By means of water we give life to everything

The Koran, Book of The Prophets 21:30
Part 1. Human Health in Water Development

Part 2. Update of the Burden of Water-related Diseases

Part 3. Progress towards the MDG Targets on Water, Sanitation and Health

Part 4. Indicators

Part 5. Comparative Risk Assessment

Part 6. Governance

Part 7. Water for Life: Making it Happen

References and Websites
Key messages:

Water-related diseases, including diarrhoea, are a leading cause of death in children of developing countries. However, they can be prevented and controlled by improving access to safe drinking water and sanitation, as well as domestic and personal hygiene. Yet progress remains very slow, especially in the provision of adequate sanitation in sub-Saharan Africa and South-East Asia. An integrated approach to human health and water resources management is urgently required. This should be characterized by flexible planning and implementation, analysis of the cost-effectiveness of local options, a significant reallocation of resources to drinking water, sanitation and hygiene, and attention to the most vulnerable groups in urban and rural settings. This is essential to save the lives of millions and ensure considerable long-term economic benefits.

Infectious diseases, especially diarrhoea followed by malaria, continue to dominate the global burden of water-related disease. Substantial progress has been made in reducing the mortality associated with diarrhoeal disease but morbidity remains essentially unchanged, while the burden of malaria is increasing.

Globally, the drinking water target set by MDG 7 is on schedule, but the sanitation target will not be met by 2015 without extra inputs and efforts. In sub-Saharan Africa, the trends observed since 1990 indicate that neither of the targets will be met by 2015.

The water-related disease burden and the relative efficiency of water interventions are key criteria in water/health decision-making. Disability-Adjusted Life Years (DALYs) and cost and effectiveness of interventions should be put upfront as key decision-making criteria.

Understanding of drinking water quality as it relates to health has evolved from rigid standards applied at the treatment facility to a process of risk assessment and management from catchment to consumer.

The importance of both accelerated access to safe water and adequate sanitation, and better Integrated Water Resources Management (IWRM) practices to achieving most MDG targets, need a higher profile. This can be achieved by refining and publicizing the correlations between water indicators and the indicators for childhood illness/mortality and nutritional status.

Below: A teacher assists a young girl to wash her hands with soap and clean water after using a sanitary latrine in a school in North Khway Ye village in Myanmar. Some 3,800 children die every day from diseases associated with lack of access to safe drinking water, inadequate sanitation and poor hygiene.
Part 1. Human Health in Water Development

A range of water conditions and parameters essentially determine the health status of communities. Human health, therefore, cuts across all sectors responsible for water resources development, management and use.

In water for food and energy, the focus is on the lack of access to sufficient supplies of safe drinking water, adequate sanitation, and the promotion of hygiene practices, all in relation to diarrhoeal and other water-related diseases. While infectious diseases are of principal concern, other health risks may be important under specific circumstances.

In water for food and energy, the focus is on the hydrological changes caused by dam construction (see Chapter 5) and irrigation development (see Chapter 7) and the ensuing transmission risks of vector-borne diseases, such as malaria, schistosomiasis, filariasis and Japanese encephalitis. The impact of irrigated crop production on the nutritional status of communities varies. On the whole, it is positive, but there may be vulnerable groups whose nutritional status declines with the introduction of irrigation, which shifts the economic balance from subsistence to cash crops. Over time, irrigation development may result in significant improvements in the economic status of communities, allowing better access to health services and, indirectly, an improved community health status. Increased energy generation through hydropower development benefits large segments of the population, the urban populations often disproportionately so; communities vulnerable to adverse health impacts live in the vicinity of dams and reservoirs (see also Chapters 5 and 9).

In water for ecosystems, the evidence base for associations between natural ecologies, biodiversity conservation and human health still requires substantial development. It may be safely assumed that many of the environmental services provided by wetlands, for example, are important to sustaining the health of communities that depend on these ecosystems for their livelihood. Yet, in specific settings, such as wetlands, there may also be health risks related to water-associated vector-borne diseases, sanitation-related diseases and impaired access to health services. However, health can be a key motivator in mobilizing communities to participate in nature conservation and environmental management.

Improvements in access to safe drinking water, adequate sanitation and hygiene have an impact on water development issues, a fact that has been summarized by the Water Supply and Sanitation Collaborative Council (WSSCC, 2006) for the Millennium Development Goals (MDGs) (see Table 6.1). Human health cuts across all water issues. Community health status is, therefore, the ultimate indicator of the success or failure of integrated water resources development and management. During and after water resources development, both negative and positive health effects can occur. Documented cases of adverse health impacts in the wake of water resources development abound; a recent example comes from Rajasthan, India (see Box 6.1).

BOX 6.1: THE EMERGENCE OF MALARIA IN INDIA’S THAR DESERT

The massive Indira Gandhi Nahar Paryanjana project is changing the face of the Thar Desert in Rajasthan, and will eventually irrigate 1.9 million hectares (ha) of arable land. Halfway through the project development, the number of locally transmitted malaria cases has risen from a few thousand to 300,000 a year. Key environmental changes include a rise in groundwater levels, more surface water bodies, changed water-retention properties of the soils, and an elevated relative humidity. The associated mosquito species succession from Anopheles stephensi to A. culicifacies has resulted in intensified transmission, which has shifted from seasonal to perennial. Between 1980 and 1995, the proportion of Rajasthani malaria cases registered in the desert districts grew from 14.1 percent to 53.3 percent, and the share of Plasmodium falciparum cases (the most virulent malaria parasite species) rose from 11.6 percent to 62.5 percent. On the other hand, the extension of the canal system has made large quantities of water available for domestic use. Regrettably, the trend is that the ingenious traditional water supply systems of desert villages, consisting of small earthen underground reservoirs, are abandoned as soon as irrigation water becomes available. The increased quantities of water available for domestic use are nonetheless likely to provide important health benefits, despite the increased number of cases of malaria.

The two major environmental risk factors (seepage water collections from the canals, and pools of uncontrolled surplus run-off water) can be reduced by forestation and land reclamation, and by meticulous application of wet and dry irrigation management techniques meticulously. Such measures must be backed up by raising awareness among farmers and irrigation managers, and establishing effective institutional arrangements between health and irrigation authorities. Their application will greatly reduce (but not eliminate) the need for standard malaria control measures, such as case detection and treatment, and the use of insecticide-treated mosquito nets.

