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## TELECOM, LAND TRANSPORT, WATER AND ELECTRICITY



## *Chapter 5*

### The Impacts of Change on the Long-term Future Demand for Water Sector Infrastructure

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## 1. Introduction

### *Background*

Water is like no other commodity, excepting food, in that it is essential to human life. The greatest challenges facing us relate to the conditions in which we live, how we are nourished and sheltered. Water is a central issue in a world that is increasingly urbanised and has a rising population to feed and seemingly ever increasing risks.

The 20th century saw global population triple and the development of megacities. Water consumption rose, both in total amount needed and in per capita demand. Increasing pollution loads and abstractions have outstripped the assimilative capacity of ecosystems. Across the world, urbanisation has progressed through stages of ever denser habitation. Water service and infrastructure are meant to keep pace with these changes in developed countries: typically, there is an assumption that the services will follow the newest needs in terms of how people work and live. (For a fuller discussion see Juuti and Katko, 2005.) Ironically, in many of the countries, water is undervalued by the citizens who live in towns and cities because it is readily available from the tap. Once used, it is then flushed away down the toilet or the sink and is never seen or thought of again. Up to one-third of the water supplied to domestic properties is used for toilet flushing and a further significant proportion is used for purposes other than drinking; in some countries, including Australia, water used for domestic gardening can constitute more than 50% of domestic use. Worldwide, the demand for water for irrigation is now consuming some 75% of the total abstracted. In anticipation of this explosion in water use there was significant investment in the past in the provision and operation of water infrastructure, much of it in informal and low-technology groundwater pumping, some of which helps grow cheap crops exported from the developing countries to the developed world. Worryingly, much of this water use is unsustainable (New Scientist, 2006).

Consumption rates reflect availability and continuity of supply, relative wealth including size of property, and to some extent correlate with climate. WHO/UNICEF specifies that reasonable access to water means at least 20 litres per person per day (l/h/d), accessible within 1 km of that person's dwelling. However, this is a bare minimum; 50 l/h/d are required to ensure health and hygiene (Stephenson, 2001). Per capita consumption rates of more than 500 litres per day used to be common in the United States, but this has now declined to below 400 litres, depending on the state. In most European countries the

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consumption is between 100 and 200 l/h/d. In countries with only standpipe supplies, average per capita consumption rates are some 20-60 l/h/d. The question of what consumption rates are to be met and in what manner has a huge impact on the development of water resources and the nature of the services provided, as well as the financial and institutional implications for the country. Metering of domestic consumption is not applied globally even in the most developed countries, and evidence suggests that it may have only a limited effect on constraining long-term use. In the United States not all properties are metered; in the Netherlands and the United Kingdom some 20-30% are metered, with slightly more in Germany and Denmark and some 75% in Australia. In a survey of 27 major Asian cities with populations exceeding 1 million in 1996, the ADB found that 15 were fully metered, six had metering for less than 7% of the population, and virtually no metering existed in major Indian cities (Twort, Ratnayaka and Brandt, 2000).

While most of the developed world and the wealthiest customers in the developing countries do not pay the true economic costs of water services, the poorest have to purchase water from local carriers or bottles at up to 500 times the cost for their wealthy neighbours in the same country. Despite the availability of good-quality, continuous water supply from the tap in developed countries, there is an increasing demand for bottled water. This may be due to perceptions that it is of better quality, or for taste, fashion or convenience. Globally, the expenditure on bottled water has now reached some USD 100 billion per year and consumption is growing at a rate of 10% per annum (Gleick, 2004). The largest consumers are the United States, Mexico and China, with consumption in China growing the fastest in the period 1997-2002. Regionally, there has been considerable growth between 1997 and 2002 on all continents except in Africa. The amounts being spent on bottled water worldwide could pay for piped supplies to most of the world currently lacking these facilities, and the material and transport resource use and pollution from the packaging (mostly PET plastic) have major impacts (Ferrier, 2001). In some developing countries, manufacturers continue to over-abstract from aquifers to produce high-cost bottled water, compromising local supplies (Earth Policy Institute, 2006). Although the demand for bottled water could potentially reduce the need for global infrastructure for piped supplies this may be offset by the ensuing increases in energy demand, waste production and transport infrastructure needs. Increasing demand for bottled water may also influence decisions about the need to maintain the serviceability of existing water infrastructure assets. Ironically, the quality of bottled water is often dubious.

In addition to domestic supplies, water is also provided for:

- *Agriculture* – irrigation of crops, livestock, horticulture – very dependent on activities, local soils and sources and climate.

- *Trade and industry* – factories, shops and institutions such as hospitals; also for power generation and cooling. Consumption is very specific to the nature of the activities, but in a number of developed countries industrial demand has fallen due to: general decline in heavy industry in favour of service industries; better use of recycling and reuse/recovery of water locally; and better water accounting and auditing, reducing wastage and unnecessary use. Overall, demand in this sector is expected to rise by a small percentage worldwide from current levels of about 20% of global water use.
- *Public amenities* – parks, street washing, firefighting, flushing mains and sewers. This may be water provided free of charge (and unmeasured) where the water service provider (WSP) is a municipality. Firefighting is a major reason for ensuring that water main pressures are maintained, and for supplying high-rise buildings.
- *Losses* – in distribution systems, domestic leaks and dripping taps, where "unaccounted for" water is due to metering errors, unauthorised use and general unrecorded consumption (Alegre *et al.*, 2000). Unaccounted for water (including all losses) may comprise from 6% up to 55% of the total water supplied in areas with ageing mains and service pipes. Current leakage rates in London from the mains are up to 40%.

Only 2.3% of the earth's water is fresh, with two-thirds of that permanently frozen – although the percentage is declining due to global warming. Sources of water are mainly through direct precipitation, which is usually stored temporarily in natural areas or in man-made reservoirs that hold some 8 000 $km^3$. Some 8% of the annual freshwater renewable resource is used, with 26% of evapo-transpiration and 54% of runoff. Table 5.1 shows the regional availability of water resources compared with population distribution.

Table 5.1. **Regional availability of water resources**

| % World's | North and Central America | South America | Europe | Africa | Asia | Australia and Oceania |
|---|---|---|---|---|---|---|
| Water | 15 | 26 | 8 | 11 | 36 | 5 |
| Population | 8 | 6 | 13 | 13 | 60 | <1 |
| Ratio (%) | 1.9 | 4.3 | 0.61 | 0.84 | 0.6 | 5 |

Some 2 million tonnes of waste is discharged daily, polluting some 12 000 $km^3$ of receiving waters. Climate change is expected to increase precipitation from latitudes 30° N and 30° S, with lower and more variable rainfall in tropical and subtropical regions. Extremes of weather will be more common, with more frequent disasters worldwide (UN, 2003). Levels of water supply and sanitation provision are given in Table 5.2 (WHO/UNICEF, 2005) and global water use in Table 5.7.

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Table 5.2. **Percentage of population served by water supply and sanitation services (2002)**

| Infrastructure | | World | Developed countries | Eurasia | Developing regions |
|---|---|---|---|---|---|
| Water supply | Urban | 95 | 100 | 99 | 92 |
| | Rural | 72 | 94 | 82 | 70 |
| | Total | 83 | 98 | 93 | 79 |
| Sanitation | Urban | 81 | 100 | 92 | 73 |
| | Rural | 37 | 92 | 65 | 31 |
| | Total | 58 | 98 | 83 | 49 |

Table 5.2 illustrates those regions with less than 100% coverage of safe (or improved) systems of water supply and sanitation. It does not differentiate where service provision is local or provided via major and/or centralised infrastructure. The significance of this is illustrated in Table 5.3, which shows the proportions of urban dwellers with in-house facilities (Tipping, Adbm and Tibaijuka, 2005), and in Table 5.4, which shows the proportion of households connected to mains water and sewers (UN, 2003). Although having a flush toilet is not necessarily an appropriate measure in developing countries, Table 5.3 is indicative of the more local access to water and sanitation – information not explicit in Table 5.2.

