The United Nations World Water Development Report 3

WATER IN A CHANGING WORLD

World Water Assessment Programme

UN WATER

Facts and Figures

Chapter 1

Benefits from investing in water

- Investment in safe drinking water and sanitation contributes to economic growth. For each $1 invested, the World Health Organization (WHO) estimates returns of $3-$34, depending on the region and technology.[1]
- The overall economic loss in Africa alone due to lack of access to safe water and basic sanitation is estimated at $28.4 billion a year, or around 5% of GDP.[2]
- Poverty remains high in Sub-Saharan Africa. Almost 50 percent of the population lives below the absolute poverty line of $1.25 per day whereas as much as 75 percent of the overall population is below $2 per day.

Better preparedness to cope with disasters:

- Investments in water infrastructure by the US Army Corps of Engineers between 1930 and 1999 yielded returns of $6 for each $1 spent and controlled flood damage despite rising population numbers and property value at risk over the period.
- In poor countries where annual GDP per capita is below $760, the cost of disasters as a share of GDP is as high as 14 percent. In rich countries (i.e. GDP per capita > $9,361), this rate is around 4 percent.

Meeting the Millennium Development Goals on water supply and sanitation

- The world is on track to meet the Millennium Development Goal (MDG) target on drinking water. Current trends suggest that more than 90% of the global population will use improved drinking water sources by 2015.[3]
- The world is not on track to meet the MDG sanitation target. Between 1990 and 2006 the proportion of people without improved sanitation decreased by only 8 percentage points. Without an immediate acceleration in progress, the world will not achieve even half the sanitation target by 2015. Based on current trends, the total population without improved sanitation in 2015 will have decreased only slightly, from 2.5 billion to 2.4 billion.[4]

Global crises and water

- Demographics and the increasing consumption that comes with rising per capita incomes are the most important drivers or pressure on water.
- Demand for energy – for heat, light, power and transportation – is increasing rapidly (see Figure 1.8). The increase in the production of bioenergy has potentially important impacts on water quality and availability.
- Agriculture is the largest consumer of freshwater by far – about 70% of all freshwater withdrawals go to irrigated agriculture. Water scarcity may limit food production and supply, putting pressure on food prices and increasing countries' dependence on food imports. Rising demand for food caused by growing populations and shifting diets, production shortfall in some countries, increased costs for key agricultural inputs such as fertilizers (driven in turn by energy costs), bioenergy-related incentives in some countries and possible financial speculation have all contributed to the steep rises in food prices (see Figure 1.9).

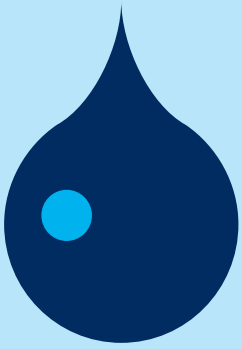
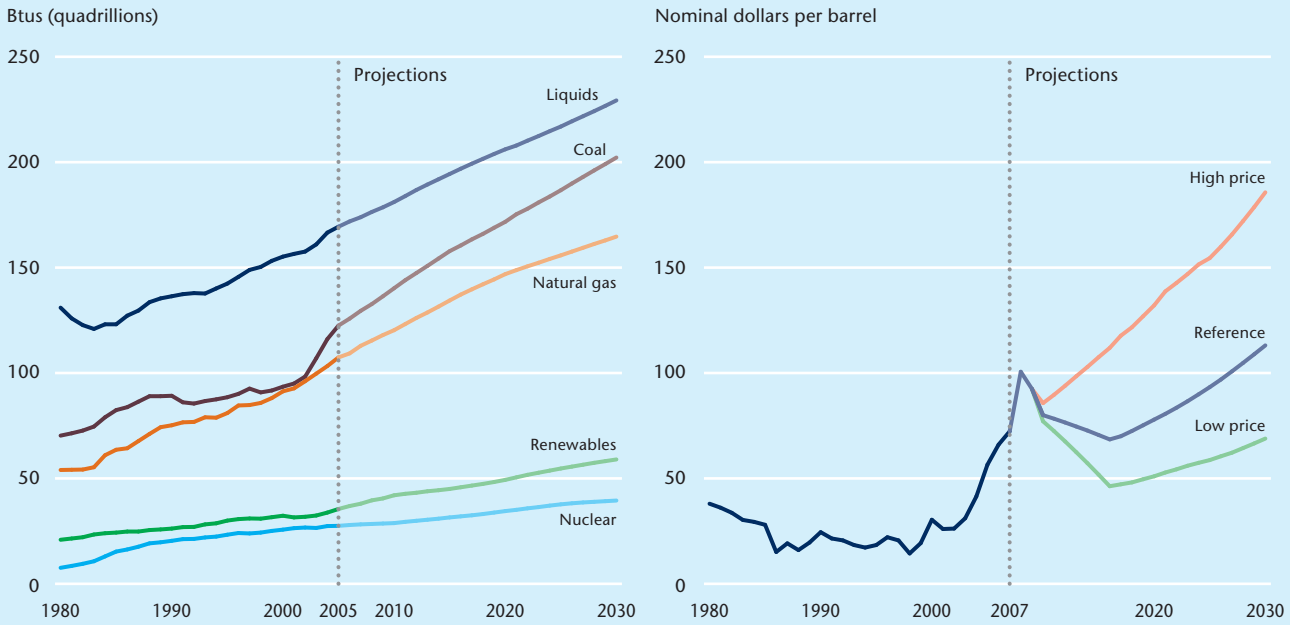


