

Facts and Figures

FROM THE UNITED NATIONS WORLD WATER DEVELOPMENT REPORT 4

Managing Water under Uncertainty and Risk

Chapter 1

Recognizing the centrality of water and its global dimensions

- Water for irrigation and food production constitutes one of the greatest pressures on freshwater resources. Agriculture accounts for ~70% of global freshwater withdrawals (up to 90% in some fast-growing economies).
- Global population growth projections of 2–3 billion people over the next 40 years, combined with changing diets, result in a predicted increase in food demand of 70% by 2050.
- Many of the impacts of natural hazards on socio-economic development occur through water. Between 1990 and 2000, in several developing countries natural disasters had caused damage representing 2–15% of their annual GDP (World Bank, 2004; WWAP, 2009).

- Of all energy produced globally, 7–8% is used to lift groundwater and pump it through pipes and to treat both groundwater and wastewater (Hoffman, 2011) – a figure that rises to ~40% in developed countries (WEF, 2011a).
- In 2009, the number of people without access to electricity was 1.4 billion or 20% of the world’s population (IEA, 2010b).
- Biofuels are an increasingly prominent component of the energy mix, as exemplified by the EU target for biofuels to constitute 10% of transport fuel by 2020 (EU, 2007). This target has been hotly debated as it acts as a driver for conversion of land from food to biofuel production, placing upward pressure on food prices, and in some cases leading to the conversion of forest ecosystems to land to grow biofuels.
- Even modest projections of biofuel production indicate that if by 2030 – as the IEA suggests – just 5% of road transport is powered by biofuels, this could amount to at least 20% of the water used for agriculture globally (Comprehensive Assessment of Water Management in Agriculture, 2007).

Beyond the basin: The international and global dimensions of water governance

- The cost of adapting to the impacts of a 2°C rise in global average temperature could range from US\$70

to \$100 billion per year between 2020 and 2050 (World Bank, 2010). Of this cost, between US\$13.7 billion (drier scenario) and \$19.2 billion (wetter scenario) will be related to water, predominantly through water supply and flood management.

- Water is not confined to political borders. An estimated 148 states have international basins within their territory (OSU, n.d., 2008 data), and 21 countries lie entirely within them (OSU, n.d, 2002 data).
- About 2 billion people worldwide depend on groundwater supplies, which include 273 transboundary aquifer systems (ISARM, 2009; Puri and Aureli, 2009).
- Sixty per cent of the world's 276 international river basins lack any type of cooperative management framework (De Stefano et al., 2010).
- There are numerous examples where transboundary waters have proved to be a source of cooperation rather than conflict. Nearly 450 agreements on international waters were signed between 1820 and 2007 (OSU, n.d., 2007 data).
- The need to meet a 60% increase in demand for energy over the next three decades, combined with the imperative to invest in clean energy to mitigate climate change, is already making hydropower and biofuels critical parts of the development equation (Steer, 2010).
- Only 5% of total hydropower potential has been exploited in Africa (IEA, 2010a), where many hydropower sites are situated on transboundary rivers, thus providing significant opportunities for increased cooperation on benefit sharing among neighbouring states.

Recognizing water in global policy

- The world is on track to meet the Millennium Development Goal (MDG) on 'access to safe drinking water', although progress varies across regions and sub-Saharan Africa and the Arab region lag behind. By contrast, the sanitation target (which is not necessarily linked to water, although hygiene is) currently appears out of reach, as half the population of developing regions continue to lack access to basic sanitation.
- UN-Water conducted a global survey in 2011 to determine progress towards sustainable management of water resources using integrated approaches. Preliminary findings from the analysis of data from more than 125 countries show that there has been widespread adoption of integrated approaches with significant impact on development and water management practices at the country level: 64% of countries have developed integrated water resources management (IWRM) plans, as called for in the Johannesburg Plan of Implementation, and 34% report an advanced

stage of implementation. However, progress appears to have slowed in low and medium Human Development Index (HDI) countries since the 2008 survey.

Chapter 2

Water demand: What drives consumption?

Food and agriculture

- Irrigation is only a modest part of agricultural water consumption but it accounts for more than 40% of the world's production on less than 20% of the cultivated land.
- Concerns about food insecurity are growing across the globe and more water will be needed to meet increasing demands for food and energy (biofuels). Withdrawals for agriculture tend to decrease with increasing levels of development.
- In many countries, water availability for agriculture is already limited and uncertain, and is set to worsen. Agricultural water withdrawal accounts for 44% of total water withdrawal in OECD countries, but for more than 60% within the eight OECD countries that rely heavily on irrigated agriculture. In the BRIC countries (Brazil, Russian Federation, India and China), agriculture accounts for 74% of water withdrawals (this ranges from 20% in the Russian Federation to 87% in India). In the least developed countries (LDCs), the figure is more than 90% (FAO, 2011b).
- Globally, irrigated crop yields are ~2.7 times those of rainfed farming, hence irrigation will continue to play an important role in food production. The area equipped for irrigation increased from 170 million ha in 1970 to 304 million ha in 2008. There is still potential for expansion, particularly in sub-Saharan Africa and South America, in places where sufficient water is available.
- Although there is still potential to increase the cropped area, some 5–7 million ha (0.6%) of agricultural land are lost annually because of accelerating land degradation and urbanization, which reduces the number of farms as more people move to the cities. Increasing population means that the amount of cultivated land per person is also declining sharply: from 0.4 ha in 1961 to 0.2 ha in 2005.
- The world population is predicted to grow from 6.9 billion in 2010 to 8.3 billion in 2030 and to 9.1 billion in 2050 (UNDESA, 2009a).
- With expected increases in population, by 2030, food demand is predicted to increase by 50% (70% by 2050) (Bruinsma, 2009), while energy demand from hydropower and other renewable energy resources will

rise by 60% (WWAP, 2009). These issues are interconnected – increasing agricultural output, for example, will substantially increase both water and energy consumption, leading to increased competition for water between water-using sectors.

- The main challenge facing the agricultural sector is not so much growing 70% more food in 40 years, but making 70% more food available on the plate. Reducing losses in storage and along the value chain may go a long way towards offsetting the need for more production.
- Although projections vary considerably based on different scenario assumptions and methodologies, FAO estimates an 11% increase in irrigation water consumption from 2008 to 2050. This is expected to increase by ~5% from the present water withdrawal for irrigation of 2,740 km³. Although this seems a modest increase, much of it will occur in regions already suffering from water scarcity (FAO, 2011a).
- Nitrate is the most common chemical contaminant in the world's groundwater resources. The USA is currently consuming the largest amount of pesticides, followed by countries in Europe, especially those of Western Europe (FAO, 2011b). In terms of use per unit area of cultivated area, Japan is the most intensive user of pesticides.
- Economic growth and individual wealth are shifting diets from predominantly starch-based to meat and dairy, which require more water. Producing 1 kg of rice, for example, requires ~3,500 L of water, 1 kg of beef ~15,000 L, and a cup of coffee ~140 L (Hoekstra and Chapagain, 2008). This dietary shift is the greatest to impact on water consumption over the past 30 years, and is likely to continue well into the middle of the twenty-first century (FAO, 2006).
- Livestock contributes 40% of the global value of agricultural output (but less than 2% of global GDP).
- The expansion of land for livestock has led to deforestation in some countries (e.g. Brazil) while intensive livestock production (mainly in OECD countries) is already a major source of pollution. Livestock produces some 18% of greenhouse gases (GHGs) (Steinfeld et al., 2006).
- In 2010, it was estimated that only US\$10 billion was invested globally in irrigation systems, a surprisingly low figure given the importance of water for the agricultural sector. In comparison, the global market volume for bottled water in the same year was US\$59 billion (Wild et al., 2010).

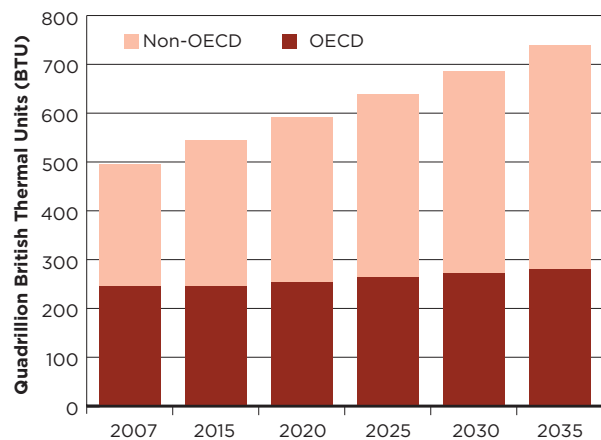
Energy

- The treatment of wastewater requires significant amounts of energy, and demand for energy to do

this is expected to increase globally by 44% between 2006 and 2030 (IEA, 2009), especially in non-OECD countries where wastewater currently receives little or no treatment (Corcoran et al., 2010).

- EIA (2010) estimates that global energy consumption will increase by ~49% from 2007 to 2035 (Figure 1). This increase in energy consumption will be higher in non-OECD countries (84%) than in OECD countries (14%), with the primary driver being the expected growth in GDP and the associated increased economic activity.