### Table 6.1: The relationship between the Millennium Development Goals (MDGs) and water, sanitation and hygiene

<table>
<thead>
<tr>
<th>MDGs and their targets</th>
<th>The water, sanitation and hygiene perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 1. Eradicate extreme poverty and hunger</strong>&lt;br&gt;Target 1: Halve, between 1990 and 2015, the proportion of people whose income is less than US $1 a day.&lt;br&gt;Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.</td>
<td>■ The security of household livelihoods rests on the health of its members; adults who are ill themselves or must care for sick children are less productive.&lt;br&gt;■ Illnesses caused by unsafe drinking water and inadequate sanitation generate high health costs relative to income for the poor.&lt;br&gt;■ Healthy people are better able to absorb nutrients in food than those suffering from water-related diseases, particularly helminth infections, which rob their hosts of calories.&lt;br&gt;■ Access to safe drinking water and adequate sanitation helps reduce household expenditures on health care.&lt;br&gt;■ The time lost because of long-distance water collection and poor health contributes to poverty and reduced food security.</td>
</tr>
<tr>
<td><strong>Goal 2. Achieve universal primary education</strong>&lt;br&gt;Target 3: Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.</td>
<td>■ Promotion of a healthy school environment is an essential element of ensuring universal access to education. School enrolment, attendance, retention and performance are improved; teacher placement is improved.&lt;br&gt;■ Improved health and reduced water-carrying burdens improve school attendance, especially among girls.&lt;br&gt;■ Separate school sanitation facilities for girls and boys increases girls’ attendance, especially after they enter adolescence.</td>
</tr>
<tr>
<td><strong>Goal 3. Promote gender equality and empower women</strong>&lt;br&gt;Target 4: Eliminate gender disparity in primary and secondary education, preferably by 2005, and to all levels of education no later than 2015.</td>
<td>■ Sanitation improvement allows women and girls to enjoy private, dignified sanitation, instead of embarrassment, humiliation and fear from open defecation.&lt;br&gt;■ Access to safe drinking water and sanitation reduces the burden on women and girls from looking after sick children or siblings and from water carrying, giving them more time for productive endeavours, (adult) education and leisure.&lt;br&gt;■ Water sources and sanitation facilities closer to home reduce the risk of assault for women and girls when collecting water or searching for privacy.</td>
</tr>
<tr>
<td><strong>Goal 4. Reduce child mortality</strong>&lt;br&gt;Target 5: Reduce by two-thirds, between 1990 and 2015, the under-5 mortality rate.</td>
<td>■ Improved access to sanitation, safe drinking water sources and improved hygiene behaviour lead to a sharp decline in infant and child morbidity and mortality from diarrhoeal diseases.&lt;br&gt;■ Better nutrition and a reduced number of episodes of illness lead to the physical and mental growth of children.</td>
</tr>
<tr>
<td><strong>Goal 5. Improve maternal health</strong>&lt;br&gt;Target 6: Reduce by three-quarters, between 1990 and 2015, the maternal mortality ratio.</td>
<td>■ Good health and hygiene increase chances of a healthy pregnancy.&lt;br&gt;■ Safe drinking water and basic sanitation are needed in health-care facilities to ensure basic hygiene practices following delivery.&lt;br&gt;■ Accessible sources of water reduce labour burdens and health problems resulting from carrying water, thereby reducing maternal mortality risks.</td>
</tr>
</tbody>
</table>
## Table 6.1: continued

<table>
<thead>
<tr>
<th>MDGs and their targets</th>
<th>The water, sanitation and hygiene perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal 6. Combat HIV/AIDS, malaria and other diseases</strong></td>
<td></td>
</tr>
<tr>
<td>Target 7: Have halted by 2015 and begun to reverse the spread of HIV/AIDS.</td>
<td>■ Reliability of drinking water supplies and improved water management in human settlements contribute to reducing malaria and dengue fever transmission risks.</td>
</tr>
<tr>
<td>Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.</td>
<td>■ A reduction in stagnant water around tap points translates into less breeding places for mosquitoes. ■ Less pressure by other infections on the immune system of HIV/AIDS sufferers allows for better health. ■ Better, more hygienic and dignified possibilities to take care of ill people lift their burden. ■ Safe drinking water and basic sanitation help prevent water-related diseases, including diarrhoeal diseases, schistosomiasis, filariasis, trachoma and intestinal helminth infections.2</td>
</tr>
</tbody>
</table>

| **Goal 7. Ensure environmental sustainability** | |
| Target 9: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources. | ■ Adequate treatment and disposal of wastewater result in a sharp decrease in environmental contamination by faeces, which contributes to better ecosystem conservation and less pressure on scarce freshwater resources. |
| Target 10: Halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation. | ■ Careful use of water resources prevents contamination of groundwater and helps minimize the cost of water treatment. ■ Better health is linked to a reduction in poverty, which in turn helps to put less strain on natural resources. |

| **Goal 8. Develop a global partnership for development** | |
| Target 12: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system. | ■ Development agendas and partnerships should recognize the fundamental role that safe drinking water and basic sanitation play in economic and social development. ■ Countries that illustrate improved access to and quality of safe drinking water and sanitation are more attractive, boosting tourism and national image. ■ These countries have more options for employment creation, as water supply and sanitation provision is labour intensive. ■ Safe drinking water and better sanitation provide a better chance for completing schooling, which leads to higher youth employment. ■ Including health impact assessment in water resources development planning prevents the transfer of hidden costs to the health sector. |
| Targets 13 and 14: Address special needs of less developed countries, landlocked and small island developing countries. | |
| Target 15: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term. | |
| Target 16: In cooperation with developing countries, develop and implement strategies for decent and productive work for youth. | |
| Target 17: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries. | |
| Target 18: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications. | |

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1. Helminths are parasitic intestinal worms that include tapeworms, hookworms, whipworms and roundworms.

2. Human schistosomiasis is a chronic, usually tropical disease caused by infection with parasitic blood flukes that have certain aquatic snail species as their intermediate host. Depending on the Schistosoma species, the infection will lead to disorders of the liver or urinary system. Filariasis is a parasitic disease caused by thread-like worms, which are transmitted by mosquitoes and invade the lymphatic vessels causing chronic swelling of the lower extremities. Trachoma is a contagious infection of the eye caused by a bacteria-like organism and can cause damage to the cornea leading to visual impairment and blindness.

Source: Adapted from WSSCC, 2004.
Part 2. Update of the Burden of Water-related Diseases

The basic measures of disease frequency are incidence (new cases that occur in a population over time) and prevalence (existing cases in a population at a certain point in time). In principle, disease incidence data could be obtained from routine government health information systems. However, such data remain scant, inaccurate and often unreliable and fail to attribute diseases to specific social and environmental determinants. Data collected directly at the user/household level are generally more reliable. These data are mostly obtained through cross-sectional surveys that provide prevalence, not incidence, figures. For example, the proportion of people surveyed with helminth eggs in their stools provides an estimate of the prevalence of helminth infection. If there is prospective surveillance of large populations, direct incidence figures can be available. For diarrhoea, there are now sufficient results from longitudinal studies to make it possible to arrive at reliable global estimates of incidence (Kosek et al., 2003). For some diseases, such as scabies, no studies have been done and reliable global data, whether incidence or prevalence, are currently unavailable.

Mortality rates express the incidence of death in a particular population during a defined period of time. Mortality data are more widely available than comparable information on disease incidence rates (morbidity) and functional disabilities. Many of the water-related diseases affect children in particular, and the database for estimating child mortality is unquestionably much better developed than that for adult mortality (Murray and Lopez, 1994a). This provides a strong rationale for reporting mortality data for the under-5 years age group separately.

The first UN World Water Development Report described the methodology for assessing water-related health impacts at the global level (UN-WWAP, 2003; Prüss, et al., 2002). It referred to the Disability-Adjusted Life Year (DALY), a summary measure of population health, as an important indicator for assessing the disease burden associated with, for example, environmental exposures, and evaluating options for public health interventions. The DALY was developed under the Global Burden of Disease study (Murray and Lopez, 1994) and was a major step towards rational information-based health policy. One DALY represents the loss of one healthy life year. For each disease, DALYs are calculated at the global and regional levels as the discounted sum of years lost due to premature mortality and the years lost due to disability for incident cases of the ill-health condition. DALYs are a powerful tool for assisting policy-makers in sector-wide decision-making on the basis of cost-effectiveness analysis. It is therefore the unit of choice for monitoring the burden of disease over time and across populations in relation to improvements in water supply and sanitation. Although not yet utilized for this purpose, it would also be a good measure in health impact assessment (HIA) of hydraulic infrastructure development projects, such as dams and irrigation schemes.

