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World water markets

High investment requirements mixed with institutional risks

The world's water markets are confronted with major challenges. The growth of the global population goes hand in hand with a rise in demand for food, energy and other goods. This means the demand for water will increase accordingly – in the face of a limited supply of this vital resource. Usage conflicts are inevitable, and will become more acute on account of wasteful use and pollution. Scarcity of water is a humanitarian problem and it can curb economic growth. Climate change will amplify many water-related problems and create new ones.

We put the annual investment required in the global water sector at about EUR 400-500 bn. Measured by this yardstick the sector is a picture of underinvestment, especially because water prices in many areas are subsidised and thus too low. As a result, there is a lack of incentives for necessary investments. The prices do not reflect the scarcity of water as a resource; wastage is encouraged. Corruption and the absence of ownership rights compound the problems. To turn the tide, water prices in many countries would have to be boosted. The need to incorporate social considerations in the process greatly reduces the scope for making such increases in practice.

Governments will not be able to raise the funding needed to cope with the upcoming tasks on their own. While there is considerable disquiet about private firms investing in the water sector, the public sector is simply unable to meet all the challenges single-handedly. For this reason, we believe it makes sense for governments and the private sector to cooperate more closely.

Makers of "water technologies" stand to benefit from huge sales potential over the next few decades – despite the risks cited. There is likely to be a particularly sharp increase in the demand for efficient irrigation technologies, seawater desalination and sewage treatment facilities, technical equipment (e.g. pumps, compressors and fittings), filter systems and disinfection procedures.

We have used a scoring model to rank the attractiveness of various countries for investments in the water industry. The Top 20 include many countries from the Middle East that are rich due to their oil deposits, located in very dry regions and relatively stable politically. Two big industrial countries, Germany and the US, and the world's two most populous nations, India and China, are also among the Top 20 in our ranking. In principle, though, all countries require a substantial amount of investment in the water sector.

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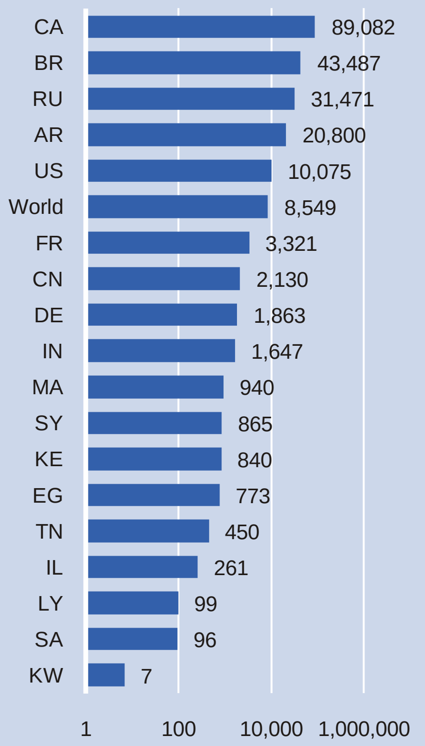
Water availability varies considerably

Renewable water resources (m³ per capita and year, logarithmic scale, 2006)



Sources: UN, WRI 1

Fossil water

So-called fossil water is water that has not been integrated into the hydrologic cycle in Earth's recent history and that is also not renewed via precipitation. There are groundwater basins under the Sahara Desert, for instance, which contain fossil water. In Libya, this water is being pumped to the surface as part of the Great Man-Made River project. The water is used for agricultural purposes and to supply Libyans with drinking water. Even though this has boosted the standard of living for the people benefiting from the project, this type of water use is of course not sustainable in the normal sense of the word since the water resources are not renewed. Besides, there are fears, and in some cases already complaints, about the water table sinking in neighbouring regions.

1. Introduction

The global water sector is facing a variety of challenges. The world's population will increase by around 2.5 billion people by the year 2050. Demand for food, energy and all types of consumer goods and services will rise as a consequence. This will ultimately mean an increase in demand for water – in the face of a limited supply of this vital resource. Usage conflicts are inevitable, and will become more acute on account of wasteful use and pollution. Investments in water infrastructure as a whole will have to increase over the next few decades to be able to satisfy the growing demand. Naturally, the focus of investment in industrialised countries differs from that in developing countries and emerging markets. Generally, though, the need for investment has to be reconciled with funding bottlenecks in the public sector.

Analytical approach in this study

In this report we shall start out by discussing the main characteristics and key figures of the world water market. Note, though, that the data basis is fraught with difficulties. In the third section we analyse the key challenges to be mastered in the global water sector. Our focus is on problems resulting from the growth of agricultural production and increasing urbanisation and industrialisation. Furthermore, we cast a glance at potential technological and political solutions, but also at their limitations. Climate change will exacerbate many of the existing problems surrounding the water sector and create new ones in the years ahead. This aspect will be discussed in a separate section. Finally, we will look at the global water market from the standpoint of water companies and potential investors in addition to highlighting related opportunities and risks.

2. World water markets: Characteristics and key figures

The water market differs in many respects from other markets. One characteristic on the supply side is that the amount of water in the world always remains the same, since water exists in a cycle of evaporation and precipitation. Water covers over 70% of the Earth's surface. But of the nearly 1.4 bn cubic kilometres of water on Earth "only" about 2.5% is freshwater. In turn, close to 70% of this water is captured in the form of ice, especially at the polar caps and in glaciers and thus is not immediately available for human use. Groundwater makes up about 30% of the world's freshwater resources, so in many countries it is the most important source of supply. Only 1% or so of the freshwater on Earth is found in lakes, rivers, wetlands and different types of soil (including permafrost). Nevertheless, surface water from lakes and rivers (and thus also from precipitation) plays the dominant role in humankind's water supply. On a global average, over 70% of the water used by humans is drawn from surface sources. In several countries, especially in the oil-rich Arab states, a significant proportion of the water supply is based moreover on seawater desalination.

Unequal distribution of precipitation seasonally and regionally

In purely mathematical terms there is enough water on Earth to satisfy all the needs of humankind on a sustainable basis. According to Germany's Federal Institute for Geosciences and Natural Resources (BGR), annual worldwide withdrawals of groundwater equal less than 10% of groundwater recharge. Nonetheless, many countries and regions suffer from a scarcity of water or even shortages (see box).

This is mainly attributable to several demand components (overextraction, waste and pollution) which we shall return to presently. A major supply-side reason for a shortage of water is, of course, climatic conditions. The reason is that the volume of surface water is closely correlated with precipitation, which in turn varies by season and by region; this holds true not only globally, but also for individual countries. One well-known example is India, where in certain regions over 90% of the annual precipitation falls during the summer monsoon. During the remainder of the year, by contrast, huge parts of the country suffer from persistent drought and high temperatures.[1] This phenomenon can also be witnessed in several industrial countries. For instance, there is much less precipitation in southern Spain on average than there is in northern Spain. Moreover, the precipitation occurs primarily in the winter months. Of course, there are also countries in which only little rain falls during the year as a whole, this being the main reason for water scarcity or shortages.

Water scarcity and water shortage

A generally acknowledged definition for the concepts of water scarcity and water shortage is given by the so-called Falkenmark Water Stress Index, named after Swedish scientist Malin Falkenmark. It says that a country has no stress in terms of the availability of drinking water if its annual renewable freshwater resources exceed 1,700 m³ per person. Water stress is an issue if these resources total between 1,000 and 1,700 m³ per person and year. Chronic water scarcity exists at values of between 500 and 1,000 m³ and a country is beyond the “water barrier” of manageable capability if renewable water resources total less than 500 m³. This index serves only as a rough guide, of course, since the distribution of precipitation in many countries varies appreciably by region and season. Moreover, it does not take account of the technological adaptability of individual countries in coping with an inadequate natural supply of water (e.g. via seawater desalination). The index is not ideal for a discriminating discussion on the problem of water scarcity. Nonetheless, as a guideline for the supply situation it is a good fit – albeit partly for lack of an alternative. To illustrate: according to the World Resources Institute (WRI), Germany has renewable freshwater resources totalling close to 1,900 m³ per person and year. In Egypt, the reading is slightly less than 800 m³ and in Canada over 91,000 m³ per capita and year; the world average totals roughly 8,550 m³, which is why, on paper, there is sufficient water on Earth even if the world population does continue to increase. In most countries, the available water resources are not in full use; Germany’s water industry association, the Bundesverband der Energie- und Wasserwirtschaft (BDEW), says the figure for Germany is little more than 20%.

The renewable freshwater resources correlate closely with the levels of precipitation in a given country. But there are exceptions. Much of the renewable water resources in Egypt, for instance, come from the River Nile, but the Nile is mainly fed from sources and precipitation in other countries of East Africa.

Water is not substitutable

The water market has a number of special features on the demand side, too. Water is indispensable for the survival of virtually all organisms on the face of the Earth; as a good, water is not substitutable. This is a major difference compared to most other economic goods.[2] Direct consumption of water (drinking or preparation of food) by humankind is negligible in terms of total water consumption.[3] But the absence of safe drinking water (potable water) and sanitation facilities is an existential problem affecting many people. In the latest UN report on the status of the Millennium Development Goals[4] it is affirmed that worldwide there are still nearly 900 million people without access to safe drinking water (of whom some 750 million live in rural areas). However, the numbers are trending down.[5] The situation is more difficult in the area of wastewater. Worldwide, about 2.5 billion people do not have basic sanitation facilities; the UN figures that this number can only be reduced minimally over the coming years because of the strong population growth. Some 1.5 million people die every year because of illnesses attributable to polluted water.

Agriculture is the biggest user of water

The biggest user of freshwater by far is irrigation farming (roughly 70% of global water consumption). In many developing countries and emerging markets this value at times noticeably exceeds 90%. The irrigated agricultural area on Earth has more or less doubled over the past 50 years (see section 3.1). The second most important users are the industrial and energy sectors with a combined share of around 20%. Finally, private households account for about 10% of

[1] See Heymann, Eric et al. (2007). 450 bn reasons to invest in India’s infrastructure. Current Issues. Deutsche Bank Research. November 28, 2007. Frankfurt am Main.

[2] For this reason, many institutions have demanded for years that access to safe drinking water be defined as a fundamental or human right.

[3] As the total supply of water resources is embedded in a hydrologic cycle, it is actually (more) correct to speak of water use.

[4] The water-related target is to halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.

[5] Between 1990 and 2006, about 1.6 billion people obtained access to safe drinking water. The greatest progress was made in the Far East.

Measurement of demand for water

There are various ways of measuring demand for water or water consumption. The most common way is to look at the amount of water that a country withdraws from surface water or groundwater sources. This reading can be set in relation to a country's renewable water resources in order to see whether it uses these resources sustainably or overtaxes them.

A further way that has attracted considerable attention for some time now focuses on so-called virtual water consumption. In this case, the focus is not only on a human being's direct water consumption, but also on all the water used for the production of goods and services destined for human consumption. According to calculations by the Water Footprint Network, the production of one kilogramme of beef requires roughly 15,500 litres of water from the beginning of the value chain right up to consumption. It is only natural that the industrial countries outstrip the developing countries and the emerging markets in the consumption of virtual water given their consumption patterns. With an analysis of virtual water consumption it is also possible to examine trade flows in respect of their impact on the use of water resources: when Europe imports consumer goods from China, the result is higher water consumption in that country; China thus exports virtual water, too. The fact that this virtual water consumption is not factored into the Falkenmark Index is a further weak point.