Figure 1 World marketed energy consumption, 2007–2035



Source: EIA (2010, p. 1).

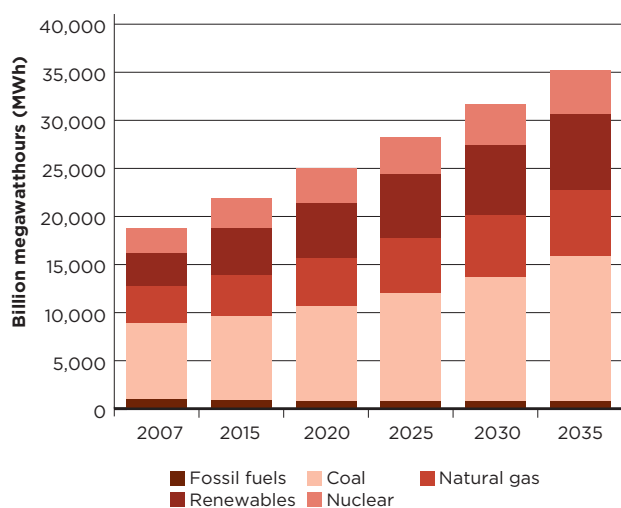
- Thermal power plants (coal, gas, oil, biomass, geothermal or uranium) account for 78% of world electricity production (EIA, 2010) and output is expected to grow, implying that even more water cooling will be needed.
- Hydropower presents the largest renewable source of electricity generation (15% of global production in 2007), and it is estimated that two-thirds of the world's economically feasible potential is still to be exploited (WEC, 2010).
- In 2007, biofuel production was dominated by Brazil, the USA, and to a lesser extent, the EU. Biomass and waste represented 10% of the world's primary energy demand in 2005, more than nuclear power (6%) and hydropower (2%) combined (IEA, 2007).
- If a projected bioenergy supply of 6,000–12,000 million tonnes of oil equivalent were to be reached in 2050,¹ this would require one-fifth of the

¹ IEA (2006) states that, taking into account very rapid technological progress, the higher figure could be 26,200 million tonnes of oil equivalent instead of 12,000. However, IEA also indicates that a more realistic assessment based on slower yield improvements would be 6,000–12,000. A mid-range estimate of ~9,500 would require about one-fifth of the world's agricultural land to be dedicated to biomass production.

world's agricultural land (IEA, 2006). Biofuels are water intensive and can add to the strains on local hydrological systems and GHG emissions.

- No increases can be expected in electricity from liquid fossil fuels, and very little from nuclear production (Figure 2). The production of electricity from coal, renewable energy and natural gas, however, is expected to increase significantly. Electricity production from renewables is expected to more than double until 2035, with hydropower growing in overall production, but less significantly in percentage than wind, solar and PV (EIA, 2010; WWF, 2011).

Figure 2 Projections for world net electricity generation, 2007–2035



Note: for this figure, fossil fuels refers to liquids such as petroleum and liquefied gases. Coal and natural gas are considered separately.

Source: Data from EIA (2010).

- Wind and solar photovoltaic (PV) currently account for 3% of global electricity production. During operation, these technologies use virtually no water with the exception of washing of blades or solar cells (WEF, 2009). However, water requirements for washing solar panels can be important to remove dust when they are operating in or near deserts. Also, in the case of large-scale deployment of concentrating solar power, the electricity is generated via the same steam cycle as thermal power plants and will therefore have cooling water requirements, which can be a challenge in hot and dry regions (Carter and Campbell, 2009).
- The anticipated water requirements for energy production will increase by 11.2% by 2050 if current consumption modes are kept. Under a scenario that assumes increasing energy efficiency of consumption modes, WEC (2010) estimates that water

requirements for energy production could decrease by 2.9% until 2050. Unfortunately, the water availability required for energy production is often not considered when new energy production facilities are planned. Similarly, energy needs for water systems are often overlooked.

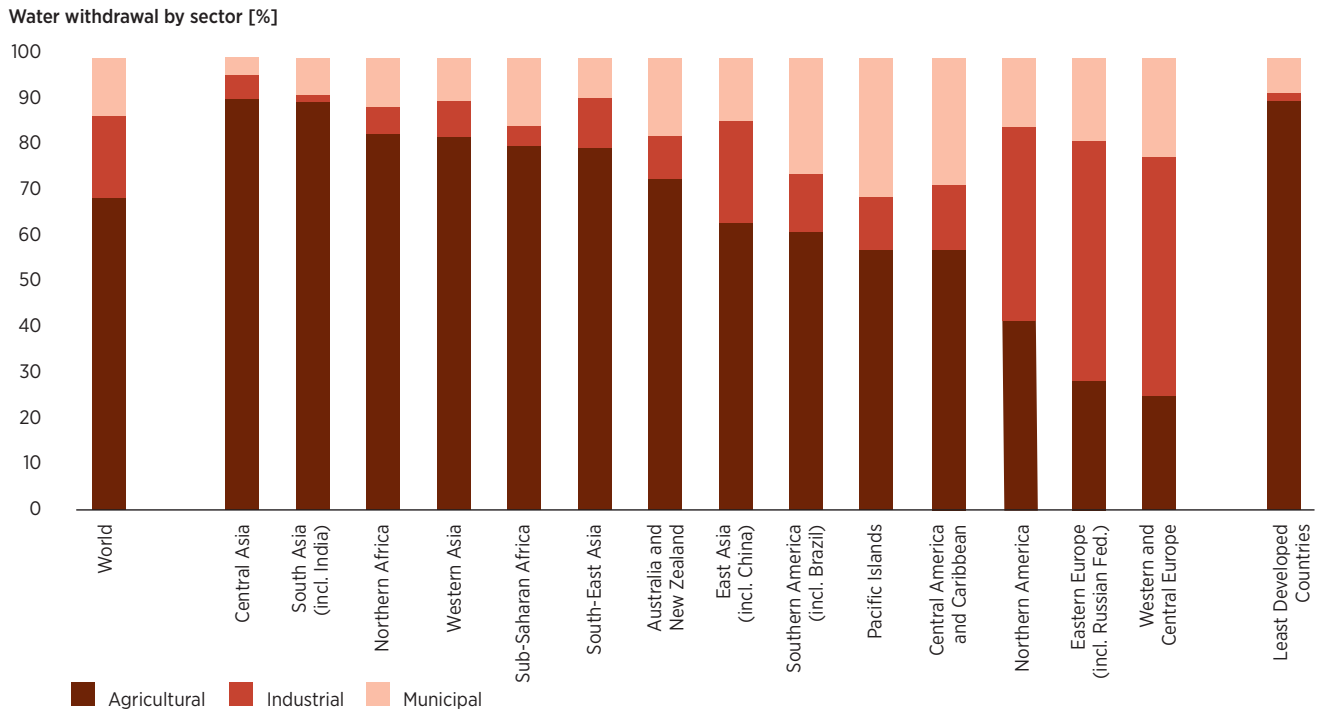
- In life-cycle analyses, it has been observed that desalination of locally available sources generally requires significantly more energy than importing water sources (Strokes and Horvath, 2009), and requires generally six times more energy than wastewater treatment (WEF, 2011a).

Industry

- Although industry uses relatively little water on a global scale, it requires an accessible, reliable and environmentally sustainable supply. It is generally reported that ~20% of the world's freshwater withdrawals are used by industry, although this varies between regions and countries.
- The percentage of a country's industrial sector water demands is generally proportional to the average income level, representing only ~5% of water withdrawals in low-income countries, compared to over 40% in some high-income countries (Figure 3).

Human settlements

- Between 2009 and 2050, the world population is expected to increase by 2.3 billion, from 6.8 to 9.1 billion (UNDESA, 2009a). At the same time, urban populations are projected to increase by 2.9 billion, from 3.4 billion in 2009 to 6.3 billion total in 2050. Thus, the urban areas of the world are expected to absorb all of the population growth over the next four decades, while also drawing in some of the rural population. Furthermore, most of the population growth expected in urban areas will be concentrated in the cities and towns of less developed regions (UN-Habitat, 2006).
- Worldwide, 87% of the population gets its drinking water from improved sources, and the corresponding figure for developing regions is also high at 84%. Access is far greater, however, in urban areas (at 94%), while only 76% of rural populations have access to improved sources (WHO/UNICEF, 2010).
- Urban areas, although better served than rural areas, are struggling to keep up with population growth (WHO/UNICEF, 2010). Projected demographic growth in urban areas raises concern: if efforts continue at the current rate, improvements in sanitation facility coverage will only increase by 2% – from 80% in 2004 to 82% in 2015 (an additional 81 million people) (WHO/UNICEF, 2006).

Figure 3 Water withdrawal by sector by region (2005)

Source: FAO AQUASTAT (<http://www.fao.org/nr/water/aquastat/main/index.stm>, accessed in 2011).