DALY estimates depend on the availability of data of sufficient quality as well as on assigning a certain class of severity of disability to each disease (Murray and Lopez, 1994b, 1996). This is based mainly on expert opinion and partly on empirical population valuations from surveys, such as those documented in recent World Health Reports (WHO 2003a, 2004a). In the case of certain water-related infectious diseases, such as intestinal helminth infections and schistosomiasis, DALYs are estimated on the basis of the number of new individuals infected with an associated low disability weight (i.e. less severe). Once better data on clinical signs and symptoms associated with such diseases become available from community-based epidemiological studies, more appropriate disability weights can be assigned, and the DALY estimates will become more empirically based and less modelled. Furthermore, global estimates have to be validated by locally measured epidemiological data. For example, a study by Wirthwaite et al. (2001) in an area of Burkina Faso found much higher percentages of total burden of disease (mortality and morbidity) caused by malaria, diarrhoea, intestinal helminth infections and malnutrition than the Global Burden of Disease study (Murray and Lopez, 1996). Such differences are bound to have important implications.
Clearly, water-related diseases continue to impose a large burden on health, especially in Africa and Asia (see Chapter 14). Globally, diarrhoeal diseases and malaria accounted, respectively, for 4 percent and 3 percent of DALYs lost and 1.8 and 1.3 million deaths in the year 2002. This burden is almost entirely concentrated in the group under 5 years of age. While the burden of

<p>| Table 6.2: Global burden of disease: Deaths by age, gender, region and cause for the year 2002 |</p>
<table>
<thead>
<tr>
<th>Cause</th>
<th>Total number of deaths [thousands]</th>
<th>0–4 years</th>
<th>Gender</th>
<th>AFR</th>
<th>SEAR</th>
<th>WPR</th>
<th>EMR</th>
<th>AMR</th>
<th>EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>[%]</td>
<td>[%]</td>
<td>[%]</td>
<td>[%]</td>
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<td>All causes</td>
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<td>52</td>
<td>48</td>
<td>19</td>
<td>26</td>
<td>21</td>
<td>7</td>
<td>10</td>
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<td>90</td>
<td>52</td>
<td>48</td>
<td>39</td>
<td>34</td>
<td>9</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
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<td>48</td>
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<td>5</td>
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<tr>
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<td>8</td>
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<td>23</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<td>n/a</td>
<td>n/a</td>
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<td>n/a</td>
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<td>Dengue</td>
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<td>1</td>
<td>63</td>
<td>20</td>
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<td>Japanese encephalitis</td>
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<td>40</td>
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<td>n/a</td>
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<td>n/a</td>
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<td>13</td>
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<td>40</td>
<td>26</td>
<td>5</td>
<td>10</td>
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<td>69</td>
<td>31</td>
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<td>35</td>
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<p>| Table 6.3: Global burden of disease: DALYs by age, gender, region and cause for the year 2002 |</p>
<table>
<thead>
<tr>
<th>Cause</th>
<th>Total DALYs [thousands]</th>
<th>0–4 years</th>
<th>Gender</th>
<th>AFR</th>
<th>SEAR</th>
<th>WPR</th>
<th>EMR</th>
<th>AMR</th>
<th>EUR</th>
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<tr>
<td></td>
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<td>Male (%)</td>
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<td>[%]</td>
<td>[%]</td>
<td>[%]</td>
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<td>4</td>
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<td>Onchocerciasis</td>
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<td>0</td>
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<tr>
<td>Dengue</td>
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<td>Japanese encephalitis</td>
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<td>52</td>
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<td>43</td>
<td>45</td>
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<tr>
<td>Trachoma</td>
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<td>Intestinal nematode infections</td>
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<td>54</td>
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<td>21</td>
<td>12</td>
<td>6</td>
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<tr>
<td>Drowning</td>
<td>10,840</td>
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<td>31</td>
<td>18</td>
<td>25</td>
<td>35</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

1. WHO defines the regions of the world as follows:
   - AFR – Africa south of the Sahara
   - SEAR – South East Asia (includes India)
   - WPR – Western Pacific (includes China)
   - EMR – Eastern Mediterranean (includes Sudan, Afghanistan, Pakistan)
   - AMR – the Americas
   - EUR – Europe (includes Central Asian republics)
   - WHO – World Health Organization

2. Based on the reality that individuals prefer benefits now rather than in the future, future life years are discounted.

3. For mortality rates that are zero, there can be no percentage.

4. Malnutrition is both a medical and a social disorder. It can occur as a primary disorder (with consequences for the susceptibility to infectious diseases) or as a secondary disorder, prompted by infectious diseases, many of which are water related.

5. Drowning is a major, non-communicable water-associated health problem.

6. The Disability-Adjusted Life Year is a summary measure of population health. One DALY represents a lost year of healthy life and is used to estimate the gap between the current health of a population and an ideal situation where everyone in that population would live into old age in full health.

diseases, notably Guinea worm infection, onchocerciasis, lymphatic filariasis and trachoma. These programmes, and those aimed at controlling intestinal helminth infections and schistosomiasis, are based on the mass treatment of at-risk populations. Low-cost, safe and effective drugs are available, but there are problems with respect to the insufficient capacity of health care delivery systems. This also applies to malaria control, where prompt treatment of patients and promotion of insecticide-treated nets (ITNs) is the backbone of the current strategy.

The following sections focus on the most important water-related diseases for which global data are available. There are many more water-related infectious as well as non-infectious diseases for which no data are available, and these cannot therefore be used to monitor progress in water-related development activities.

2a. Diseases related to lack of access to safe drinking water, poor sanitation and insufficient hygiene

Diarrhoeal diseases

It is estimated that, on average, each child under 5 years of age in a developing country suffers from three episodes of diarrhoea per year, with little change over the years (Kosek et al., 2003). While the number of cases has remained very high, substantial progress has been made in reducing the mortality associated with diarrhoeal disease. According to the Global Burden of Disease study by Murray and Lopez (1996), 2.9 million people died of diarrhoea in 1990, compared to 1.8 million in 2002, a decline of 37 percent. DALYs lost to diarrhoea went down with the same percentage from 99 million to 62 million. The reduction in mortality is probably due to improved case management, particularly oral rehydration therapy (ORT) (Victora et al., 2000). Despite this reduction, diarrhoeal diseases remain the leading cause of death from water-related diseases in children, accounting for 23 percent of all deaths of children under 5 in developing countries (Parashar et al., 2003). Persistent diarrhoea (episodes lasting fourteen days or longer, often associated with under-nutrition) and dysentery may now cause an increasing proportion of the remaining diarrhoeal deaths. No recent numbers
People with cysts can infect others, but they can be those carrying the infection: cysts and trophozoites. Amoebiasis prevention and control (see handwashing after defecation, are very effective in its measures, especially common causes of diarrhoea, While other pathogens, such as viruses, are more Africa and later from other parts of the continent. While other pathogens, such as viruses, are more common causes of diarrhoea, Shigella is responsible for most deaths. This has important implications for control measures, as simple hygiene measures, especially handwashing after defecation, are very effective in its prevention and control (see Box 6.2).

Amoebiasis is the second most important cause of diarrhoea and results in an estimated 100,000 deaths each year (WHO/UNICEF, 1997). Two forms of Entamoeba histolytica may be found in the stools of those carrying the infection: cysts and trophozoites. People with cysts can infect others, but they can be perfectly healthy themselves. Only the trophozoite, which is the motile form, is a sign of active infection. The cysts can be very persistent in the environment. In recent years, there has been an increased recognition of the protozoan parasite Cryptosporidium parvum as the cause of water-borne disease outbreaks, especially in the industrialized countries. The cysts are resistant to chlorine that is used for drinking water disinfection. Cryptosporidium and other protozoal infections are an important cause of chronic diarrhoea in patients infected with HIV. In the developing world, where highly effective antiretroviral treatment remains unaffordable, protozoa-related diarrhoea continues, by and large, to be a major cause of morbidity and mortality in HIV-infected individuals (Lean and Pollik, 2003).

In the early 1990s, cholera was concentrated in the Americas with 400,000 cases and 4,000 deaths in 1991. From the late 1990s onwards the problem shifted to Africa, where between 100,000 and 200,000 cases are officially reported each year in 2002. A total of 123,986 cases with 3,763 deaths were reported. The actual number of cases is considered to be much higher. Poor surveillance systems and frequent under-reporting, often motivated by fear of trade sanctions and lost tourism, are the root causes.

