulatory impact assessment of any new legislation (De Nocker *et al.*, 2007). The impact assessment of the first cycle of River Basin Management Plans developed to implement the WFD provides estimates of benefits and costs of the WFD in England and Wales. One-off costs were estimated at USD 112 million (GBP 75 million) (in the first three years), and average annual costs (excluding one-off costs) were estimated at USD 12 million (GBP 8 million). On the benefits side, average annual benefits have been identified, corresponding to the general public's willingness to pay for improvements to water status. They amount to USD 15 million (GBP 10 million). Using the present values of costs and benefits as a basis for comparison shows a net benefit of the WFD in England and Wales of USD 10 million (GBP 7 million) (Defra/WAG, 2009).

In the Netherlands, several cost-benefit analyses have been performed for the WFD implementation in order to support the decision making process by informing policy makers, including the Dutch Parliament. In 2006, a strategic cost benefit analysis tried to monetise benefits as far as possible. The assessment indicated that the most important benefits of WFD measures are related to the value attached to living in a beautiful natural environment, which could be revealed in the increased value of houses in the vicinity of water. Other benefit categories identified included recreational benefits and benefits for the production of drinking water. However, as benefits could not be estimated and monetised for all categories, the numbers provided were expressed as underestimates of the real benefits. The analysis showed that the estimated benefits are significantly less than the estimated costs, and that costs increase more than the benefits (van der Veeren, 2010).

Comparison of costs and benefits of the WFD in the Netherlands



Note: Present values, in EUR 1 000 million; "WFD variant" refers to different scenarios.

Source: Ministerie van Verkeer en Waterstaat, 2007, cited in van der Veeren, 2010).

Box 5.2. **Comparing benefits and costs of the European Water Framework Directive** *(continued)*

The assessment results helped policy makers to grasp the complex economic implications for the country and for different economic sectors. It also raised ethical and general liability considerations (in particular with regards to the responsibility of today's citizens to keep an adequate state of the aquatic ecosystem for future generations) that justified the need for action even if costs were higher than (measured) benefits. Finally, the different analyses allowed a successful dialogue with the Dutch Parliament, "which resulted in a socially accepted programme of measures that is economically sound and transparent" (van der Veeren, 2010).

Source: De Nocker *et al*., 2007; Defra/WAG, 2009; van der Veeren, 2010.

Whittington (2009) carried out the exercise for a range of low-cost water and sanitation sector interventions (see Box 5.3). As Whittington (2009) stresses, not all water and sanitation projects would pass the CBA test, especially given the substantial up-front capital investments which yield benefits over a long period. As a result, it is critical to evaluate the costs as well as the benefits of alternative investments, given that different service levels may yield comparable benefits at very different costs. Whittington (2009) concludes by stating: "the key to successful water and sanitation investments is to discover forms of service and payment mechanisms that will render the improvements worthwhile for those who must pay for them. In many cases, the conventional network technologies of water supply will fail this test and poor households need alternative, non-networked technologies".

The Copenhagen Consensus analysis is useful as it helps place sector interventions into perspective and compare them with other ways of reaching similar objectives (such as a reduction in child mortality or general poverty reduction objectives). There are several limitations with this type of analysis, however, as methods for measuring benefits and costs can vary widely from one sector to the next and the results are therefore difficult to interpret.[5] In addition, the CC project compares development interventions of very different natures, when some may be relatively straightforward to implement (*e.g.* immunisation campaigns) whereas others require substantial and uncertain political negotiations (such as the Doha development agenda or peace-keeping in post-conflict situations).

Conducting comparative cost-effectiveness analysis is somewhat easier and less controversial from a methodological point of view but it allows comparing interventions on the basis of a single indicator of effectiveness. For example, the Disease Control Priorities project is an ongoing effort to assess disease control priorities and produce evidence-based analysis and

Box 5.3. **The Copenhagen Consensus project: ranking development interventions based on BCR**

The Copenhagen Consensus project was initiated by Bjørn Lomborg, a leading thinker on environmental issues who describes himself as a "skeptical environmentalist". The project consists of prioritising a broad range of global development interventions based on cost-benefit analysis. The process was first carried out in 2004, and led to additional funding allocated to HIV/AIDS projects, "which topped the economists' "to do" list".

The second edition, published in 2009, set itself to "look at ten of the biggest issues facing the planet", which included sanitation and water. Whittington et al. (2009) led the analysis on water and sanitation and estimated the cost-benefit ratios of four types of water supply and sanitation interventions in developing countries, including:

- A rural water supply program for constructing deep boreholes with hand pumps in Africa;
- A sanitation program designed to halt open defecation in South Asia (community-led total sanitation);
- Water-disinfection technology (biosand filter) installed at the household level (point-of-use);
- Large multipurpose dams in Africa.