- A comparison of the latest estimates from 2008 with those of 2000 indicates a deterioration in both water and sanitation coverage in urban areas. In both cases, this means an increase of 20% in the number of individuals living in cities who lack access to basic facilities (AquaFed, 2010).
- Urban settlements are the main source of point-source pollution. Urban wastewater is particularly threatening when combined with untreated industrial waste. In general, the ratio of untreated to treated wastewater reaching water bodies is significantly higher in developing regions of the world.
- Up to 90% of wastewater in developing countries flows untreated into rivers, lakes and highly productive coastal zones, threatening health, food security and access to safe drinking and bathing water (Corcoran et al., 2010).

Ecosystems

- All freshwater ultimately depends on the continued healthy functioning of ecosystems, and recognizing the water cycle as a biophysical process is essential to achieving sustainable water management.
- The water-related services provided by tropical forests include regulation of water flows, waste treatment/water purification and erosion prevention. These collectively account for a value of up to US\$7,236 per ha per year – more than 44% of the total value of forests, exceeding the combined value

of carbon storage, food, raw materials (timber), and recreation and tourism services (TEEB, 2009).

Chapter 3

The water resource: Variability, vulnerability and uncertainty

The vulnerability of natural long-term storage: Groundwater

- As of 2010 the world's aggregated groundwater abstraction is estimated at $\sim 1,000 \text{ km}^3$ per year, $\sim 67\%$ of which is used for irrigation, 22% for domestic purposes and 11% for industrial purposes (EUROSTAT, 2011; FAO 2011b, IGRAC, 2010; Margat, 2008; Siebert et al., 2010). The rate has at least tripled over the past 50 years and continues to increase by 1–2% per year. The estimates suggest that the abstraction of groundwater accounts for $\sim 26\%$ of total global water withdrawal and equals $\sim 8\%$ of mean global groundwater recharge (WWAP, 2009).
- Groundwater is crucial for the livelihoods and food security of 1.2–1.5 billion rural households in the poorer regions of Africa and Asia (Comprehensive Assessment of Water Management in Agriculture, 2007), but also for domestic supplies of a large part of the population elsewhere in the world.
- The global volume of stored groundwater is poorly known; estimates range from 15.3 to 60 million km^3 ,

including 8–10 million km³ of freshwater, while the remainder – brackish and saline groundwater – is predominant at great depth (Margat, 2008).

- Significant groundwater storage depletion is taking place in many areas of intensive groundwater withdrawal.

Water quality

- Over 80% of used water worldwide is not collected or treated (Corcoran et al., 2010).
- The provision of improved sanitation and safe drinking water could reduce diarrhoeal diseases by nearly 90% (WHO, 2008a).
- Human health risks are without doubt the major and most widespread concern linked to water quality. Each year ~3.5 million deaths related to inadequate water supply, sanitation and hygiene occur, predominantly in developing countries (WHO, 2008b).
- Diarrhoeal diseases, often related to contaminated drinking water, are estimated to cause the death of more than 1.5 million children under the age of five per year (Black et al., 2010).
- An important share of the total burden of disease worldwide, ~10%, could be prevented by improvements related to drinking water, sanitation, hygiene, and use of environmental management and health impact assessments.

Chapter 4

Beyond demand: Water's social and environmental benefits

Water and human health

- Every year there are 3–5 million cholera cases and 100,000–120,000 deaths due to cholera. WHO estimates that only 5–10% of cases are officially reported. The overall increase in the number of cholera cases for the decade 2000–2010 was 130% (WHO, 2010).

Cholera is endemic in regions with poor socio-economic conditions, rudimentary sanitary systems, absence of wastewater treatment, and where public hygiene and safe drinking water is lacking (Huq et al., 1996). The risk of cholera outbreaks intensifies during humanitarian crises, such as conflicts and floods, and displacement of large populations.

Ecosystem health

- Rich nations are tending to maintain or increase their consumption of natural resources (WWF, 2010), but are exporting their footprints to producer, and

typically, poorer, nations. For example, 62% of the UK's water footprint is virtual water embedded in agricultural commodities and products imported from other countries – 38% originates from domestic water resources (Chapagain and Orr, 2008).

- There is ample evidence that humans are over-consuming natural resources overall at an unsustainable rate. Various estimates indicate that, based on business as usual, ~3.5 planet Earths would be needed to sustain a global population achieving the current lifestyle of the average European or North American.

Water-related hazard risk

- Water-related hazards account for 90% of all natural hazards, and their frequency and intensity is generally rising. Some 373 natural disasters killed more than 296,800 people in 2010, affected nearly 208 million others and cost nearly US\$110 billion (UN, 2011).
- According to the UN *Global Assessment Report*, since 1900 more than 11 million people have died as a consequence of drought and more than 2 billion have been affected by drought, more than any other physical hazard (UNISDR, 2011).
- Between 1970 and 2010 the world's population increased by 87% (from 3.7 billion to 6.9 billion) (UNISDR, 2011). During the same period, the annual average population exposed to flood increased by 112% (from 33.3 to 70.4 million per year) (UNISDR, 2011).
- By 2050, rising populations in flood-prone lands, climate change, deforestation, loss of wetlands and rising sea levels are expected to increase the number of people vulnerable to flood disaster to 2 billion (UNU, 2004).
- With regard to extreme events, a recent study of 141 countries found that more women than men die from natural hazards, and that this disparity is linked most strongly to women's unequal socio-economic status (Neumayer and Plümper, 2007).

Impact of desertification on water resources

- Poor and unsustainable land utilization and management practices are leading to desertification and land degradation around the world, increasing pressure on water resources and leading to water scarcity. Estimates indicate that nearly 2 billion ha of land worldwide – an area twice the size of China – are already seriously degraded, some irreversibly (FAO, 2008a).
- Land degradation is increasing, with almost one-quarter of the global land area being degraded

between 1981 and 2003. The emphasis on land degradation has focused on dryland areas, but humid areas are also experiencing a surprisingly high level of degradation (Bai et al., 2008).

- Globally, desertification, land degradation and drought (DLDD) affects 1.5 billion people who depend on degrading areas, and it is closely associated with poor, marginalized and politically weak citizens, with 42% of the very poor living in degraded areas, compared with 32% of the moderately poor and 15% of the non-poor (Nachtergaele et al., 2010).
- India alone accounts for 26% of the population affected by DLDD, China 17%, sub-Saharan Africa 24%, the remaining part of Asia-Pacific 18.3%, Latin America and the Caribbean 6.2%, and North East and North Africa 4.6% (ICRISAT, 2008). While DLDD affects all regions of the world, it has its greatest impact in Africa where two-thirds of the continent is desert or drylands.
- Estimates are that 24 billion tonnes of fertile soils are disappearing annually, and the surface area lost over the past 20 years is equal to all of the farmland of the USA. In the face of DLDD, it is estimated that a substantial proportion of the earth's natural forests have already been destroyed, and more than 60% of ecosystem services are already degraded. Up to 90% of West Africa's coastal rain forests have disappeared since 1900 (MA, 2005). This negative trend is set to continue at an accelerating pace over the next half century.
- Statistical analysis of rainfall patterns in some of the dryland regions reveals a stepped drop in the early 1970s, which has persisted – a reduction of ~20% in precipitation levels resulting in a 40% reduction in surface runoff (EU, 2007).

In or out of balance?

- Although predicting future water demands for agriculture – the greatest user of water by far – is fraught with uncertainty, global agricultural water consumption is estimated to increase by ~20% by 2050. This increase could be even higher if substantial improvement in productivity of rainfed and irrigated agriculture are not set in place to meet the increasing demand for food from population growth and changing diets.
- The growing demand for energy will also create increasing pressure on water resources, especially in sub-Saharan Africa and in the least developed countries of South Asia, which account for 80% of the 1.5 billion people lacking access to electricity globally.

Chapter 5

Water management, institutions and capacity development

- There are 884 million people still using unimproved sources for drinking water and 2.6 billion people do not use improved sanitation (WHO/UNICEF, 2010). Measured against the more precise and rigorous standards now defined under the right to water, some estimates are that the number of people without access to safe and reliable tap water in their homes is 3–4 billion.
- The water supply and sanitation (WSS) sector has a low priority in many developing countries, where investments in health and education are often prioritized. Furthermore, 'since 1997 the proportion of development aid allocated to sanitation and drinking water fell from 8% to 5%, while development aid allocated to health increased from 7% to 11.5% and that for education remained steady at around 7%' (WHO/UN-Water, 2010, p. 15).

Chapter 6

From raw data to informed decisions

- In addition to the political and institutional barriers to the generation and reporting of water resource availability and use information, there are also substantial technical and financial constraints. The cost of a single river gauging station for a medium-size river can easily exceed US\$1 million, and the costs of ongoing operation, maintenance and reporting can be difficult to justify in poor countries where such activities compete with basic water supply for limited funds, yet bring no immediate benefits.

Chapter 7

Regional challenges, global impacts

Africa

- Sub-Saharan Africa uses barely 5% of its annual renewable fresh water. Yet access to improved water supplies, in both urban and rural contexts, is still the lowest in the world (NEPAD, 2006).