The third way of measuring water consumption and/or water demand is to examine household water consumption; it is generally measured on a per capita basis. Household water consumption has remained relatively constant in Germany over the past few years at around 125 litres per person per day; directly after German reunification household water consumption still totalled not quite 150 litres. In the US, the value comes to about 300 litres per person and day, in India merely 25.

use. Much of this household water is used for body care, flushing toilets and doing the laundry, especially in the industrial countries.

Demand for drinking water growing steadily

The key drivers of global water demand are closely correlated with population growth. This means that most of the prospective increase in demand for water is likely to be accounted for by the developing countries and the emerging markets, as 90% of the population growth forecast up to 2050 will be found in these countries.

More people will require not only more drinking water but also more food. For this reason, irrigation farming will continue to gain significance in efforts to boost agricultural yields; moreover, the quantity of pollutants finding their way into groundwater will probably increase in many countries owing to inefficient use of pesticides and fertilisers. The changing nutrition patterns in the world – greater consumption of meat and other animal products – will also contribute to incremental water use. According to the UN, bovine meat production requires 8-10 times more water than cereal production.[6]

A further reason for the increase in water consumption is the growing level of urbanisation, which is usually linked with a higher standard of living and higher water consumption. The UN estimates that the urban populations in Africa and Asia will roughly double between 2000 and 2030. All in all, 95% of the increase will be seen in cities in developing countries and emerging markets, which is why the problems of water supply and wastewater disposal are likely to be particularly acute in these areas.

Water seldom used sustainably

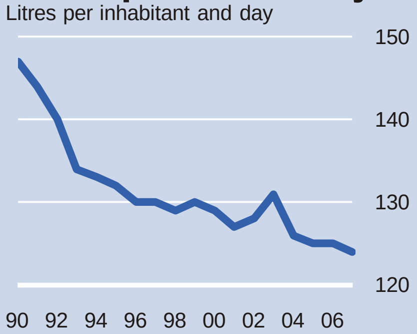
The problem of water scarcity or shortages (and also water stress) is caused, or exacerbated, in many places by wasteful use or pollution. The losses due to seepage and leaky pipes both in public supply systems and irrigation farming are in some cases far in excess of 50%, even in industrial countries. Inadequate treatment of effluent from industrial plants and households has resulted in much of the surface water in many countries becoming polluted. The UN says that more than 80% of the wastewater in developing countries and emerging markets flows untreated into lakes, rivers and seas. In China, the quality of over 70% of the water in the country's most important river systems is too poor to be used for human consumption.[7] Furthermore, problems of water availability will be exacerbated over the medium to longer term because in the very countries that have little precipitation – and agriculture is of major significance at the same time – the groundwater is being used more rapidly than it can renew itself. One of the consequences is a falling water table in the respective regions, which may cause damage to the local vegetation.

People's growing hunger for energy is a further driver of rising water consumption: the cooling of power generating plants is one factor that plays a part, but naturally also hydropower per se. A further factor worth mentioning is the increasing importance of biofuels. Already today, 2% of artificially irrigated agricultural land is planted

[6] See Schaffnit-Chatterjee, Claire (2009). The global food equation: Food security in an environment of increasing scarcity. Current Issues. Deutsche Bank Research. September 21, 2009. Frankfurt am Main.

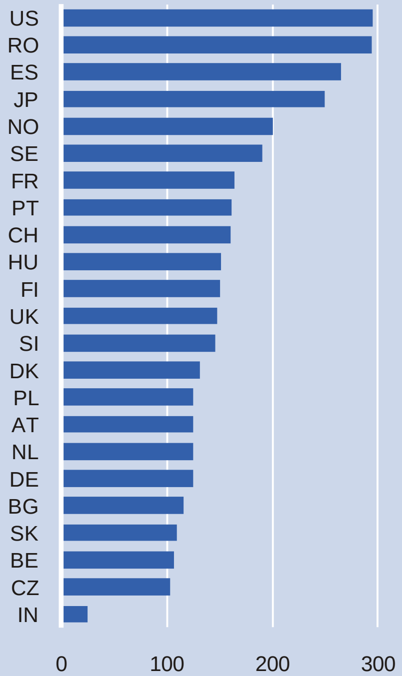
[7] See Heymann, Eric (2006). Environmental sector China: From major building site to growth market. Current Issues. Deutsche Bank Research. February 28, 2006. Frankfurt am Main.

Declining household water consumption in Germany
Litres per inhabitant and day



Source: BDEW **2**

US has highest household water consumption
Litres per inhabitant and day



Source: BDEW **3**

with crops that are ultimately used for the generation of bioenergy; in the US, this reading tends to be higher, while in Brazil, for instance, the level of rainfall usually suffices to ensure the production of "energy crops". Not only the rising demand for energy but also the growing industrialisation of the developing countries and emerging markets in particular are contributing to the increasing demand for water.

Many sectors rely on availability of water

While lack of access to drinking water is an existential problem for many humans, more and more companies have now realised that water availability may, or has already, become a factor limiting their business development. The spectrum of potentially affected sectors is huge, because no sector can get by without any water at all.[8] Besides agriculture, the food industry (including the beverage industry) is one of the sectors that requires large quantities of high-quality water. Further examples of intensive-use sectors are energy (e.g. cooling), mining (e.g. copper mines in Chile), chemicals and pharmaceuticals, paper and cellulose, textiles and clothing, and semiconductors. The tourism industry is also heavily reliant on water availability (for direct consumption by holidaymakers, swimming pools and golf courses). In many regions this results in a direct usage conflict with the local farming industry.

Given the trends discussed above, the "water availability" factor will become more important for many companies in the years ahead. Technologies enabling the available water to be recycled more frequently will gain significance (see section 3.2). The inadequacy of water availability also has huge macroeconomic effects, a fact that (so far) has mainly applied to the developing economies and emerging economies. In its report "Water in a changing world" published in 2009, the UN lists many examples of the economic cost of lack of investment in water. According to the UN, the inadequate infrastructure for water supply and sewage disposal in Africa triggers annual costs totalling about 5% of African GDP.

Demand for water now growing faster than in the past 50 years

The bottom line is that the global demand for water – as measured by withdrawals from surface water and groundwater sources – is likely to grow by about 3% per year on average over the next few years and thus at a faster pace than in previous decades. According to information from the UN, the annual increase in water withdrawals was slightly higher than 2% over the past 50 years or so.

Water stress on the rise – potential for related political conflicts

The problems of securing an adequate water supply will come to a head in the coming years owing to the above-mentioned trends and the consequences of climate change. The UN data on renewable water resources per capita enable the Falkenmark Water Stress Index to be compiled for individual countries. They show that in 2006 there were already about 1.9 billion people living in countries facing water scarcity or shortages (280 million of this total in countries experiencing shortages).[9] If extensive countermeasures are not

[8] See also Pacific Institute (2009). Water scarcity and climate change: growing risks for businesses & investors. A Ceres Report. Oakland. Moreover: Cartwright, Anton et al. (2009). Understanding water risks. A primer on the consequences of water scarcity for government and business. WWF Water Security Series 4. Godalming.

[9] Much smaller numbers are also to be found in related literature. This is probably mainly due to the fact that densely populated India fell below the statistical "threshold to water stress" (as defined by the Falkenmark Index) only recently.

ISO country codes

Abbreviation	Country
AE	UAE
AF	Afghanistan
AO	Angola
AR	Argentina
AT	Austria
AU	Australia
BD	Bangladesh
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BH	Bahrain
BR	Brazil
CA	Canada
CH	Switzerland
CI	Ivory Coast
CL	Chile
CN	China
CZ	Czech Republic
DE	Germany
DK	Denmark
DZ	Algeria
EG	Egypt
ES	Spain
ET	Ethiopia
FI	Finland
FR	France
HU	Hungary
IE	Ireland
IL	Israel
IN	India
IR	Iran
IQ	Iraq
IT	Italy
JO	Jordan
JP	Japan
KE	Kenya
KR	South Korea
KW	Kuwait
LY	Libya
MA	Morocco
MG	Madagascar
ML	Mali
MN	Mongolia
MZ	Mozambique
NE	Niger
NG	Nicaragua
NL	Netherlands
NO	Norway
PK	Pakistan

taken, both OECD and UN calculations suggest there is a risk of this figure increasing to 4 billion people by 2030.

If there is an increase in the water stress of many countries, it follows that the risk of political conflicts between individual states over shared water resources will also grow. For example, several countries claim to own rights to the waters of the rivers Nile, Jordan, Euphrates and Tigris, Indus, Colorado and Rio Grande. All of these rivers flow at least partly through very arid zones. At the same time, they are very significant for the supply of potable water, agricultural production or power generation in the countries they run through. If a bordering state uses an inordinately large amount of this water there is a risk of political conflicts, but also ecological problems, emerging downstream; the best-known example of this is the gradual disappearance of the Aral Sea, whose two chief tributaries have been tapped for decades for the irrigation of large cotton plantations. A full-scale "war for blue gold" has been prevented so far thanks to numerous international agreements governing rights on water use. Such contracts will probably become more important over the next few decades.

Government commonly exerts great influence on water industry

Governments have a sizeable influence on the sector in every country of the world, which is understandable considering the existential importance of water as an economic good. The government functions not only as a regulator but also as an operator. Water is supplied and wastewater disposed of largely by the public sector, or at least it regulates these activities. Besides, government is responsible for the bulk of investment activity in the sector; the UN says that the public share averages around 70% worldwide.

One very major difference between the water market and other goods markets is the pricing aspect. In the water sector, the price is usually set by the government and it does not reflect supply and demand. In most countries, the drinking water and wastewater prices (or charges) do not cover costs – particularly taking into consideration the scarcity rent of water as a limited resource. There are various reasons: the social component is particularly important since it is precisely in poorer countries that large swathes of the population are unable to pay anywhere close to prices that would cover costs (assuming they are connected to the public supply in the first place). In this case, there is seldom any form of control or way of metering water use. Flat-rate charges instead of consumption-related prices are not uncommon; there are even some industrialised countries (e.g. the UK) where many households nationwide are still not equipped with water meters. Besides, low water prices are used very deliberately as an instrument to foster certain sectors. This applies especially to agriculture, with farmers in some countries in fact receiving subsidies to be able to irrigate their fields (e.g. in the US, China and India). In many cases, no payment is made at all for the withdrawal of groundwater or surface water from lakes and rivers. The situation is similar for wastewater: in areas where wastewater is not treated, the users are usually not required to pay for its disposal.

Low prices lead to underinvestment in the water sector

The practices described result in prices being charged that do not reflect the scarcity of water as a resource. They encourage waste and cause or exacerbate many of the problems discussed above.

ISO country codes (cont'd)

Abbreviation	Country
PL	Poland
PT	Portugal
QA	Qatar
RO	Romania
RU	Russia
SA	Saudi Arabia
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SO	Somalia
SV	El Salvador
SY	Syria
TD	Chad
TG	Togo
TN	Tunesia
TZ	Tanzania
UG	Uganda
UK	United Kingdom
US	United States
YE	Yemen
ZA	South Africa
ZM	Zambia

The absence of ownership rights for water resources and corruption in the appropriation of funds earmarked for investments have a similar impact. Moreover, the low prices are the main reason that the actual investments in the water sector fall short of the real requirements. This holds for industrial countries, developing countries and emerging markets alike; nonetheless, it is not possible to exactly quantify the investment gap. The underinvestment impacts the reliability of the systems especially in poorer countries, so privately drilled wells or other forms of – in some cases illegal – water withdrawals gain significance; this in turn reduces the revenues of the public water utilities and results in an even smaller amount of investment in infrastructure as a consequence. This type of pricing has a daunting effect also on private investors – at least if the income needed for the amortisation of such investments cannot be raised via other instruments. For this reason, the investment gap can in many cases not be closed by private investors. Admittedly, there do not appear to be any simple solutions to these conflicts; we will discuss some possible options in section 5.