Results	Rural water	CLTS	Biosand filter
Benefits (USD /hh/month)	6.63	1.14	3.73
Costs (USD/hh/month)	2.26	0.43	1.40
Benefit-cost ratio (average)	2.9	2.7	2.8
% of sites with BCR <1	15.6%	15%	11.1%

The simulations were made using a Monte-Carlo simulation approach, to reflect the fact that the benefits and costs may vary depending on the locations and circumstances of the interventions. BCR could therefore be much higher than those average values, with 11% of sites showing a mean BCR of 6.8 for handpumps, for example. Similarly, biosand filters was the intervention with the lowest risk of a BCR below 1.

These results were then compared with those from other sectors and ranked by leading economists and development practitioners, who were asked to indicate where they would "put their money" based on this type of analysis. In the final overall ranking, WSS interventions came in about 15th to 20th position (over a total of 30 interventions), whereas health interventions to address malnutrition (such as micronutrient supplements or community-based nutrition promotion) came towards the top, largely due to their comparatively low costs and fast pay-back periods.

Source: Lomborg (2009); Whittington *et al*. (2009).

resource materials to inform health policy making in developing countries. It does so by comparing the effectiveness of various health interventions based on the estimated cost per DALY averted (see Box 5.4).

Box 5.4. **The Disease Control Priorities project: estimating the cost effectiveness of health interventions**

Chapter 41 of the second edition of the Disease Control Priorities project (Cairncross and Valdmanis, 2006) evaluated average cost-effectiveness values for a range of water and sanitation interventions, as a basis for comparing it with other health interventions reviewed in other chapters (the publication has 73 chapters reviewing a broad range of health measures).

The study found that hygiene and sanitation promotion cost respectively USD 3 and USD 11 per DALY averted. By comparison, the cost-effectiveness of promoting oral rehydration therapy, the main other measure to prevent diarrhoea mortality, was estimated at USD 23 per DALY, which means that hygiene and sanitation promotion compares favourably to such measure. These values are also well below the USD 150 per DALY cut-off value proposed by the World Bank (1993) as a cost-effectiveness criterion for investing in health.

Infrastructure investments had a much higher cost when compared to effectiveness. For example, the cost-effectiveness of constructing sanitation facilities (including promotion) was USD 270 per DALY. As for water supply, providing a community connection was estimated to cost USD 94 per DALY, while it was more than twice as much for household connections (USD 223 per DALY). These measures are still cost-effective when compared to other health measures, however. For example, the provision of antiretroviral therapy against AIDS was estimated to cost USD 922 per DALY.

Sources: Cairncross and Valdmanis (2006); *www.dcp2.org/main/Home.html*; World Bank (1993).

The cost-effectiveness of interventions can vary widely from region to region, however, as it is dependent on the levels of incidence and case fatality rates, the number of persons being reached by each intervention and the cost structures. Water and sanitation interventions are usually more cost-effective in the regions where the diarrhoea case fatality rate is high (Hutton *et al.*, 2008).

The interventions that bring the highest overall benefits (including health and non-health benefits) may also be the most expensive ones. Haller *et al.* (2007) conducted a cost-effectiveness analysis which indicates that the provision of in-house piped water supply and sewer connection is the intervention that maximises health gains but is also the most expensive intervention: they estimated that piped water supply and sewer connection would achieve a maximum health gain (71 million DALYs averted) but that investment and recurrent costs would also be quite important (ranging from USD 48 to 60 billion). From this analysis, they concluded that for many developing countries, in-house piped water supply may not be affordable in the short to medium-term and governments and households may need to settle in the short-term for second-best solutions, although health and non-health benefits would not be as large. They suggested that disinfection at point of use, which has a better cost-benefit ratio (USD 338 to USD 461 million for 17-19 million DALYs averted) could be used as an efficient short-term policy strategy to further reduce diarrhoea incidence, while time elapses during the extension of coverage and upgrading of piped water and sewage services. This investment strategy for water improvements is also recommended by Edwards (2008), in a guide to understanding costs and benefits of water interventions published by WHO.

In Europe, similar attention is given to "cost-effectiveness" assessment for ensuring proposed (environmental) policy objectives are reached at the lowest costs. Cost-effectiveness analysis (CEA) is particularly well-suited when policy objectives have already been set. The main implications of these evaluations have been as follows:

- In the field of wastewater treatment, it appears critical to consider alternative wastewater treatment techniques as opposed to large scale wastewater treatment infrastructure, as the former would typically be more cost-effective.
- To reach set water quality objectives, it is important to compare measures aimed at reducing pollution for different sectors/water uses such as better fertilisation practices in agriculture versus treatment of effluents from rural communities or additional treatment for achieving drinking water standards. This clearly places the question of WSS in the wider context of IWRM.