- Africa's rising population is driving demand for water and accelerating the degradation of water resources in many countries. By mid-2011, Africa's population (excluding the northern-most states) was ~838 million and its average natural rate of increase was 2.6% per year, compared to the world average of 1.2%. By one estimate its population will grow to 1,245 million by 2025 and to 2,069 million by 2050 (PRB, 2011).
- Sub-Saharan Africa is the world's poorest and least-developed region, with half its population living on less than a dollar a day. About two-thirds of its countries rank among the lowest in the HDI (FAO, 2008b).
- The urban slum population in sub-Saharan African countries is expected to double to ~400 million by 2020 if governments do not take immediate and radical action (UN-Habitat, 2005).
- Population growth is stabilizing: there has been a progressive reduction in the growth rate from ~2.8% in 1990–1995 to a projected 2.3% in 2010–2015 (FAO, 2005). This trend, coupled with increasing economic growth, is likely to contribute to increased socio-economic development, including better water management.
- The economies of most African countries depend largely on rainfed agriculture as the major driver of economic growth. It represents ~20% of the region's GDP, 60% of its workforce, 20% of its export goods and 90% of rural incomes. Agriculture is by far the largest user of water, accounting for ~87% of total water withdrawals (FAO, 2008b). Investing in agriculture, and especially in irrigated farming, is at least four times as effective at raising poor people's incomes as is investment in other sectors (UNEP, 2010b).
- Sub-Saharan Africa has a relatively plentiful supply of rainwater, with an estimated total average annual precipitation of 815 mm (FAO, 2008b), but it is highly seasonal, unevenly distributed across the region, and there are frequent floods and droughts. The greatest amount of rainfall occurs along the equator, especially in the area from the Niger Delta to the Congo River basin. The Sahara Desert has virtually no rainfall. In western and central Africa, rainfall is exceptionally variable and unpredictable.
- At the continental level, renewable water resources constitute only ~20% of the total rainfall and represent less than 9% of global renewable resources (FAO, 2005). Internal renewable water resources per person in sub-Saharan Africa fell from an average of more than 16,500 m³ per inhabitant in 1960 to ~5,500 m³ per inhabitant in 2005. This was largely as a result of population growth (FAO, 2008b). Groundwater represents 15% of total renewable resources, but an estimated 75% or more of the African population uses groundwater as their main source of drinking water (UNEP, 2010b).
- Significant variations both between and within subregions account for the low average per capita water withdrawals of 247 m³ per year. Africa's annual total water withdrawal is 215 km³, or barely 5.5% of the renewable water resources on the continent, and less than 6% of water withdrawals worldwide (FAO, 2005).
- About 66% of Africa is arid or semi-arid and more than 300 of the 800 million people in sub-Saharan Africa live in a water-scarce environment – meaning that they have less than 1,000 m³ per capita (NEPAD, 2006).
- The coverage of drinking water supply in sub-Saharan Africa² is barely 60%; the world average is ~87%. Of the 884 million people in the world still using unimproved drinking water sources, 37% live in this region. Provision of improved water sources in urban areas remained at 83% between 1990 and 2008. In rural areas, it was only 47% in 2008, although this represented an 11% increase on 1990 figures, or 110 million more people gaining access to improved water supplies (WHO/UNICEF, 2010).
- In sub-Saharan Africa, only 31% of the population uses improved sanitation facilities, with large differences between urban coverage, which was ~44% in 2008, and rural provision, which was 24%. Although the proportion of the population practising open defecation in the region is declining, in absolute numbers, it increased from 188 million in 1990 to 224 million in 2008 (AMCOW, 2010).
- Between the mid-1990s and 2008, undernourishment in sub-Saharan Africa increased from 200 million people to ~350–400 million people (FAO, 2008b). Climate change and climate variability are likely to severely compromise agricultural production and food security in many African countries (Boko et al., 2007).
- Since the mid-1960s, agricultural production has increased by an average of less than 2% annually, while the population has grown by ~3% (UNECA, 2006). Some 97% of the region's croplands depend on rainfed agriculture, which produces most of Africa's food (FAO, 2008b). Africa needs to increase its agricultural output at a rate of 3.3% a year if it is to achieve food security by 2025. Water is a key component of its ability to feed its population because irrigated cropland accounts for only 20% of its irrigation

2 WHO's definition of northern Africa and sub-Saharan Africa excludes Algeria, Egypt, Libya, Morocco and Tunisia.

potential. In fact, in all but four countries in the region, less than 5% of the cultivated area is irrigated – so there is considerable scope for expanding irrigation to increase food security (UNEP, 2010b).

- Scenarios suggest that increasing the area under irrigation by a factor of three would represent only a 5% contribution to the increase in food production needed by 2025 (UN-Water/Africa and AMCOW, 2004).
- Only one person in four in Africa has electricity.
- Hydropower supplies 32% of Africa's energy, but it is underdeveloped. Only 3% of its renewable water resources are exploited for hydroelectricity (UNEP, 2010b).
- The Africa Infrastructure Country Diagnostic (AICD) (Foster and Briceño-Garmendia, 2010) estimates that US\$22 billion is needed annually by the WSS sector to close the infrastructure gap, meet the MDGs and achieve national targets in Africa within ten years.
- The AICD also assessed the potential investment needed for small-scale irrigation systems in Africa to be -US\$18 billion and \$2.7 billion for large-scale systems over a 50 year investment horizon.
- Africa has about one-third of the world's major international water basins – basins larger than 100,000 km². Virtually all sub-Saharan African countries, and Egypt, share at least one international water basin. Depending on how they are counted, there are between 63 (UNEP, 2010b) and 80 (UNECA, 2000) transboundary river and lake basins on the African continent.
- Over 90 international water agreements were drawn up to help manage shared water basins on the African continent (UNEP, 2010b).

Europe and North America

- North Americans, the highest per capita water users in the world, consume 2.5 times what Europeans use. One reason for this is that water is relatively inexpensive compared to other industrialized countries (CEC, 2008).
- European and North American populations consume a considerable amount of virtual water embedded in imported food and products. Each person in North America and Europe (excluding former Soviet Union countries) consumes at least 3 m³ per day of virtual water in imported food, compared to 1.4 m³ per day in Asia and 1.1 m³ per day in Africa (Zimmer and Renault, n.d.).
- The per capita water used for food production in Western Europe and North America has decreased substantially in past decades (Renault, 2002).

- Between 1976 and 2006 in the EU, both the area affected by drought and the number of people whose lives were influenced by it doubled. These impacts include declines in cereal and hydropower production and they can have economic repercussions.
- Floods have affected more than 3 million people in the UNECE region since the beginning of the century, and the associated costs have increased rapidly.
- The IPCC predicts with high confidence that water stress will increase in central and southern Europe, and that by the 2070s, the number of people affected will rise from 28 million to 44 million. Summer flows are likely to drop by up to 80% in southern Europe and some parts of central and eastern Europe. Europe's hydropower potential is expected to drop by an average of 6%, but rise by 20–50% around the Mediterranean by 2070 (Alcamo et al., 2007).
- Some 120 million people in Europe do not have access to safe drinking water. Even more lack access to sanitation, resulting in the spread of water-related diseases.

Asia-Pacific

- The Asia-Pacific is home to 60% of the world's population but it has only 36% of its water resources (APWF, 2009). Nevertheless, this represents the world's largest share of renewable freshwater resources, with an annual average of 21,135 billion m³. Given its large population and economic growth, its water withdrawal rate is also high, averaging -11% of its total renewable water resources, which is on par with European rates, and ranks it second in the world after the water-scarce Middle East (ESCAP, 2010). Per capita availability here is the lowest in the world (ESCAP, ADB and UNDP 2010).
- Progress has generally been slow in providing improved sanitation, except in North-East and South-East Asia. About 480 million people still lacked access to improved water resources in 2008, while 1.9 billion still lacked access to improved sanitation.
- Water availability, allocation and quality remain major issues. Irrigated agriculture is the biggest water user. Agriculture consumes an average of -80% of the region's renewable water resources (APWF, 2009).
- Food security is an important issue as about two-thirds of the world's hungry people live in Asia (APWF, 2009): 65% of the world's undernourished people are concentrated in seven countries, five of which are in the region: India, Pakistan, China, Bangladesh and Indonesia (APWF, 2009).
- Internal migration and urbanization are driving the rise in the number of megacities (ESCAP, 2011). The region has some of the world's fastest-growing cities

and between 2010 and 2025 a predicted 700 million people were added to the growing numbers requiring municipal water services (ESCAP, 2010).