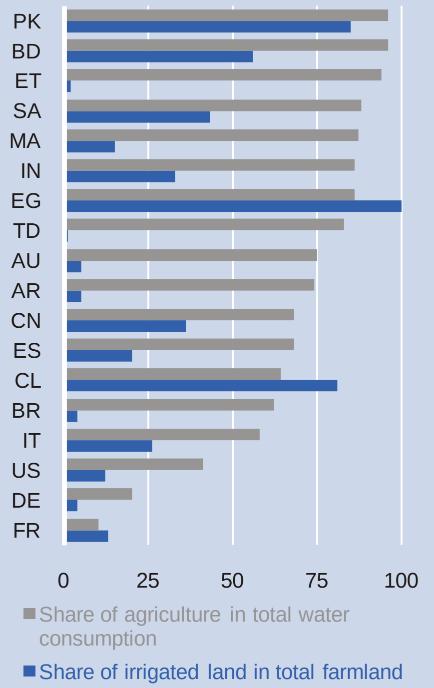
Water market is large – data basis fraught with uncertainty

Owing to the uncertainties pertaining to information on water prices, actually invoiced quantities and many other data problems it is difficult to calculate the volume (by revenue) of the global water market. Depending on which stages of the value-added chain are factored in, the numbers can vary sharply. The estimates to be found in the literature agree, however, that it is indeed a very large-volume market. As a rule, the amounts cited go into triple-digit billions per year. Roland Berger Strategy Consultants estimate that the global volume in the sustainable water management segment totals EUR 360 bn per year. The VDMA (the German Engineering Federation) puts the volume for the water market as a whole at USD 460-480 bn annually. Goldman Sachs plumps for USD 425 bn, and Berliner Wasserbetriebe, the Berlin utility, cites EUR 400 bn.[10] There are also varying estimates for the investment requirements. We will address this issue separately in section 5. One message is ultimately beyond dispute, however: the world water market offers sufficient potential for private companies to become stakeholders if the political and economic environments are conducive to doing so. Revenues in the sector are likely to grow more rapidly than the pure demand for water (3% p.a.), because the water prices are set to climb over the next few years.

[10] The readings are probably based on estimates/extrapolations, since only very few countries keep statistics on the volume of water market revenues. The example of Germany illustrates, however, that the stated magnitude is not unrealistic. For in Germany alone the revenue generated by the public water supply and wastewater disposal facilities totals roughly EUR 11 bn (2007), according to turnover tax statistics from the Federal Statistical Office. However, these statistics do not include revenues from the building of infrastructure or from technical equipment, for instance. If they are factored in and then an attempt is made to extrapolate a world market volume from the German values, e.g., on the basis of population figures, one very rapidly reaches the given dimensions.

Agriculture a key factor in water consumption

%



Source: World Bank 4

3. Major fields of action in the world water sector

3.1 Agriculture has greatest leverage

Agriculture accounts for 70% of global water use. The increasing global population and the changing nutrition patterns (more meat and more dairy products) necessitate an increase in agricultural output.[11] This in turn raises the need for irrigation. Such developments bring additional pressure to bear on already scarce water resources, making subsequent usage conflicts inevitable. In some developing countries today already more than 80% of the water supply is used for agriculture, even though only a fraction of the farmland is irrigated (see chart). From a global standpoint, the UN currently says that about 20% of cultivated land is watered by artificial irrigation – and the trend is to the upside. But this area yields around 40% of agricultural output, which indicates the positive impact of irrigation on unit productivity.

Food supply is major challenge

It will be very difficult for farmers to secure the world's food supply over the next few decades, with water availability being only one of the building blocks – albeit a very important one. Inadequate funding structures, mismanagement, ring-fencing of agricultural markets, inefficiencies in the distribution of foodstuffs or their waste are further reasons for food shortages in some countries. In many areas, the agricultural production methods are not sustainable. Soil quality suffers from exhaustive production, increasing salination or the decline in the water table. This often leads to even greater use of fertilisers and artificial irrigation – a vicious circle in the making. Up to 1.5 million hectares of farmland (almost the size of the state of Thuringia in Germany) become over-salinated every year simply because of inadequate irrigation methods; the sealing of the Earth's surface in the course of urbanisation and the spread of desertification compound the problems. Naturally, there are also cases in which agricultural land is gained, but this often occurs in ecologically questionable ways (e.g. deforestation).

List of measures for the agricultural sector

There is no disputing the fact that agricultural yields per hectare will have to increase to be able to meet humankind's rising demand for food; there is considerable latent potential for achieving this increase especially in the developing countries and the emerging markets. To boost the efficiency of water use in agriculture, particular attention should focus on the following measures:

— Raising water prices for farmers or at least phasing out subsidies in order to curb the amount of water wasted;

— Deploying more efficient irrigation technologies to reduce water consumption and avoid irrigation's negative side-effects (soil salination);

— Converting agricultural production in arid countries to products requiring little water;

— Encouraging trade in agricultural products.

Comprehensive approach needed

These measures, which we will address in more detail in the following, are closely linked with one another. They ought to be supplemented by other measures in keeping with a comprehensive approach to boosting efficiency in agriculture as a whole. Some of

[11] See DB Climate Change Advisors (2009). Investing in agriculture: far-reaching challenge, significant opportunity. London, New York.

the key parameters include education, more efficient use of fertiliser and herbicides, adaptation of crop rotation, seed type and planting methods to the respective climatic and topographical features (e.g. terraced fields).

Liberalisation of the global agricultural markets is overarching task

A factor of overarching significance is the liberalisation of the global agricultural markets to enable poorer countries in particular to gain access to important customer markets; this is a major prerequisite if productivity-boosting investments by farmers in developing countries and emerging markets are to pay off.

Higher water prices needed for agriculture

In most countries of the world farmers pay nothing or very low prices for the water they use. The absence of price signals results in more careless – or to be more precise: in inefficient – use of the scarce resource water. In countries with sufficient water resources this may not be dramatic. However, in arid zones this has fatal long-term ecological and economic consequences. Higher water prices for agriculture can sustainably reduce inefficiencies. But price hikes would be met with enormous political resistance. Nevertheless, it is clear that production in arid zones withdraws the basis of farmers' very existence if water use is not adapted to the natural features.

An alternative to higher water prices would be usage rights or quotas for withdrawals of groundwater or surface water. This is already the case in practice (e.g. in the US, Canada and Australia). Of course, this is predicated on ownership rights for water as a resource in addition to metering of water consumption and also sanctions on overuse.

Efficient irrigation technologies needed

When water prices for agriculture are introduced or existing prices increased, this puts farmers in a worse situation – ceteris paribus – than where they were before. This can however be (partially) balanced out via, for instance, the granting of government funding to farmers for the modernisation of their irrigation technology, since leaky pipes lead to water losses of 50% or more in irrigation farming worldwide. With many conventional procedures (e.g. surface or sprinkler irrigation, flooding) a large part of the water is lost to evaporation before it reaches the plants in the first place. Besides, the risk of soil salination is very considerable with these procedures because surface water that comes from, say, rivers has a higher salt content than rainwater. If the fields are irrigated with surface water for a fairly long period, the salt content of the soil increases. Part of the water evaporates, and the salt is deposited on the surface. If this process occurs in countries with little natural precipitation, the salt ultimately fails to be washed out of the soil. At the end of the day, the fertility of the cropland suffers.

Compared with the current situation it would be better to grant farmers subsidies to purchase more efficient irrigation technologies than to keep water prices artificially low. On balance, the farmers' financial situation could remain unchanged, which would reduce the political objections to higher water prices. Shifting subsidies in this manner ought to remain a limited exercise, of course, since farmers benefit in the long term from the more efficient irrigation technologies. The ecological advantages attributable to lower water consumption are obvious in any event.

There are many modern irrigation technologies which use water very much more efficiently than conventional processes. Drip irrigation is of major significance (see box). Irrigation technology is a

Case study: India

In parts of southern Asia (e.g. India) a rapidly increasing number of wells are being dug by farmers privately without prior government approval. The smallholders are thus seeking to raise the reliability of their water supply. Since water consumption is neither controlled nor metered these wells tend to lead to unusually strong overuse of the groundwater and thus to a decline in the water table.

Drip irrigation

A good way to minimise water consumption in agriculture is by using drip irrigation. In this method, a system of hoses is installed with outlet valves ("drippers") at regular intervals; these allow a constant, albeit small amount of water to be released. The advantage of the system is that evaporation and runoff losses can be reduced considerably; soil salination is also reduced. The water is released under low pressure, lowering energy costs. According to a study conducted on behalf of Germany's VDI, the Association of German Engineers, drip irrigation systems are over 90% efficient (instead of roughly 50% as with surface irrigation). In combination with supplementary metering, control and regulation technologies as well as membrane technology the water released can also be regulated at every dripper. If this system also offers the possibility of fertilising crops, one refers to the process as "fertigation". One disadvantage of drip irrigation is the risk of the drippers becoming plugged. For this reason, the procedure is predicated on having relatively clean water.

One solution using particularly sophisticated technology is soil moisture sensors that can be monitored and controlled by GPS to ensure irrigation of only those areas that require water. Other sensors can determine whether the soil is contaminated with arsenic or some other heavy metal.

A further method of irrigation is known as sub-irrigation. In this case, water is delivered from the ground below the plants for their absorption. One advantage over the conventional sprinkling method is smaller losses due to evaporation. One disadvantage is the high investment costs for laying underground piping systems. Besides, this type of irrigation is not suited for flat-rooting crops.

rapidly growing, innovative sector. The modern processes are to be found increasingly often in the industrial countries. Positive experience has also been reported with sealed greenhouses (e.g. in southern Spain). They offer very promising ways of irrigating plants using alternative methods that require very little water. The water that the plants lose via evaporation is kept in the system and can thus be used more than once. Water consumption can be reduced anyway in irrigation farming by using greenhouses or simple plastic films.

Because of high costs, some of the technologies mentioned are initially better suited for use in industrial countries. But water availability for farmers can already be improved by using inexpensive and relatively simple catchment and storage systems. In some cases, wastewater can also be used for irrigating fields. Used properly, wastewater is a low-cost fertiliser with a positive impact on agricultural output especially for poorer countries. Naturally, any risks to human health must be ruled out, making such a solution contingent on proper training.

Suitable plants for the given location

Crops that require large amounts of water should not be planted in dry zones

At first glance, one relatively simple way of reducing water consumption in agriculture is to adapt the types of crop planted to the local climatic conditions. Agricultural products requiring a relatively large amount of water (e.g. wheat, bananas, tomatoes or rice) should not be grown in places where it seldom rains or surface water and groundwater are in short supply. In these regions it makes sense to plant crops that are fairly resistant to drought or aridity (e.g. maize, millet, olives, grapes or dates). However, such a conversion of agricultural production may encounter considerable opposition, since the farming structures in many countries have taken decades to develop and can only be changed with difficulty. Ultimately, higher water prices may be an incentive to change practices in this respect, too.

Opportunities in genetic engineering and biotechnology

Genetic engineering and biotechnology offer opportunities to reduce the water requirements of cultivated plants so that they can also be grown in dry regions. This potential should not be wasted frivolously. It is therefore key that policymakers and the companies operating in these fields intensify their research so they can learn more about the related opportunities and risks; this is already advisable on the grounds of securing the global food supply alone.