5.2 Using benefit information for policy and investment decisions

Even though there are substantial variations between figures, a number of key messages for policy makers transpire from the analysis, as summarised below.

The "low-hanging" fruits at the global level lie in the provision of access to improved water, sanitation and hygiene, as embodied in the MDG targets for water and sanitation. The magnitude of the challenge is clear and the benefits substantial, at the level of each country but also for the global economy overall, thanks to a number of indirect effects. For example, as mentioned in Chapter 2, providing access to water, sanitation and hygiene can make a substantial contribution to reducing child mortality, which can contribute to reducing fertility rates (amongst other factors) and slowing down population growth following a demographic transition. Even though progress towards meeting the MDGs has been substantial, particularly for access to water, the sanitation MDG will not be met in a large number of countries, particularly in Sub-Saharan Africa, with an associated negative impact on social and economic development. For example, the AICD (Africa Infrastructure Country Diagnostic) project, conducted by World Bank researchers with funds from a variety of donors, found that current levels of spending were substantially below what is needed to meet the water and sanitation MDGs in Sub-Saharan Africa.[6] African governments recently committed to spending 0.5% of their GDP on sanitation through the eThekwini Declaration adopted at AfricaSan in 2008. According to Foster and Briceño-Garmendia (2009), this would bring them closer to the amounts needed to meet the MDGs but could not compensate for the accumulated backlog.

Given the substantial costs of providing access to water and sanitation and financial resource constraints, focus should be placed on investments with the highest cost-effectiveness ratios. For example, good hygiene and sanitation may prove more important to protect health than clean safe water to drink delivered at the tap and is comparatively very cost-effective. In addition, the adoption of hygienic practices has been found to be a necessary condition for the benefits of investments in access to water and sanitation to be effectively realised. A number of experts have also recommended relying on point-of-use water treatment until more expensive water networks with centralised water treatment can be extended. At present, according to the DAC database, access to basic water and sanitation is receiving less than a quarter of total aid to water and sanitation from OECD countries in the water sector, compared with almost half for water and sanitation large systems.

In developing countries, simply placing an emphasis on meeting the MDGs for water and sanitation will not be sufficient, however. Protecting the resource is critical for being able to serve existing and newly connected households on a sustainable basis. This will require investing in adequate and sustainable sanitation, but may or may not include wastewater treatment. In some cases where sewerage coverage is very low, promoting household investment in improved latrines and making available services and infrastructure to ensure the sustainable use (and emptying) of these latrines can prove a much more cost-effective way of achieving those objectives. In addition, ensuring the reliability of supplies through adequate management of the supply and demand balance will be essential in the context of climate change and rising water scarcity. The AICD mentioned above found that in Africa, water storage is grossly under-developed (standing at about 200 cubic meters per capita, when storage capacity can be counted in the thousands in other continents) and will require massive investments going forward in order to cope with increased variability in rainfall patterns.

A broader perspective may therefore need to be adopted in order to define international targets beyond the MDGs, which have been very much focused on access to basic services so far. In the run up to 2015 (the target date for the MDGs), it will be important to use findings on benefits in order to contribute to the definition of new targets. In doing so, the international community should set objectives which will be valid over the long-term. For example, as noted by Bartram (2008b), there is growing evidence that the benefits of providing access to a water point at community level are very limited, whereas there are large benefits when water is available in every household, in terms of hygiene, productivity and time saved. Defining new targets will require going beyond simple access measures in order to consider the broader economic impacts that lack of adequate water and sanitation services generate.

The "dirty water" side is not receiving enough attention compared to the "clean water side". Data on investments in sanitation (as opposed to water) tend to be difficult to locate reliably, given that figures on water and sanitation investments are usually combined (including in the OECD DAC database, although increasing efforts are made to separate those out). The JMP estimated that in the 1990s, water received USD 12.6 billion annually whereas sanitation received only USD 3.1 billion, or roughly four times less. Given the benefits that sanitation provide, not only in terms of health and productivity gains but also in terms of water resource protection, investments in sanitation clearly appear to be lagging as compared with water.