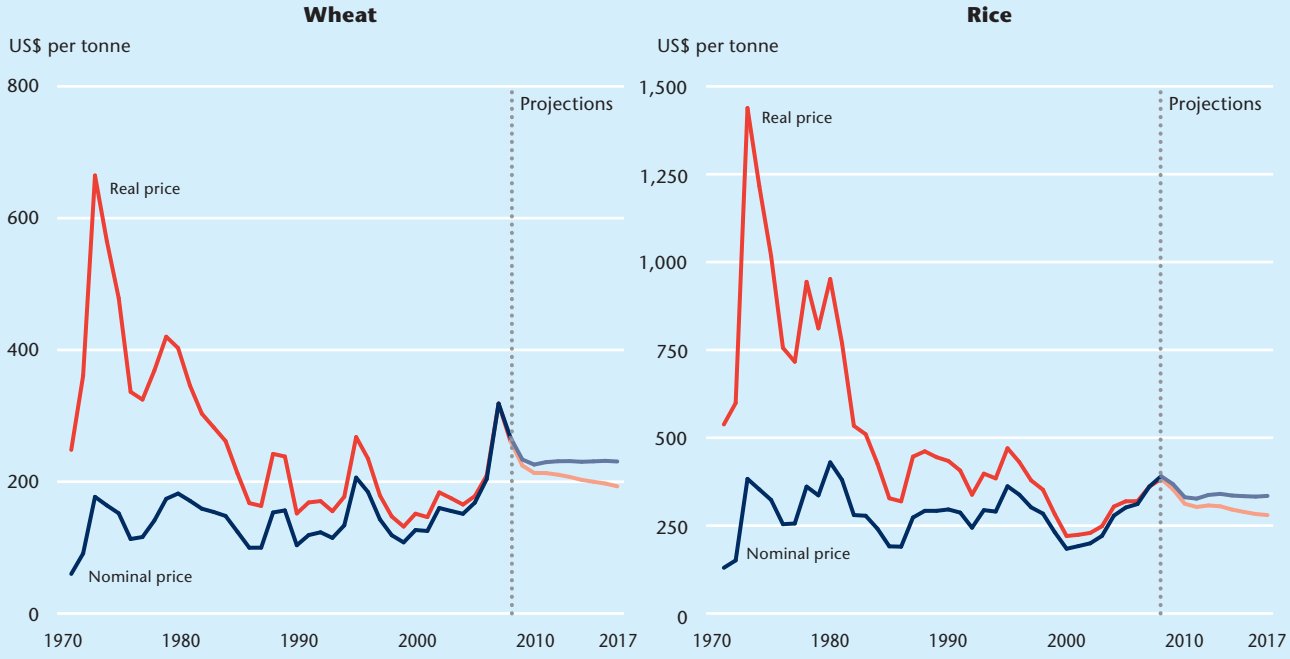
Figure 1.8 Historical and projected energy demand and oil prices show steadily rising demand and rapidly rising prices



Note: The reference case assumes average GDP growth of 2.4% a year, the high case assumes 3.0% a year, and the low case assumes 1.8% a year.
Source: Based on EIA 2005, 2008a.

Figure 1.9 Wheat and rice prices have risen sharply in recent years

Historical and projected prices of wheat and rice, 1970-2017



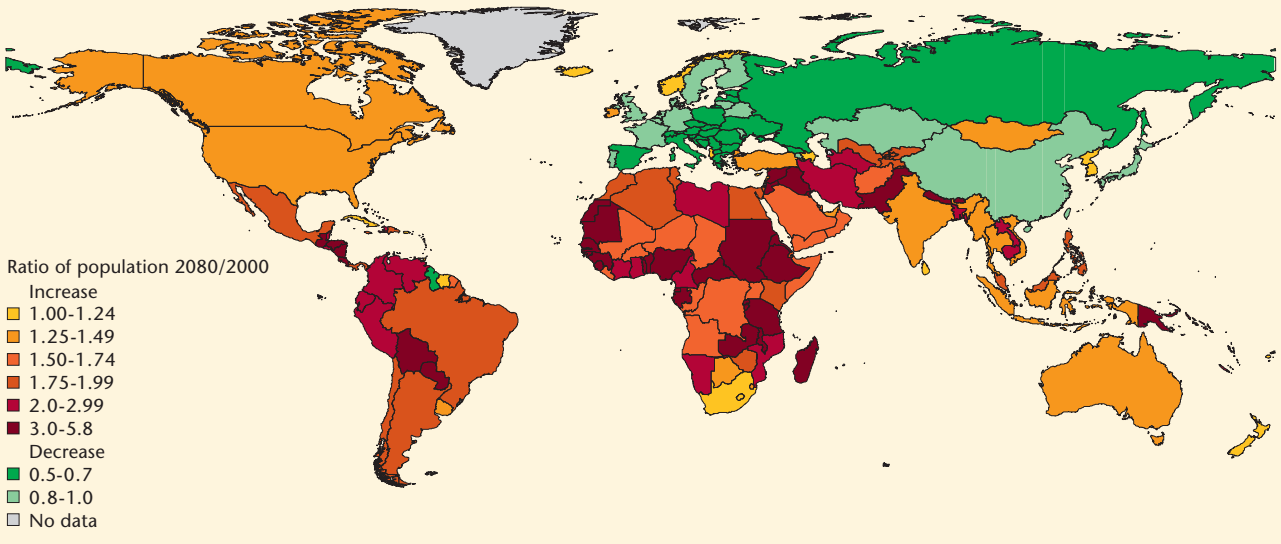
Source: Based on OECD and FAO 2008.