Case study: Saudi Arabia

Even though Saudi Arabia has very low renewable water resources (not quite 100 m^3 per capita and year), it operates large cattle farms and raises many agricultural products on its soil. To do so, it relies on seawater desalination plants or (fossil) groundwater which, in the first case, is very energy-intensive and, in the second, unsustainable on a long-term horizon. From the standpoint of resources it is not economically feasible to produce food in this country, for it would be cheaper to export the energy used for this purpose in the form of crude oil and to import agricultural products (and thus water) from countries with more suitable climatic conditions. In fact, when Saudi Arabia exports food it sends one of its scarcest resources abroad. Of course, security policy considerations play a role in such measures: a country does not want to have to rely on food imports if at all possible. But the acute scarcity of water in Saudi Arabia has brought about a change of heart. Officials say that the only source of wheat up to 2016 will be imports.

Trust in the virtues of trade

The aspect discussed above is directly linked with demands to expand trade in agricultural products and to trust in the existence of comparative advantages. Countries in which the production of certain agricultural products is only possible at very high costs and/or with very high water use ought to import these products instead. The best negative example known for years is agricultural production in the desert kingdom of Saudi Arabia (see box).

As a matter of principle, trade in agricultural products has to take the virtual consumption of water into account, for every agricultural product shipped abroad is virtually also a water export. For this reason, particularly countries with water stress should very closely examine what products should be raised in the domestic market.

A major task, but not impossible

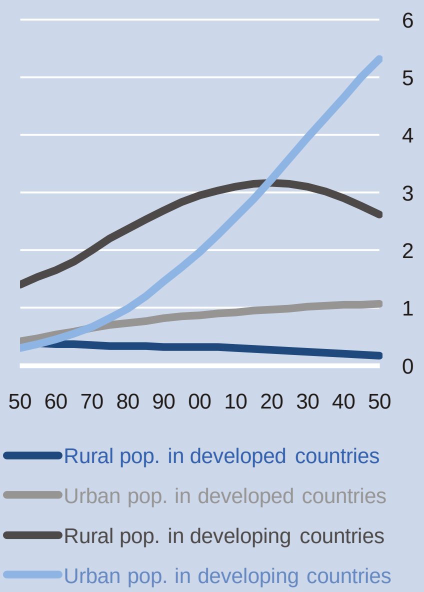
To put it in a nutshell, the agricultural industry faces major challenges – especially, but not only, because of the growing scarcity of water. Nonetheless, technologies do exist that enable more efficient use of water. Governments require courage to change the policy framework in such a way that less water is wasted; this holds for price hikes in particular. And the sector itself must respond flexibly and as rapidly as possible to the developments which it can scarcely influence anyway; more efficient irrigation technologies play a particularly important role in this regard. There is even a role for the financial industry, for both countries and farmers require capital to be able to fund the new technologies. As an example, many smallholders could be helped – by means of microcredits – to make the necessary investments to adapt their forms of agricultural production.

Microcredits for agriculture may help to boost the efficiency of irrigation

3.2 Challenges arising from urbanisation and industrialisation

Cities in developing countries growing rapidly

Population (bn)



Source: UN **5**

In 2008, more people lived in cities than in the countryside for the first time in history. In section 2 we pointed out that the growth of the urban population would continue to outpace that of the rural population in future. By 2030 about 60% of the total population will live in cities. The absolute growth will be seen mainly in the developing countries and the emerging markets, where many people hoping to find employment will move from the countryside to the city. In 2030 about 80% of the urban population will live in cities in developing countries and emerging markets; today the figure is about 72%.[12]

Parallel to this development, the degree of industrialisation particularly in the developing countries and the emerging markets is also on the increase. For instance, the secondary sector in China and India has been an above-average driver of economic growth. Its contribution to total value-added increased by over 5 percentage points in China between 1990 and 2009, and around 2 pp in India. Many poorer countries will not see the start of a significant industrialisation process until several years down the road. While the tertiary sector has been predominant in Western industrial countries for years, industry is still a major economic driver here, too.[13]

These two trends will mean a steady increase in the demand for water in urban areas over the next few years. This will go hand in hand with major challenges for the different levels of government, an aspect we shall address in the following.

Cities in water stress

In cities around the world, infrastructural shortcomings have reached gigantic proportions. Cities have to cope with challenges in water management while taking into consideration sometimes very diverse political, social and economic circumstances. The water infrastructure of the cities was neglected for so long that a problem which could have been solved gradually in the past has now necessitated a rapid rethink.

Infrastructure expanding more slowly than population

Major allocation conflicts

The explosive increase in the urban population – while the growth of government revenues has been losing steam – has come to mean

[12] See Just, Tobias (2008). Megacities: Boundless growth? Current Issues. Deutsche Bank Research. March 12, 2008. Frankfurt am Main.

[13] See Ehmer, Philipp (2009). Services in the throes of structural change: Knowledge-intensive business services on an uptrend. Current Issues. Deutsche Bank Research. September 10, 2009. Frankfurt am Main.

that public funding for infrastructure cannot cover the actual investment requirements; this holds above all for poorer nations. Particularly the slums expanding on the fringes of major cities owing to a lack of urban planning are finding themselves in a precarious situation. In such cases, the required development of the infrastructure trails hopelessly behind the pace of expansion. Many slums have absolutely no infrastructure; access to drinking water and sanitation facilities is the exception. This is often exacerbated by a gulf between rich and poor: in developing countries, relatively affluent urban areas are more likely to be connected to the government-subsidised utility system; their supply is more reliable and relatively cheap. The inhabitants in many poor areas lacking access to the public water supply often have to pay large sums to mobile traders who truck in their drinking water. This is a case where the poor subsidise the rich.

Sizeable water losses due to home-grown problems

Examples of water losses

According to the BDEW, Germany posts the smallest water losses in the public supply network in the EU, at about 7%. The loss rate in the larger countries of western Europe ranges from 20% to 30%. The American Society of Civil Engineers (ASCE) estimates that around 26.5 million cubic metres of safe drinking water (or 15% of the total) are lost every day in the United States on account of leaky pipes. The World Bank puts the physical losses of tap water in the urban regions of the world at close to 33 billion cubic metres per year; this would be enough to cover consumption in New York City for over 20 years. Add to this a further roughly 16 bn m^3 of treated tap water for which no payments change hands because, for example, its consumption is unmetered. The World Bank says the overall economic losses from non-revenue water (leaky pipes and missing payments) total nearly USD 15 bn per year.

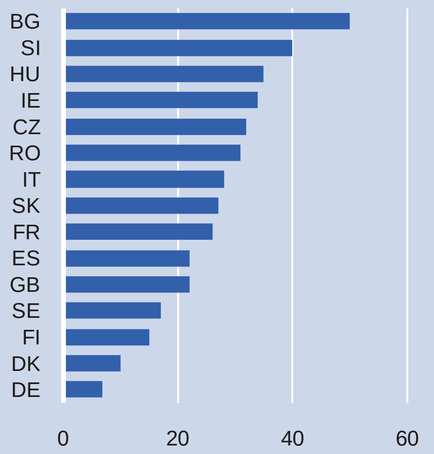
Crumbling and incomplete water infrastructure can have serious consequences. The losses due to pipeline leaks are skyrocketing, and because water meters are thin on the ground it is not possible to charge for actual water consumption by the user. Much of the water piped into the system is not paid for (this phenomenon is referred to as non-revenue water). A World Bank estimate puts this share at around 35% in the emerging markets, and in fact as high as 50-60% in some developing countries. On the one hand, potential investors may be scared off because it is harder for the investments to be amortised in the absence of appropriate countermeasures. On the other hand, though, there is a chance of turning non-revenue water into revenue water via targeted investments. The industrial countries are not spared this problem, but they do tend to have the financial and technical capacities to cope with it.

The reasons for these inefficiencies are the age and poor maintenance of the systems, which in turn are linked with funding bottlenecks and political mismanagement. Many governments tend to subsidise water with a view to currying the favour of the electorate. However, this leads to a further deterioration of the system. In order to reduce the share of non-revenue water governments also ought to be more rigorous in tackling the rampant corruption in many areas of the public sector. According to UN estimates, in some countries roughly 30% of the funds budgeted for the water supply are lost to corruption. A further reason for the infrastructure shortcomings is that the authorities responsible for the water supply in cities and municipalities frequently lack the required expertise, are insufficiently motivated or understaffed. This hampers the development of the regulatory and institutional structures necessary for more efficient “water policy”.

The problems discussed appear predominantly in developing countries and emerging markets. But, in the final analysis, similar challenges once also confronted the cities in today’s industrial countries. Here, too, it took several decades to develop the water infrastructure and at the end of the day this only succeeded because the users made a fairly major contribution to its funding. Now, new problems dominate the agenda in the industrial countries. The infrastructure of cities such as London, New York, Paris or Berlin was installed over 100 years ago in some cases. Since modernisation requirements were long neglected the need for a revamp is all the more urgent: the dilapidated water and sewage systems are linked with health risks, for example.

Minor water losses in Germany

Water losses in public supply network (%)



Source: BDEW 6

Technical advances are a help

Impressive technologies that address urban water challenges are emerging all over the world. To get to grips with the problem of defective pipes, an Israeli firm recently developed a pilotless drone that flies above cities sending water data to computers. Cities can also install technologies such as acoustic or ultrasonic sensors. Microorganisms and UV disinfection equipment can be used to purify and sterilise drinking water. Even residential areas that currently rely on water deliveries by tank trucks can benefit from new cost-saving alternatives. In Peru, for instance, water can be “combed” out of moist air with the help of fog catchers made of plastic and channelled into storage basins. Even though only small water quantities are collected, they are sufficient to make a significant contribution to household water consumption.

The negative consequences of inadequate wastewater disposal

The WHO estimates that inadequate wastewater disposal prevents or harms close to 65 million life years every year. According to these estimates it is annually the cause of 1.5 million hepatitis A infections, 133 million worm diseases, 160 million cases of schistosomiasis, 120 million gastrointestinal infections and 50 million cases of respiratory disorders.

Spot pollution arises because of, for example, leaks in sewage canals or wastewater containers. Diffuse pollution results from, for example, the direct discharge of untreated effluents into the environment or the direct use of wastewater for agricultural purposes. When suspensions enter bodies of water in large volumes the water darkens with negative consequences for autotrophic organisms (e.g. seagrasses or algae). Toxic materials, metals and pathogenic germs cause acute or fatal harm to marine organisms.

Water charges should enable full cost recovery

Many studies indicate that people in industrial countries would be prepared to pay more for drinking water if they were aware of the high risks facing their future water supply; this would presumably apply similarly to people in developing countries. But people often lack the mindset to pay an appropriate price for water. Without such information, though, price hikes usually encounter stiff public opposition.

In some countries high prices are demanded – and paid – for water, which explains why there are very big differences in its price internationally. According to Global Water Intelligence, water prices in, say, Berlin are 80 times higher than in Delhi; this means that the difference is eight times the relation of per capita GDP between India and Germany no less. Even in most of the OECD countries, the prices charged for water are too low to completely cover operating and maintenance costs. Therefore, an important lever could be gained if the governments made it clear to their citizens that greater security of supply and water quality usually go hand in hand with higher water prices. This holds particularly for countries that hitherto have had very high subsidies, which is why the objections voiced there could be loudest. It goes without saying that segments of the population unable to pay the higher prices must continue to be supplied at largely no cost. One option might be to subsidise the basic needs of poorer households. But generally rising prices would be charged for water consumption for additional or commercial purposes. Consumption-related prices – instead of flat rates – are a key signal to discourage the wasting of water. Naturally, the revenue generated must also be used for the further development of the infrastructure so that the consumers directly recognise the positive effect of higher prices.