Protecting the resource and treating wastewater before discharging it back into the environment can lead to substantial reductions in treatment costs and preserve the resource for a multitude of other uses, including critical uses for the economy as a whole (such as aquaculture or tourism). Such resource protection is now a critical investment driver in developed countries, where most health benefits for WSS have already been reaped and the focus is now on environmental benefits. Cost-benefit analysis of such proposed investments may not give positive results if benefits are estimated purely on the basis of incremental environmental improvements. But the benefits of protecting the resource for the economy as a whole and for future generations may provide sufficient justification to go ahead with the investments. In addition, adequate treatment allows re-using the sludge or treated wastewater for productive uses, such as for agriculture or energy production, which can generate substantial income streams and help with financing sanitation investments in the first place. This calls for defining financing channels that allow leveraging these revenue streams.

Adopting a strategic planning view in order to select the most cost-effective investment options across the entire value chain is critical in order to avoid excessive costs, both now and in the future. In many countries, there is an initial focus on investing in providing access to drinking water. However, even if such investments have benefits, they can also have disbenefits as the volume of untreated wastewater discharged in the local environment increases, thereby increasing the amount of dirty water lying around (with increased risks of spreading diseases such as malaria via insects breeding in pools of dirty water), spreading the risk of epidemics and contaminating groundwater. Similarly, when investments in sewerage networks are made without corresponding investments in sewage treatment, this can have benefits for the local environment but disbenefits for the population in another area, as it creates point source pollution where the raw sewage is discharged into a river or the sea for example.[7] Part of the issue with estimating overall benefits is therefore linked to the sequencing of investments, given that investments are usually not made all at once, due to limited access to finance, limited capacity to implement, etc.

5.3 Additional research needed to support policy-making

Even though studies on the benefits of investing in WSS are numerous, there are few cases where such studies have been used to directly influence decision-making. In Brazil, for example, the study by Barreto *et al.* was the first comprehensive study to analyse the impact of a city-wide sanitation programme on reduction in childhood diarrhoea. Although the study gained prominence within academic circles, it came too late to influence the political and policy debate during the programme (see Box 2.3. for more information). In the case of the adoption of the Water Framework Directive (WFD) in Europe, for example, the objectives introduced in the directive (such as "good ecological status" for receiving water bodies) were defined through the political process rather than as a result of a thorough evaluation of benefits. Given the difficulties that relate to the estimation of benefits from water investments (which, in the context of the WFD, go beyond WSS), the WATECO guidance document on the implementation of the economic aspects of the WFD indicates that a full cost-benefit analysis is required only if a country has decided to seek derogation from the stated objectives, in the event that the costs of implementing the measure are likely to be "disproportionate" when compared to the expected benefits (WATECO, 2003).

***Similarly, in the developing world, the MDGs for water and sanitation were defined based on what appeared at the time as targets that were reasonable and achievable, and yet sufficiently challenging to represent a meaningful target*.** There was no preliminary CBA carried out for setting that objective and a CBA was only carried out ex-post, which found a BCR of around 8 (Hutton and Haller, 2004).

This report has put forward the way in which information on the benefits from investing in water and sanitation could assist with defining policy and setting investment priorities in this area. However, we have identified a number of areas where research needs to be strengthened in order to make the most useful contribution to the policy debate.

Improving the comparability of results from isolated studies would help build a global picture of benefits and strengthen the benefit studies conducted at a local level to support policy-making and investment decisions. From a methodological standpoint, it would be useful to use common "metrics" so that benefits can be compared more easily across study areas and jurisdictions. For example, willingness-to-pay studies are often reported as a net amount that a household is willing to pay (or invest itself) in order to obtain a given service improvement. In a similar way, benefits could be reported as benefit amounts per capita, or as percentages of household incomes. The latter would help for comparing benefits with costs, proxied by the average household WSS bill. This would also improve the comparability of results from one country to another, and allow overcoming differences in purchasing power parities.

Efforts would be required to assess and illustrate the magnitude of "costs avoided" from improved investment sequencing, both in relative terms as compared to total investment costs (past or foreseen) and in terms of "foregone benefits". This would require considering today's costs, but also the costs avoided when replacing WSS infrastructure – clearly, an important issue with benefits for future generations that are too often disregarded. Such analysis could also be done in the context of a broader range of development interventions, to examine whether water and sanitation investments should be carried out early in the process (as "engines" for growth) or later on, once economic infrastructure is in place that will ensure adequate operation and maintenance of the water and sanitation assets.