Outbreaks of diarrhoea, such as those caused by cholera, draw a lot of attention and often result in the mobilization of resources and policy changes. However, it is the day-to-day diarrhoea of small children that causes the great majority of deaths each year.

Diarrhoea is caused by a wide variety of microorganisms, including viruses, bacteria and protozoa. Rotavirus is the most common cause of watery diarrhoea in children in developed as well as developing countries. The primary pathway of rotavirus transmission is faecal-oral and infection can occur through ingestion of faecally contaminated water or food and contact with contaminated surfaces. An important cause of diarrhoea, especially in developing countries, is Shigella; infection with this bacterium often leads to bloody diarrhoea (diabetes). Typical for Shigella is the very small infective dose; therefore, it can spread easily from person to person.

The mainstay of diarrhoeal disease case management is oral rehydration therapy (ORT) to prevent dehydration. The discovery of ORT was an important public health advance of the twentieth century and has saved many lives. ORT is, however, most effective against acute watery diarrhoea and has less effect in preventing death due to dysentery. Treatment of shigellosis usually involves antibiotics, in addition to ORT. Unfortunately, most Shigella bacteria have developed resistance to common antibiotics.

Simple hygiene measures are very effective in control and prevention of shigellosis, especially handwashing after defecation. Measures to improve the quality of drinking water, for example by boiling or adding chlorine to the water, are important for the prevention of rotavirus transmission, but are unlikely to have an impact on the transmission of Shigella.

Preventing the contamination of human fingers, legs of flies, water and food by the sanitary disposal of faeces would have an impact on both Shigella and rotavirus transmission. This provides a strong rationale for placing sanitation top of the agenda to combat diarrhoea.

Sources: Kolhoff et al., 1999; Victora et al., 2000; Parashar et al., 2003.
subsequent World Health Reports, can be attributed to an adjustment in the calculations and does not necessarily reflect a real reduction in the number of cases. Had symptoms and effects of disease been taken into account consistently, the estimated burden of disease would be much higher. It was estimated at 39 million DALYs for the year 1990 (see Table 6.4).

A recent update of the infection prevalences (see Table 6.5) shows that this has declined markedly in the Americas and Asia, but prevalence rates in Africa remain stagnant. This study (de Silva et al., 2003) also demonstrates the strong and reciprocal links between poverty and helminth infections, in particular hookworm infection.

Periodic drug treatment of school-age children living in areas of high endemicity is the control measure to obtain immediate benefits (WHO, 2002a). Long-term sustainable control will only be obtained by safe disposal of human faeces. The provision of culturally acceptable sanitary facilities for disposal of excreta and their proper use are necessary components to be included in any programme aimed at controlling intestinal parasites. In poor urban areas, sewerage and rainwater drainage can have a significant effect on the intensity of intestinal helminth infections by reducing transmission in the public domain (Moraes et al., 2004).

Skin and eye infections

Many infectious skin and eye diseases are related to poor hygiene and inadequate water supplies. Once enough water is available and used for personal and domestic hygiene, the prevalence of these diseases diminishes and they are therefore often classified as water-washed diseases. Trachoma is the leading cause of preventable blindness in the world, with an estimated 146 million cases, 6 million of which have caused actual blindness. The disease is related to poverty, illiteracy and unhygienic, crowded living conditions, particularly in dry dusty areas. Eye-seeking flies are important in the transmission of trachoma.

A number of water-related pathogens have emerged as new problems in developing as well as industrialized countries. These include Hepatitis E, *Escherichia coli* O157, and *Legionella pneumophila*, which can colonize water systems in buildings.

Typhoid fever is not a diarrheal disease, but it is associated with poor water supply, sanitation and hygiene. The global burden for the year 2000 was estimated at 21.6 million cases (with 216,510 deaths), half of which were from the WHO South-East Asia region (Crump et al., 2004).

**Intestinal helminth infections**
The roundworm (*Ascaris*), the whipworm (*Trichuris*), and hookworms (*Ancylostoma* and *Necator*) are mainly transmitted through soil that is contaminated with human faeces and are, therefore, directly related to the level of sanitary facilities. These soil-transmitted helminths flourish where poverty, inadequate sanitation and minimal health care prevail. In 1947, it was estimated that 1.5 billion people were infected with these worms. Fifty years later, this figure had increased to 3.5 billion. Taking account of the population increase, the proportion of the world population infected with these parasites remains virtually unchanged despite all the advances in medicine and technology (Chan, 1997). The clinical importance of a worm infection very much depends on the worm-burden. Above a certain number of worms, there are detrimental effects on physical fitness, growth development and school performance. In addition, hookworm infections cause blood loss from the intestine and are recognized as a major contributor to iron deficiency anaemia in adolescent girls and women of childbearing age. Globally, iron-deficiency anaemia is the most common micronutrient disorder known to be associated with high maternal mortality and morbidity.

The reduction in DALYs lost from intestinal worm infections between 2000 and 2002, as reported in the subsequent World Health Reports, can be attributed to an adjustment in the calculations and does not necessarily reflect a real reduction in the number of cases. Had symptoms and effects of disease been taken into account consistently, the estimated burden of disease would be much higher. It was estimated at 39 million DALYs for the year 1990 (see Table 6.4).

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**Table 6.4: Estimated global burden of disease associated with soil-transmitted intestinal helminth infections, 1990**

<table>
<thead>
<tr>
<th>Helminth</th>
<th>Number of infections (millions)</th>
<th>Morbidity (cases, millions)</th>
<th>Mortality (deaths per year, thousands)</th>
<th>DALYs lost (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascaris</td>
<td>1,450</td>
<td>350</td>
<td>60</td>
<td>10.5</td>
</tr>
<tr>
<td>Trichuris</td>
<td>1,050</td>
<td>220</td>
<td>10</td>
<td>6.4</td>
</tr>
<tr>
<td>Hookworms</td>
<td>1,300</td>
<td>150</td>
<td>65</td>
<td>22.1</td>
</tr>
</tbody>
</table>

2b. Vector-borne diseases associated with water

Water is the breeding site for many disease vectors that play a key role in the spread of disease-causing organisms. Malaria, Japanese encephalitis, filariasis and schistosomiasis are major vector-borne diseases associated with water resources development.

In 2003, WHO commissioned from the Swiss Tropical Institute a number of systematic literature reviews focusing on the association between water resources development and four vector-borne diseases (malaria, lymphatic filariasis, Japanese encephalitis and schistosomiasis). The research led to global estimates of people at risk of these diseases in irrigation schemes and transmission and are associated with poor environmental sanitation. The provision of pit latrines in villages in Gambia resulted in a significant reduction of fly-eye contact and trachoma prevalence (Emerson et al., 2004).

The main burden is in sub-Saharan Africa, with focal areas in the eastern Mediterranean and South and Central Asia.

There is sufficient scientific evidence to support the notion that with improved hygiene and access to water and sanitation, trachoma will disappear from these areas as it has from Europe and North America (Mecaskey et al., 2003).

Trachoma is the leading cause of preventable blindness in the world, with an estimated 146 million cases, 6 million of which have caused actual blindness.