A key aspect of a pricing reform, moreover, has to be the conversion to cost-oriented basic prices and operating prices (i.e. fixed and variable shares in the overall price). In most countries (including Germany) the basic price is too low (by about 20%) in relation to the considerable fixed costs; by contrast, the operating price is too high (often by about 80%). Therefore, in a price reform the ratio should be reversed. This would take better account of the scarcity of water as a resource and would result in financial sustainability. A decisive factor, naturally, is an appropriate pricing model to cover both the fixed and variable cost components in order to stop people from wasting water; this holds particularly for countries with water stress. All in all, such a conversion leads to greater benefits for users without its having a negative impact on producers.

Potential for public-private partnerships

It is a major challenge for almost every city to find a way to reconcile cost-covering water prices with social aspects. There is no universal solution. What might be of assistance is a comparison of cities to determine some of the reasons for inefficiencies and water losses. In most cases it is probably economically and ecologically more sensible to first raise the efficiency of existing systems (that is: reduce pipeline leaks and improve revenue collection procedures), instead of tapping additional water resources via a large-scale redevelopment of the infrastructure. For the water that because of leaky pipes currently fails to reach the end-consumer could provide additional supply for millions of people. Of course, rapidly expanding cities will have no choice but to expand their infrastructure. The measures needed in the respective cases are best decided by the local politicians; centralised systems are probably inferior.

An important contribution to higher efficiency in the water supply system can be made by public-private partnerships (PPPs). PPP models are often the subject of public controversies, but they are a way of securing the necessary know-how and funding. Private-sector involvement is successful in those areas in which existing infrastructure has to be modernised; however, PPPs are also possible with newbuild projects. It is vital to note that the government always retains sovereignty over the policy framework (see also section 5).

Wastewater: The often unrecognised problem

People naturally focus mainly on access to safe drinking water since it is vital for human survival. But an aspect that is frequently neglected is the major economic and ecological significance of wastewater and the infrastructure necessary for its disposal. Industry plays a particularly important role in this respect since wastewater arises not only in private households but also and especially in industrial processes. The challenges linked with the high and rising volumes of wastewater are very complex.

Inadequate wastewater treatment harms health, drinking water and soil

A missing or inadequate wastewater disposal system is the cause of a multitude of illnesses that develop via contact with pathogenic organisms (germs, bacteria and viruses). These can trigger infections such as diarrhea, cholera, gastritis, typhus or fever illnesses which lead to the death of about 1.5 million people every year. Apart from pathogenic organisms, the high concentration of nutrients in wastewater can accelerate the growth of algae. Some types of algae have a toxic effect on the human organism. Wastewater can contaminate drinking water resources and soil either at particular spots or by diffusion through the system. The body of soil or water polluted by human activity is not suitable for direct human use (e.g. as a source of drinking water) or commercial use (e.g. fisheries).

The phosphorus cycle

The natural phosphorus cycle on Earth proceeds in periods that last several million years at a time. The mining of phosphorus-containing rock brings about 18 m tonnes of phosphorus into the cycle every year. Justus von Liebig identified phosphorus as a limiting factor in agricultural yields in 1840. Nearly 90% of raw phosphates are processed into fertiliser. In addition, phosphorus is a component of genetic make-up. The vitally necessary daily dose totals about 0.6-0.7 grammes. Phosphorus is an element that can be economically extracted from existing deposits – as things stand today – for a maximum of about 115 years. For reasons of resource economy and ecology it is therefore essential to use phosphorus sparingly. Modern concepts such as “ecological sanitation” can help to fulfil these objectives.

Eutrophication (Overfertilisation) of bodies of water

Effluents not only from households and industry but also from agricultural processes may lead to harmful effects on bodies of water. The damage is caused by both inefficient fertilisation in agriculture and the influx of nutrient-containing urban and industrial effluents; the most significant nutrients are phosphorus and nitrogen. These are linked with harm to, or the loss of, flora and fauna in the affected water. According to estimates from the United Nations Environment Programme (UNEP), the nutrient concentration in seas and oceans will rise by about 10-20% in the next 30 years. The forecast says that particularly Asia and Europe will be impacted by this development.

From the aspects of sustainability and economic efficiency, a reduction of the nutrient emissions into bodies of water is the order of the day. This could be done by ensuring that the nutrients from the wastewater are separated and subsequently recycled. Moreover, this would be a way of reducing the costs of procuring nutrients. The most important lever, though, probably lies in raising the efficiency of fertilisation. Considerable progress on this score is still possible worldwide.

Demographics require changes in infrastructure

In many regions, demographic change will mean a decline in population. This will lead to technical problems such as a lower flow rate in sewage systems. In addition, the high fixed costs of the sewage system will be spread over fewer inhabitants, leading to an increase in the specific charge per cubic metre of wastewater and person. All in all, the existing wastewater systems will have to be adapted to the changing framework conditions over the medium term.

High-tech solutions for treating wastewater

Wastewater management is a high-tech business in the developed countries. However, adaptation strategies may be necessary to accommodate changes in the framework conditions. In what follows we will explain concepts which, because of high investment costs, are mainly suitable for industrial countries. In section 3.3 we will discuss several low-tech solutions for developing countries and emerging markets.

Ecological sanitation

Wastewater as a recoverable resource

The concept of ecological sanitation (ecological wastewater management) is based on the recycling of materials. This is tantamount to a paradigm shift: wastewater is not regarded as "waste material" but instead as a recoverable resource. Two main advantages emerge: first, the reduction of emissions into bodies of soil and water and, second, the recycling of recoverable resources. While production-related closed processing and cooling-water loops are in many cases state of the art in industry, the concept of ecological sanitation additionally covers the use and reuse of wastewater from households or industry.

Household wastewater consists of three main components (grey water, yellow water and brown water) with diverse properties. While (faeces-contaminated) brown water contains most of the organic substances (substrate), (urine-contaminated) yellow water contains nearly all the soluble nutrients such as nitrogen, phosphorous, potassium etc. The type of wastewater found most frequently is grey water (household wastewater excluding yellow and brown water), which shows very low nutrient loads. Different use features emerge as a result. Following treatment, grey water may be channelled back into the household water cycle, into a receiving water course (e.g. river), or be allowed to drain back into the soil for groundwater recharge. The material substances can then be recovered from the yellow and brown water; the remaining water can be released into a receiving water course. The at times very high investment costs and the lack of experience in running such systems can be a problem. In the following we shall present three different ecological sanitation concepts:

— **Separation toilets and gravity system:** With this system, yellow water and brown water are channelled into separate containers. The yellow water is used for agricultural purposes. The brown water composts in the container. The ripe compost can be used for agriculture, too. Grey water can be treated separately in, for example, a constructed wetland or a membrane filtration system. The purified grey water can subsequently be released into the household water system or the environment. Choosing this decentralised disposal option obviates the need for conventional sewage systems, which substantially reduces the cost of capital. For this reason, this system is appropriate for sparsely populated regions. One disadvantage is the expense involved in emptying the containers.

— **Vacuum toilet with biogas plant:** In this model, yellow water and brown water are channelled from a vacuum toilet to a biogas plant. There, the wastewater is treated anaerobically. The biogas extracted is used to generate electricity or heat. The digested sludge from the biogas plant can be used in agriculture. The grey water is treated separately as in the preceding example.

Grey, yellow and brown water

Grey water is domestic wastewater that is not discharged into the environment via sanitation facilities. This includes, e.g. water used in washing machines, dishwashers and showers. Yellow (urine) water and brown (faeces) water are terms for effluent from sanitation facilities. Together, yellow water and brown water may also be referred to as black water.

A single person creates a grey water volume totalling between 25,000 and 100,000 litres per year. By comparison, a person produces 500 litres of yellow water and 50 litres of brown water during the same period. The main nutrients in this wastewater are nitrogen, phosphorus and potassium. A nitrogen load of 4-5 kg is emitted per person per year. The bulk (nearly 90%) of the nitrogen load is found in yellow water. Emissions of phosphorus per person and year total a mere 0.75 kg. 50% of this amount is in yellow water and about 40% in brown water. Some 54% of the potassium (emission volume of about 1.8 kg per person and year) is in yellow water, and just over one-third in grey water. The substrate determines in particular the level of the chemical oxygen demand in wastewater, which is about 30 kg per person per year. Some 47% of this load is in brown water, about 41% in grey water and merely 12% in yellow water.

Case study: Vacuum systems

An integrated sanitation concept with vacuum toilet, vacuum dehydration and biogas plant has been implemented in Luebeck's Flintenbreit housing estate for about 350 inhabitants. A vacuum pump station is set up next to a digester tank. Besides biogas, the plant also produces liquid fertiliser. The fertiliser produced is stored in containers until it is transported away to a farming operation.

Rainwater management

The aim of rainwater management is to allow precipitation to run off locally and thus to provide relief for the sewage pipes and treatment plant. One positive ecological side-effect is the promotion of local groundwater recharge. There is a whole host of applicable measures. The demolition of unused buildings and the unsealing of sealed surfaces improve the flow patterns in the sewage system when it rains. Rooftop cultivation is also a good variation on the theme of rainwater management. The plants act as a storage medium from which part of the rainwater evaporates, so there is less run-off. Besides, the run-off is spread over a longer period thanks to rooftop cultivation, so this helps to reduce peak run-off flows in the sewage system. Fairly large open areas are required for these measures – which are often thin on the ground in urban centres in particular. To enable the rainwater to run off nonetheless, different drainage systems can be set up. Of course, these do require investment. It might be helpful to impose rainwater charges to incentivise its drainage on private property; the higher the share of drainage, the lower the charges.

— **Adaptation of the existing wastewater system to incorporate separation toilets:** The use of separation toilets in the conventional sewage system means yellow and brown water can be captured separately. One can opt for centralised or decentralised collection. In decentralised collection, yellow water is stored on a decentralised basis and drained off. In centralised collection, by contrast, yellow water with a low pollution content is released into the sewage system and captured and stored separately in the treatment plant. Thanks to telecontrol technology the time for emptying the containers may be optimised so that a concentrated yellow water flow can be captured upon arrival at the treatment plant. This would allow the plant to only process grey water that could be returned to the urban water cycle or released into the surrounding environment.

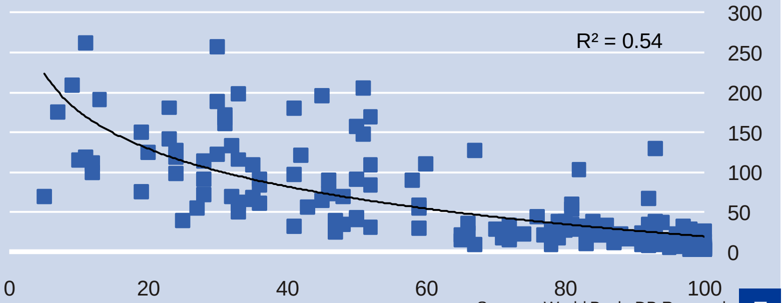
Treatment of industrial wastewater

Besides wastewater from households, which has been in the spotlight up to now, industrial wastewater also has to be treated. This is largely guaranteed already in the industrial countries, but in many developing countries and emerging markets this poses a huge challenge, because in these regions much of the wastewater is discharged untreated into surface water. In order to change this situation the use of traditional regulatory legislation has proved its worth: the government sets limits on the level of pollution in effluents that industrial companies are allowed to release into surface water or the public sewage system. If the limit values are exceeded, heavy sanctions are imposed. This requires that the monitoring of the limit values be guaranteed, necessitating the existence of reliable political structures. Naturally, it is possible to support companies when they install the corresponding infrastructure. The upcoming challenge can only be managed one step at a time. However, there are good prerequisites for doing so, since the emitters of the wastewater are, as a rule, more likely to have the necessary funds at their disposal than households.