Local-level decisions need to be based on cost-benefit analysis of alternative investment strategies, including not only the selection of investment options, but also the design of overall investment strategies and sequencing aspects. Although several guidance documents on cost-benefit analysis of water projects exist, guides to evaluating the benefits and costs in the context of decision-making for water and sanitation sector reforms (rather than for particular projects) may still be needed. This would emphasise the need to value benefits or disbenefits at all steps of the value chain and to evaluate whether current levels of investment for each of these steps is adequate. However, conducting solid cost-benefit analysis is an expensive exercise that cannot be done in all circumstances: one approach may be to carry out a CBA only in areas where there are significant issues (akin to "hot spots") and where there is a need to carefully determine the most appropriate investment response. This is the approach that was taken for the application of economic analysis in the context of the Water Framework Directive, which calls for conducting cost-benefit analyses only when proposed measures are likely to generate "disproportionate costs".[8]

Given the eminently local nature of WSS, a global estimation of benefits may not be warranted at this stage. Based on the study findings, it appears that conducting a global study of the benefits of investing in WSS, such as the Stern Review for climate change or the Millennium Impact Assessment for ecosystem services, would both be extremely challenging and of comparatively more limited use. From a practical point of view, the present report has repeatedly highlighted the variability in benefits from WSS depending on local factors, such as the prevalence of diarrheal diseases, the quality of receiving waters, etc. For example, Olmstead (2010) indicates that the "non-uniform mixing" of most water pollutants makes it difficult to design cost-effective policies for pollution control. Unlike air pollution, water pollution or water scarcity are eminently local issues. In the case of water pollution, for example, pollutants cannot be aggregated in the same way as the contribution of carbon emissions to climate change is estimated for example. Besides, remedial actions are to be taken at the local level and a global coordinated policy response (assuming it is feasible) would be of less use for water and sanitation than for climate change.

By contrast, a set of illustrative case studies in typical settings or regions conducted based on a common methodology could make a very important contribution to support the case for investing in water and sanitation services. The case studies could be selected to reflect typical situations with different sets of pressures (such as relative water scarcity, population growth rates, competing uses of water, condition of pre-existing water and sanitation assets, etc.). A coherent set of case studies could contribute to raise awareness at the global level and to influence a reallocation of financial resources towards the sector, or within the sector (*i.e.* to allocate resources to more cost-effective interventions based on a more rigorous analysis of benefits). Should such a study be conducted, we would recommend that it covers the benefits of investing in all types of water investments, based on IWRM principles, as its main purpose would be to highlight the need for additional investments to address increasing water scarcity and the deterioration of the resource. Whereas municipal water use is a significant contributor to such pressures, it is by no means the main contributor, with other uses (for agriculture, industry or power production) taking the lion share.

Notes

1. *www.independent.co.uk/environment/climate-change/water-scarcity-now-bigger-threat-than-financial-crisis-1645358.html.*

2. McKinsey & Company (2009) evaluated the economic impact of such deficit in specific areas likely to be particularly affected, such as the river basins on the Eastern Coast of China, where rising municipal use competes with agricultural and industrial uses, and evaluated a broad range of supply and demand-side measures that could be developed and implemented to reduce this gap.

3. However, Stern (2007) indicates that there are good reasons to give more emphasis to a higher climate change scenario, which could result in a 9% loss in GDP in India and South East Asia and a 7% loss in Africa and the Middle East by 2100.

4. Most multilateral donors would estimate the internal rate of return (IRR) of a given project but would not necessarily seek to monetise the benefits of that project, as this can be a relatively costly exercise.

5. For example, Whittington (2009) used a 6% discount rate instead of the "prescribed" 3% by the CC project designers, as he deemed that it was more applicable to WSS investments.

6. See: *www.infrastructureafrica.org/aicd/* for more information and to download the full report.

7. For example, Bennett (2009) evaluated this impact in the context of a water project in Cebu (Philippines) and found that a neighbourhood's complete adoption of piped water increases public defecation and garbage by 15-30 percent.

8. European Commission (2001).

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Annex A

Evaluating the benefits: methodological issues

This Annex sets out in more detail methodologies that are commonly used to evaluate the types of benefits generated by investments in water and sanitation services. It examines how benefits can be defined and how each main category of benefits can be measured, with respect to health, environmental, economic and intangible benefits.

A.1. Defining and valuing benefits

Benefits can be defined in a number of ways. In cost-benefit analysis terms, benefits can be defined as net improvements from a given intervention (including a given investment) or as an "avoided cost" irrespective of whether the intervention has taken place or not. For example, a recent OECD report estimated the "costs of inaction" for selected environmental policy challenges (see OECD, 2008). In this report, inaction was defined as the hypothetical scenario that "no new policies would be taken beyond those which currently exist".

Benefits may include direct and indirect effects. For example, the direct effects from investing in water would include the health impact from improved quality whereas the indirect effect would include the impacts on improved productivity, school attendance or reduction in fertility rates (resulting from a drop in child mortality).