Chapter 2

Demographic drivers

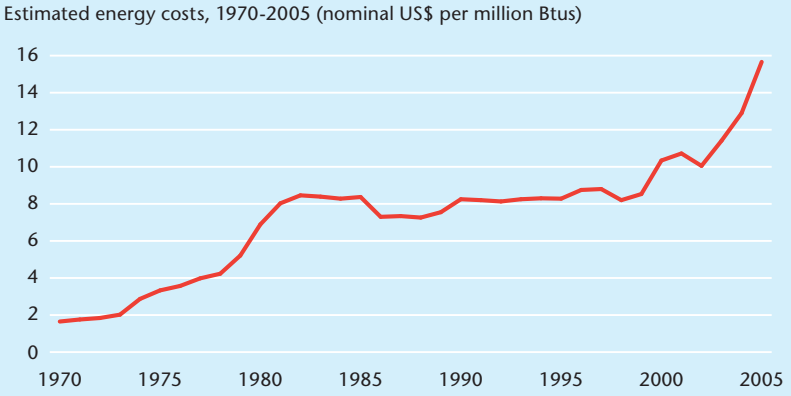
- The world's population is growing by about 80 million people a year, implying increased freshwater demand of about 64 billion cubic metres a year.[5]
- An estimated 90% of the 3 billion people who are expected to be added to the population by 2050 will be in developing countries, many in regions where the current population does not have sustainable access to safe drinking water and adequate sanitation.[6]
- Most population growth will occur in developing countries, mainly in regions that are already experiencing water stress and in areas with limited access to safe drinking water and adequate sanitation facilities (see Map 2.1).
- More than 60% of the world's population growth between 2008 and 2100 will be in sub-Saharan Africa (32%) and South Asia (30%). Together, these regions are expected to account for half of world population in 2100.
- By 2050, 22% of the world's population is expected to be 60 years old or older, up from 10% in 2005. At the same time, nearly half the world population is under the age of 25.
- Natural resource needs, including freshwater is expected to increase due to longer life expectances and globalization of trade and advertising tempting more consumption by young people in developed and developing countries.
- The urban population is expected to double between 2000 and 2030 in Africa and Asia. By 2030 the towns and cities of the developing world will make up an estimated 81% of urban humanity.[7]
- By 2030 the number of urban dwellers is expected to be about 1.8 billion more than in 2005 and to constitute about 60% of the world's population.
- Today, there are an estimated 192 million migrants worldwide, up from 176 million in 2000.[8]
- Coastal areas, with 18 of the world's 27 megacities (populations of 10 million or greater), are thought to face the largest migration pressures.
- Approximately 75% of people residing in low-lying areas are in Asia, with the most vulnerable being poor people.
- The net implication of these demographic processes is clear; the world will have substantially more people in vulnerable urban and coastal areas in the next 20 years.
- 95% of the increase in urban populations is expected in developing countries, especially in Africa and Asia, where the urban population is projected to double between 2000 and 2030.
- Urbanization rates are much lower in developed countries and are even declining in some countries.

Map 2.1 **Expected areas of population growth and decline, 2000-2080**



Source: Lutz, Sanderson, and Scherbov 2008.

Figure 2.2 **The cost of energy to consumers has been rising since the 1970s**



Source: Based on EIA 2008.

Economic drivers

- Growth in global output is currently estimated to slow to 2.2% in 2009, though this will likely be less because of the economic volatility arising from the global financial crisis.
- Brazil, China, India and the Russian Federation are, on Goldman Sachs' latest forecast, expected to overtake the combined economic strength of the G-8 by 2032.
- Sub-Saharan Africa, long a growth straggler, is experiencing growth rates of 6% or more, fuelled largely by oil and commodities.
- Adequate investments in water management, infrastructure and services can yield a high economic return by avoiding costs related to water pollution, contamination and disasters.
- Gains from globalization have not been evenly distributed. An estimated 1.4 billion people live on just $1.25 a day.[9]
- Cost of energy has been rising steadily since the early 1970s (see Figure 2.2).
- According to the International Energy Agency, the world will need almost 60% more energy in 2030 than in 2020. Water is needed for the production of energy of all types, so expansion of energy supply will affect water resources.
- Virtual water are goods and services with a substantial water content either in the finished product or in its production. The global volume of virtual water flows in commodities is 1,625 billion cubic metres a year, accounting for about 40% of total water consumption. About 80% of these virtual water flows relate to agricultural products trade, and the remainder to industrial products trade.

Chapter 3

Recent trends and advances in science and technology

- Innovation has accelerated in response to recent public and political pressure to reduce greenhouse gas emissions thought to be contributing to global climate change.
- The use of renewable energy resources has risen worldwide (See Figure 3.2) with technical innovation lowering costs.
- If current policies are maintained, global energy demands are expected to grow by as much as 55% through 2030, according to the International Energy Agency.
- China and India alone would account for about 45% of this projected increase (based on conservative economic growth figures), and developing countries overall for 74%.
- Electricity generation from hydroelectric and other renewable energy resources is projected to increase at an average annual rate of 1.7% between 2004 and 2030, for an overall increase of 60%.
- Since renewable energy resources alone are not sufficient to meet the predicted dramatic increase in energy demands through 2030, fossil fuel extraction and development of nuclear energy will continue to increase, as will their impacts on water resources and the environment.
- The greatest number of patents for monitoring environmental impacts between 1978 and 2002 was granted for water pollution treatment, attesting to the importance of information and communications technology innovations in the sustainable management of water resources.
- The green revolution in Asia doubled cereal production during 1970-95, while increasing the land area devoted to cereals by only 4%. By the late-1990s it was clear that many people, including segments of the poorest population groups, had reaped substantial benefits from higher incomes, less expensive food and increased demand for their labour associated with the green revolution.

- More than one-third of maize production in the United States in 2008 was being used to produce ethanol and about half the vegetable oils produced in the European Union were being used for biodiesel fuel. Although the impact is extremely difficult to assess, bioenergy production is estimated to have caused up to 70%-75% of the rise in the global prices of some food stocks, including approximately 70% of the increase in maize prices.

Chapter 4

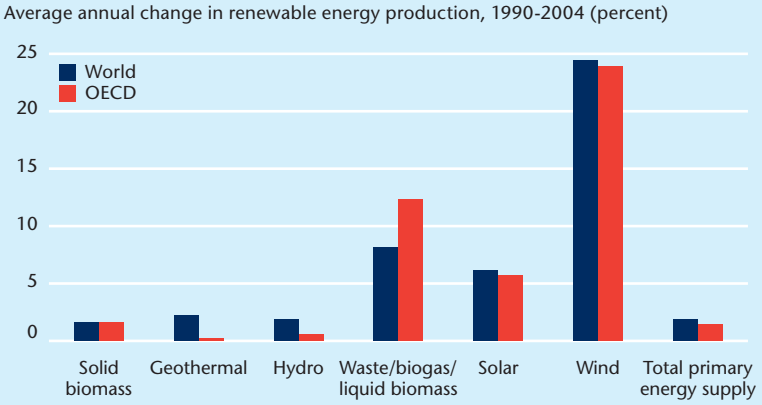
Policies, laws and finance

- There are more than 400 registered agreements over shared watersheds,[10] most between two riparian countries.
- According to estimates corruption in the water sector can raise the investment costs of achieving water- and sanitation-related MDG targets by almost $50 billion (Global Corruption Report 2008).[11]
- According to the Global Corruption Report 2008, in some countries corruption siphons off as much as 30% of the budget. By diverting funds from investment or operation and maintenance, corruption reduces access to water.