3.3 Water for the nation's poorest

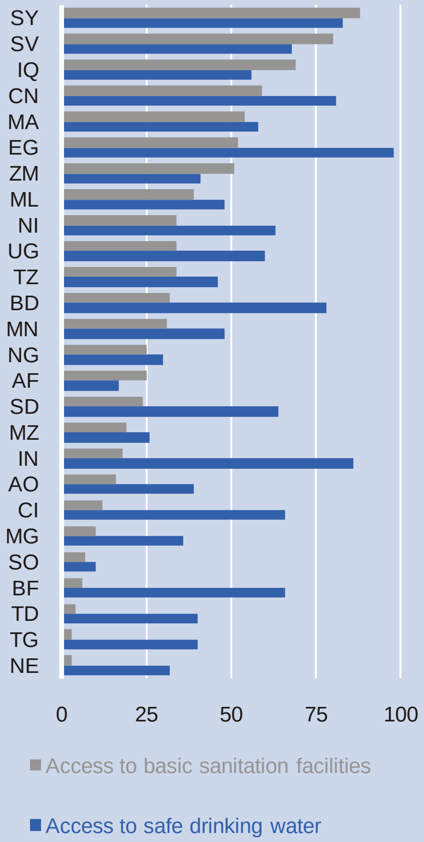
In section 2 we outlined the existential problems linked with water supply and wastewater disposal confronting particularly the rural populations in developing countries and emerging markets. In arid zones, the challenges increase exponentially. The ratio of connections to the public water supply and disposal systems is very much lower in rural areas than in urban areas. The absence of appropriate water infrastructure is closely linked with problems such as poverty, hunger and the spread of disease particularly in sub-Saharan Africa as well as south and east Asia. Of the poorest strata of society in the world some 75% live in rural areas. Poverty and insufficient access to an adequate drinking water supply or basic sanitation facilities are closely meshed with one another. Without a local water supply, children, youths and women in many rural areas often have to spend several hours per day just to procure water for their families from far-away wells or springs. This reduces their chances of getting an education and ties up labour.

High child mortality in countries with inadequate access to sanitation facilities
X-axis: Share of population with access to basic sanitation facilities (%)
Y-axis: Mortality rate of children under 5 (per 1,000 births)



Sources: World Bank, DB Research 7

Rural population in developing countries poorly supplied
Share of rural population with access to water infrastructure (%)



Source: World Bank 8

Demand for cheap, targeted solutions

There is no universal solution to these problems, since, among other things, there are exceedingly diverse climatic and topographical conditions in the affected countries or differences in the way the different segments of the population live. Nonetheless, there are many approaches aimed at improving the supply situation for poor people in the developing countries and emerging markets. It goes without saying that these have to be geared to demand, for often it does not take much to achieve a noticeable improvement in the water supply. By contrast, many high-end technologies that are developed for say the Western European market are not suitable for the rural population in poor countries: they are too expensive and in some cases cannot be operated or repaired by the local population.

It is helpful particularly in countries with little precipitation to take measures that enable water to be stored over a fairly long period. According to the UN, only about 4% of the water resources available annually in sub-Saharan Africa are now stored for later use. Simple collection basins or rainbarrels, underground cisterns or so-called sand dams are, in principle, appropriate options. The sand dams are barriers across small tributaries or anywhere where water runs off in relatively large quantities following rainfalls. These dams are filled with sand. This enables the rare rainfalls to be caught and stored in the sand for a fairly long time. Without sand the water would evaporate or drain away very much more quickly. Besides, the sand also has a filter function and raises the water quality.

The local groundwater deposits can be tapped by drilling wells. Simple pumps (also hand-operated ones) may suffice as appropriate solutions for rural populations. It is helpful during the planning and construction of such facilities – besides simply providing water for household use – to examine the possibilities for other types of use (e.g. for irrigation, animal husbandry, processing and refining of agricultural products or developing small-scale business operations). The agricultural yields can be boosted via more efficient irrigation technologies (see section 3.1), which enables farmers to engage in trading of their products. The recycling of water for various purposes (e.g. personal hygiene and irrigation) can also help to reduce the scarcity of water. Water quality can be boosted via relatively simple filter and water treatment systems (e.g. ceramic filters).[14]

[14] See FAO (2008). Water and the rural poor. Interventions for improving livelihoods in Sub-Saharan Africa. Rome.

Low-tech systems for treating wastewater

Simple sanitation facilities improve living conditions

Affordable technical solutions enabling access to sanitation facilities for large numbers of people also exist for rural areas in poor countries. These systems are simple in function and can improve the living conditions of many people with a modest amount of investment. One example is dry toilet systems that store the collected matter in septic tanks and subsequently recycle it for agricultural use. The advantage here is that nutrient and substrate-rich human excrement is re-used for agricultural purposes, allowing the substitution of biological fertilisers for conventional types. Dry toilets involve relatively low investment and installation costs, and require little maintenance.

Accompanying measures are important

To enable the poorest strata of the population in developing countries and emerging markets to achieve a permanent improvement in their way of life, water infrastructure measures require supplementary programmes. It is particularly important to gain knowledge about the local water systems, the possibilities and also the limits on the use of existing water resources, and about any technical facilities already in place. Clearly defined ownership rights for croplands increase the level of individual responsibility felt by local farmers. Not only more efficient irrigation methods but also access to suitable seed and/or fertilisers can boost agricultural yields. The scope for selling excess agricultural produce would be enhanced if the respective markets in industrial countries were opened to a greater degree. A combination of cooperative ventures between the local farmers in developing countries and emerging markets and external consultancy ought to ease the process of stimulating trade. Naturally, politically stable conditions are helpful for making progress on the supply situation.

Who picks up the tab?

Development aid an important source of funding for water projects

The above-mentioned measures cost money. And, naturally, the means of the poorest section of the population are heavily restricted in rural areas. Unlike the urban population, rural dwellers generally are not required at present to pay for the water they use, and cost-covering prices will remain illusory for the foreseeable future. This raises the question as to who should fund the investments. Since, as a rule, no self-sustaining business model exists and humanitarian aid is at the fore, traditional development aid is predestined to be a source of funding. There are indeed a host of water-related projects which are funded via development aid, the World Bank or comparable institutions. Foundations that pursue humanitarian objectives might also find water projects in poor countries to be lucrative fields of endeavour. It generally holds that investments in water infrastructure provide considerable leverage for boosting human health and cutting the economic costs resulting from inadequate infrastructure. The WHO calculates that for every euro invested in developing countries in water supply and sanitation facilities it is possible to generate a return in the form of mitigated economic costs of EUR 4-12. If these numbers hold water, it is a wonder that many more measures haven't been taken to improve the supply situation. Probably a key reason for this is that a potential investor does not benefit from the decrease in macroeconomic costs.

Besides external funding, it is also possible to subsidise basic provision from tax revenues. A further funding option is to grant microcredits. These could flow into low-tech water projects and thus create the prerequisites for the development of entrepreneurial units in agriculture, for example, so that the credits can also be repaid.

Fields of activity for private businesses as well

In most cases it is probably not lucrative for private companies from the water sector (e.g. suppliers of the technologies discussed above) to go it alone in rural areas of developing countries and emerging markets. Nonetheless, private companies can make a substantial contribution towards improving the living conditions of the people affected, i.e. by offering their know-how in the framework of, for example, development aid projects. In such cases, the proceeds for the companies do not come from the people for whom the investments were made but instead from the organisations responsible for the projects (see also section 5).

Settlement and population policy are key

Climate change increases burden on sewage systems

The increased number of sealed surfaces and the more frequent heavy rain events occurring due to climate change can be a burden on existing sewage systems due to higher peaks when water runs off. The consequence is higher hydraulic pressures in sewers and treatment plants combined with an increasing level of untreated wastewater being released from the sewage system into the environment (so-called discharge quantities). A negative view has to be taken particularly in mixed water systems of the rising number of discharge events releasing nutrients and substrate loads into the environment.

Water consumption correlates closely with the growth of the population. For this reason, when looking for solutions to the inadequate supply situation in rural areas of poor countries it is imperative to also cast a glance at settlement and population policies. The fact of the matter is that when large numbers of people are allowed to settle in dry zones or massively expand already established settlements there, this only increases the degree of water stress. In underdeveloped countries in particular it is not a simple job to embed water availability in settlement and population policy.

The situation could be slightly defused – relative to the situation in the cities – in the longer term because of the fact that from about 2020 the population figure in rural areas is likely to fall also in the less developed countries.

4. Climate change: A new challenge

Higher temperatures on Earth …

A majority of scientists now acknowledge that anthropogenic greenhouse gas emissions make a key contribution to climate change on Earth. While uncertainties remain about the concrete consequences of climate change, some trends are considered very likely to last. Over the next few years the Earth will probably continue to grow warmer; since the beginning of industrialisation global average temperatures have risen by about 0.8°C. As a consequence, scientists, among others, expect more frequent and/or more pronounced weather extremes (e.g. droughts or heavy rainfalls), changes in precipitation patterns, a shifting of climate zones, a decline in biodiversity, a gradual melting of many glaciers and a steady rise in the sea level.[15]

Climate change has major impact on water cycles

… have impact on local and global water cycles

The factors of climate change discussed above will also impact the local and global water systems.[16] Longlasting droughts may lead to a decline in the water table or surface water (e.g. rivers) may dry up. After long drought phases the soil is often unable to absorb any rainfall. In such cases, heavy rainfalls flow off rapidly aboveground, accelerate erosion of the soil and may trigger large-scale flooding. These set back very poor countries in their economic development for years. The UN estimates that heavy flooding in Mozambique in 2000 was to blame for the ensuing nearly 25% contraction of GDP.

[15] For more on this subject see e.g. the reports of the Intergovernmental Panel on Climate Change (IPCC) from 2007.
[16] See for example: UN (2009). Water in a changing world. London, Paris.

Case study: China

Precipitation in China is spread very unevenly. In the heavily populated north-eastern part of the country there is much less precipitation than in the south or south-eastern parts. Because of the population growth, the intensity of agricultural production and the rapid economic expansion, the scarcity of water in northern China is on the increase. The Chinese government has thus decided to implement a plan developed back in the 1950s to supply northern Chinese regions with water from southern China. The plan provides that water is diverted via three different routes (western, central and eastern) from the upper, middle and lower reaches of the Yangtze to the Yellow, Huai and Hai rivers; some of the connections already exist. All in all, over 50 bn m³ of water are to be transferred annually once the project has been completed; this corresponds to nearly one-third of the reservoir storage of Egypt's Aswan dam. The total costs of the project are estimated at USD 62.5 bn. According to the WWF, it is the world's most costly water transfer project. Several hundred thousand people will have to be resettled for the project to be realised.

Case study: Aswan Dam

The most important dam on the River Nile is the Aswan Dam. This blocks the Nile to form Lake Nasser, which has a reservoir volume of around 165 bn m³. On average, roughly 65 bn m³ of water flow into Lake Nasser every year, while some 55 bn m³ flow out. The difference of 10 bn m³ is lost to evaporation. The dam has positive economic effects for Egypt. Besides an improved water supply, the downstream level of the Nile can be regulated and thus infrastructure can be protected from flooding. Conversely, the dam guarantees the availability of water also during dry spells. The dam noticeably enhances the possibilities for full-year irrigation of agricultural land. The production of wheat, maize, rice and sugar cane has risen significantly since the dam's construction. Moreover, the Aswan Dam makes the Nile navigable the whole year through. Finally, the Aswan hydroelectric power station has an installed capacity of 2,100 MW; it thus covers about 15% of Egyptian demand for electricity.