A critical issue is to define a common unit in which to express the benefits. The unit in which benefits are expressed would usually depend on the type of benefits: for example, DALYs are used for expressing health impacts, whereas % GDP may be used to assess economic impacts. To be able to compare and aggregate different types of benefits, it is necessary to express benefits in a single monetary unit in order to be able to compare different types of benefits. Doing so requires attributing monetary values to benefits that may be difficult to quantify: for example, whereas DALYs can be "translated" into monetary benefits by attributing a value to human life, this raises a number of methodological issues such as how to value the life of an under-5 as opposed to that of an adult. This is particularly important for WSS given that those most affected by inadequate water and sanitation are children under 5 years old.

Using benefit values: the limits of benefit transfer. Transferring benefit values across countries is a difficult and potentially misguiding exercise, particularly if such values are transferred between developing countries and developed countries. This is important to bear in mind, given that transferring benefit values is often used, somewhat abusively, to cut the costs of measuring benefits. Some more reflections on the use of benefit transfers are given in Box A.1.

Box A.1. **Benefit transfer: limitations and opportunities**

Applying economic values measured on one site to another site for a similar good can be a useful tool, especially when the alternative consists of having no value estimates at all, given that collecting primary data is a costly and time-consuming exercise. However, several risks and uncertainties are linked to using benefit values across sites, which is referred to as "benefit transfer". Several issues need to be considered, including converting values from one currency to another or accounting for income differences from one country to the other. Given the need to make assumptions, benefit transfers inevitably increase subjectivity and uncertainty compared to the original study. It has to be decided on an individual basis whether this is acceptable and whether the transferred values are still informative.

Given the potentially essential role of benefit values in the environmental decision-making process, it is surprising that no generally accepted practical transfer protocols exist to guide analysts. However, well accepted recommendations can be found. They include amongst others:

- Accuracy and quality of the original study have to be carefully examined;
- The study site and the newly considered site must be similar in terms of population characteristics; otherwise, implications of the differences on the WTP values have to be considered;
- Changes with respect to the good in question should be similar on both sites;
- The use of meta-analysis (combining the results of several similar studies) or the adaptation of a benefit function to the new situation should be preferred over applying single values directly.
- All judgements and assumptions made when transferring benefits and their potential impact on the final estimates must be made clear.

In general, the greater the similarities between the two sites, the smaller the risk of error is likely to be. Finding study sites similar and close to the site under review should therefore be a priority.

Sources: EPA 2000b; OECD 2006b; Ready and Navrud, 2006.

The magnitude of benefits is directly influenced by the level of economic development. For example, investing in wastewater treatment activities would have higher benefits (in monetary terms) in southern Spain, for example, where revenues from tourism are very dependent on the quality of bathing waters than in some remote area in developing countries. This can partly be corrected in two ways: first, by using locally-relevant values (such as the value of a statistical life, based on domestic income values) and by evaluating the benefits against the local GDP.

Evaluating benefits: marginal benefits and location-specific factors. Benefit values are very difficult to measure in absolute terms: instead, one has to focus on the marginal benefits of an additional action, depending on what has happened previously. For example, investments driven by the European Nitrate Directive resulted in a substantial reduction in nitrate levels in the 1990s. As a result, any additional reduction has a much higher marginal cost than what has happened previously. With respect to the impact of providing access to water and sanitation on diarrheal diseases, the actual benefits are highly dependent on the prevalence of such diseases in the area under concern prior to the intervention.

A.2. Measuring health benefits

Health benefits can materialise at different steps of the value chain, from providing access to water and sanitation services or from investing in wastewater treatment so as to improve the overall environment (such as bathing water quality for example).[1]

Common ways of measuring health benefits include:

Measuring the direct health care costs: this evaluation can be based on the actual medical costs or, if those are either unavailable or too difficult to collect, on the number of hospital days or the costs of medicine that result from water-related illnesses. These are likely to be under-estimates as they would only include the direct costs associated with a particular episode of illness (as opposed to the long term impacts, such as on child malnutrition for example). However, this methodology can be well-suited to specific outbreaks, such as resulting from a sewer outflow or the contamination of drinking water.

Impact on productivity: this can be estimated through the impact of sickness on overall labour productivity (through estimating the number of days of work lost to sickness affecting the individual or a close relative), reduced labour productivity, reduced school attendance, etc. Time away from work or home activities due to sickness can be valued through an estimation of the opportunity cost of time, based on alternative measures (such as the average compensation of employees, the minimum wage or the average wage).