- In 2010, approximately one-fifth of Pakistan was inundated, affecting more than 20 million people in the flooded areas along the length of the Indus River. Flooding also destroyed more than 1.6 million acres of crops (Guha-Sapir et al., 2011).
- Domestic sewage is a particular concern because it affects ecosystems near densely populated areas. Approximately 150–250 million m³ per day of untreated wastewater from urban areas is discharged into open water bodies or leached into the subsoil. This has consequences ranging from poor human health and increased infant mortality to widespread environmental degradation.
- The proportion of the region's population that has access to an improved drinking water source increased from 73 to 88% between 1990 and 2008 – an increase of 1.2 billion people (ESCAP, 2010a). China and India together account for a 47% share of the 1.8 billion people globally who gained access to improved drinking water sources over this period. Since 1990, 510 million people in East Asia, 137 million in South Asia and 115 million in South-East Asia gained access to piped water connections on their premises (WHO/UNICEF, 2010).
- Of the 2.6 billion people who do not use improved sanitation facilities, 72% live in Asia (WHO/UNICEF, 2010). Rapid progress in improved sanitation occurred in North-East Asia, with a 12% increase in access between 1990 and 2008, and in South-East Asia, with a 22% increase. In contrast, the situation in South Asia and South-West Asia is a concern. Although the number of people with access to sanitation doubled since 1990, the 2008 average coverage was still only 38%, with the number without access actually higher than in 2005. Some 64% of the world's population that defecate in the open live in South Asia. This is despite the fact that the practice decreased most in this area, down from 66% in 1990 to 44% in 2008 (WHO/UNICEF, 2010). In India alone, 638 million people still defecate in the open.

Latin America and the Caribbean (LAC)

- More than 8% of the world's population lives in LAC – some 581 million people – with half of them living in Brazil and Mexico (UNEP, 2007).
- Although average poverty rates have fallen steadily over the past 20 years, an estimated 30% of the population, or some 177 million people, still live in poverty, and 12% are considered extremely poor (ECLAC, 2011).

- Population growth, expanded industrial activity, especially mining in Andean countries, and high irrigation demand have led to a ten-fold increase in total water extraction in the LAC region during the twentieth century. Between 1990 and 2004, extraction grew by 76% (UNEP, 2010a). By the mid-2000s it amounted to some 263 km³ per year, with Mexico and Brazil together accounting for just over half that amount (UNEP, 2007).
- Water use for energy can be expected to rise throughout the region in line with economic growth. Hydropower produces 53% of the region's electricity; installed capacity grew by 7% between 2005 and 2008. Hydropower is expected to provide a significant proportion of the new energy demand (UNEP, 2010a).
- The region's glaciers are receding because of climate change. Glacier retreat affects the water supply of an estimated 30 million people in the region (UNEP, 2010a).
- Droughts already occur regularly, and between 2000 and 2005 they caused serious economic losses and affected 1.23 million people (UNEP, 2010a).

Arab and Western Asia region

- At least 12 countries in the Arab and Western Asia region suffer absolute water scarcity, meaning they have less than 500 m³ of renewable water resources available per capita per year.
- Nearly all Arab countries suffer from water scarcity, with water consumption significantly exceeding total renewable water supplies.
- An estimated 66% of the Arab region's available surface freshwater originates outside the region.
- Cyclical conflict has characterized the Arab region for decades, generating large numbers of internally displaced persons – the ESCWA region contains 36% of the world's displaced persons (ESCWA, 2009). Conflict has also caused increased regional migration and has strained water resources and services in areas receiving the displaced populations.
- Agriculture is a primary source of water stress in the Arab region. It accounts for more than 70% of the total water demand in most ESCWA countries. In Iraq, Oman, the Syrian Arab Republic and Yemen, agriculture accounts for more than 90% of water use. Nevertheless, the region is unable to produce sufficient food to feed its population, with ESCWA members importing 40–50% of their total cereal consumption. The situation seems likely to worsen – climate change is predicted to cause a decline of as much as 25% in agricultural productivity in most countries in the region by 2080 (Cline, 2007).

Regional-global links: Impacts and challenges

- Saudi Arabia, one of the Middle East's largest cereal growers, announced it would cut cereal production by 12% a year to reduce the unsustainable use of groundwater. To protect its water and food security, the Saudi government issued incentives to Saudi corporations to lease large tracts of land in Africa for agricultural production. By investing in Africa to produce its staple crops, Saudi Arabia is saving the equivalent of hundreds of millions of gallons of water per year and reducing the rate of depletion of its fossil aquifers.
- India is growing maize, sugarcane, lentils and rice in Ethiopia, Kenya, Madagascar, Senegal and Mozambique to feed its domestic market, while European firms are seeking 3.9 million ha of African land to meet their 10% biofuel target by 2015 (Cotula et al., 2009).
- The Chinese government anticipates that by 2020, 15% of China's transport energy needs will be met by biofuels (Kraus, 2009).
- The amount of water required for biofuel plantations could be particularly devastating to regions such as West Africa, where water is already scarce (UNCTAD XII, 2008), given that 1 L of ethanol from sugarcane requires 18.4 L of water and 1.52 m² of land (Periera and Ortega, 2010).



Chapter 8

Working under uncertainty and managing risk

- Most modern flood management plans include the use of floodplains and wetlands. Key services of these lands include their ability to rapidly absorb and slowly release (regulate) water, and to increase ecosystems resilience by regulating sediment transfer. These services alone account for some of the highest land/nature values thus far calculated; for example, US\$33,000 per ha of wetlands for hurricane risk reduction in the USA (Costanza et al., 2008).
- Potential damage from storms, coastal and inland flooding, and landslides can be considerably reduced by a combination of careful land-use planning and maintaining or restoring ecosystems to enhance buffering capacity. Tallis et al. (2008) showed that planting and protecting nearly 12,000 ha of mangroves in Viet Nam cost US\$1.1 million but saved annual expenditures on dyke maintenance of US\$7.3 million.



Chapter 9

Understanding uncertainty and risks associated with key drivers

- Water productivity for food production increased by nearly 100% between 1961 and 2001.
- The global population is likely to reach 9.1 billion in 2050, if not sooner. According to UNDESA (2009b), 68% of these 9 billion people will reside in urban settings.
- Water availability is expected to decrease in many regions. Yet future global agricultural water consumption alone (including both rainfed and irrigated agriculture) is estimated to increase by ~19% by 2050, and will be even greater in the absence of any technological progress or policy intervention. Current trends show that water withdrawals are expected to increase by at least 25% in developing countries (UNEP, 2007).
- While agriculture continues to use at least 70% of water resources globally, other economic sectors will continue to compete for water resources, and some intensely, without an explicit mechanism for allocation decision-making.
- Water used for cooling power plants in the USA represents 40% of the country's industrial water use. This figure is expected to reach 30% in China in 2030 (UNEP, 2011 and sources therein). Increased energy production using current technology, at current levels of efficiency, is therefore likely to exert multiplied pressures on scarce water resources.
- The development of sustainable urban agriculture could provide resilient avenues for ensuring local food supply.



Chapter 10

Unvalued water leads to an uncertain future

- World Bank research estimates that Indonesia lost US\$6.3 billion (2.3% of GDP) in 2006 from poor sanitation and hygiene. The result was increased health costs, economic losses and offsetting costs in other sectors (World Bank, 2008c). Corresponding losses in the Philippines as part of the same overall study amounted to US\$41.4 billion or 1.5% of GDP (World Bank, 2008b).
- Investment in safe wastewater collection and treatment, including industrial effluents, can remove a potential brake on economic activity. It has been

estimated that water pollution in South Africa costs the country 1% of its annual national income (Pegram and Schreiner, 2010). The principal benefits of wastewater treatment are avoidance of the costs of pollution and the use of contaminated water by downstream users, such as other municipalities, industries, farmers and the tourist industry. In serious cases, the pollution of water bodies has caused industries to be closed down and relocated at great cost.

Chapter 11

Transforming water management institutions to deal with change

- The inability to meet water supply demands and protect people and property against floods and droughts is a significant threat to all countries, but is felt most notably by developing states unable to build the infrastructure needed to reduce the adverse impacts of such events. The reality is that water management systems are not designed to satisfy all demands, given the full range of possible expected extreme events under what is understood to be contemporary hydrological variability. They are designed to minimize the combination of risks and costs of a wide range of hazards to society.

Chapter 12

Investment and financing in water for a more sustainable future

- Improving access to safe water and basic sanitation could have huge economic returns. World Bank studies in five South-East Asian countries estimate that ~2% of their combined GDP is lost because of poor sanitation, and in the worst case (Cambodia) this figure rises to over 7% (World Bank, 2008a). Economic benefits due to improvements in health include lower health system costs, fewer days lost at work or at school through illness or caring for an ill relative, and convenience time savings (Hutton et al., 2007). The prevention of sanitation- and water-related diseases could save ~US\$7 billion per year in health system costs, and the value of deaths averted, based on discounted future earnings, would add a further US\$3.6 billion per year (Hutton et al., 2007).
- The WHO estimates that the overall economic benefits of halving the proportion of people without sustainable access to improved drinking water and

sanitation, by 2015, would outweigh the investment cost by a ratio of 8:1 (Prüss-Üstün and Corvalán, 2006).

- Total aid for all aspects of water fell from 8% to 5% between 1997 and 2008 (WHO/UN-Water, 2010). Domestic and foreign aid are not necessarily well targeted to where need is greatest. Less than half of the funding from external support agencies for water and sanitation goes to low income countries, and a small proportion of these funds is allocated to the provision of basic services, where it would have the greatest impact on achieving the MDG target (WHO/UN-Water, 2010).