Table 5.3. **Percentage of households with in-house access to safe drinking water and reliable sanitation**

| Facility | North Africa | | Sub-Saharan Africa | | Southeast Asia | | South, central, west Asia | | Latin America | |
|---|---|---|---|---|---|---|---|---|---|---|
| Wealth | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor | Poor | Non-poor |
| Water on premises | 75 | 92 | 31 | 46 | 36 | 50 | 59 | 74 | 59 | 74 |
| Flush toilet | 88 | 97 | 28 | 32 | 67 | 88 | 48 | 60 | 44 | 67 |

Table 5.4. **Proportion of households in major cities connected to mains water and sewers**

| % with this facility | North America | Europe | Oceania | Latin America and Caribbean | Asia | Africa |
|---|---|---|---|---|---|---|
| House or yard connection for water | 100 | 96 | 73 | 78 | 78 | 43 |
| Sewer connection | 96 | 92 | 14 | 34 | 45 | 17 |

Agriculture in general – and irrigated agriculture specifically – is by far the biggest consumer of water. Overall agriculture now accounts for about 75% of global water use (Gleick, 2004). Globally the number of irrigated hectares has almost doubled since 1960, with China, India and Pakistan accounting for almost all of that growth. The amount of irrigated area is falling per capita of the world's population, despite continuing to rise in absolute terms to 270 million hectares in 2001. The vast majority of this area is in Asia (190 million ha), with Europe showing a decline to 25 million ha in 2001 from a peak of 28 million in 1980. Elsewhere the irrigated area is stable. By volume, India, China, Pakistan and the United States together account for 75% of total agricultural usage. Data on agricultural usage are not reliable, as they are often severely underestimated for countries like India. If it is considered that the vast majority of this is under flood irrigation, which has an efficiency of at best 40%, then it is evident that a tremendous resource is not only going to waste but producing problems of aquifer exhaustion and soil salinisation. It also means that the economic productivity of this huge infrastructure that captures, stores and distributes water for irrigation is questionable.

### *Historic overview*

Formal infrastructure systems for supplying water are almost as old as humanity. Between 16 000 and 10 000 years ago, agriculture developed and permanent settlements were established, requiring irrigation; hence, seasonal and other water shortages were experienced (Cosgrove, 2003). Reportedly the first major water infrastructure systems were constructed around 3000 BC by the Egyptians and the Sumerians. Around this time China was formally irrigating and by 2000 BC Egypt was maintaining large dams. In the period that followed, up to the birth of Christ, the Romans, Persians and others built major water supply and sanitation structures, some of which survive today. These advances were in response to urbanisation and the growth of towns and cities. Before major settlements, people followed the water, settling near rivers, lakes, and springs, and moving to others if these dried up because of climate variability. As technology evolved and settlements became larger, people moved the water to them. In the so-called Middle Ages, water was generally distributed by water carriers, or collected directly from wells, ponds and rivers. It was only in the mid-19th century that the connection between water and disease was established, highlighting the need for separation between sewage disposal and water supplies. Before then, sewage was disposed of via watercourses that provided the supply for others. This situation still prevails today in many less developed countries, even where water is abundant. The industrial revolution in the West and later in the East could not have occurred without adequate water or reliable and healthy workers. It is no coincidence that many of the countries nowadays with the most comprehensive water

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infrastructure are those that were at one time colonial powers. Revenue from colonisation provided the funds to construct many of the water infrastructure assets in the 19th century, most of which are still relied on today.

The establishment of modern water systems was originally largely based on private initiatives. These proved unreliable and from 1861 to 1901 the share of municipal water supplies in England, for example, grew from 40 to 90%. A similar trend was also evident in the United States. The growth of urban infrastructure was the most dynamic element of the British economy from the 1870s to the 1930s. Investments in public health, local transport, water, electricity and gas were by the early 1900s as much as one-quarter of all capital formation in Britain. In North America many urban water supply systems were built from 1830 to 1880; it proved more difficult to fund sewage systems (rather like many developing countries today). Ultimately the needs of society, businesses and industries hastened the birth of water works, making public works necessary. New York, Chicago and other cities started water acquisition and distribution with the help of private enterprise (Juuti and Katko, 2005).

Nowadays the less developed countries are faced with the need to industrialise rapidly to fulfil the expectations of their people, but often without the resources (governance, technical, financial and social capital) to provide the essential infrastructure to support this (Wolf, n.d.) and with an over-reliance on imported and sometimes inappropriate expertise and technology. This has often led to hasty and inappropriate exploitation of resources – including water – and neglect with regard to closing the water cycle, by concentrating on the provision of water supplies without accompanying sanitation. Dhaka provides an example of this, where the lack of sanitation means that water supplies are polluted by sewage during monsoon periods.

Impact studies from developing countries show variations in effectiveness in terms of public health from introducing water and sanitation systems, depending on conditions. Yet, the overall trend is that improved water supply results in reduced mortality and the beneficial impacts are larger when sanitation is introduced. The best results will be gained if health education is also introduced (Juuti and Katko, 2005). The value of providing water and sanitation in developing countries is highlighted in the recent report on delivering the UN WWD Water for Life (2003) challenges, in which cost/benefit ratios for provision of water and sanitation are given (Table 5.5). The conclusion is that there is likely to be a total payback of USD 84 billion a year from the USD 11.3 billion a year investment needed to meet the stated Millennium Development Goals' (MDGs') drinking water and sanitation target.

Locally and regionally, competition for water is increasing. To this must be added the threats to regional and global ecosystems caused by anthropogenic and natural climate change (Cosgrove, 2003). Available global water resources

Table 5.5. **Benefit/cost ratio for interventions in developing regions and Eurasia**

WHO/UNICEF, 2005

| Result of intervention | Benefit/cost ratio |
|---|---|
| Halving the proportion of people without access to improved water sources by 2015 | 9 |
| Halving the proportion of people without access to improved water sources and improved sanitation by 2015 | 8 |
| Universal access to improved water and improved sanitation services by 2015 | 10 |
| Universal access to improved water and improved sanitation, with water disinfected at the point of use by 2015 | 12 |
| Universal access to a regulated piped water supply and sewage connection in house by 2015 | 4 |

are becoming progressively diminished while populations are increasing, leading to greater scarcity and predictions of an increase in conflicts. In 1999 there were reported to be 261 international transboundary basins that together covered 45% of the earth's land surface, encompassing 40% of the world's population, and providing 60% of the earth's entire freshwater volume. A total of 145 countries' land areas fall partially or completely within international basins. Although water wars are not common, the diminishing of water quality or quantity destabilises regions, especially within transboundary basins (Wolf, n.d.). It is postulated (Hassan, 2001) that from a historical perspective, an integrative ethic of water management is now needed. This is due to the current paradox in developed world attitudes to water – a result of the fragmentation of management and a marketing ethos that regards everything (including water) as a commodity and profit as the ultimate objective (Hassan, 2001), and the simultaneous perception of water as a human right. Global co-operation must be based on the real exchange of benefits and cost-sharing, and ethical criteria for established priorities related to water must be created.