Financing – the missing link

- In the United States bringing water supply and sewerage infrastructure up to current standards will cost more than $1 trillion over the next 20 years, with hundreds of billions more required for dams, dikes and waterway maintenance.
- The World Business Council for Sustainable Development estimates that the total costs of replacing ageing water supply and sanitation infrastructure in industrial countries may be as high as $200 billion a year.
- In most urban public water systems charges often barely cover the recurrent costs of operation and maintenance, leaving little or no funds to recover the capital costs of modernization and expansion. A survey of such systems in 132 cities in high-, middle and low-income countries found that 39% did not recover even their operation and maintenance costs (true of 100% of cities in South-East Asia and the Maghreb)
- Moreover, water infrastructure deteriorates over time. Leakage (loss) rates of 50% are not uncommon in urban distribution systems.

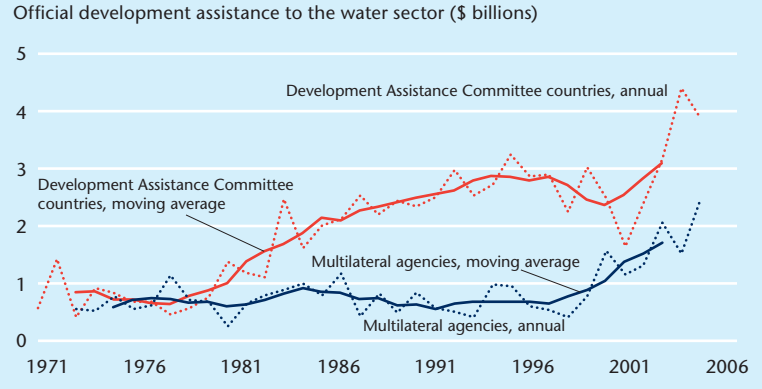
Figure 3.2 **The use of renewable energy sources rose worldwide between 1990 and 2004**



Source: Based on OECD 2008.

- In rural areas neglect of operation and maintenance budgets and cost recovery contribute to widespread non-functionality. A recent survey of almost 7,000 rural water schemes in Ethiopia found that 30%-40% were non-functional. A shortage of finance for wages, fuel, materials and spare parts was a common factor.
- If estimates of current costs are correct, resources in the sanitation sector would have to be almost doubled to meet the 2015 target (although estimates of current spending probably underestimate the contributions by households to their own sanitation services).
- The World Health Organization estimates the total annual cost of meeting the 2015 Millennium Development Goal target for sanitation at just over $9.5 billion.

Figure 4.8 **Official development assistance to the water supply and sanitation sector is rising again after a decline during the 1990s**



Source: Based on OECD-DAC 2008.

Table 4.4 **Commitments of official development assistance from bilateral and multilateral agencies, 2004-06**

(US$ millions)

Sector	2004	2005	2006
Water transport	416	503	304
Hydropower plants	755	480	652
Agricultural water resources	608	830	790
Water supply and sanitation	3,127	4,405	3,879
Total water sector	4,951	6,218	5,625
Total all sectors	79,431	107,078	104,369
Water sector as share of all sectors (%)	6.2	5.8	5.4

Source: OECD, DCD/DAC 2007.

- If the full cost of tertiary wastewater treatment for waste streams in urban areas is added, the total rises to $100 billion, the current value of total annual official development assistance.

Charging for water

- In developing countries the picture is complicated by the widespread use of informal and small-scale private water distributors charging full market prices; in these cases the poorest households can pay 3%–11% of income on water.[12]

Financing through external aid

- Official development assistance from donor countries and multilateral donors to the water supply and sanitation sector increased during the 1970s and 1980s but decreased during the 1990s, with less aid for large infrastructure, before rising again in 2000 (see Figure 4.8).
- Leaders at the meeting of the G-8 in Evian, France, in June 2002 made a commitment to give priority to the water sector. Official development assistance increased substantially in the years immediately thereafter. While the amount going to the water supply and sanitation sector increased, aid to the other water sectors remained relatively unchanged (see Table 4.4). However, overall lending for water remained at less than 6% of total official development assistance, and the share of total lending declined.

Chapter 5

Climate change and possible futures

- Current International Panel on Climate Change (IPCC) projections of rising temperatures and sea levels and increased intensity of droughts and storms suggest that substantial population displacements will take place within the next 30-50 years, particularly in coastal zones.
- An estimated 40% of development investments are currently at risk, according to analyses by the Organisation for Economic Co-operation and Development (OECD).[13] These analyses indicate that while many development efforts contribute to reducing vulnerability to climate variability and change, climate risks are seldom explicitly factored into development projects and programmes.
- The Stern Review in 2006 concluded that by 2050 extreme weather could reduce global GDP by 1% and that, unabated, climate change could cost the world at least 5% in GDP each year.[14] If even more dramatic predictions come to pass, the cost could rise to more than 20% of GDP.

The cost of adapting to climate change

Estimates vary because they depend on future greenhouse gas emissions, mitigation measures and assumptions about anthropogenic climate change itself and about how effectively countries will adapt to it. The following are some estimates of the costs of adaptation for developing countries:

- World Bank estimates of the additional costs to adapt or climate-proof new investments range from $9 to $41 billion a year. And a recent update by the United Nations Development Programme put the mid-range of the costs of adaptation at about $37 billion a year in 2015.[15]
- The United Nations Framework Convention on Climate Change estimates additional investments for adaptation to climate change at $28-$67 billion and as high as $100 billion a year several decades from now. Estimates of the additional investments needed in water supply infrastructure in 2030 are $11 billion, 85% of it in developing countries.[16]

- Oxfam estimates the current costs of adaptation to climate change for all developing countries at more than $50 billion a year. While there is considerable debate about these estimates, they provide useful order-of-magnitude numbers for assessing resources available for adaptation.[17]
- Current Global Environment Facility funds (about $160 million) are several orders of magnitude too little to meet these projected needs.[18]

Technological innovation and policies

- *World Energy Outlook* 2006 projected an average rate of growth of bioenergy production of 7% a year.[19]
- By 2030 biofuels are expected to meet 4% of road-transport fuel demand worldwide, up from 1% today.