- More than 70% of the 1.1 billion poor people surviving on less than US\$1 per day live in rural areas, where they are directly dependent on ecosystem services (Sachs and Reid, 2006).

- Improved weather and flood forecasting is crucial to flood risk management and especially in reducing the impact of floods. In Kenya, losses from flooding from El Niño in 1997–1998 and drought from La Niña in 1998–2000 ranged from 10 to 16% of GDP during those years. Investment in weather forecasting and hydrometeorological services can be highly cost-beneficial.

- Estimates of measures to cope with climate scenarios imply an annual increase in adaptation costs of US\$13–17 billion for developing countries as a whole. This represents 3% of their GDP.

- Projections are that the annual cost of climate change adaptation in developing countries in the industrial and municipal raw water supply sector would be between US\$9.9–10.9 billion (net) and US\$18.5–19.3 billion (gross). Costs for riverine flood protection are projected between US\$3.5–5.9 billion (net) and US\$5.2–7.0 billion (gross).³

- The Private Participation in Infrastructure (PPI) database, maintained by the World Bank and the Public-Private Infrastructure Advisory Facility, reported that in 2009 the number of water projects reaching financial or contractual closure had declined by 46% compared with 2008, and that annual investment commitments had fallen by 31% over the same period.

- In Africa, under-collection of water bills is valued at US\$0.5 billion annually. Improving the collection rate is an obvious way of increasing water revenues without raising tariffs. Although the better performing water utilities in Africa normally manage collection rates of 80% or more (Mehta et al., 2009), persistent non-payment, especially by public departments and agencies,

³ Gross costs include all costs incurred by adaptation to climate change. Net costs allow for (i.e. deduct from gross) any negative costs (i.e. cost savings) that may arise from climate change. The method used in this study nets out positive and negative cost items for each country, but not across countries within a region (World Bank, 2010c).

leaves a big hole in the accounts of water authorities normally be expected to be self-sufficient.

- Although the share of water in total official development assistance (ODA) has declined since the mid-1990s, the absolute volume of ODA has started to increase. In 2007–2008, the bilateral annual aid commitments of DAC countries to water and sanitation rose to US\$5.3 billion. Including concessional outflows of multilateral agencies, the total ODA for water and sanitation for that period was US\$7.2 billion (OECD-DAC, 2010) compared with US\$5.6 billion in 2006.

Chapter 13

Responses to risk and uncertainty from a water management perspective

- The International Water Management Institute (IWMI) predicts that climate change will have dire consequences for feeding an ever-expanding global population, especially in areas of Africa and Asia where millions of farmers rely solely on rainwater for their crops. In Asia, 66% of cropland is rainfed, while 94% of farmland in sub-Saharan Africa relies on rain alone, according to IWMI. These are the regions where water storage infrastructure is least developed and where nearly 500 million people are at risk of food shortages.

Chapter 14

Responses to risks and uncertainties from out of the water box

- A WHO study revealed that the return on investment from each dollar spent on water and sanitation in developing countries would be US\$5–28 (Hutton and Haller, 2004).
- The International Energy Organization (IEA) predicts that ‘at least 5% of global road transport will be powered by biofuel [by 2030] – over 3.2 million barrels per day. However, producing those fuels could consume between 20–100% of the total quantity of water now used worldwide for agriculture’ (WEF, 2011b, p. 31) if production processes and technology remain unchanged.

References

- Alcamo, J. et al. 2007. Europe. M. L. Parry et al. (eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. New York, Cambridge University Press, pp. 541–80.
- AMCOW (African Ministers' Council on Water). 2010. *A Snapshot of Drinking Water and Sanitation in Africa – 2010 Update: A Regional Perspective Based on New Data from the WHO/UNICEF Joint Monitoring Programme for Water and Sanitation*. Prepared for AMCOW as a contribution to the Third Africa Water Week, Addis Ababa, Ethiopia, 22–26 November 2010. http://www.childinfo.org/files/Africa_AMCOW_Snapshot_2010_English_final.pdf
- APWF (Asia Pacific Water Forum). 2009. *Regional Document: Asia Pacific*. 5th World Water Forum.
- AquaFed. 2010. *Access to Drinking Water is Deteriorating in the Urban Half of the World*. Press release issued 6 September 2010. Stockholm, AquaFed. http://www.aquafed.org/pdf/AquaFed_UrbanTrends_PressRelease_Stockholm_EN_Pd_2010-09-07.pdf
- Bai, Z. G., Dent, D. L., Olsson, L. and Schaepman, M. E. 2008. Proxy global assessment of land degradation. *Soil Use and Management*, Vol. 24, No. 3, pp. 223–34.
- Black, R. E., Cousens, S., Johnson, H. L., Lawn, J. E., Rudan, I., Bassani, D. G., Jha, P., Campbell, H., Walker, C. F., Cibulskis, R., Eisele, T., Liu, L. and Mathers, C. 2010. Presentation for the Child Health Epidemiology Reference Group of WHO and UNICEF. Global, regional, and national causes of child mortality in 2008: A systematic analysis. *The Lancet*, Vol. 375, No. 9730, pp. 1969–1987. http://www.who.int/child_adolescent_health/data/cherp/en/index.html (Accessed 3 October 2011.)
- Boko, M. et al. Africa. 2007. M. L. Parry et al. (eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge UK, Cambridge University Press, pp. 433–67.
- Bruinsma, J. 2009. *The Resource Outlook to 2050: By How Much do Land, Water and Crop Yields Need to Increase by 2050?* Prepared for the FAO Expert Meeting on ‘How to Feed the World in 2050’, 24–26 June 2009, Rome.
- Carter, N. T. and Campbell, R. J. 2009. *Water Issues of Concentrating Solar Power (CSP) Electricity in the U.S. Southwest*. Washington DC, Congressional Research Service (CRS). <http://www.circleofblue.org/waternews/wp-content/uploads/2010/08/Solar-Water-Use-Issues-in-Southwest.pdf>
- CEC (Commission for Environmental Cooperation). 2008. *The North American Mosaic: An Overview of Key Environmental Issues. Water Quantity and Use*. Montreal, Quebec, CEC Secretariat. http://www.cec.org/Storage/32/2366_SOE_WaterQuantity_en.pdf
- Chapagain, A. K. and Orr, S. 2008. *UK Water Footprint: The Impact of the UK's Food and Fibre Consumption on Global Water Resources*. Volume 1. Godalming, UK, World Wide Fund for Nature (WWF).
- Cline, W. 2007. *Global Warming and Agriculture: Impact Estimates by Country*. Washington DC, Center for Global Development and Peterson Institute for International Economics.
- Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in*