Much contemporary thinking about the value of water includes ethical issues such as water as a social or public good or as a commodity (Gleick, 2004; Tipping, Abdm and Tibaijuka, 2005). This is important as water access is recognised as essential in delivering all eight of the Millennium Development Goals (WHO/UNICEF, 2005). Over the past 100 years, the disparity in wealth and opportunity for development within and between nations has had serious implications for the sense of self-worth and hope of many parts of the world. The threat to the well-off is now not only from a territorially based "enemy". The threat is endemic and contagious, and manifested via international terrorism. Conflicts over water are not solely due to governmental policies, but are at once local, among communities and populations, and global. They frequently involve multinational corporations (directly or indirectly involved in the management or exploitation of water resources) and international monetary and regulatory

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bodies. Commentators in this area stress the need to build institutional capacity to help avoid conflicts over water, and to build the capacity within communities to understand the issues and develop shared responsibilities (Hassan, 2001; Cosgrove, 2003; Wolf, n.d.).

In technological terms, the mode of delivery of water services must shift from the conventional hard engineering (large new assets) approach to a balanced soft-hard and environmental (or ecological) engineering approach that better considers the viability of local, regional and global regimes and accounts properly for whole-life perspectives. For long term sustainability it will be important to transform the management mode of water systems from "technical fixes" to appropriate systems that include community management and encompass a diverse range of delivery options. This means that all stakeholders need to be better informed and included in decision making. In addition to large, hi-tech projects, small, community projects must be considered – various scales are required. Sustainability is about diversity and the overall scope of management must be broadened to better include the social dimensions of water systems. External systems or stresses will be the main change drivers, and of those climate is likely to be the most significant. In Australia for example, droughts and water stress in the main cities of Melbourne, Sydney, Adelaide and Perth have forced the adoption of a whole new range of approaches to managing water. These are based much more on the concepts of reuse, recovery and matching water quality to particular water use, and on educating users (CSIRO, 2004). It could be argued that Australia is currently in the vanguard of innovative water service provision in the developed world.

### *Sectoral scope*

The sectoral scope of this report is principally urban water services and to a lesser extent rural water services. However, with some 75% of the world's water being used for agriculture, there are issues of allocation and competition for resources (quantity) as well as water quality. Thus agricultural consumption cannot be ignored, even if in-depth consideration of the infrastructure needed for irrigation lies outside the scope of this report. In addition, there are a lot of dual-use water resources and hydropower schemes with many more now envisaged as part of the ambitions of the MDGs. These will not be considered in detail here due to their variability.

Water supply and wastewater management infrastructure for urban areas comprise four major systems:

1. Water abstracted for agricultural use – for rural communities and small urban areas. Most of this is groundwater.

2. Water resources – abstraction (and possibly storage) for human needs. The source can be upland rivers, lakes, lowland surface water, groundwater, sea or brackish sources or from evaporation systems.
3. Water supply network, including inputs from abstraction, treatment, storage and distribution, and outputs, including management of residual sludge.
4. Wastewater system, including stormwater and sanitary drainage, treatment, effluent disposal and management of residual sludge.

Of these, in urban areas in the developed countries, the networks in 3) and 4) are generally the most valuable assets, comprising some 60-80% of the total value of all urban water and wastewater systems. For example, in the United Kingdom, the current value of existing sewage assets alone is some USD 200 billion.

Service standards or levels are important in terms of assessing the current state of and demand for water-related infrastructure. These vary worldwide and are also not static, with ever increasing standards expected in the developed world and a bare minimum standard in a number of other countries. In the developing world, large networks and end-of-pipe treatment plants are being installed, even though "ecosanitation" is likely to be a more appropriate form of infrastructure, particularly in the less dense settlements. This is low-technology using VIP latrines and local water supplies stored and treated with basic but adequate standards. Joining the supply side to the waste side with reuse and recovery, a feature of ecosanitation, also makes nutrient and energy management more efficient. Even in developed countries, "eco-villages" in Sweden aim for a zero emission, supply-based water system. This approach is echoed in the WSSTP (2005) strategic research agenda, and in the 4th World Water Forum (in Mexico, March 2006) where Integrated water Resource Management (IWRM) is seen as a major solution option for the future (Sommen, 2006). Notwithstanding the disadvantages, a number of developing world urban areas were and still are encouraged by developed world consultants, with the tacit support of donor organisations, to utilise large-scale centralised wastewater systems. This is despite the use of precious water to transport the wastes, making it unsuitable in the long term for regions with water scarcity. In many places this has already led to an overexploitation of limited renewable water resources (Werner *et al.*, 2004).

Rural water requires infrastructure systems different from the urban ones outlined above. Although some rural supplies come from surface sources, usually wells or boreholes are drilled and installed to access groundwater. Institutionally the governance and financing arrangements differ considerably from urban areas, and often the same level of service is not available.

To sum up this section, although the majority of the world's population, now and in the future, are likely to live in urban conurbations, there are important water needs in rural areas that also need to be considered. This requires consideration of infrastructure for: all sources of abstraction (surface or groundwater) and storage; water treatment processes; transmission and distribution; wastewater collection and conveyance systems; and wastewater treatment and residuals management.

### *Geographic scope*

Globally the main actors may be nation states, although increasingly multinational organisations seem capable of operating semi-autonomously. Nevertheless, here the most successful countries worldwide will be considered in terms of the future needs for water infrastructure. These are the 30 OECD countries plus China, India, Brazil and Russia. Mention will also be made of states in Central and Eastern Europe and Central Asia (the former Soviet Bloc) as well as some mention of sub-Saharan Africa, as those countries here represent the majority of the less developed countries, which are particularly important with respect to the Millennium Development Goals.

## 2. Past trends in infrastructure investment

### *Introduction*

Access to water and sanitation infrastructure is reportedly now more equitable than for most other main infrastructure provision (Fay and Yepes, 2003), with an accessibility ratio of high to low income of 1.3 for water and 2.2 for sanitation. Interactions between services are also important, as transport systems are needed to build and service infrastructure and waste systems can confound effective drainage. Energy is required increasingly worldwide, and there are existing and proposed conjunctive use schemes with large water resources and energy generation from hydropower. In developed countries much more pumping of wastewater and high-energy treatment has become common; in Europe this is due to the Urban Wastewater Treatment Directive, and in the United States to high-energy disinfection of sewage effluents. In developing countries the interaction between agricultural demand for water and human direct use is important in rural areas, as is the use of human waste as fertiliser, whereas in urban areas the main problem relates to the lack of solid waste handling systems. The latter situation leads to refuse collecting in wastewater channels, causing blockage, flooding and human health impacts.

Investment in infrastructure has varied greatly globally. In general, water services require high rates of capital and maintenance investment with a low return on assets (typically 5%). Nevertheless, returns are low risk – as illustrated by the English water companies, where there is a high level of indebtedness but good returns for investors. While the populations of much of Western Europe, North America and most of the OECD countries now have effectively full access to water and sanitation services, access by much of the rest of the world is patchy. Services are provided by almost every conceivable mix of public and private involvement and tend to be centralised with large treatment facilities and distribution and collection networks. In the rest of the world, local and very variable services exist for water supplies, often with informal sanitation (open air). This is common even in industrially developing countries such as India. In the recent past most OECD countries have at least attempted to maintain their water assets and extended these where necessary to cope with increasing populations, demands and expectations. Often the capacity of the original systems is stretched due to suburban growth.