### Table 6.5: Global estimates of prevalence and the number of cases of soil-transmitted helminth infections by region and age group, 2003

<table>
<thead>
<tr>
<th>Helminth</th>
<th>Population (millions)</th>
<th>Infection prevalence (%)</th>
<th>Estimated number of infections (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At risk</td>
<td>Total</td>
<td>0-4</td>
</tr>
<tr>
<td><strong>Ascaris</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAC</td>
<td>514</td>
<td>530</td>
<td>16</td>
</tr>
<tr>
<td>SSA</td>
<td>571</td>
<td>683</td>
<td>25</td>
</tr>
<tr>
<td>MENA</td>
<td>158</td>
<td>313</td>
<td>7</td>
</tr>
<tr>
<td>SAS</td>
<td>338</td>
<td>363</td>
<td>27</td>
</tr>
<tr>
<td>India</td>
<td>808</td>
<td>1,027</td>
<td>14</td>
</tr>
<tr>
<td>EAP</td>
<td>560</td>
<td>564</td>
<td>36</td>
</tr>
<tr>
<td>China</td>
<td>1,262</td>
<td>1,295</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>4,211</td>
<td>4,775</td>
<td>26</td>
</tr>
<tr>
<td><strong>Trichuris</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAC</td>
<td>523</td>
<td>530</td>
<td>19</td>
</tr>
<tr>
<td>SSA</td>
<td>516</td>
<td>683</td>
<td>24</td>
</tr>
<tr>
<td>MENA</td>
<td>52</td>
<td>313</td>
<td>2</td>
</tr>
<tr>
<td>SAS</td>
<td>188</td>
<td>363</td>
<td>20</td>
</tr>
<tr>
<td>India</td>
<td>398</td>
<td>1,027</td>
<td>7</td>
</tr>
<tr>
<td>EAP</td>
<td>533</td>
<td>564</td>
<td>28</td>
</tr>
<tr>
<td>China</td>
<td>1,002</td>
<td>1,295</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>3,212</td>
<td>4,775</td>
<td>17</td>
</tr>
<tr>
<td><strong>Hookworm</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAC</td>
<td>346</td>
<td>530</td>
<td>10</td>
</tr>
<tr>
<td>SSA</td>
<td>646</td>
<td>683</td>
<td>29</td>
</tr>
<tr>
<td>MENA</td>
<td>73</td>
<td>313</td>
<td>3</td>
</tr>
<tr>
<td>SAS</td>
<td>188</td>
<td>363</td>
<td>16</td>
</tr>
<tr>
<td>India</td>
<td>514</td>
<td>1,027</td>
<td>7</td>
</tr>
<tr>
<td>EAP</td>
<td>512</td>
<td>564</td>
<td>26</td>
</tr>
<tr>
<td>China</td>
<td>897</td>
<td>1,299</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>3,195</td>
<td>4,775</td>
<td>15</td>
</tr>
</tbody>
</table>

Abbreviated regions are as follows:

- LAC – Latin America and the Caribbean
- SSA – sub-Saharan Africa
- MENA – Middle East and North Africa
- SAS – South Asia
- EAP – East Asia and the Pacific Islands

Source: de Silva et al., 2003.
In many parts of Africa the population faces intense year-round malaria transmission, resulting in a high disease burden, especially among children below 5 years of age and pregnant women. In all malaria-endemic countries in Africa, on average 30 percent of all outpatient clinic visits are for malaria (WHO/UNICEF, 2003). In these same countries, between 20 percent and 50 percent of all hospital admissions are malaria-related. International efforts to reduce the malaria burden are coordinated by the WHO-led Roll Back Malaria (RBM) initiative, which was launched in 1998. The main strategy is to promote prompt diagnosis and treatment, and the use of insecticide-treated nets (ITNs).

Malaria
Malaria remains one of the most important public health problems at a global level, causing illness in more than 300 million people each year. Its share of the global burden of disease has increased over the past few years and now stands at 46.5 million DALYs, 3.1 percent of the world’s total. This is an increase of 23 percent, compared with the year 1990. Mortality increased by 27 percent from 926,000 in 1990 to 1,272,000 in 2002. The majority of the burden of malaria is concentrated in sub-Saharan Africa. In many parts of Africa the population faces intense year-round malaria transmission, resulting in a high disease burden, especially among children.

Table 6.6: Global estimates of people at risk of four vector-borne diseases

<table>
<thead>
<tr>
<th>Estimated numbers of</th>
<th>Malaria (million)</th>
<th>Lymphatic filariasis (million)</th>
<th>Japanese encephalitis (million)</th>
<th>Schistosomiasis (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>People at risk globally</td>
<td>&gt;2,000</td>
<td>&gt;2,000</td>
<td>1,900</td>
<td>779</td>
</tr>
<tr>
<td>People at risk near irrigation schemes, globally</td>
<td>851.3</td>
<td>213</td>
<td>180–220</td>
<td>63</td>
</tr>
<tr>
<td>People at risk near dams, globally</td>
<td>18.3</td>
<td>n.a.</td>
<td>n.a.</td>
<td>42</td>
</tr>
<tr>
<td>People at risk in urban settings (no access to improved sanitation)</td>
<td>395</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
</tr>
<tr>
<td>People at risk near dams and irrigation schemes, sub-Saharan Africa</td>
<td>9.4</td>
<td>n.a.</td>
<td>n.a.</td>
<td>39</td>
</tr>
<tr>
<td>People at risk near dams and irrigation schemes, excluding sub-Saharan Africa</td>
<td>860.3</td>
<td>n.a.</td>
<td>n.a.</td>
<td>66</td>
</tr>
<tr>
<td>People at risk near irrigation schemes, Western Pacific</td>
<td>n.a.*</td>
<td>n.a.</td>
<td>n.a.</td>
<td>40</td>
</tr>
<tr>
<td>People at risk near irrigation schemes, South East Asia and Western Pacific</td>
<td>n.a.*</td>
<td>n.a.</td>
<td>132 (in irrigated areas) 167 (in rice irrigated areas) 923 (in rice irrigated areas) 36 (in rice irrigated areas)</td>
<td></td>
</tr>
</tbody>
</table>

*Not segregated to this level.

Sources: Erlanger et al., 2005; Keiser et al., 2005a,b; Steinman et al., in press; www.who.int/water_sanitation_health/resources/envmanagement/en/index.html
**Water management for malaria control**

Water resources development projects, especially irrigation systems, can provide the ecological conditions suited to the propagation of malaria vectors. The relationship between malaria and water resources development is, however, highly situation-specific, depending on the ecology, biology and efficiency of local vectors, people’s behaviour and climate. The opportunities for malaria vector breeding are often associated with faulty irrigation design, maintenance or water management practices. The case of irrigation-related malaria in the Thar Desert is described in Box 6.1.

In Africa, but also in parts of Asia, several empirical studies have shown the counter-intuitive result of no intensification of malaria transmission in association with irrigation development and increased mosquito vector densities; socio-economic, behavioural and vector ecological factors may all play a role in this phenomenon, dubbed the ‘paddy paradox’ (Ijumba and Lindsay, 2001; Klinkenberg et al., 2004). Studies in West Africa on rice irrigation and farmers’ health showed that irrigation affected the transmission pattern but did not increase the burden of malaria (Sisoko et al., 2004). It was also documented that irrigated rice cultivation attracted young families, improved women’s income and positively affected treatment-seeking behaviour by shortening the delay between disease and initiation of treatment.

Globally, it is estimated that only 18.9 million people (most of whom are in India) live close enough to large dams to be at risk of malaria transmitted by mosquitoes associated with man-made reservoirs (Keiser et al., 2005a). The population living close to irrigation sites in malaria endemic areas is much larger and has been estimated at 851.5 million (see Chapters 7 and 8). However, in Africa, where the main burden of malaria rests, only 9.4 million people live near large dams and irrigation schemes. Hardly any information is available on the impact of small dams, of which there are many hundreds of thousands in malaria endemic areas in Africa and elsewhere. Cumulatively, these could well be more important for malaria transmission than large dams and irrigation schemes. The potential for the further expansion of small dams is considerable, particularly in sub-Saharan Africa. There is therefore a pressing need for strategic health impact assessment as part of the planning of small dams that should encompass a broad approach towards health, including issues of equity and well-being (Keiser et al., 2005a).