- Agriculture*. London/Colombo, Earthscan/International Water Management Institute.
- Corcoran, E., Nellemann, C., Baker, E., Bos, R., Osborn, D. and Savelli, H. (eds). 2010. *Sick Water? The Central Role of Wastewater Management in Sustainable Development. A Rapid Response Assessment*. The Hague, UN-Habitat/UNEP/GRID-Arendal.
- Costanza, R., Pérez-Maqueo, O. M., Martínez, M. L., Sutton, P., Anderson, S. J. and Mulder, K. 2008. The value of wetlands for hurricane protection, *Ambio*, Vol. 37, No. 4, pp. 241–8.
- Cotula, L., Vermeulen, S., Leonard, R. and Keeley, J. 2009. *Land Grab or Development Opportunity? Agricultural Investment and International Land Deals in Africa*. London/Rome, IIED/FAO/IFAD.
- De Stefano, L., Duncan, J., Dinar, S., Stahl, K. and Wolf, A. 2010. *Mapping the Resilience of International River Basins to Future Climate Change-induced Water Variability*. World Bank Water Sector Board Discussion Paper Series 15. Washington DC, The World Bank.
- ECLAC (United Nations Economic Commission for Latin America and the Caribbean). 2011. *Social Panorama*. Santiago, ECLAC.
- EIA (US Energy Information Administration). 2010. *International Energy Outlook 2010: Highlights*. Washington DC, Office of Integrated Analysis and Forecasting, EIA, US Department of Energy. <http://www.eia.gov/oiarf/archive/ieo10/highlights.html> (Accessed 3 November 2011.)
- ESCAP (United Nations Economic and Social Commission for Asia and the Pacific). 2010. *Statistical Yearbook for Asia and the Pacific, 2009*. Bangkok, ESCAP.
- 2011. *Population Dynamics: Social Development in Asia-Pacific*. Bangkok, ESCAP. <http://actionbias.com/issue/population-dynamics>
- ESCAP, ADB (Asian Development Bank) and UNDP (United Nations Development Programme). 2010. *Achieving the Millennium Development Goals in an Era of Global Uncertainty*. Asia-Pacific Regional Report. Bangkok, ESCAP, ADB and UNDP. http://content.undp.org/go/cms-service/stream/asset/?asset_id=2269033
- ESCWA (United Nations Economic and Social Commission for Western Asia). 2009. *Trends and Impacts in Conflict Settings: The Socio-Economic Impact of Conflict-Driven Displacement in the ESCWA Region*. Issue 1. E/ESCWA/ECRI/2009/2. New York, ESCWA. <http://www.escwa.un.org/information/publications/edit/upload/ecri-09-2.pdf>
- EU (Council of the European Union). 2007. Energy efficiency and renewable energies. *Presidency Conclusions of the Brussels European Council (8/9 March 2007)*. Brussels, EU, pp. 20–22.
- EUROSTAT. 2011. Online database. Brussels, European Commission (EC). <http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/>
- FAO (Food and Agriculture Organization of the United Nations). 2005. *Irrigation in Africa in Figures: AQUASTAT Survey – 2005*. FAO Water Report No. 29. Rome, FAO. ftp://ftp.fao.org/agl/aglw/docs/wr29_eng.pdf
- 2006. *World Agriculture: Towards 2030/2050 – Interim Report – Prospects for Food, Nutrition, Agriculture and Majority Commodity Groups*. Rome, FAO.
- 2008a. *Sustainable Land Management*. Rome, FAO. http://www.un.org/esa/sustdev/csd/csd16/documents/fao_factsheet/land.pdf
- 2008b. Mapping poverty, water and agriculture in sub-Saharan Africa. J.-M. Faurès and G. Santini (eds), *Water and the Rural Poor: Interventions for Improving Livelihoods in sub-Saharan Africa*. Rome, FAO. <ftp://ftp.fao.org/docrep/fao/010/i0132e/i0132e03a.pdf>
- 2011a. *The State of the World's Land and Water Resources: Managing Systems at Risk*. London, Earthscan.
- 2011b. AQUASTAT online database. Rome, FAO. <http://www.fao.org/nr/water/aquastat/data/query/index.html>
- Foster, V. and C. Briceño-Garmendia (eds). 2010. *Africa's Infrastructure: A Time for Transformation*. Africa Infrastructure Country Diagnostic (AICD). Washington DC, The World Bank. http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf
- Guha-Sapir, D. et al. 2011. *Annual Disaster Statistical Review 2010: The Numbers and Trends*. Brussels, CRED. <http://www.undp.org/crmi/docs/cred-annualdisstats2010-rt-2011-en.pdf>
- Hoekstra, A. Y. and Chapagain, A. L. 2008. *Globalization of Water: Sharing the Planet's Freshwater Resources*. Oxford, UK, Blackwell Publishing.
- Hoffman, A. R. 2011. *The Connection: Water Supply and Energy Reserves*. Washington DC, US Department of Energy. <http://waterindustry.org/Water-Facts/world-water-6.htm> (Accessed 10 May 2011.)
- Huq, A., Xu, B., Chowdhury, A. R., Islam, M. S., Montilla, R. and Colwell, R. R. 1996. A simple filtration method to remove plankton-associated *Vibrio Cholerae* in raw water supplies in developing countries. *Applied And Environmental Microbiology*, Vol. 62, No. 7, pp. 2508–12.
- Hutton, G. and Haller, L. 2004. *Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level*. Geneva, World Health Organization (WHO). http://www.who.int/water_sanitation_health/wsh0404.pdf
- Hutton, G., Haller, L. and Bartram, J. 2007. *Economic and Health Effects of Increasing Coverage of Low-cost Household Drinking-Water Supply and Sanitation Interventions to Countries Off-Track to Meet MDG Target 10*. Geneva, World Health Organization (WHO).
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 2008. *Climate Change and Desertification Put One Billion Poor People at Risk*. Hyderabad, India, ICRISAT. <http://www.icrisat.org/Media/2007/media14.htm>
- IEA (International Energy Agency). 2006. *World Energy Outlook 2006*. Paris, IEA.
- 2007. *World Energy Outlook 2007*. Paris, IEA.
- 2009. *World Energy Outlook 2009*. Paris, IEA.
- 2010a. *Renewable Energy Essentials: Hydropower*. Paris, IEA. http://www.iea.org/papers/2010/Hydropower_Essentials.pdf
- 2010b. *World Energy Outlook 2010*. Paris, IEA.
- IGRAC (International Groundwater Resources Assessment Centre). 2010. *Global Groundwater Information System (GGIS)*. Delft, The Netherlands, IGRAC.
- ISARM (International Shared Aquifer Resources Management). 2009. *Transboundary Aquifers of the World (2009 update)*. Presented during a special meeting at World Water Forum 5. Utrecht, The Netherlands, ISARM. <http://www.isarm.net/publications/319#>
- Kraus, M. 2009. *Fuelling New Problems: The Impact of China's Biodiesel Policies*. Asia Paper. Brussels, Brussels Institute of Contemporary China Studies (BICCS).
- MA (Millennium Ecosystem Assessment). 2005. *Living Beyond Our Means. Natural Assets and Human Well-Being: Synthesis from the Board*. Washington DC, World Resources Institute (WRI). <http://www.millenniumassessment.org/documents/document.429.aspx.pdf>
- Margat, J. 2008. *Les eaux souterraines dans le monde*. Paris, BGRM/Editions UNESCO.
- Mehta, M., Cardone, R. and Fugelsnes, T. 2009. *How Can Reforming African Water Utilities Tap Local Financial Markets? Insights and recommendations from a practitioners' workshop in Pretoria, South Africa, July 2007 (Revised in 2009)*. Washington DC/Tunis, Tunisia, Water and Sanitation

- Programme (WSP)/Public-Private Infrastructure Advisory Facility (PPIAF)/African Development Bank (AfDB).
- Nachtergaele, F., Petri, M., Biancalani, R., Van Lynden, G. and Van Velthuizen, H. 2010. *Global Land Degradation Information System (GLADIS): Beta Version. An Information Database for Land Degradation Assessment at Global Level*. Land Degradation Assessment in Drylands Technical Report No. 17. Rome, Food and Agriculture Organization of the United Nations (FAO).
- NEPAD (New Partnership for Africa's Development). 2006. *Water in Africa: Management Options to Enhance Survival and Growth*. Addis Ababa, United Nations Economic Commission for Africa (UNECA). <http://www.uneca.org/awich/nepadwater.pdf>
- Neumayer, E. and Plümpner, T. 2007. The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life expectancy, 1981-2002. *Annals of the Association of American Geographers*, Vol. 97, No. 3, pp. 551-66.
- OECD-DAC (Organisation for Economic Co-operation and Development-Development Assistance Committee). 2010. *Focus on Aid to Water and Sanitation*. Paris, OECD. <http://www.oecd.org/dac/stats/water>
- OSU (Oregon State University). n.d. TFDD: Transboundary Freshwater Dispute Database. Corvallis, Oreg., Department of Geosciences, Oregon State University. <http://www.transboundarywaters.orst.edu>
- Pegam, G. and Schreiner, B. 2010. *Financing Water Resource Management: South African Experience. A Case Study Report* prepared by Pegasys Consultants for the OECD Expert Meeting on Water Economics and Financing, March 2010. European Water Initiative (EUWI) and Global Water Partnership (GWP).
- Pereira, C. L. and Ortega, E. 2010. Sustainability assessment of large-scale ethanol production from sugarcane. *Journal of Cleaner Production*, Vol. 18, No. 1, pp. 78-82.
- PRB (Population Reference Bureau). 2011. *World Population Data Sheet: The World at 7 Billion*. Washington DC, PRB. http://www.prb.org/pdf11/2011population-data-sheet_eng.pdf
- Prüss-Üstün, A. and Corvalán, C. 2006. *Preventing Disease through Healthy Environments: Towards an Estimate of the Environmental Burden of Disease*. Geneva, World Health Organization (WHO).
- Puri, S. and Aureli, A. (eds.) 2009. *Atlas of Transboundary Aquifers - Global Maps, Regional Cooperation and Local Inventories*. Paris, UNESCO-IHP ISARM Programme, UNESCO. [CD only.] <http://www.isarm.org/publications/322>
- Renault, D. 2002. *Value of Virtual Water in Food: Principles and Virtues*. Paper presented at the UNESCO-IHE Workshop on Virtual Water Trade, Delft, The Netherlands, 12-13 December. <http://www.fao.org/nr/water/docs/VirtualWater.pdf>
- Sachs, J. D. and Reid, W. V. 2006. Investments toward sustainable development. *Science*, Vol. 312, p. 1002. http://www.unmillenniumproject.org/documents/ScienceMag_19-05-06.pdf
- Siebert, S., Burke, J., Faures, J., Frenken, K., Hoogeveen, J., Döll, P. and Portmann, T. 2010. Groundwater use for irrigation - a global inventory. *Hydrology and Earth System Sciences*, Vol. 14, pp. 1863-80.
- Steer, A. 2010. *From the Pump Room to the Board Room: Water's Central Role in Climate Change Adaptation*. Washington DC, The World Bank. http://www.d4wcc.org.mx/images/documentos/Presentaciones/andrew_steer_keynote_presentation_water_event_december_2_final.pdf
- Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C. 2006. *Livestock's Long Shadow: Environmental Issues and Options*. Rome, Food and Agriculture Organization of the United Nations (FAO)/LEAD. <ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e.pdf>
- Strokes, J. R. and Horvath, A. 2009. Energy and air emission effects of water supply. *Environmental Science and Technology*, Vol. 43, No. 8, pp. 2680-87.
- Tallis, H., Kareiva, P., Marvier, M. and Chang, A. 2008. An ecosystem services framework to support both practical conservation and economic development. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, Vol. 105, No. 28, pp. 9457-64.
- TEEB (The Economics of Ecosystems & Biodiversity), 2009. *TEEB Climate Issues Update*. Geneva, United Nations Environment Programme (UNEP). <http://www.teebweb.org/InformationMaterial/TEEBReports/tabid/1278/language/en-US/Default.aspx>
- UN (United Nations). 2011. *United Nations Secretary General Report to the 66th General Assembly on the Implementation of the International Strategy for Disaster Reduction*. New York, UN.
- UN-Habitat (United Nations Human Settlements Programme). 2005. *Financing Urban Shelter: Global Report on Human Settlements 2005*. London/Nairobi, Earthscan/UN-Habitat. — 2006. *Meeting Development Goals in Small Urban Centres: Water and Sanitation in the World's Cities*. Nairobi/London, UN-Habitat/Earthscan. <http://www.unhabitat.org/content.aspx?typeid=19&catid=555&cid=5369>
- UN-Water/Africa and AMCOW (African Ministers' Council on Water). 2004. *Outcomes and Recommendations of the Pan-African Implementation and Partnership Conference on Water (PANAFCON)*. Presented in Addis Ababa, 8-13 December 2003. http://www.uneca.org/eca_resources/publications/sdd/panafcon%20outcomes.pdf
- UNCTAD XII (United Nations Conference on Trade and Development). 2008. *Biofuels Development in Africa: Supporting Rural Development or Strengthening Corporate Control?* UNCTAD XII Workshop held in Accra, Ghana 12 May.
- UNDESA (United Nations Department of Economic and Social Affairs, Population Division). 2009a. *World Population Prospects: The 2008 Revision, Highlights*, Working Paper No. ESA/P/WP.210. New York, UN.
- UNDESA (United Nations Department of Economic and Social Affairs). 2009b. *World Population Prospects, The 2008 Revision - Executive Summary*. New York, UN.
- UNECA (United Nations Economic Commission for Africa). 2000. *Transboundary River/Lake Basin Water Development in Africa: Prospects, Problems, and Achievements*. Addis Ababa, UNECA. http://www.uneca.org/awich/Reports/Transboundary_v2.pdf — 2006. *African Water Development Report*. Addis Ababa, UN-Water/Africa and UNECA. http://www.uneca.org/awich/AWDR_2006.htm
- UNEP (United Nations Environment Programme). 2007. *Global Environment Outlook (GEO-4)*. Environment for Development Home Page. <http://www.unep.org/geo/geo4.asp> (Accessed 10 October 2011.) — 2010a. *Global Environment Outlook: Latin America and the Caribbean (GEO LAC) 3*. Panama City, UNEP, Regional Office for Latin America and the Caribbean. http://www.unep.org/pdf/GEOLAC_3_ENGLISH.pdf — 2010b. *Africa Water Atlas*. Nairobi, UNEP, Division of Early Warning and Assessment (DEWA). <http://na.unep.net/atlas/africaWater/book.php>. — 2011. *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*. Nairobi, UNEP. http://www.unep.org/GreenEconomy/Portals/93/documents/Full_GER_screen.pdf