Social change

- In the world's richest countries, growing awareness of climate change is slowly inducing people to alter their lifestyles and live in a more sustainable manner.
- These changes alone are unlikely to substantially counteract the pressure from rising living standards in emerging market economies consuming more goods and services.

Chapter 6

Can we afford not to invest in water?

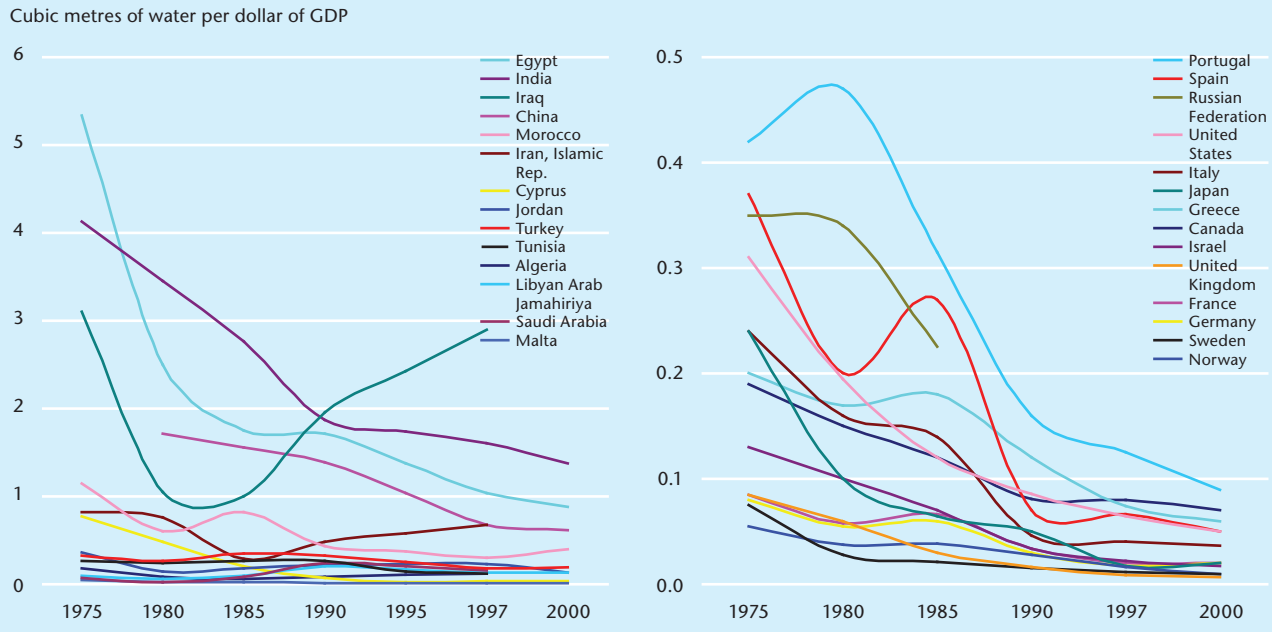
Examples of the economic cost of lack of investment in water:

- In Kenya the combined impact of the winter floods of 1997/98 and drought between 1998 and 2008 has been estimated at $4.8 billion – effectively a 16% reduction in GDP.[20] Evidence suggests that floods and drought in Kenya translate into a direct annual loss of 22% of GDP over a 2.5 year period.
- The Mozambique floods of 2000 caused a 23% reduction in GDP and a 44% rise in inflation.
- Inability to tackle hydrologic variability in Ethiopia has been estimated to cause a 38% decline in GDP and a projected 25% increase in poverty for 2003-15.[21]
- Worldwide, more than 7,000 major disasters have been recorded since 1970, causing at least $2 trillion in damage and killing at least 2.5 million people.[22]

GDP, water investments and water use

- As of 2007, 3 billion people live in rural areas, most of them dependent on agriculture for their livelihood.
- While there is a strong relation between water investment and growth, the relation between the quantity of water used and a country's level of development is inconclusive.

Figure 6.3 **The ratio of water use to GDP has been declining in many countries**



Source: Based on Margat and Andréassian 2008.

- Many water-poor economies have developed, while the ratio of water use to GDP in many developed countries has been declining (see Figure 6.3).

Water and poverty reduction

- Almost two in three people lacking access to safe drinking water survive on less than $2 a day and one in three on less than $1 a day. More than 660 million people without adequate sanitation live on less than $2 a day, and more than 385 million on less than $1 a day. This evidence highlights clearly the financing difficulties of improving access through household investment. This is important because households, not public agencies, often make the largest investment in basic sanitation, with the ratio of household to government investment typically being 10 to 1.[23]
- Some 1.4 billion people are classified as poor; 44% in South Asia, about 24% each in sub-Saharan Africa and East Asia, and 6.5% in Latin America and the Caribbean.[24]
- The urban poor often live in informal settlements following rapid urban growth; 77% of the population in Latin America is urban; 38% in Africa. Those figures are expected to rise over the next few decades with projected urban expansion.

Water and health

- Every $1 invested in improved water supply and sanitation yields gains, on average, of $4-$12, depending on the type of intervention.
- Almost one-tenth of the global disease burden could be prevented by improving water supply, sanitation, hygiene and management of water resources. Such improvements reduce child mortality and improve health and nutritional status in a sustainable way.
- In 2000 diarrhoea accounted for 17% of the 10.6 million deaths in children younger than five, and malaria for 8%.[25]
- Some 1.4 million children die each year from preventable diarrhoeal diseases. Ordinary diarrhoea remains the major killer among water-, sanitation- and hygiene-related diseases, contributing to 43% of deaths.[26] Sub-Saharan Africa and South Asia are the most affected regions.
- Undernutrition is an underlying cause of 53% of all deaths in children younger than five.
- Global under-five mortality has fallen from 93 per 1,000 live births in 1990 to 72 per 1,000 in 2005 – a decline of 22.5% – but the pace of progress has been uneven across regions and countries. The decline has been slowest in sub-Saharan Africa.
- Malnutrition accounts for about a third of the disease burden in low- and middle income countries.[26]
- Lack of access to adequate, safe food, partly related to water resources management, is one cause of malnutrition, but up to 50% of malnutrition is related to repeated diarrhoea or intestinal nematode infections as a result of unclean water, inadequate sanitation or poor hygiene.
- Of the estimated 350-500 million clinical disease episodes occurring annually, around 60% are in sub-Saharan Africa, as are 80% of the deaths. Most of the more than 1 million Africans who die from malaria each year are children under age five.
- How much malaria could be eliminated by managing the environment – by eliminating stagnant water bodies, modifying reservoir contours, introducing drainage or improving irrigation management – differs across regions with variations in vector habitats, with a global average of 42%.