The role of the aquatic environment as an essential condition for malaria transmission was recognized long ago. Environmental management methods were used for malaria control, especially in Asia, Central America and the Caribbean, Europe and the US (Kromann et al., 2004; Keiser and Utzinger, 2005). A lack of scientific evidence of effectiveness, uncertainty about the present-day feasibility of implementation and remaining vertical vector control structures prevent environmental management methods from playing a more important role in present-day malaria control. The joint World Health Organization (WHO), Food and Agriculture Organization (FAO), United Nations Environment Programme (UNEP) Panel of Experts on Environmental Management for Vector Control (PEEM) has played a central role in research and capacity-building in this field since the early 1980s. Recently, international research initiatives have focused on possibilities for reducing malaria as part of an ecosystem approach to human health, by looking at the relationship between all components of an ecosystem in order to define and assess priority problems that affect the health and livelihood of people and environmental sustainability.9

The Consultative Group on International Agricultural Research’s (CGIAR) Systemwide Initiative on Malaria and Agriculture (SWA) looks at the interaction of people with land, water and crops as they farm existing agricultural areas or develop new areas for farming. This is expected to lead to the identification of specific environmental management measures for the reduction of the disease transmission potential. In the absence of an effective vaccine, treatment of patients and promotion of insecticide-treated nets will remain the main evidence-based strategies for malaria control. But even in the African context, vector control (largely by indoor house-spraying with residual insecticides) and proper management of the environment is increasingly recognized as an indispensable part of malaria control.9 (See the recent work done in Sri Lanka discussed in Box 6.3.) In low transmission areas such as in many parts of Asia and in the latitudinal and altitudinal fringes of malaria distribution in Africa, environmental management is re-emerging as an important component of an integrated approach to malaria control. In such areas, it is also important that health impact assessments be part of the planning process of hydraulic infrastructure projects, in order to identify, qualify and possibly quantify adverse health effects at the earliest possible stage and suggest preventive solutions (Lindsay et al., 2004). In rural areas of Africa where mosquito breeding places are diffuse and

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9. See www.idrc.ca/ecohealth

10. For more information, go to www.idrc.ca/ecohealth

Mosquitoes are becoming increasingly resistant to insecticides and malaria parasites to inexpensive drugs
In rural areas of Africa where mosquito breeding places are diffuse and varied, there may be little scope for environmental control measures. The situation is different in African cities. In urban and peri-urban areas, breeding sites can be detected more easily than in rural areas, and environmental management is proposed as a main feature for an integrated control approach (Keiser et al., 2004). This can have an important impact on the overall malaria burden. According to different plausible scenarios, an estimated 25 to 100 million malaria cases occur in African cities.

**Filarial Infections**

Mosquito-borne lymphatic filariasis is rarely life-threatening but causes widespread and chronic suffering, disability and social stigma. Globally, an estimated 119 million people are infected, with 40 million suffering from severe chronic disease. More than 40 percent of those infected live in India and 30 percent in Africa. In India alone, the disease causes losses of US $1 billion annually (Erlanger et al., 2005). The current Global Programme to Eliminate Lymphatic Filariasis (GPELF), led by WHO, is based on mass drug administration of the vector of lymphatic filariasis (Manga, 2002). In India, the vectors of lymphatic filariasis and malaria are different, but vector control, including proper sanitation, a robust drainage infrastructure and environmental management to minimize mosquito-breeding places, has been shown to contribute significantly to the reduction of transmission risks. In the rural areas of Africa, where anopheles mosquitoes are the vectors, an estimated 213 million people are at risk because of their proximity to irrigation schemes (Erlanger et al., 2005). While densities of the mosquito vector are often much higher in irrigated areas as compared to irrigation-free sites, relatively few studies have been done aimed at linking water resources development and filarial disease. More research is needed to better define the potential of water management approaches for vector control in this connection. In rural areas of Africa, the vector of lymphatic filariasis also transmits malaria. Therefore, vector control activities such as implemented under the Roll Back Malaria initiative can be expected to reduce the transmission of malaria as well as lymphatic filariasis (Manga, 2002). In India, the vectors of lymphatic filariasis and malaria are different, but vector control, including breeding-site reduction and environmental control interventions as a component of an integrated control programme. Some of the interventions being field-tested today are based on the approaches used during the first half of the twentieth century, while others have come about through the use of modern technologies in an attempt to counter the new challenges resulting from large-scale changes in the freshwater environment. The experiences clearly point to the site-specific nature of the interventions, reflecting the different patterns of transmission, disease-vector ecology and the local capacities available for implementation. Extensive field research and close collaboration between the water management and health sectors provide opportunities for a significant contribution to malaria control.

Recent work in Sri Lanka assessed options for the control of malaria vectors through different water management practices in irrigation conveyance canals and streams. The approach was based on the use of existing irrigation structures regulating the water levels in the waterways and was aimed at eliminating the principal breeding sites of the most important malaria vector in the country. Overall, the result demonstrated a high potential for effective vector control by feasible changes in irrigation and stream water management, resulting from periodic fortnightly releases from upstream reservoirs, to eliminate mosquito breeding sites and render the habitat less conducive to Anopheles culicifacies breeding for some time after the water release (see Chapter 14). The approach followed did not result in a loss of water, since the water was captured in reservoirs downstream. The designated water management strategy was far cheaper than the use of chemical larvicides.

**BOX 6.3: MALARIA CONTROL THROUGH STREAM WATER MANAGEMENT**

From a global perspective, the use of environmental and engineering-based control interventions that make the water environment less conducive for vector-breeding plays a limited role in current malaria control efforts. However, research from around the world has shown the potential for using environmentally based control interventions as a component of an integrated control programme. Some of the interventions being field-tested today are based on the approaches used during the first half of the twentieth century, while others have come about through the use of modern technologies in an attempt to counter the new challenges resulting from large-scale changes in the freshwater environment. The experiences clearly point to the site-specific nature of the interventions, reflecting the different patterns of transmission, disease-vector ecology and the local capacities available for implementation. Extensive field research and close collaboration between the water management and health sectors provide opportunities for a significant contribution to malaria control.

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**Sources:** Konradsen et al., 1998; 1999; Matsuno et al., 1999; Keiser and Utzinger., 2005.
management, can have an impact on different vector species and both diseases (Pratlong, 2002).

Guinea worm infection is unique in that it is the only communicable disease that is transmitted exclusively through drinking water containing infected intermediate hosts. These are small crustaceans infected with the parasite Dracunculus medinensis, which causes the disease in humans. Thus, it is the only disease that can be prevented entirely by protecting supplies of drinking water. Guinea worm infection is about to be eliminated by improvements in water supply. In Africa, the number of cases has declined from 3.5 million in 1986 to 35,000 in 2003 (WHO/UNICEF, 2004). The majority of remaining cases are in Sudan, where many areas are inaccessible to eradication efforts due to ongoing civil conflicts.

**Schistosomiasis**

Schistosomiasis (bilharzia) is contracted by humans through contact with water infested with the free-swimming larval stages of parasitic worms (cercariae) that penetrate the skin and develop in the human body to maturity. Parasite eggs leave the human body with excreta. They hatch in freshwater and infect aquatic snail intermediate hosts. Within the snails they develop into cercariae, which are, in turn, released into the water to infect new human hosts. Transmission can take place in almost any type of habitat from large lakes or rivers to small seasonal ponds or streams. Man-made water bodies, including irrigation schemes, are particularly important, as the human population density is usually high around these and water contact patterns are intense. The disease occurs in seventy-four countries in sub-Saharan Africa, South America and Asia, with an estimated 200 million people infected, 85 percent of whom live in sub-Saharan Africa.

Schistosomiasis is a chronic, debilitating parasitic disease, which may cause damage to the bladder, liver and intestines, lowers the resistance of the infected person to other diseases and often results in retarded growth and reduced physical and cognitive functions in children. The current estimate of the global burden of disease due to schistosomiasis as presented in the World Health Report is based on the number of people infected with an associated low disability weight because many infections do not result in clinical disease. With better data on morbidity and mortality now becoming available, DALYs due to schistosomiasis should be recalculated (Crompton et al., 2003). Recent estimates from sub-Saharan Africa indicate that 280,000 deaths per year can be attributed to schistosomiasis, much higher than the 15,000 listed by the Global Burden of Disease Initiative (van der Werf et al., 2003).