The most developed countries now recognise that the large-scale centralised systems may no longer be viable, due to high maintenance costs and resource needs. This is true for both water supply and wastewater infrastructure. In Australia, water management at or near the source of rainfall via direct roof runoff collection and storage, and through grey water recycling and even recycling of sewage at source are all options now part of the portfolio of how best to provide and maintain water supplies. As well as changes in ambient technologies, new water policies are being introduced that establish water markets allowing trade to reallocate water both between users and between sectors (WSAA, 2005).

Various commentators suggest that more dispersed and localised wastewater systems are required even in the major developed cities (*e.g.* Tjandraatmadja *et al.*, 2005) along with nutrient recovery and better control of substances introduced into wastewater systems (Matsui *et al.*, 2001). Although there are arguments over the relative merits of localised (or "on-site") systems for wastewater management, serving individual or small groups of properties – compared with the "end-of-pipe" systems traditionally used – there is a growing usage of on-site sanitation in countries such as the United States. Such systems can recover nutrients and energy and also be linked to local water supply and reuse technologies. In the United States, on-site sanitation systems now comprise some 40% of all new developments (USEPA, 2002). This potentially changes the approach to service provision in the future, with systems being smaller and requiring much less up-front capitalisation for their implementation. Decentralised systems are also better at coping with the need to expand services. In the area of storm water drainage, there is also a growing use of "source control" technologies that handle storm water near the point of generation, *i.e.* locally, also providing opportunities for direct use for, *e.g.*, toilet flushing.

A large number of small wastewater systems will require business models different from the large centralised systems traditionally used. In countries like the United Kingdom and France, moves to decentralisation could be more difficult due to the service providers being larger and concerned

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to maintain their core centralised infrastructure systems. In developing countries, decentralised systems are seen by many as the only affordable option (*e.g.* Werner *et al.*, 2004). Estimates of the average costs of infrastructure provision in developed countries are given by Lee *et al.* (2001) and are summarised in Table 5.6. These figures are undated but presumably are current for 2000 and for French conditions, and relate to service standards that are generally accepted in Europe. The water supply costs do not include large dams or similar infrastructure as this is locally specific.

Table 5.6. **Costs of water supply and wastewater infrastructure for centralised systems**

US dollars

| Service | Water supply[1] | Sewage disposal: Combined sewer[1] | Sewage disposal: Separate sanitary sewer[1] | Separate storm water |
|---|---|---|---|---|
| Networks (cost fraction) | 85% | 90% | 88% | 100% |
| Treatment (cost fraction) | 15% | 10% | 12% | Storage only |
| Financing costs[2] | Up to 40 | 15-25 | 10-16 | 9-15 |
| Maintenance costs[2] | Up to 45 | 13-25 | 8-15 | 5-13 |
| Operating costs (30% labour)[2] | 15-60 | 30-40 | 15-35 | 12-18 |
| Taxes[2]/other | 3-15 | 4 | 2.5 | 2 |
| Infrastructure cost per head for 180-210 l/h/d (min.-max.) | 700-800 Ave (450-1 800) | 1 000-1 300 (900-2 200) | 700-900 (650-1 400) | 650-700 (970-1 250) |

1. Includes centralised treatment system.
2. Costs per 100 $m^3$ per year.
*Source:* Lee *et al.*, 2001.

Some advances have been made in providing water and sanitation services elsewhere. The water supply and sanitation decade (1981-90) was reasonably successful in cutting the numbers of people without these services, despite a tripling of population and a sixfold increase in the human use of water (Cosgrove and Rijsberman, 2000). Even so, sanitation provision is not keeping pace with population growth. In parallel, there have been significant investments in wastewater treatment that have improved environments, although in the two most rapidly developing countries, China and India, environmental degradation due to sewage discharges and other impacts is a major problem. Water for food, a major issue, has given rise to an explosion in groundwater use. Globally, almost without exception, centralised water and related services are subsidised even where provided by private companies. In Greece and Spain for example, water is priced at some 25-30% of the true costs, and in the United Kingdom at about 90%. In other countries water endowments cut costs to users, by USD 0.8 in Canada and USD 2.24 in Germany (Lee *et al.,* 2001). This contrasts with the poorest unserviced populations who have to pay high costs for bottled or locally available water. Even in these countries, however, water for irrigation or industry may be subsidised. In India it is estimated that irrigation is subsidised directly (USD 800 million/year) and indirectly through a USD 4 million subsidy for electricity for pumping (Lee *et al.,* 2001). It is suggested that without this the country would starve (New Scientist, 2006). In Europe at least, the water framework directive is supposed to ensure that the full economic costs of water services are passed on to the users by 2015 (Sommen, 2006).

Service standards or levels are key to understanding the recent trends in infrastructure provision, as they dictate forms of service and the performance expected of those services. Overall the approach in the 20th century has been to try to satisfy demand from all sources and latterly to introduce more controls and services to minimise the pollution caused by returning contaminated water into the environment. Only recently has it been recognised that demand management must also go hand in hand with satisfying demand, and that a more integrated and overall approach is needed (*e.g.* WSSTP, 2005; WSAA, 2005). In most OECD countries and in certain developing countries, service standards are specified and may be enshrined in regulations. Investment in infrastructure provision has then been tailored to meet these, via new asset investment or maintenance of existing infrastructure. In recognition of the need for some standardisation, the ISO is developing specifications for service levels in the water and sanitation area (ISO/TC, 2004). Worldwide the most accepted standards are those defined by the WHO for drinking water (WHO, 2004), but these relate to the quality of the water rather than the quantities or the services that provide these.

There has been both an assumption and a desire on the part of the poorest, that developed world water supply and sanitation technologies be applicable worldwide. Apart from the impossibility of providing waterborne sanitation for all – because that would require the use of all available free water sources – other considerations militating against this are cost, energy use and loss of the valuable nutrients contained in sewage (Matsui *et al*., 2001). Nonetheless, major funders have promoted the use of these technologies and stipulated their use as a condition for lending funds for or funding new infrastructure, along with promoting privatisation of service delivery. There are examples of successes and failures arising from this approach; it is clear that no one technology perspective or business model guarantees success (WDM, 2005). Failures have been attributed to local circumstances, including governance and corruption, poor service provision once a franchise or partnership has been awarded, excessive charging increases, and lack of promised investment. Successes are best illustrated by the English and French models, where investment in water services has been substantial in the past 20 years and there are clear regulatory systems and targets. This may be contrasted with the United States, where there are strong standards but nationally a surprisingly wide variety of providers and forms of provision.

Current evidence indicates a waning of interest on the part of the major private company players in large-scale investment in urban water and sanitation services. The risks and returns appear to be not as favourable as in the past (*e.g.* OECD *et al.*, 2003). Wholesale rural water service investments have never been attractive to the private sector, and private participation is typically via specific activities such the supply and distribution of bottled water or the offering of particular services within the water supply and disposal chain (Water Management Consultants Ltd., 2004). In rural areas local SMEs have a more important role in these services.