Chapter 7

The many realities of water use

- Water use is uneven across countries. The 10 largest water users (in volume) are India, China, the United States, Pakistan, Japan, Thailand, Indonesia, Bangladesh, Mexico and the Russian Federation.
- Agriculture is by far the main user of water. Irrigated agriculture accounts for 70% of water withdrawals, which can rise to more than 90% in some regions.
- Around 20% of total water used globally is from groundwater sources (renewable or not), and this share is rising rapidly, particularly in dry areas.[28]

Trends in water use

Recent trends:

- With rapid population growth, water withdrawals have tripled over the last 50 years.
- This trend is explained largely by the rapid increase in irrigation development stimulated by food

demand in the 1970s and by the continued growth of agriculture-based economies.[29]

Expected trends over the next 50 years:

- There is still substantial uncertainty on the scale of future demands. Between 2000 and 2050 the world's population is projected to grow from 6 billion to 9 billion, and demand for food and other goods will increase significantly.
- The Mediterranean Action Plan is exploring possible futures for agriculture-based economies that are most vulnerable to anticipated climate change effects.[30]

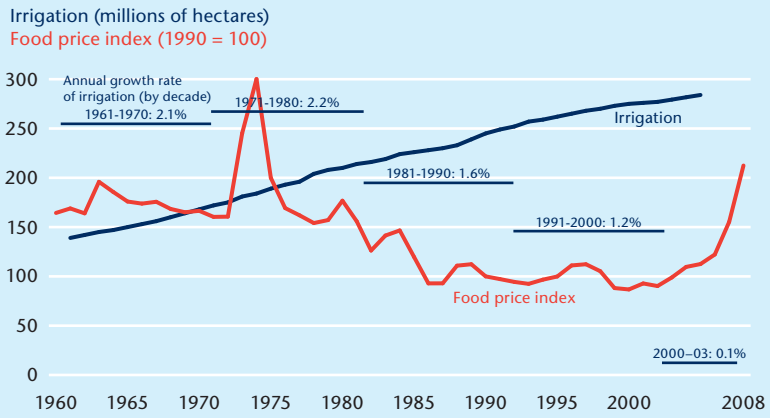
Domestic water supply and sanitation

- In 2006, 54% of the world's population had a piped connection to their dwelling, plot or yard, and 33% used other improved drinking water sources. The remaining 13% (884 million people) relied on unimproved sources.
- Progress has been greatest in East Asia, with an increase in coverage of improved drinking water sources from 68% in 1990 to 88% in 2006.[31]
- Except for sub-Saharan Africa and Oceania, all regions are on track to meet the Millennium Development Goal (MDG) drinking water target. But if current trends continue, 2.4 billion people will still be without access to basic sanitation by 2015.[32]
- Coverage is much higher in urban than in rural areas for both water supply and sanitation. Global and regional aggregates for water and sanitation coverage do not show the large differences between countries.

Trends and current situation of water use in agriculture

- Agriculture accounts for 70% of freshwater withdrawals from rivers, lakes and aquifers – up to more than 90% in some developing countries.
- Rainfed agriculture covers 80% of the world's cultivated land, and is responsible for about 60% of crop production.
- Today, irrigated agriculture covers 275 million hectares – about 20% of cultivated land – and accounts for 40% of global food production.
- This success in agricultural production led to a 30-year decline in food prices in most countries (see Figure 7.6), a trend that lasted until very recently.

Figure 7.6 **As irrigation area expanded, food price fell for 30 years before starting to rise again**



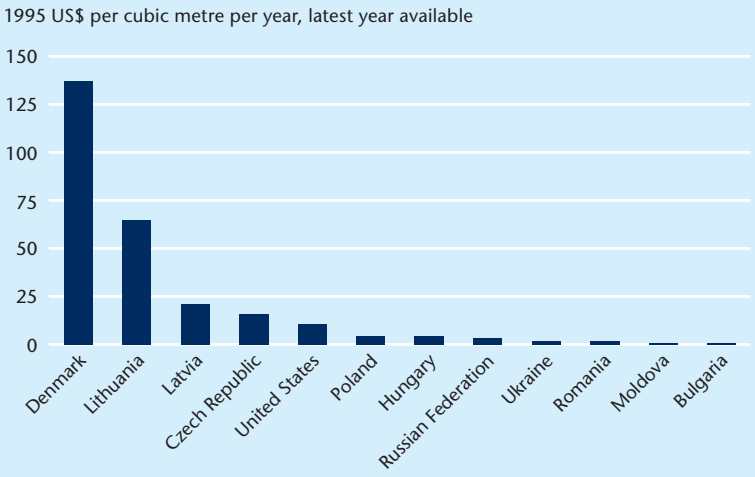
Source: Based on Comprehensive Assessment of Water Management in Agriculture 2007; FAO FAOSTAT.

- Growth in world demand for food will mirror population growth, progressively declining from 2.2% a year in the last decades of the 20th century, to 1.6% in 2015, 1.4% in 2015-30, and 0.9% in 2030-50.[33]
- Part of the current pressure on water resources comes from increasing demands for animal feed. Meat production requires 8-10 times more water than cereal production.
- The latest projections available show an average increase of 0.6% a year in irrigated land from 1998 until 2030, compared with 1.5% over the 1950s-1990s.
- In the same period (1998-2030), because of continued increases in agricultural productivity, 36% more food will be produced with 13% more water.[34]

The implications of food prices for food security

- Recent increases in the prices of the main agricultural commodities have caused the number of people suffering from hunger to rise from 850 million to 963 million.
- Between September 2007 and March 2008 the price of wheat, corn, rice and other cereals rose an average of 41% on the international market.
- From the beginning of 2000 to the middle of 2008, butter and milk prices tripled, and poultry prices have almost doubled.
- Prices have fallen since mid-2008 thanks to good prospects for world food production, the overall slowdown of the world economy and reductions in the price of oil.