One of the negative aspects of the Aswan Dam is that it has substantially reduced the transport of nutrients and fertile silt along the Nile. In the lower reaches of the Nile and particularly in the Nile delta this has resulted in soil erosion along the shorelines and increased the use of fertilisers. The Nile delta no longer grows out into the Mediterranean, but instead is eroded by the latter's pounding waves. In addition, the lower nutrient content has a negative impact on fish stocks. In the long run, reservoir capacity is at risk because the Nile's silt deposits collect behind the dam.

Over the next few decades, the rise in sea level will result in coastal groundwater being displaced or mixed with salt water. This will narrow the scope of agricultural production and worsen soil salination.

The gradual melting of glaciers induces, among other things, pronounced changes in seasonal and long-term river flow quantities (increases initially, decreases over the longer term). This has an influence on all areas whose water supply hinges on the existence of glaciers or on rivers fed by glaciers or precipitation in mountainous regions. This applies not only to many rapidly expanding cities in south and east Asia, but also to central Europe, where the glaciers in the Alps have been shrinking for years.[17] In India, the monsoon is expected to see greater extremes in both the rainy season and drought periods.

Poor countries are hit hardest

Ultimately, climate change will leave an imprint on the living conditions of many people as well as on the economic production possibilities of virtually every country. Generally, the poorest countries are the ones hit hardest by climate change. This is because the huge importance of agriculture there makes their economy more dependent on climatic conditions than is the case in the industrial countries. In addition, most of the developing countries and emerging markets are found outside the temperate climate zones, which is why they are more vulnerable to weather extremes anyway. Finally, the possibilities for poor countries to adapt to climate change are limited owing to an absence of financial and technological resources. The tragic part for these worst-hit countries is that because they themselves emit minor amounts of greenhouse gases they can only be blamed to a small degree for climate change itself.

Naturally, climate change will also have an impact on many industrial countries and their water supply situation. For example, the costs of agricultural production in southern Europe and the southwestern US will probably rise because the declining amounts of precipitation in the vegetation phase are going to necessitate an even stronger emphasis on artificial irrigation than up until now. Wherever the conditions for irrigation farming are limited, harvest yields are likely to decline. The water-intensive industries mentioned in section 2 could also encounter economic problems if climate change hampers their water supply over the next few decades.

Potential measures for adapting to climate change

There are several ways of adjusting to the effects of climate change on local water resources and to water stress in general. One may differentiate between two adaptation strategies. First of all, the availability of water can be increased by, for example, transfering water from areas with adequate resources or else by purifying seawater or wastewater. And secondly, efforts can focus on reducing the amount wasted.

— **Water transfers:** Importing water via pipelines or canals from areas with adequate water resources to dry regions is a suitable means of boosting the availability of supply in regions with shortages. The costs of the transfer depend on diverse

[17] The glaciers are melting rapidly, but the shrinking process in the Himalayas will proceed much more slowly than claimed in the IPCC report of 2007. The error on the pace of glacial melting contained in the report was recently a subject of controversy in the media.

underlying conditions, such as the length of the pipelines or canals, the material used and/or the topographical features. There are many examples of water transfers (e.g. in California, between the US and Canada, in Australia and China).

— **Dam systems:** Dams serve many purposes. They are used mainly in places that experience extreme periods of drought and rainfall; the seasonal precipitation fluctuations can thus be neutralised. Furthermore, dams protect against flooding. Moreover, dams can improve the unbroken navigability of waterways since they ensure that shipping channels have an adequate depth. Another advantage of dams is that electricity can be generated via hydropower. But dams also represent technological intervention in the aquatic environment, with sometimes negative consequences. Upstream, the rates of flow decline, and this results in slower transports of sediment and nutrients. All in all, this may culminate in the dammed section silting up. Downstream from the dam, by contrast, erosion increases. If dams are located in torrid zones, a double-digit percentage of the water in the dam can evaporate in the course of a year. In the case of major dam projects, human resettlement is often an issue.

— **Seawater desalination:** In many countries and on a number of islands, seawater desalination is already the only way to ensure the supply of drinking water. Given the rise in the sea level, climatic changes and population growth, this method of obtaining potable water is continually growing in significance. Technologically, various processes may be applied to derive freshwater from seawater (see box).

— **Wastewater recycling:** Unlike water transfers and seawater desalination, wastewater recycling is possible virtually everywhere. However, the additional availability of potable or non-potable water in the supply system is limited to the amount of wastewater already collected. The most important aspect is wastewater as a resource for irrigation purposes. The use of wastewater for industrial processes (e.g. in refrigeration or process water cycles) is already widespread. Particularly expensive treatment procedures can turn urban wastewater into drinking water. Less technologically sophisticated procedures can be used to upgrade wastewater to non-potable water that can be used, for example, for flushing toilets and fire-fighting.

— **Use of rainwater:** Given the quality of rainwater it is often not necessary to upgrade it for use as non-potable water (irrigation, sanitary engineering) or process water. Rainwater may be held in storage facilities and tapped for any given purpose.

— **Minimisation of water consumption in agriculture (see section 3.1):** This area offers huge leverage particularly in adapting to the effects of climate change.

— **Minimisation of urban water consumption:** Using efficient household appliances can also save large amounts of water. Substantial progress has already been made in the developed countries in this respect. Many modern domestic appliances (dishwashers and washing machines) consume only half as much water as their predecessor models. Similar achievements have been made in sanitary engineering. Besides the measures discussed, water consumption can also be minimised by cutting water losses in the distribution network. In principle, the greater

Types of seawater desalination

The electrodialysis process enables pure water to be extracted from seawater by electrochemical means. To do so, seawater is introduced into electrolysis cells. These cells contain numerous chambers formed by alternating cation and anion-impermeable membranes. Applying an electric current to them produces concentrated salt water on the one hand and desalinated water on the other. This procedure is not very widespread yet since the membranes and the water to be desalinated have to meet high quality standards. Moreover, blockage of the membranes is also proving to be a problem in practice.

In the reverse osmosis process, pure water is won by creating filtration pressure. In this case, the water molecules of the seawater are pressed through a membrane, whereas the salt ions are unable to pass through. Concentrated saltwater is formed on one side of the membrane, while desalinated water collects on the other. However, before beginning the reverse osmosis process it is necessary to pre-treat the seawater to remove foreign substances that may block or damage the membrane. The process can be applied particularly efficiently when upgrading surface water with a low salt concentration. In practice, seawater can be desalinated at a cost of less than one euro per cubic metre of water.

In multi-stage flash distillation, seawater is purified by thermal means. In this case the seawater is heated and steam is produced. The steam is subsequently liquefied in a condenser which thus produces freshwater. The process is very energy-intensive and is therefore applied mainly in countries with substantial resources of primary energy.

the water stress in the area at issue, the more urgently the pipeline losses should be reduced.

The economic attractiveness of the given technologies to adapt to climate change or water stress depends on the respective framework conditions. Particularly sophisticated methods are only likely to be applied if the local water prices are high enough or if water stress does not allow any other alternative. It is precisely the low water prices to date that have prevented the technologies from finding greater application so far.

Climate funds are a financing option

Case study: Windhoek

The capital of Namibia, Windhoek, lies in an arid region. The nearest rivers carrying water the entire year are 700 km and 900 km away from the city. Because the city is situated at 1,650 metres above sealevel and at a distance of about 250 km from the Atlantic Ocean, seawater desalination does not make business sense. Therefore, the city secures its water requirements not only via drilled wells and dams projects but also by using wastewater. Two treatment plants turn wastewater into non-potable and potable water. The cost of doing so comes to less than one euro per cubic metre of water, which is affordable for the local population.

The issue of funding arises also in relation to the technologies described above. Companies from industrial countries must themselves ensure that the necessary adjustments are made. In the case of developing countries and emerging markets, all the forms of funding already outlined at the end of section 3.3 may be taken into consideration. Since these measures are meant to pursue the objective of adjusting to the negative consequences of climate change, so-called climate funds may serve as an additional source of financing. These may be fed, for example, from the proceeds of auctions of emission allowances. To illustrate, the share of allowances to be auctioned off in EU emissions trading will increase steadily from 2012; a portion of the receipts is likely to be earmarked for climate protection and adaptation measures in the developing countries and emerging markets.

5. Investments in the water market

There is a huge need for investment in the global water sector, though the focus varies from region to region. Going forward, the industrial countries will have to boost investment in the maintenance and modernisation of their existing water infrastructure. Extensive expansion and newbuild projects are not considered to have top priority there – simply because the demographic development is moderate in comparison with that of developing countries and emerging markets. Nonetheless, such expansion is necessary, for in countries such as the United States and France the population will continue to grow. In the emerging markets, the big challenge is to ensure that the development of the infrastructure keeps pace with the population growth, the rising degree of industrialisation and the increasing demands of agriculture. Neither challenge was met in the past: in many industrial countries the water infrastructure was not maintained adequately. And in the poorer countries the development of the infrastructure has lagged behind the increase in demand for water.

Climate funds

During the Copenhagen climate conference in late 2009 it was set out in the Copenhagen Accord that a total of USD 30 bn was to flow from the rich countries to the poor countries between 2010 and 2012 so the latter could lower their own greenhouse gas emissions and adapt for the negative consequences of climate change. From 2020, some USD 100 bn is to be made available annually. Although the Copenhagen Accord is not legally binding, the prospective financial transfers are one of the few concrete results of the climate conference.

Investment requirements go into the triple-digit billions

Enormous pent-up demand in developing countries and emerging markets

As a consequence there is enormous pent-up demand for investment in the water sector. Estimates differ on the actual investment needs. For example, the World Business Council for Sustainable Development (WBCSD) estimates that the investment required for exchanging the outdated infrastructure in the OECD countries alone will total about USD 200 bn per year.[18] Since much

[18] The OCED itself estimates that the annual operating and investment expenditures for water supply and wastewater disposal in the OECD countries run to about USD 600 bn. In Germany, the actual investment figures for public water supply and wastewater disposal alone add up to around EUR 7 bn per year. This does not include corporate investments and spending by households, which could reach a similar scale. The condition of the water infrastructure is better in Germany than in most of the other industrial countries, though, which is why the investment

of the water infrastructure in the developing countries and the emerging markets still has to be built from scratch, total global investment requirements are expected to be much higher. For example, there were scarcely 1,000 sewage treatment plants in all of China in 2006. Their number has grown in the meantime, but a comparison with Germany (roughly 10,000 plants) is an indication of the still immense gap between them.

Demand for investment of EUR 500 bn per year

All in all, the global investment requirements in the global water market are likely to total EUR 400-500 bn per year. The range of this forecast is partly a function of the inadequate statistical database. However, the estimate partly also depends on which steps of the value chain are included, what level of technology is assumed and whether, for example, investments for adaptation to climate change are also taken into account.[19]

Hurdles obstructing faster implementation of necessary investments

Tight public budgets

There are all sorts of reasons for the investment backlog in the global water sector. First and foremost are the chronic budget deficits in many countries, for governments are responsible for the lion's share of the respective investment activity (70%). Priority is often given to consumption over investment for policy reasons: what is buried under the surface in the form of water and sewage lines is not as easy to sell politically as are direct transfers to the populace. The high losses from pipeline leaks and the moribund condition of the infrastructure are in many cases neither tangible for nor visible to the electorate.