## *Global trends in water resources, supply and consumption*

An overview of past trends in selected countries can be found in the Endnote Profile that concludes this chapter.*

The three main drivers behind the expansion of water resources during the 20th century are population growth and increased per capita demand, the increase in irrigated agriculture and industrial development. It has been estimated that at least 54% of accessible runoff is already appropriated for human use, a figure that could rise to 70% by 2025 (Gleick, 1998). Globally the withdrawals of water for irrigation account for some 70-75% of the total while about 20% is for industry and the remainder for domestic use (see Table 5.7). In general, per capita water consumption in developed countries has been decreasing in recent years, reflecting the changes in forms of economic activity and the (relatively) more efficient use of the available water abstracted. In the United States, total per capita withdrawal peaked in the 1980s at about 2 700 $m^3$/p/a, while actual consumption stands at about 500 $m^3$/p/a. In spite of this it has been estimated

Table 5.7. **Global water use**

Cubic kilometres

| Use | 1900 | 1950 | 1995 | 2025 |
|---|---|---|---|---|
| Agriculture | | | | |
| Withdrawal | 500 | 1 100 | 2 500 | 3 200 |
| Consumption | 300 | 700 | 1 750 | 2 250 |
| Industry | | | | |
| Withdrawal | 40 | 200 | 750 | 1 200 |
| Consumption | 5 | 20 | 80 | 170 |
| Domestic | | | | |
| Withdrawal | 20 | 90 | 350 | 600 |
| Consumption | 5 | 15 | 50 | 75 |
| **Total** | | | | |
| Withdrawal | 600 | 1 400 | 3 800 | 5 200 |
| Consumption | 300 | 750 | 2 100 | 2 800 |

that, assuming a "business as usual" scenario, a significant number of both developed and developing countries will experience moderate to high water stress. Per capita water availability will continue to decline.

The Drinking Water Supply and Sanitation Decade of the 1980s (1981-90), which focused primarily on the underserved populations (80% in rural areas), resulted in nearly USD 100 billion in investments (WHO, 1992), and as a result water sector performance improved. By the end of the decade 1 104 million people had obtained access to safe water, the majority being in rural areas (Dieterich, 2004). Moreover, the number of city dwellers in the developing world with access to adequate water increased by 80%. This still left 204 million in urban areas and 41% of those living in rural areas not served. Now some 1 100 million people do not have access to safe water and 2 600 million do not have access to sanitation (WaterAid, 2005). About 80% of all diseases in the developing world are water related, and it has been estimated that each year they account for 1.7 million deaths and the loss of 49.3 million Disability Adjusted Life Years (DALYs), excluding malaria (UN, 2003) – population increases and urbanisation having wiped out the earlier gains, such as they were. Between 1990 and 2000, access to adequate water supply in developing countries as a whole increased from 73% to 79% (Mainardi, 2003). But these aggregate trends hide disparities. In Africa and Asia, where most of the world's poor are concentrated, access to water supply and sanitation presents a far from comfortable picture. In the developing world and especially Africa, developments in the water sector have not been well targeted, technologies used have been up to 10 times more expensive than necessary, and services have been improved for a few rather than for all (WaterAid, 2005).

Examination of the relationship between income levels and infrastructure coverage across 15 countries shows that as income levels rise from USD 100 to USD 250 per month, coverage of all infrastructure services rises rapidly, with water connections following electricity in terms of priority. There is a marked disparity between urban and rural access and the very poor rarely have any infrastructure services at all (Komives, 2001).

Table 5.8. **Water supply coverage 1994**

| Region | Urban population served | | Rural population served | | Total population served | |
|---|---|---|---|---|---|---|
| | Millions | % | Millions | % | Millions | % |
| Africa | 153 | 64 | 173 | 37 | 326 | 46 |
| Latin America and Caribbean | 306 | 88 | 70 | 56 | 376 | 79 |
| Asia and the Pacific | 805 | 84 | 1 690 | 78 | 2 495 | 80 |
| Western Asia | 51 | 98 | 20 | 69 | 71 | 88 |
| Global | 1 315 | 82 | 1 953 | 70 | 3 268 | 75 |

*Source:* Warner, 1997.

Prior to 1980, water supply management was supply driven, harnessing more and more of the available water resources to supply the rising demands. A notable feature of water resources management was to address the uneven distribution of resources in time and space and to redistribute water when and to where people wanted it. However, some countries have been more successful than others in this respect. Whereas arid rich countries such as the United States and Australia have built over 5 000 $m^3$ of water storage per capita, and middle-income countries like South Africa, China and Mexico can store about 1 000 $m^3$ per capita, India by comparison can only store 200 $m^3$. Given the enormous scale of investment involved, most development projects relied on government funding and management in one form or another. The World Commission on Dams estimated that USD 2 trillion had been spent building some 45 000 dams in the 20th century (WCD, 2 000) and that annual investment was running at USD 40 billion (not all for water resource purposes). Only when resource constraints, economic factors and environmental concerns started to become significant issues did it occur that traditional approaches such as large dams and reservoirs may no longer be the solution.

New water infrastructure projects have become increasingly expensive compared with other alternatives, placing a strain not only on existing budgets but also on future income streams. There has been a growing appreciation that issues of social equity and ecosystem integrity have to be included in decisions.

Systems of public water provision often insulate the public utilities from the influence of the market, restricting their very ability to respond to increasing needs or changes in service standards. Politicians, in responding to equity concerns and/or short-term gain, often keep prices for infrastructure services below cost recovery, making service providers dependent on politically motivated budgets (World Development Report, 2004). Arising from the demands of urban groups of consumers with generally higher living standards and greater political articulation, every increase in water quantity will correspondingly give rise to calls for better quality, and since rising urban demands mean more residential sewage and industrial pollution, every increase in consumption could lead to concurrent deterioration in water quality. Thus the problems can become associated with allocation and management rather than resource development.

The efficiency with which water is used has become a major consideration, especially in urban supply as the scale of losses has become increasingly apparent. A significant percentage of distributed water never reaches the final user but is lost due to leakage. Average leakage rates for Public Water Supply (PWS) range from 10% in Austria, Australia and Denmark to 33% in the Czech Republic (OECD, 1999). In the United Kingdom in the 1980s some 30% of all water was lost from water distribution systems, and in some parts of London that figure reached 60% (*The Guardian,* 2003). Such problems are most acute in long established urban areas with ageing assets. Water infrastructure such as pipes can be expected to last for between 50 and 100 years depending on conditions, implying replacement rates of 2% per annum. Most systems in urban areas were laid at the beginning of the 20th century but replacement work has often been neglected: 0.01% in London and 0.8% in Munich for example (SAM, 2004). A major difficulty is in defining what levels of leakage may be acceptable from "public" mains. In England and Wales, Economic Level of Leakage (ELL) is used to specify targets for the water companies. ELL represents an agreed leakage rate above which it is believed economic to tackle the problem and below which it would supposedly cost more than it would save to deal with. ELL suffers from the notorious difficulty of assigning economic and marginal costs and is a highly contested concept. Typical agreed ELL are of the order of more than 20%. A further problem is leakage from customer supply pipes. Only where there is universal metering does the customer have an incentive to reduce the leakage. In England the water companies have consequently offered to take control of customer supply pipes (and also sewers), in order to ensure that these are better maintained.

Losses from distribution systems are a global problem, but the situation in the developing world is especially acute, with too many people without access to safe and affordable water supplies and sanitation. For a variety of reasons water systems have been unable to keep up with the rapid urbanisation of developing countries. While in the 1980s more people in urban areas gained access to safe drinking water – many countries doubling the provision of new water services – more recently the population has begun to outpace the gains made. In Jakarta the water supply and disposal system was designed for half a million people; in 2000 the city population was more than 15 million (Cosgrove and Rijsberman, 2000). It has been estimated that in 1980 there were some eight cities in the world with populations over 8 million people; by 2015 there will be 36, of which 23 will be in Asia (Brinkhoff, 2004). To add to these difficulties in many major cities in the developing world, piped water supplies are intermittent and do not meet accepted quality guidelines (World Development Report, 2004).