Figure 7.8 **Industrial water productivity varies greatly across countries**



Source: Based on UNIDO 2007.

How will bioenergy affect agricultural water use?

- Around 10% of the total energy supply comes from biomass, and most of that (80%) comes from the 'traditional' biomass sources of wood, dung and crop residues.
- Globally, irrigation water allocated to biofuel production is estimated at 44 km^3, or 2% of all irrigation water.[35] Under current production conditions it takes an average of roughly 2,500 litres of water (about 820 litres of it irrigation water) to produce 1 litre of liquid biofuel (the same amount needed on average to produce food for one person for one day).
- The share of irrigation water used for biofuel production is negligible in Brazil and the European Union and is estimated to be 2% in China and 3% in the United States.[36]
- Implementing all current national biofuel policies and plans would take 30 million hectares of cropland and 180 km^3 of additional irrigation water.

Water for industry and energy

- Industry and energy together account for 20% of water demand.
- Industrial water use is only partially linked to a country's level of industrialization, as exemplified by the large difference in water productivity between two high-income countries: more than $138 per cubic metre in Denmark and less than $10 per cubic metre in the United States (see Figure 7.8).
- Around the Mediterranean Sea seasonal water demands from the tourism industry increase annual water demand by an estimated 5%-20%.

Water use for energy production

- Hydropower supplies about 20% of the world's electricity,[37] a share that has remained stable since the 1990s.
- According to the International Energy Agency, electricity generation from hydropower and other renewable energy sources is projected to increase at an average annual rate of 1.7% from 2004 to 2030, for an overall increase of 60% through 2030.

Oil prices and energy choices

- The renewable energy share of world electricity production is projected to fall slightly, from 19% in 2004 to 16% in 2030, as growth in the consumption of coal and natural gas for electricity generation worldwide exceeds that in renewable energy sources.
- While average commercial energy use in high-income countries is about 5,500 kilograms of oil equivalent per capita, it is still well below 500 kilograms in low-income countries.[38]

Chapter 8

Impacts of water use on water systems and the environment

- On average freshwater species populations were reduced by half between 1970 and 2005, a sharper decline than for other biomes.
- As of 2000 there were more than 50,000 large dams in operation.
- Some 589 large dams were built in Asia from 1999 to 2001.
- Of the world's 292 largest river systems in 2005[39] (accounting for 60% of the world's runoff), more than a third (105) were considered to be strongly affected by fragmentation, and 68 moderately affected.[40]

Social, economic and environmental risks

- A recent study of the water economics of the Middle East and North Africa region estimates that groundwater resource depletion has substantially reduced GDP in some countries – Jordan by 2.1%, Yemen 1.5%, Egypt 1.3% and Tunisia 1.2%.[41]

Growing risks: pollution and degradation of water quality

- Despite improvements in some regions, water pollution is on the rise globally.
- More than 80% of sewage in developing countries is discharged untreated, polluting rivers, lakes and coastal areas.[42]
- Many industries – some of them known to be heavily polluting (such as leather and chemicals) – are moving from high-income countries to emerging market economies.
- Although rural populations in Asia are projected to remain stable over the next 20 years, urban populations are likely to increase by 60% before 2025, which affect prospects for water scarcity.[43]
- Globally, the most prevalent water quality problem is eutrophication, a result of high-nutrient loads (mainly phosphorus and nitrogen), which substantially impairs beneficial uses of water.
- In 1998 approximately 90% of the coastal and marine biotopes in the Baltic Sea were threatened by loss of area or reduction in quality from eutrophication, contamination, fisheries and settlements.
- Today, up to 70 million people in Bangladesh are exposed to water that contains more than the World Health Organization threshold value of 10 micrograms of arsenic per litre. Up to half the estimated 10 million tubewells in Bangladesh might be contaminated with arsenic.
- Natural arsenic pollution of drinking water is now considered a global threat with as many as 140 million people affected in 70 countries on all continents.[44]
- A recent study on drinking water in France estimated that more than 3 million people (5.8% of the population) were exposed to water quality that does not conform to World Health Organization standards (for nitrates, non-conformity was found in 97% of groundwater samples).[45]

Industrial pollution control is improving

- There has been a steady growth in companies seeking certification through ISO 14001, the international standard for environmental management administered by the International Organization for Standardization.
- By the end of 2002 nearly 50,000 companies in 118 countries had received ISO 14001 certification.[46]

Chapter 9

Managing competition for water and the pressure on ecosystems

- Competition for water exists at all levels and is forecast to increase with demands for water in almost all countries.
- In 2030, 47% of world population will be living in areas of high water stress.[47]
- More than 5 billion people – 67% of the world population – may still not be connected to public sewerage systems in 2030.[48]
- Desalination is rarely used for agriculture (1%), but its use for high-value crops in greenhouses is gradually increasing. Desalination accounted for only 0.4% of water use in 2004 (nearly 14 cubic kilometers a year), but production should double by 2025.

Chapter 10

Overview of the global hydrologic cycle

- Freshwater is but a small fraction – about 2.5% – of the total water on Earth. Precipitation is the ultimate source of freshwater
- A study showed that 85% of the world's population resides in the drier half of the Earth.[49] More than 1 billion people living in arid and semi-arid parts of the world have access to little or no renewable water resources.
- It is estimated that less than 20% of the world's drainage basins exhibit nearly pristine water quality and that the riverine transport of inorganic nitrogen and phosphorus has increased several fold over the last 150-200 years.[50]

Chapter 11

Changes in the global water cycle

- There is a consensus among climate scientists that climate warming will intensify, accelerate or enhance the global hydrologic cycle.[51]
- The mechanism most often cited is that warmer air temperatures result in higher saturation vapour pressure (about 7% higher per degree Kelvin) and hence atmospheric water vapour content. Some argue that recent satellite observations do not support subdued sensitivity, and report increases in water vapour content, precipitation and evaporation of about 6% per degree Kelvin.[52]
- The IPCC has found global average increases in surface air temperatures overland of 0.74°C ± 0.18°C for 1906-2005.[53]