The key element in the current control strategy is the regular treatment of at-risk populations, especially school children, with the drug praziquantel. This has to be combined with improvements in sanitation, which will prevent eggs from entering the environment. Contact with infested water has successfully been reduced by improving water supplies and providing laundry and shower facilities and footbridges. It has been stated that linking schistosomiasis control to improvements in water supply and sanitation has the potential to ensure long-term control and, in many instances, elimination of the disease (Utzinger et al., 2003). Results from national control programmes in endemic countries such as Brazil, China and Egypt are encouraging (see Chapter 14). However, there is currently little or no schistosomiasis control in sub-Saharan Africa (Engels and Chitsulo, 2003).

Of the estimated population at risk (779 million globally), some 105 million live close to dams and irrigation schemes (Sternman, in press). Proportionally, a high percentage of these live in the western Pacific region (China and Philippines).

The introduction or spread of schistosomiasis has been documented in relation to the construction of large dams and irrigation systems. In these settings, it is important to combine mass chemotherapy and improvements in water supply and sanitation with snail control. Reductions in snail populations can be achieved by various engineering means, including proper drainage, canal lining, removal of aquatic vegetation from canals, regular flushing of canals, increasing the flow velocity, drying of irrigation systems and changing water levels in reservoirs. Such often capital-demanding interventions should be focused on locations where water contact is intense. Of even greater importance for increased schistosomiasis transmission in the future could be the thousands of small dams that are being built on the African continent for agriculture, livestock, and drinking water supply.

**Arboviral infections**

**Japanese encephalitis:** Restricted to the Asian region, Japanese encephalitis (JE) is closely associated with irrigated rice ecosystems, where the Culex mosquito vectors prefer to breed. Transmission risks are greatly enhanced where pig rearing is practised as a source of food and income generation: pigs are amplifying hosts of widely ranging encephalitis viruses, including Japanese and West Nile encephalitis, which typically only affect humans and other non-human primates. With more than 400,000 cases and 10% mortality recorded in the last decade, JE is a severe health threat in Asia. The disease is considered to be of increased public health importance as a result of climate change: climate models suggest increased risk areas moving northwards. There is a need for better understanding of the environmental drivers of JE transmission, improved identification of zoonotic reservoirs, and development of improved surveillance and disease control techniques, including the introduction of vaccine technologies. The challenge to managing JE is to identify and implement optimal strategies to control mosquitoes, reduce human contact with mosquitoes, and improve medical management of patients.

**Yellow fever:** Yellow fever (YF) is a viral disease transmitted by Aedes mosquitoes and also occurs in monkeys, which are its main reservoir hosts. It is distributed across the world and is endemic to 15 countries in the Americas, Africa and southern Asia. The virus circulates in cycles involving mosquitoes and a variety of monkey species, with human infection sporadic and limited to locations with frequent mosquito-human contact. YF poses a threat to international travelers and to the domestic population of areas with inadequate mosquito control and health care systems. While YF is not extensively communicable in human populations, it can cause widespread mortality in susceptible human populations. The burden of YF in Africa is estimated to be higher than the number of people annually affected by malaria, and in the Americas, the number of deaths is higher than that attributed to tuberculosis. Disease control is mainly based on the use of vector control strategies and mass vaccination campaigns. International travel is a major risk factor for the spread of YF. YF vaccine offers an effective and attractive approach for prevention and control of YF, which is essential to prevent the introduction of YF, especially from the Americas. The introduction of an effective, safe, and affordable YF vaccine is a priority for the World Health Organization (WHO).
Dengue ranks as the most important mosquito-borne viral disease in the world. In the last fifty years, its incidence has increased thirty-fold. An estimated 2.5 billion people are at risk in over 100 endemic countries.

Between 1998 and 2004, the strategy achieved the elimination of vectors from thirty-two out of thirty-seven communities, covering 309,730 people. As a result, no dengue cases have been detected in any of the communities since 2002, and the deployment of the strategy indicates so far its applicability and sustainability wherever large water storage containers are major sources of the vectors.

Source: Kay and Nam, 2005.
mortality caused by drowning as an exceptional peak resulting from a phenomenon for which early warning is key (see Chapters 1, 10 and 14).

The strategy to improve rural drinking water supply by installing low-cost hand pumps that draw groundwater uncontaminated by disease-causing microbes, has been applied on a large scale in several countries. In Bangladesh alone, more than 4 million tubewells have been installed over the past twenty years to provide drinking water to 95 percent of the population. It is believed that over 20% of all diarrhoeal diseases result from a phenomenon for which early warning is key (Fewtrell, 2004). However, a return to surface water would inevitably result in an increase in diarrhoeal disease (Lokuge et al., 2004). In India, an estimated 66 million people rely on groundwater with fluoride concentrations exceeding WHO recommended norms for their drinking water needs. While arsenic is toxic and carcinogenic, an excess of fluoride leads to the mottling of teeth and, in severe cases, crippling skeletal deformities, as well as other health problems. In addition to the Indian subcontinent and China, clinical forms of dental and skeletal fluorosis are particularly common along the East African Rift Valley (WHO/MA, 2006; see also Chapter 14).

The situation in Bangladesh and other areas, including parts of India, China and East Africa, calls for a pragmatic combination of practical, affordable and sustainable water supply programmes aimed at minimising the combined risk to health posed by diarrhoeal disease, fluoride, arsenic and other chemical contaminants that may be present in the environment. Installing filters or other devices in millions of tubewells to remove arsenic and fluoride is an almost impossible task. Yet, it is imperative that water from each and every tubewell be tested for arsenic and fluoride in affected areas, before it is made available for consumption. Even in affected villages, one or more pumps could provide water with permissible arsenic and fluoride levels. In other cases, there might be no choice but to use surface water sources that are also used for agriculture and other uses with suitable treatment. This calls for clear, integrated policies on the joint use of surface and groundwater resources, as illustrated in Box 6.6.

There are many other chemicals that can cause health problems. However, at the global level these are not as important as fluoride or arsenic. Nitrate pollution of groundwater is a major environmental issue in developing as well as industrialized countries (see Chapter 5).

Nevertheless, a recent review of the global burden of disease related to nitrate in drinking water concluded that nitrate is just one of the factors that play a role in the sometimes complex causal web underlying methaemoglobinaemia ‘blue baby syndrome’. Given the apparently low incidence of this condition and the complex nature of the role of nitrates and individual behaviour, it is currently inappropriate to attempt to link disease incidence with drinking water nitrate levels (Fewtrell, 2004).

The Guidelines for Drinking-water Quality (WHO, 2004b) establishes values for the concentrations of substances.

**Box 6.5: Recreational Water Use, Pollution and Health**

Drowning is not the only risk associated with recreational water use. Swimming may be exposed to health hazards at many places where raw or partially treated sewage is pumped into seas every day. Chemical contamination of seas and rivers arises principally from direct waste discharge (e.g. industrial effluent) or chemical spills and is typically local or regional in nature. Little is known about the adverse effects of exposure to chemical contaminants, but exposure from recreational water is likely to be a very small fraction of total exposure.

Recreational waters in the tropics and subtropics pose special hazards, not just from some of the local aquatic or amphibious predators such as crocodiles, but also from the causative agents of a number of tropical diseases, especially schistosomiasis. WHO produces international norms on recreational water use and health in the form of guidelines. Volume 1 of the WHO Guidelines for Safe Recreational Water Environments addresses the health aspects of coastal and fresh waters.