As water for industrial use has become both scarcer and relatively more costly, usage has declined. In Japan industrial water use has dropped by some 25% since the 1970s in spite of increasing industrial output. In the United States there have been similar trends, due in part to improvements in manufacturing technology but also to the changing economic structure of industry. In parts of England (East) and in Sydney, Australia, increases in domestic demand have been met from the serendipitous reduction in industrial water use in the past decade. In Sydney, some 900 000 more inhabitants have not increased the total water used, due to falling industrial use and vigorous demand management initiatives changing domestic fittings and appliances to low water use. However, in transition economies, water use by industry is

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increasing and often use per unit of output is two to three times higher for the same product than in OECD countries. This is generally because these industries are not charged the full economic cost of the services. Similarly, there has been a trend for industries to utilise their own wastewater treatment systems, and in many cases recover waste resources or energy. In Europe and a number of developed countries, this is encouraged by legislation and a desire by companies to achieve environmental accreditation to ISO 14000 or equivalent.

Groundwater is now an important component in Asian economies. A recent estimate has put the agricultural value at some USD 25-30 billion per annum (Shah, 2003, cited in Gleick, 2004). This far exceeds the economic value from surface sources. Table 5.9 shows the dependency on groundwater for a number of regions.

Table 5.9. **Groundwater extraction in selected regions**

| | Number of structures extracting groundwater (thousands, 2003) | Average extraction per structure ($m^3$/yr) | Population dependent on groundwater (%) |
|---|---|---|---|
| India | 19 000-26 000 | 7 900 | 55-60 |
| Pakistan (Punjab) | 500 | 90 000 | 60-65 |
| China | 3 500 | 21 500 | 22-25 |
| Iran | 500 | 58 000 | 12-18 |
| Mexico | 70 | 414 285 | 5-6 |
| USA | 200 | 500 000 | <1-2 |

*Source:* Gleick, 2004.

By volume, four countries account for more than 60% of the world's groundwater abstraction: India, China, Pakistan and the United States. These countries account for 75% of the agricultural usage. Data are, however, not as reliable as they are often for private well abstractions for individual farmers – thus agricultural use is likely to be severely underestimated for many countries like India. Over-abstraction, where withdrawal exceeds recharge, is occurring in a number of Middle Eastern countries and also in Turkey and Mauritania. By 2000 some 25% of Mexico's aquifers were known to be overexploited in arid parts of the country. A similar picture is also expected to be true of India and China in certain regions. In India, Pakistan, China and Iran a significant proportion of the population depends on groundwater abstractions, through a high number of very small structures. In Asia this was part of the "green revolution" of the 1960/70s. In contrast, in Mexico and the United States there are fewer but larger structures controlled by a smaller number of people.

Evidence shows that crop yields in areas using groundwater are invariably greater as these water sources tend to be more stable than surface sources. A recent EU study has highlighted the economic benefits of irrigation and the future challenges from the WFD and CAP (Vecino and Martin, 2004). In areas of Spain for example – where irrigation uses 80% of all water supplied, and for which 20% comes from groundwater – irrigation with the latter leads to crop production five times as economically productive, and provides three times the employment, compared with other areas where there is surface irrigation. The reliability of supplies is estimated to result in twice the economic value of simply increasing the volume; hence opening up groundwater access in India in the 1960/80s has led directly to a stabilisation of agricultural production and been a major part of India's economic development and decline in poverty of rural communities.

In view of the lack of, or poor quality of, groundwater data in these "boom" areas, it is impossible to gauge the possible future macro-level implications of declining availability, falling water tables or quality reductions. Information in this area needs improving, as it is so vital for the economic stability of some of the largest countries in the world (Gleick, 2004).

Over-extraction of groundwater can lead to saline intrusion from adjacent coastal waters, or other naturally or human-contaminated water. There are other problems, such as in Bangladesh, where 22 million people risk being poisoned by naturally occurring arsenic in groundwater. In these areas there may be no alternative but to consume polluted water as there are no other affordable sources, although alternatives are being sought such as direct rainwater harvesting. Arsenic is a more widespread problem in groundwaters and has recently been reported in sources used for supply in Italy, Pakistan, Mexico and China (SAHRA, 2006; Stedman, 2006).

## 3. Overview of trends in water demand and infrastructure

### *Introduction*

It is apparent that the world is, or will soon be, facing an unprecedented challenge when it comes to water services (see this chapter's Endnote Profile). In part this is due to population growth, but it is also caused by expectations, new demands and climate uncertainty. The recognition that the poorest and those without adequate access to water and sanitation should be appropriately serviced has grown over the last two decades, and is challenging future management and delivery of water-related services. To address the issue, the international community has established Millennium Development Goals against which to gauge investment and progress (UNDP 2000). Target 10, within MDG 7 to "Ensure environmental sustainability", is: "to halve by 2015 the proportion of people without sustainable access to safe drinking water." While this target may be both feasible and on track, it is five times less ambitious than the notion of universal access; even when "average" progress meets this target "the situation for disadvantaged groups is in fact stagnant or deteriorating"

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(Vandemoortle, 2001). This means that the MDG targets could be satisfied without necessarily achieving access for the poorest sectors of society (Water Management Consultants Ltd., 2004). It is also clear that whatever the debates are around the achievement of the MDG, the impetus to meet them will continue to be a major investment driver for the next few years (*e.g.* Sommen, 2006).

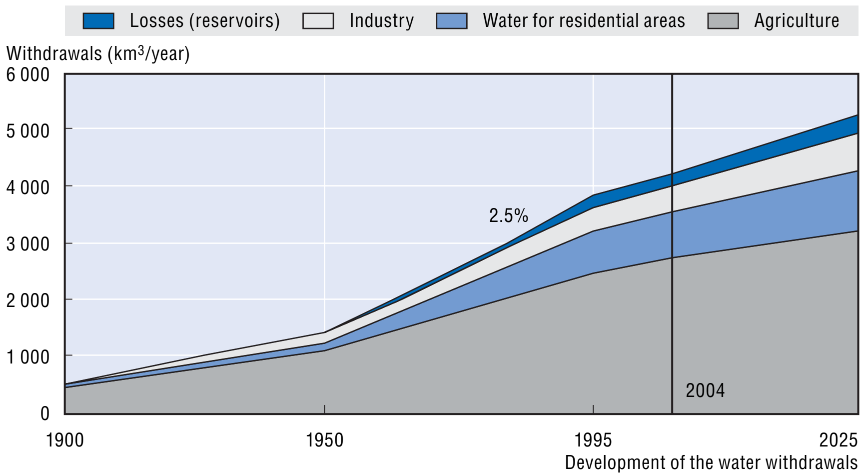
Among the other major challenges facing the water sector are the institutional changes required to modernise and strengthen the legal, policy and administrative arrangements that govern the sector. Water institutions are strongly influenced by factors such as resource endowment, demography, and science and technology. Private sector participation has a relatively strong presence in the delivery of water services in high- and middle-income countries; major cities have some form of involvement although smaller sizes of systems, particularly in LICs, are less attractive (OECD, 2000; Estache and Goicoechea, 2005). The vast majority of private contracts have been granted in urban areas. This trend is most marked in East Asia where there are some concessions and many Build-Operate-Transfer and service deals managed by international private companies. China has been perceived as a potential growth market and in other areas such as Latin America and Eastern Europe, national private enterprise plays and will continue to play an important role. By contrast, low-income and poor countries such as sub-Saharan Africa, South Asia and the Middle East are not attracting much interest from private capital other than in management contracts. Private sector participation is highly concentrated among a few trans-national corporations (TNCs) that are well established in the water sector, with ten companies – all based in OECD countries – holding the majority of contracts. One company for example has more than 25 million customers on four continents (Bakker, 2005).