Chapter 12

Evolving hazards – and emerging opportunities

- A review of recent changes in the global water cycle that analysed more than 100 studies (based on observations) found rising global and regional trends in runoff, floods and droughts, and other climate related events and variables in the second half of the 20th century that together support the perception of an intensification of the hydrologic cycle.[54]
- Mediterranean ecosystems are diverse and vulnerable, susceptible to changes in water conditions. Even with a temperature rise of 2°C, the Southern Mediterranean may lose 60%-80% of species.
- Tundra and Arctic regions face the loss of permafrost and the potential for methane release with greater warming at the poles.
- Mountains are seeing shortened and earlier snow and ice melt and related changes in flooding. At higher altitudes increased winter snow can lead to delayed snow melt.
- Wetlands will be negatively affected where there is decreasing water volume, higher temperatures and higher intensity rainfall.
- The IPCC report suggests that by 2050 annual average runoff will have increased by 10%-40% at high latitudes and decreased by 10%-30% over some dry regions at mid-latitudes and semi-arid low latitudes.[55]
- Globally, the number of great inland flood catastrophes was twice as large per decade between 1996 and 2005 as between 1950 and 1980, and economic losses were five times as great. The dominant drivers of these upward trends are socioeconomic factors, such as population growth, land use change and greater use of vulnerable areas.
- Documented trends in floods show no evidence for a globally widespread change.
- More intense droughts, affecting more people and linked to higher temperatures and decreased precipitation, have been observed in the 21st century.[56]
- A study of spatial and temporal changes in streamflow droughts using a dataset of more than 600 daily European streamflow records from the European Water Archive of the UNESCO Flow Regime from International Experimental Data (FRIEND) detected no significant changes for most stations.[57] However, distinct regional differences were found.
- Globally, very dry areas (land areas with a Palmer Drought Severity Index of 3.0 or less) have more than doubled since the 1970s (from about 12% to 30%), with a large jump in the early 1980s due to an El Niño Southern Oscillation-related precipitation decrease over land and subsequent increases due primarily to surface warming.[58]
- The conversion of native vegetation to agriculture has been shown to increase soil erosion rates 10- to 100-fold.[59]
- With agricultural land now occupying about 37% of the ice-free area of the continents, it is clear that agriculture has had an enormous impact on global erosion rates.

Chapter 13

Bridging the observational gap

Many terrestrial hydrologic networks are shrinking for several reasons:

- Available records fulfill present hydrologic information requirements.
- No direct economically justifiable use of hydrologic information is apparent (for example, in pristine basins or stations close to the mouths of rivers and delta areas).
- Logistical problems.
- Budgetary or resource problems.

Hydrologic data from North and Central America, the Caribbean, Europe and Mediterranean Asia are far greater than data from other regions.

Chapter 14

Options inside the water box

Programs and activities are under way around the world that directly address the assessment, allocation or conservation of water resources. Improving water governance includes more efficiently managing available water resources and current and anticipated water uses, and informing water users, stakeholders and decision-makers about the consequences of actions taken (or not taken) to address such issues.

Implementing integrated water resources management is proving more difficult than envisioned. Practical examples of solutions within the water domain that show promise involve:

- Institutional and human capacity development, to prepare institutions for current and future water and related challenges.
- Water law, both formal and customary, including regulations in other sectors that affect water resources management.
- Consultation with stakeholders and accountability in planning, implementation and management to build trust, as effective management involves pluralistic governance, transparency and interactions among parties with different interests.
- Use of financial options and economic instruments to support the reliability and quality of the services provided.
- Innovation and research to develop appropriate realistic and sustainable solutions.
- Payment for environmental services as an incentive for improving water management efforts and for supporting sustainable ecosystems and water security.
- Creation by water sector decision-makers of a favourable investment climate

Notes

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The United Nations World Water Development Report 3: Water in a Changing World

Coordinated by the World Water Assessment Programme, the *United Nations World Water Development Report 3: Water in a Changing World* is a joint effort of the 26 United Nations agencies and entities that make up UN-Water, working in partnership with governments, international organizations, non-governmental organizations and other stakeholders. The United Nations' flagship report on water, the *United Nations World Water Development Report* offers a comprehensive review of the state of the world's freshwater resources and provides decision makers with the tools to implement sustainable use of our water. It brings together some of the world's leading experts to analyse changes in our water supplies and in how we manage them, and tracks our progress towards achieving international development targets. Published every three years since 2003, it offers best practices as well as in-depth theoretical analyses to help stimulate ideas and actions for better stewardship of this most essential resource.

This third edition of the report, *Water in a Changing World,* has benefitted from the involvement of a Technical Advisory Committee composed of members from academia, research institutions, non-governmental organizations, and public and professional organizations. To strengthen the scientific basis and potential for implementation of its recommendations, interdisciplinary expert groups were also created for a number of topics, including 'Indicators, Monitoring and Databases', 'Business, Trade, Finance and Involvement of the Private Sector', 'Policy Relevance', 'Scenarios', 'Climate Change and Water', 'Legal Issues' and 'Storage'.

The *United Nations World Water Development Report 3: Water in a Changing World* is presented with an accompanying case study volume: Facing the Challenges, which examines the state of water resources and national mechanisms for coping with change in 23 countries and numerous small island developing states. Adopting the premise that local actions and on-the-ground insights are the starting point of a global strategy to improve management of the world's freshwater resources, these 20 case studies from around the world examine water challenges and the differing management approaches taken in response in Bangladesh, Cameroon, China, the Cholistan desert (Pakistan), Estonia, the Han River basin (Republic of Korea), Istanbul (Turkey), the Lake Merín basin (Brazil and Uruguay), La Plata River basin (Argentina, Bolivia, Brazil, Paraguay and Uruguay), the Netherlands, Pacific island states, the Po River basin (Italy), the Autonomous Community of the Basque Country (Spain), Sri Lanka, Sudan, Swaziland, Tunisia, Uzbekistan, the Vuoksi River basin (Finland and the Russian Federation) and Zambia.