A further reason for the underinvestment in the water sector is the politically motivated low price of water or complete absence of charges for its use. The prices charged frequently fall far short of a level that covers costs. The low prices – coupled with people's limited ability in poorer countries to pay their bills – curb the flow of private capital into the water sector.

Solutions to break the investment logjam

Higher water prices and charges necessary

There is a raft of solutions that can help to clear the investment logjam in the global water sector. In countries where no price is charged for water or it is subsidised, it is particularly important that the government recognises the necessity of higher water prices and charges and has the political will to push them through. This must be communicated carefully, and it ought to be done in a series of steps and take social concerns into account.[20] The higher water prices have to be supplemented by reliable use-related invoicing systems. The message to the population must be clear: without higher water prices it will be impossible to master the upcoming challenges. Nevertheless, in many countries a part of the necessary investments – at least during a transition phase – will have to be shouldered by taxpayers.

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requirements elsewhere – in relation to the population – are generally likely to be higher. This argues for the plausibility of the WBCSD numbers.

[19] The investment requirements in the water sector are thus of a magnitude similar to that of the market volume (by revenue), which is uncommon in most markets. However, this can be explained by the fact that revenues are kept down artificially because of low or absent pricing.

[20] One way might be that a minimum degree of consumption remains free of charge and that prices only rise upon higher demand.

Sensible to seek greater participation of private companies

The investment required in the global water sector cannot be funded by the public sector alone. For this reason, it is necessary to step up the integration of private capital and know-how. The question as to whether this ought to be practised in the shape of long-term concessions, Build-Operate-Transfer (BOT) models, other PPP forms or direct contracting should be answered pragmatically and not ideologically. The underlying conditions differ so much from country to country and investment project to investment project that the decision has to be made on a case-by-case basis.

Public-private partnerships may help

Public-private partnerships are not a panacea and will not guarantee success. However, negative experiences from the past should not be exploited to call into question the fundamental idea that, if the private and the public sectors join forces, both sides and also the public can benefit. Instead, they should learn from past mistakes. The responsibilty for successes and also for failures should be borne equally by the two sides. It happens too often that government policymakers blame failures on the private sector alone in order to distract attention from their own shortcomings. When private companies participate in water-supply operations it is not uncommon for prices to increase because of higher investments; these result in greater security of supply. But the real reason for the higher prices is often that the government had invested much too little before the private sector became involved.

Private sector can also help with projects lacking a sustainable business model

Higher, reliable water prices are important as a stimulus for private companies to make investments. But even if higher water prices cannot be implemented because of political considerations and this prevents the installation of a sustainable business model, the private sector can help to lower the overall costs. An invitation to tender can be worded in such a way that the company winning the contract has to be able to offer a clearly defined product package featuring the lowest costs or else the smallest need for public subsidisation. A private investor’s return to capital can also be funded from savings resulting from his investment. If, for example, a company reduces energy costs or water losses by investing in a pumping station, the need for subsidies from the public principal decreases. Part of the money saved then flows as debt service to the private investor – with potential for an at times significant internal rate of return.

Fields of activity differ in complexity

Generally, private companies may participate relatively easily in the global water-market opportunities if the respective business is not very complex. If, for example, a German engineering company delivers a pump to a Chinese water utility, the goods and financial flows as well as the number of participating contractual partners are clear and ultimately the risks are fairly predictable. Construction and operation of a sewage treatment facility or a desalination plant are already a much more difficult proposition. The performance spectrum and contract life increase; the financial flows are likely to be spread over a longer period, which is why it is important to have a stable political environment.

Many risks

If a city should want to transfer the operation of its entire water supply and wastewater disposal to a private company for a certain period, the degree of complexity increases. This holds particularly if the company assumes responsibility not only for the operation of existing infrastructure but also for expanding it. In such a case, a performance contract can cover the entire value chain starting from the civil engineering work right up to the invoicing of water consumption. Only few companies are able to offer such a full range of services. For this reason, it is only logical to consider cooperative ventures. With such deals there is naturally a substantial level of risk. This results not only from the long contract period and various uncertainties concerning the stability of the political environment. Moreover, it is very much more difficult to figure out who will pay for the necessary investments. Are the water prices permanently low for political reasons? Is the populace sufficiently willing and able to foot the bill? Can invoicing systems be circumvented? Who assumes liability for any collection problems? These and other questions will not only need to be answered by the companies involved but are also of relevance for banks and insurance companies that act as partners in such projects and also shoulder risks.

Which technologies are in demand?

Huge range of water technologies

There is huge sales potential awaiting makers of water-sector technologies over the next few decades – both in Germany and even more so abroad. A large range of technologies is needed. The demand for efficient irrigation technologies, seawater desalination and sewage treatment facilities, technical equipment (e.g. pumps, compressors and fittings), filter systems or disinfection processes (e.g. using ozone or ultraviolet light) and efficient sanitation facilities will probably pick up sharply. German companies stand good chances of success in many of these segments and are world leaders in terms of the technology. To be able to provide comprehensive offers from a single source it makes sense to consider cooperative ventures across the value chain of the water sector and naturally also across national borders (e.g. collaboration between companies from the civil engineering, pipeline construction and engineering industries).

Rich countries in arid zones are attractive locations for investments

DB Research scoring model …

Companies from the water sector are naturally faced with the question of what markets might be particularly attractive for investment. So it is more of an issue of where there are markets for private-sector solutions and not so much about the countries with serious humanitarian problems on account of water shortages but where market-based solutions are currently still unlikely. Using a scoring model we examined 78 countries on the basis of eleven criteria in order to help find an answer to this question. The data required for these countries was available; moreover, we excluded several very small economies because of their minor economic relevance.

The eleven assessment criteria are:

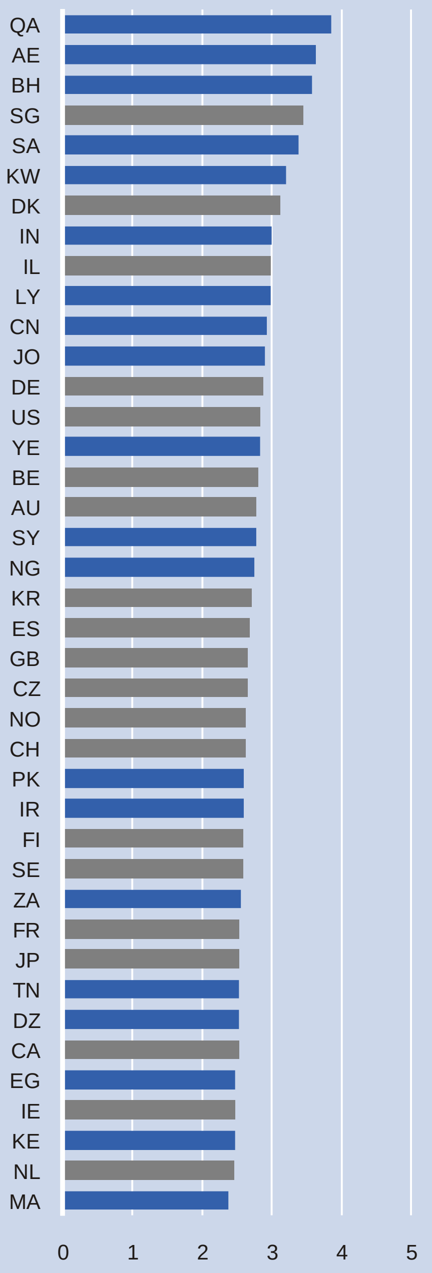
— The population and the average growth rate of the population in the period 2000 through 2050 as indicators of the size and prospective growth of a market.

… based on eleven criteria

— A country's gross domestic product per capita and government debt[21] as indicators of the solvency of households and of the government; moreover, it may be argued that in countries with a

[21] We do not have a uniform source for government debt, which limits the comparability of the data. We recorded high government debt as a negative criterion in our study, for the bulk of investment will probably have to continue to be shouldered by the government. It could of course also be argued that with a high government debt there is greater pressure to integrate private companies into the water market. In our opinion, however, the first argument carries more weight.

Attractive countries for investments in water sector
Points based on DBR scoring model*



*Maximum score: 5
Industrial countries in grey

Source: DB Research 9

high GDP per capita there is a relatively large demand for the renovation and modernisation of the water infrastructure since in the rich countries this was created decades earlier (data on the condition of existing infrastructure is not available).

— The renewable water resources per capita and the ratio of water withdrawals to renewable water resources as indicators of water stress in a country.

— The percentage of the population connected to the public drinking water supply and wastewater disposal as indicators of the investment requirements.

— The Corruption Perception Index (CPI) of Transparency International as well as the Index on the Protection of Intellectual Property and the Index on the Level of Financial Market Sophistication of the World Economic Forum as indicators of political stability and of the maturity of local financial markets.

We applied a scoring algorithm to these criteria, subdividing the readings into five equally large intervals. The country with the poorest value for the respective factor is assigned a score of 1. And the country with the best value is given a 5, the highest score.[22] We formed five equally large intervals between the two extremes. The scores were weighted differently for the individual criteria and ultimately added together. The countries with the highest readings are shown in the accompanying figure. The outcome shows us that the top rankings are held by three rich countries – Qatar, the United Arab Emirates and Bahrain – which in addition are located in arid regions of the world and are relatively stable politically. Saudi Arabia and Kuwait are two further countries that fulfil these criteria and rank in the Top 10. The Top 20 countries include two major industrial countries, Germany and the US, as well as two of the world's most populous nations, India and China. Moreover, the latter show only a small standard deviation for all eleven criteria, which suggests a certain degree of robustness in the results.

Limits of our model

This scoring model has its limits, of course. It is only one first step that may merely serve as a guideline for the choice of potentially lucrative markets. The scoring model does not, for instance, take into consideration that the demands and needs of the individual countries differ greatly from one another. A uniform scoring model cannot do this heterogeneity justice. For example, industrial countries require expensive modernisation work, whereas developing countries need low-cost new installations. For this reason it comes as no surprise that many countries in our scoring model have a high standard deviation over the chosen criteria, i.e. on some criteria they perform excellently, but on others rather poorly. This necessitates a closer look at the respective investment projects.

Besides, the list of criteria is incomplete: the quality of the political relations between the countries participating in water-sector investments is of major importance. Furthermore, for certain companies or investment projects the weightings applied to the

[22] For some criteria (e.g. population, renewable water resources per capita and ratio of water withdrawals to renewable water resources), we cut off the upper limit of the interval below the actual maximum value (e.g. for the population figure at 600 million). Otherwise the interval between the countries with the highest values (in the population example: China and India) and the rest of the world would have become unjustifiably large.

diverse criteria may deviate from our selection: a company that wants to assume the water supply of a city attaches greater importance to the political stability of a country than a company that merely wants to sell a filter system to a customer in the same country; such aspects always need to be assessed individually. Finally, there are still interesting investment projects to be found in those countries that rank lowest in our scoring model or are not even considered in the first place for reasons of data availability. This means that further information on the locations has to be gathered in every single case.

6. Conclusion

Our report has outlined not only the major challenges that characterise the global water market but also the huge opportunities. None of the problems cited can be eliminated within just a few years. But it is all the more important that the governments take rapid, determined action to address the challenges ahead, for water stress is set to increase in many countries. Such efforts will require enormous financial resources that the public sector will not, in all likelihood, be able to raise on its own even if it should manage to increase water prices over the next few years. While there is considerable disquiet about private firms investing in the water sector, the public sector will simply not be able to cope with all the challenges single-handedly. For this reason, we believe it makes sense for governments and the private sector to intensify their cooperation more often.

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