- UNISDR (United Nations International Strategy for Disaster Reduction Secretariat). 2011. *Global Assessment Report on Disaster Risk Reduction*. Geneva, UNISDR.
- UNU (United Nations University). 2004. *Two Billion People Vulnerable to Floods by 2050: Number Expected to Double or More in Two Generations*. News Release. Tokyo, UNU.
- WEC (World Energy Council). 2010. *Water for Energy*. London, WEC. http://www.worldenergy.org/documents/water_energy_1.pdf
- WEF (World Economic Forum). 2009. *Energy Vision Update 2009: Thirsty Energy: Water and Energy in the 21st Century*. Geneva/Englewood, Colo., WEF/Cambridge Energy Research Associates. <http://www.weforum.org/reports/thirsty-energy-water-and-energy-21st-century?fo=1> (Accessed 30 April 2011.)
- 2011a. *Water Security: The Water-Food-Energy-Climate Nexus: The World Economic Forum initiative*. Washington DC, Island Press.
- 2011b. *Global Risk 2011, Sixth Edition: An initiative of the Risk Response Network*. Geneva, WEF.
- WHO (World Health Organization). 2008a. *Safer Water, Better Health: Costs, Benefits and Sustainability of Interventions to Protect and Promote Health*. Geneva, WHO.
- 2008b. *The Global Burden of Disease: 2004 Update*. Geneva, WHO.
- 2010. Cholera, 2009. *Weekly Epidemiological Record*, Vol. 85, No. 31, pp. 293–308. Geneva, WHO.
- WHO (World Health Organization)/UN-Water. 2010. *GLAAS 2010. UN-Water Global Annual Assessment of Sanitation and Drinking Water: Targeting Resources for Better Results*. Geneva, WHO/UN-Water.
- WHO (World Health Organization)/UNICEF (United Nations Children's Fund). 2006. *Meeting the MDG Drinking Water and Sanitation Target: The Urban and Rural Challenge of the Decade*. Geneva/New York, WHO/UNICEF. http://www.who.int/water_sanitation_health/monitoring/jmpfinal.pdf
- 2010. *Progress on Sanitation and Drinking-Water: 2010 Update*. Joint Monitoring Programme for Water Supply and Sanitation. Geneva/New York, WHO/UNICEF. http://www.who.int/water_sanitation_health/publications/9789241563956/en/index.html
- Wild, D., Francke, C-J., Menzli, P. and Schön, U. 2010. *Water: A Market of the Future*. A Sustainable Asset Management (SAM) Study. SAM, Switzerland.
- World Bank. 2004. *Natural Disasters: Counting the Costs*. Washington DC, The World Bank.
- 2008a. *Economic Impact of Sanitation in Indonesia: A Five-country Study Conducted in Cambodia, Indonesia, Lao PDR, the Philippines, and Vietnam Under the Economics of Sanitation Initiative*. Water and Sanitation Program. Washington DC, The World Bank.
- 2008b. *Economic Impacts of Sanitation in the Philippines. Summary*. Research Report published for the Water and Sanitation Programme (WSP). Jakarta, The World Bank.
- 2008c. *Economic Impacts of Sanitation in Indonesia*. Research Report published for the Water and Sanitation Programme (WSP). Jakarta, The World Bank.
- 2010. *The Economics of Adaptation to Climate Change: Synthesis Report*. Washington DC, The World Bank.
- WWAP (World Water Assessment Programme). 2009. *United Nations World Water Development Report 3: Water in a Changing World*. Paris/London, UNESCO Publishing/Earthscan.
- WWF (World Wide Fund for Nature). 2010. *Living Planet Report 2010: Biodiversity, Biocapacity and Development*. Gland, Switzerland, WWF. http://wwf.panda.org/about_our_earth/all_publications/living_planet_report
- 2011. *The Energy Report. 100% Renewable Energy by 2050*. Gland, Switzerland, WWF. http://wwf.panda.org/what_we_do/footprint/climate_carbon_energy/energy_solutions/renewable_energy/sustainable_energy_report/ (Accessed 2 May 2011).
- Zimmer, D. and Renault, D. n.d. *Virtual Water in Food Production and Global Trade: Review of Methodological Issues and Preliminary Results*. Food and Agriculture Organization of the United Nations (FAO), Rome. http://www.fao.org/nr/water/docs/VirtualWater_article_DZDR.pdf

WWDR4

The United Nations World Water Assessment Programme (WWAP) is hosted by UNESCO and brings together the work of 28 UN-Water members and partners in the triennial *World Water Development Report* (WWDR).

This flagship report is a comprehensive review that gives an overall picture of the world's freshwater resources. It analyses pressures from decisions that drive demand for water and affect its availability. It offers tools and response options to help leaders in government, the private sector and civil society address current and future challenges. It suggests ways in which institutions can be reformed and their behaviour modified, and explores possible sources of financing for the urgently needed investment in water.

The WWDR4 is a milestone within the WWDR series, reporting directly on regions and highlighting hotspots, and it has been mainstreamed for gender equality. It introduces a thematic approach – 'Managing Water under Uncertainty and Risk' – in the context of a world which is changing faster than ever in often unforeseeable ways, with increasing uncertainties and risks. It highlights that historical experience will no longer be sufficient to approximate the relationship between the quantities of available water and shifting future demands.

The WWDR4 also seeks to show that water has a central role in all aspects of economic development and social welfare, and that concerted action via a collective approach of the water-using sectors is needed to ensure water's many benefits are maximized and shared equitably and that water-related development goals are achieved.

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