### *Future water demand trends*

The future demand for and consumption of water will be influenced not just by climatic factors but also by policy decisions, the actions of millions of individuals, the type of and access to water infrastructure and services, changes in technology, and affluence and a whole host of other factors. Projections have been made assuming no radical departures from current practices (Alcamo, Henrichs and Rösch, 2000; Rosengrant, Cai and Cline, 2002). By 2025 water withdrawals in developing countries could increase by 27% over the 1995 figures and in developed countries by 11% (Figure 5.1). Total domestic consumption will increase by 71%, of which more than 90% will be in developing countries; industrial water consumption will also grow faster in developing countries.

In developed countries water for industrial use should decline, due to the changing nature of industrial activity as well as further moves to reduce unit water usage and increase water productivity. The major drivers will be increasingly stringent environmental regulation and the cost of water.

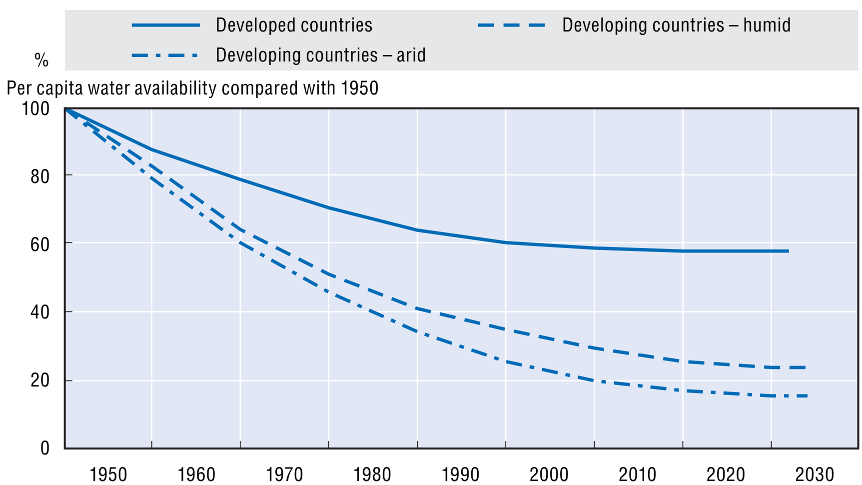
Figure 5.1. **Global water withdrawal predictions**




*Source:* Shikomanov, 1999; FAO 200.

Figure 5.2. **Global water availability**

Water availability continues to decline (1950-2030)




*Source:* Bridging Troubled Waters: Assessing the World Bank Water Ressource Strategy, World Bank, 2002.

Domestic consumption will be driven by demographic factors and structural changes related to water intensity increasing with levels of affluence. At the same time, technological changes will lead to improvements in the efficiency of water use and a decline in water intensity over time. In addition, the evolution of key technologies such as desalination may provide new sources to offset demand shortages in some areas. Water for irrigation will, however, continue to be the biggest source of increasing demand in absolute terms.

It is expected that domestic water will account for 21% of global demand in 2025, as against 10% in 1995; industrial use should remain relatively unchanged at around 20%, while agriculture as a proportion will decline from 70% in 1995 to 56% in 2025 (Alcamo, Henrichs and Rösch, 2000). In absolute terms, water consumption in North America and Western and Central Europe will decline along with that in Japan and Australia, a trend that is already well established in Europe (Eurostat, 2003).

Given both India's and China's pace of urbanisation, their demand for water in the domestic sector is expected to double by 2030 with a similar scale of increase in industrial demand (CAS, 2000; Indian Planning Commission, 2002; Briscoe, 2005). For India to meet the increases there will have to be transfers of the current allocation from agriculture to the domestic and industrial sectors. However, the problems this will cause will be exacerbated as most of the domestic growth will be located in the water-scarce areas of the country. In China there will be a target of nil growth in water consumption for irrigation, which coupled with further resource developments should cater for the increases in the irrigated areas.

### *Trends impacting on water service provision*

Crucial for the review of trends is the definition of what are appropriate water and sanitation systems for now and the future. This definition is not straightforward. The earlier details of the populations not connected to formal water supply systems (Table 5.1), showed that worldwide there are apparently between 92% and 100% of people in urban areas who are served by some form of formal water supply service and between 73% and 100% served by sanitation systems. These figures do not show the nature or quality of these services. Tables 5.2 and 5.3 illustrate examples of actual household water and sanitation provision, with very low figures in Africa for access to water within households or within close proximity. Even elsewhere, convenient accessibility to water and sanitation does not come close to the global figures above; there are low figures in Asia, Oceania and South America. In Europe, in countries such as Romania, only some 50% of the population have access to "public" water supplies. There are many people worldwide who, although not in immediate danger of not having access to water supplies or sanitation, may only have access to the most basic of services. Thus the definition of what is appropriate is fundamental to current and future trends in the demand for water, associated services and infrastructure. Worldwide there are moves and perspectives to better match water use to the defined nature of supplies (*e.g.* WSSCC, 2005). This, together with Integrated Water Resources Management (IWRM), is seen as the best way to deliver affordable and sustainable water services for all needs (Sommen, 2006).

Trends in the recent past (late 20th and early 21st centuries) may be considered in terms of:

- Supplying demands for the various sectors and actors described in Section 1, *i.e.*
  - Maintaining demands and needs in developed countries and increasingly influencing these demands.
  - Providing new supplies to those not so far connected in both developed and developing countries, via exploiting new or existing sources and providing new infrastructure.
- Maintaining, renovating and enhancing existing water and wastewater infrastructure networks in areas that already have them:
  - Sustaining and enhancing the capabilities of these systems to deliver better quality services and improved performance (enhanced quality of supply and wastewater treatment, more efficient and cost effective, higher environmental standards and stakeholder engagement, leading to sustainable systems).

Globally, a number of factors have been responsible for changes in the approach adopted to the provision of water services in developed countries in particular and increasingly elsewhere: the recognition of concepts of sustainability and sustainable development, growing awareness of climate change, other socioeconomic pressures, changes in industrial bases and globalisation, and the development and availability of new technologies. Technological developments now make appropriate service provision feasible at reasonable cost, although there are needs for smarter and more robust approaches (WSSTP, 2005). For example, emerging and more efficient desalination processes using membrane bioreactors (MBRs) have been hailed by many as the future way of satisfying water demand. However, these processes use high amounts of energy and discharge concentrated brine effluents that can impact adversely on ecosystems (Harding, 2006). Currently there are more than 7 500 such plants worldwide, 60% of them in the Middle East. Energy needs to run a plant for a medium-sized city, such as Santa Barbara (United States) are some 50 million kWh/yr (California Coastal Commission, 2006) and unit costs are of the order of USD 1 per $m^3$ of water produced (Twort, Ratnayaka and Brandt, 2000), which is up to ten times the cost from other sources. Recently plans for a new desalination plant in Sydney, Australia were shelved on environmental grounds following public opposition; similar objections were also cited for the rejection of a proposed plant in London.