Impact on mortality: inadequate water and sanitation can result in loss of life, in which case the value of such life lost needs to be measured. Such value would vary depending on level of development and age of individuals. Alternative methods to estimate the value of statistical life (VSL) include the human capital approach. A common method estimates the VSL based on the future discounted economic output of the individual lost following death. This method has been criticised as it only values life based on the productive capacity of an individual. It is also not particularly suited to estimating the value of life for children under 5, since they have not yet reached a productive age. Alternative methods include hedonic pricing (based on the observation of labour markets and measurement of the premium that individuals ask for to take comparatively riskier jobs) and contingent valuations (based on the stated preferences from individuals exposed to risk).

Box A.2. **Measuring Disability Adjusted Life Years (DALYs) and the Burden of Disease**

The World Health Organisation (WHO) defines **Disability Adjusted Life Years (DALYs)** as the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. It extends the concept of potential years of life lost due to premature death to include equivalent years of "healthy" life lost by virtue of being in states of poor health or disability. As a result, mortality and morbidity are combined into a single, common metric: one DALY is equal to one year of healthy life lost. This unit is becoming increasingly common in the field of public health and health impact assessment and is also being used in measuring the impact of measures such as water, sanitation and hygiene. The sum of these DALYs across a given population is referred to as "**the burden of disease**". This can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

In 1996, WHO published the first "Global Burden of Disease" report, using data from 1990 (and hence referred to as GBD 1990). This report was the first consistent and comparative description of the burden of diseases and injuries and the risk factors that cause them, in order to inform health decision-making and planning processes. That study quantified the health effects of more than 100 diseases and injuries for eight regions of the world in 1990, using DALYs as a common metric. This study was subsequently updated, and incorporated analysis of the mortality and burden of disease attributable to 26 global risk factors, one of which being water, sanitation and hygiene. The next update of the study, the GBD 2005 study, is due to be published in late 2010. This revised study will also assess trends in the Global Burden of Disease from 1990 to 2005.

Source: the Global Burden of Disease project. *www.who.int/healthinfo/global_burden_disease/about/en/index.html*.

Methods that use wage data in order to derive the value of life (or death avoided) are highly sensitive to differences in wage levels across countries. Whereas the value of life in less developed countries can be as low as USD 4 500 (as per the estimates shown in Table 2.3. in the main text), estimates in developed countries are higher by several orders of magnitude. For example, the US EPA typically a VSL estimate of more than USD 6 million, which takes into account estimates from dozens of published VSL studies using hedonic wages and contingent valuation studies (EPA, 2000b).

Impact on morbidity: short of causing death, poor water and sanitation can cause repeated illness. To measure the combined negative impact on morbidity and mortality from a broad range of health interventions, the World Health Organisation has defined DALYs (Disability Adjusted Life Years) as a single indicator of health conditions. In cases where benefits are not monetised, a common practice is to compare the cost-effectiveness of alternative interventions in terms of DALYs averted (see Box A.2. and Box 5.3).

A.3. Estimating environmental benefits

Assigning values to the environment. In order to describe the different types of values linked to the environment, ecosystem goods and services are often classified according to how they are used. The different categories are frequently differentiated into (Pagiola *et al.* 2004, see also OECD 2000):

- **Direct use values**: This type of value refers to ecosystem goods and services that are used directly, either by *consumptive uses* (*e.g.* extraction of timber for construction, food, medicinal plants) or by *non-consumptive use*. The latter includes for example nature related tourism, education or scientific research. Mainly people visiting or living in the ecosystem itself are benefiting from direct use values.
- **Indirect use values**: Benefits from indirect use refer to ecosystem services that occur outside the ecosystem itself and which support economic activities or human welfare. This includes the water filtration function of wetlands, water retention or carbon sequestration.
- **Option values**: This kind of value is based on the option to use the ecosystem goods and services in the future, either by oneself (*option value*) or by others/heirs (*bequest value*) .[2]
- **Non-use values**: This category refers to the enjoyment people may feel by knowing that a resource exists even if they never expect to use that resource directly themselves. This value is often also known as *existence value*.

Some economists define furthermore an intrinsic value, which "reflects the belief that all living organisms are valuable regardless of the monetary value placed on them by society" (NOAA, web).

Valuation methods. The valuation of environmental assets involves placing monetary values on ecosystem related goods and services as well as on changes in environmental quality which results from human activities. Contrary to other goods and services, environmental ones are less often subject to market transactions. Their value is therefore not revealed by market prices and needs different valuation approaches (OECD 2000). The valuation of environmental goods and services is largely based on the assumption that individuals are willing to pay for keeping or augmenting environmental benefits. Determining the willingness-to-pay (WTP) is hence one important instrument to attach values to the environment.