Source: www.who.int/water_sanitation_health/bathing/en/
give values for some twenty organic substances of
importance. Most pollutants originating from agricultural
activities are pesticides and a large part of them (or their
residues) have never been detected in drinking water, while
another substantive part occurs at concentrations well
below those at which toxic effects may occur. Finally, the
guidelines single out the cyanobacterial toxins produced by
many species of Cyanobacteria occurring naturally in lakes,
reservoirs, ponds and slow-flowing rivers.

BOX 6.6: AVAILABILITY AND QUALITY OF DRINKING WATER IN THE RUHUNA BASINS, SRI LANKA

The Ruhuna Basins in southern Sri Lanka were
described as a pilot case study in the first World
Water Development Report (UN-WWAP, 2003; see
also Chapter 14). Recent studies in the area have
confirmed the observation that seepage from
irrigation canals and reservoirs is indispensable for
maintaining water levels in shallow wells that
people use for drinking. Canal seepage accounted
for more than half of groundwater recharge, and
canal closure resulted in groundwater levels
decreasing by 1 to 3 metres within a few days,
leading to the drying up of many shallow wells and
problems of access to domestic water supplies for
farmers. To make agricultural water use more
efficient, several canals were lined with concrete
and this has reduced seepage and further
restricted the availability of water for domestic use.

To improve the drinking water supply for the
people that settled in newly developed irrigated
areas in the Ruhuna Basins, many tubewells were
constructed in order to exploit deeper
groundwater resources. However, a large
proportion of these wells are not used by the local
population, because the water is unpalatable, due
to salt or other chemicals. Water quality testing
showed that surface water was polluted by faecal
matter, therefore presenting a potential risk for
case-fauci transmitted diseases, especially
diarrhoea, if used for drinking. Shallow wells had
lower levels of pollution, and tubewells had the
lowest level of faecal indicator bacteria, often
meeting the zero pathogen criterion referred to
in the WHO guidelines for Drinking-water Quality.
While the tubewell water from deeper aquifers
was of good bacteriological quality, the water
generally had high contents of iron, salt and
fluoride. Prevalence of dental fluorosis among
14-year-old students in the area was
43 percent.

In basins such as these, providers of drinking water
are faced with a dilemma. Taking availability and
biological and chemical water quality into account,
shallows wells seem to be the best water source for
domestic purposes, especially those protected by a
wall from surface inflows. However, irri gation
rehabilitation programmes that include the lining of
canals are threatening this source of drinking
water. Residents may then be forced to look for
alternative water sources and may have to resort to
untreated surface water from larger canals and
reservoirs if shallow wells fail. This stresses the
need for a governance structure with intersectoral
and integrated planning, development and
management of water resources to ensure that the
needs of at least the most important stakeholder
are met.

Sources: Boelee and van der Hoek, 2002; van der Hoek
et al., 2003; Rajasooriyar, 2003.
Part 3. Progress towards the MDG Targets on Water, Sanitation and Health

In 1990, 77 percent of the world’s population used improved drinking water sources. Considerable progress was made between 1990 and 2002, with about 1.1 billion people gaining access to improved sources. Global coverage in 2002 reached 83 percent, keeping the world on track to achieve the MDG target; however, there are great regional disparities. Table 6.1 reviews the water and sanitation targets in relation to the MDGs.

3a. Status of MDG 7: Drinking water and sanitation targets

The region that made the greatest progress towards sustained access to safe drinking water is South Asia, where coverage increased from 71 percent to 84 percent between 1990 and 2002. This jump was fuelled primarily by increased access to improved water sources in India, home to over 1 billion people. Coverage in sub-Saharan Africa increased from 49 percent to 58 percent between 1990 and 2002. Yet this falls short of the progress needed to achieve the MDG target of 75 percent coverage by 2015 (see Map 6.1). Nevertheless, there are a number of success stories in water supply, sanitation and hygiene in sub-Saharan Africa, some of which are reported in the Blue Gold Series of the World Bank Water and Sanitation Programme (see also Chapter 14).

Global sanitation coverage rose from 49 percent in 1990 to 58 percent in 2002. Still, some 2.6 billion people – half of the developing world and 2 billion of whom live in rural areas – live without improved sanitation. Sanitation coverage in developing countries (49 percent) is only half that of the developed world (96 percent). Major progress was made in South Asia between 1990 and 2002. Yet, more than 60 percent of the region’s population still did not have access to sanitation in 2002. In sub-Saharan Africa, sanitation coverage in 2002 was a mere 36 percent, up 4 percent from 1990. Over half of those without improved sanitation – nearly 1.5 billion people – live in China and India.

To take the proportion of people without improved sanitation, global coverage needs to grow to 75 percent by 2015, from a starting point of 49 percent in 1990. However, if the 1990–2002 trend continues, the world will fall short of the sanitation target by more than half a billion people. In other words, close to 2.4 billion people will be without improved sanitation in 2015, almost as many as there are today. The proportion of the world’s population with improved sanitation has increased by just 9 percent since 1990, a rate far slower than that required to meet the MDGs. The widening gap between progress and target (see Figure 6.1) signals that the world will meet its sanitation goal only if there is a dramatic acceleration in the provision of services.

3b. Status of the other MDG targets with respect to water-related health issues

Some of the indicators for monitoring progress towards meeting the MDGs are especially relevant in connection with water-related diseases. WHO and the United Nations Children’s Fund (UNICEF) are responsible for providing the UN Statistics Division with relevant international statistics and analyses of quantitative and time-bound indicators directly linked to water and sanitation. Data sets and information on water supply and sanitation coverage are derived from their Joint Monitoring Programme (JMP). In addition, progress towards the MDGs is monitored by a number of indicators that are health-related but that cut across different sectors. While there is progress in many parts of the world with respect to targets on child mortality, nutrition and water-related infectious diseases, the situation remains extremely worrisome in sub-Saharan Africa.

Figure 6.1: Projected population without access to improved sanitation


For more information, go to www.wsp.org/08_BlueGold.asp
Map 6.1: Coverage with improved drinking water sources, 2002

Source: WHO/UNICEF, 2004. The boundaries shown on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

A significant part of child mortality rates can be attributed to water-associated diseases

- MDG Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger

  One of the two indicators for monitoring progress towards achieving this target is the prevalence of underweight children under 5 years of age.

  It is unlikely that the MDG target of reducing 1990-level prevalence of underweight children by 50 percent in the year 2015 can be met, mainly due to the deteriorating situation in Africa (de Onis et al., 2004).

  Worldwide, the percentage of underweight children has been projected to decline from 26.5 percent in 1990 to 17.6 percent in 2015, a decrease of 34 percent. However, in Africa, the rate was expected to increase from 24 percent to 26.8 percent. In developing countries, stunting has fallen progressively from 47 percent in 1980 to 33 percent in 2000, but with very little, if any, progress in large parts of Africa (de Onis et al., 2000). Estimated trends indicate that overall stunting rates in developing countries will continue to decrease to 16.3 percent in 2020 (de Onis and Blossner, 2003). The great majority of stunted children live in South Asia and sub-Saharan Africa, where only minor improvements are expected.

- MDG Target 3: Reduce by two-thirds, between 1990 and 2015, the under-5 mortality rate

  Progress in reducing child mortality is low. No country in sub-Saharan Africa is making enough progress to reach this target. The developing world only achieved a 2.5 percent average annual decrease during the 1990s, well short of the target of 4.2 percent (UNDP, 2003). A significant part of this mortality rate can be attributed to water-associated diseases.

- MDG Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases

  Throughout sub-Saharan Africa, the decrease in under-5 mortality from all combined causes, apparent during the 1970s and 1980s, levelled off in the 1990s, perhaps partially as a result of increased malaria mortality (WHO/UNICEF, 2003).
Map 6.2: Coverage with improved sanitation, 2002

Source: WHO/UNICEF, 2004. The boundaries shown on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.