Different valuation methods exist, but only the most relevant ones for the values given in this report are presented below:

The Contingent Valuation Method (CVM): The CVM is one approach to value non-market environmental goods, including for example option and existence values. They attempt to measure the WTP for environmental improvements by directly questioning a representative sample of individuals (OECD 2000). The CVM survey includes a questionnaire presenting a scenario or hypothetical market which describes an improvement or a decline in environmental quality. The interviewed persons are then asked to estimate their willingness to pay (*e.g.* through higher utility charges) for the improved environmental good or service. Based on the individual responses, the mean and median willingness-to-pay for an environmental improvement are estimated as an indication of its value. However, CVM studies may be subject to certain biases, *e.g.* the respondent's belief that his answers may be used to affect government policy, leading him to intentionally understate or overstate his willingness to pay to achieve the desired policy result. To minimise bias, analysts must be very careful when designing surveys and conducting interviews (NOAA, web).

Choice experiments: Unlike CVM studies, choice experiments confront respondents with a set of alternatives relative to environmental policy options. Using this method, preferences for various components or attributes can be examined at a more detailed level. This provides the analyst with a more complete understanding of individual preferences. Whereas CVM lead to a single value for a change in environmental quality, choice experiments provide independent values for the individual attributes of an environmental change (NOAA, web).

Travel cost method (TCM): This method can be applied to the valuation of recreational benefits of a specific site. It relies on deriving a demand curve from data on actual monetary and time costs of travel to the destination of recreation, collected through surveys (Pagiola, 2007). These expenditures are considered as an indicator of the willingness-to-pay for accessing the recreational services provided by the site (NOAA, web). This method has limits, for example when trips include several destinations (Pagiola, 2007). Furthermore, the TCM cannot be used to measure non-use values (NOAA, web).

Hedonic pricing: The quality of the water environment (driven partly by the quality of water and sanitation services) would typically affect the value of land or housing stock situated next to the water bodies. Examination of land market values can reveal the value attached to cleaning up water pollution.

A.4. Accounting for economic benefits

Economic benefits can be measured via the impact of water and sanitation on economic activities, such as power production, fishing, aquaculture or tourism. These benefits can be estimated based on the lost economic outputs linked to the impact of poor quality water and sanitation. Economic benefits may also materialise in the form of time gained from not having to collect water or seek a secluded spot to defecate: such time would need to be valued based on the opportunity cost of the individuals concerned.

When measuring economic benefits, it is crucial to avoid double-counting. For example, if health benefits are estimated by looking at increase in productivity (*i.e.* reduction in number of sick days), this should not be counted as a separate economic benefit. Similarly, if environmental benefits are measured based on the impact on fish population and fish production, this cannot be included as a separate benefit. However, there are likely to be some overall economic benefits (such as on tourism or agriculture) which have not been adequately captured through the other types of benefits.

Indirect economic benefits may be significant but cannot always be accounted for. For example, if there is an increase in school attendance as a result of building toilets in school, this could later results in higher incomes for the girls who attended school. Although the impact may be significant, it may be difficult to quantify as it only materialises over time.

A.5. Including other benefits

Other benefits may be more difficult to quantify and value, such as the non-health impacts from water and sanitation services, including the impact on dignity, amenity value, etc. Methodologies exist to value those types of benefits, especially based on contingent valuations but they have not been applied on a consistent basis to estimate the benefits of water and sanitation investments.

Notes

1. This section borrows heavily from Hutton *et. al*. (2008).

2. Some analysts also add a quasi-option value, *i.e*. the value of avoiding irreversible decisions until new information reveals whether certain ecosystem services have values we are not currently aware of (Arrow and Fisher 1974, in: Pagiola *et al*., 2004).

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Benefits of Investing in Water and Sanitation

AN OECD PERSPECTIVE

The provision of water supply, sanitation and wastewater services generates substantial benefits for public health, the economy and the environment. Benefit-to-cost ratios can be as high as 7 to 1 for basic water and sanitation services in developing countries.

Wastewater treatment interventions, for example, generate significant benefits for public health, the environment and for certain economic sectors such as fisheries, tourism and property markets.

The full magnitude of the benefits of water services is seldom considered for a number of reasons, including the difficulty in quantifying important non-economic benefits such as non-use values, dignity, social status, cleanliness and overall well-being. Also, information about the benefits of water services is usually hidden in the technical literature, where it remains invisible to key decision-makers in ministries.

This report draws together and summarises existing information on the benefits of water and sanitation.

Further reading

Pricing Water Resources and Water and Sanitation Services (2010)

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