It is difficult for water utilities to generate sufficient internal revenues to ensure basic financial sustainability. There are conflicting priorities for national government investment, and it is easy to postpone water investments. The sector has a high level of indebtedness, and its institutions

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have poor creditworthiness. It is also true that the supply of finance influences the level of investments – project sponsors would make greater efforts if they knew that funds were available on acceptable terms. The profile of urban water investment projects typically involves a high initial capital outlay, followed by a very long payback period from long-lived assets. As a result, the risk of repayment default is high relative to many other projects. In many developing countries, borrowing in local currency is only available at short maturities that do not match the long-term financing needs of water projects. When countries borrow in foreign currency, they must repay the debt using revenues generated in the local currency. There are a number of examples where an unfavourable movement in the exchange rate has triggered payment default in water projects (*e.g.* Argentina). However, the fundamental root of the finance problem in the water sector is poor governance. Providers of centralised water and wastewater services are monopolists by nature, and therefore require careful regulation. The information asymmetry between governments and water utilities, and the political sensitivity of water pricing, leave the sector vulnerable to *ad hoc* politics and social criticism. As a result, the sector often suffers from a high level of political interference, and a confusion of its social, environmental and commercial aims.

Decentralisation, a worthy aim in a sector of this kind, has led to a devolution of responsibilities for service to sub-sovereign levels of government, but without a commensurate allocation of the required financial means. Water utilities often lack operational autonomy, and their relationship with their political masters is ambiguous. They often have a poor management structure and find it difficult to attract the best staff. They are frequently in a poor financial condition because they are unable or unwilling to charge customers the economic rate for their services, and this then prevents effective reinvestment. Politicians often burden the sector with financial and regulatory arrangements that are *ad hoc*, unpredictable and not sustainable. That makes it impossible for water utilities to properly maintain their assets or attract necessary finance, and leaves them dependent on the fickleness of governments when it comes to funding their new investments. Lack of clarity about ownership of assets is often an additional obstacle to investment. It is true that the water sector may present opportunities for low-cost investments with a quick return. As this experience shows, financing water infrastructure is not restricted to one-off capital investments: sizeable recurrent spending is also required to operate and maintain the assets. If these outlays are not made, the infrastructure may deteriorate and even collapse. There is a growing acceptance of the need for full cost recovery in water services, but this must be done in a way that safeguards the needs of the poor. Valuing water has become critical to optimising investment and obtaining viable private sector participation in the efforts to raise the needed projected investments of USD 180 billion per year until 2025.

The emerging trends driving investment needs may be distinguished by the nature of the various country contexts. Broadly speaking it is possible to see differences between developed economies in high-income countries, transition economies in middle-income countries, and developing economies in low-income countries. In developed economies generally, water service coverage rates are high and there are corresponding concerns over the maintenance of existing assets, whether urban or rural. At the same time a new wave of (sub)urbanisation, responding to demographic changes, rising levels of affluence and expectations, is driving needs for investment in new infrastructure provision. Thus provision for new growth is a substantial driver. Coupled with this is a realisation of the growing scarcity and competition for resources, prompting interest in demand management and (in some cases) calls for "closing the water cycle" (WSSTP, 2005). There are few signs as yet however that this is being tackled in the most developed countries other than Sweden and Australia, although it seems to be a major perspective for the 4th World Water Forum (Sommen, 2006).

The present diversity of organisational forms of institutions will continue to be a feature of the industry in the future. There will, however, be substantial changes. In Europe for example, drivers such as the WFD and even climate change might be expected to prompt organisational change with respect to scale of operations, but not asset ownership changes. Regulation of the industry and of companies providing services will probably become an increasing feature of service provision as governments seek to ensure that services are delivered efficiently and cost-effectively, while at the same time continuing to move towards full cost recovery. Affordability ratios (spending on water and sewage as a proportion of household budgets) in Western Europe are in the 1-1.5% range, around 1% in Northern Europe (Germany = 1.2%) and below 1% in southern EU countries. In England the average government target is around 3%, but in some areas retired citizens are paying as much as 7%. By contrast the ratio is 0.5% in the United States but rises to as much as 3% in less well developed economies (EBRD, 2005). A number of agencies use figures of 3%, with a maximum of 5% in some cases. At the same time, in developing countries the ratio of revenues to costs in the water sector stands at approximately 0.3 (Hoornweg, 2004). Environmental protection and pollution control could also have profound impacts on future service. The best available exemplar of this is the WFD in Europe. Its full cost impact is still a matter of discussion; however, one estimate suggests it will cost some USD 300 billion to implement by 2017 (WSSTP, 2005; SAM, 2004). It seems that the adoption of increasingly stringent environmental protection measures is in some ways a reflection of societal expectations and norms and concerns about the nature of sustainability, and a product of a wealthier society. The importance of these perspectives in high-income countries and their potential impact on other economies should not be

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underestimated, as it is the developed countries that exert the greatest influence on global norms and often set the conditions of engagement that others are expected to aspire to and adopt.

In transition economies, such as the EECCA, there are a set of similar drivers and concerns. However, these are modulated by the need to improve service coverage and at the same time address the residual problems of poor governance, infrastructure and organisational neglect and inefficiency that have resulted in the continuing deterioration of the asset base. Following a meeting in Almaty in October 2000, EECCA and other ministers and senior representatives from several OECD countries, and senior officials from international financial institutions, international organisations, NGOs and the private sector recognised the critical condition of the urban water supply and sanitation sector in EECCA and endorsed "Guiding Principles for the Reform of the Urban Water Supply and Sanitation Sector in the NIS". Since then and in preparation for a five-year review meeting in November 2005, the state of the water assets has been further reviewed and found to be continuing to decline (OECD, 2005b).

Thus the emphasis may need to be on replacement rather than maintenance for these countries and many that recently accessed the EU, as the means of improving service and addressing environmental pollution. The need for new investment in infrastructure coupled with the low rates of cost recovery and other factors has focused attention on the corresponding need for capacity building and to restructure the way in which services are delivered. There is a direct relationship between collection rates and affordability (Frankhauser and Tepic, 2005), and poor revenue collection affects almost all of the countries in the former Eastern Bloc. There have been drives for the reorganisation of water services to encourage greater levels of private sector participation, through measures such as corporatisation, concessions and leases and other forms of contract, as a way of freeing the sector up from state control or reliance on state financing.

In developing economies there is an even greater need to extend basic services to burgeoning populations, often in rapidly urbanising situations. Here the need for basic services tends to take precedence over other concerns. Thus there is less of an emphasis on institutional forms and more on partnerships and capacity building, although the institutional and legal frameworks have needed reform in order to facilitate improvement of service provision. In order to meet the MDG, annual spending on water and sanitation needs to double, from around USD 14 billion to USD 30 billion, which indicates that there is a funding gap of some USD 16 billion per year to be met (WaterAid, 2005), at a time when aid from donor countries is generally in decline.

### *Investment needs*

The estimation of future investment needs here has depended more on the availability of information than on sophisticated estimation methodologies. Information is often most readily available from central sources such as industry regulators. The reliability and usefulness of information become problematic when the sources are not centralised, where there are multiple sources of information and where several bodies and agencies are involved. Ideally, expenditure information should distinguish between operation and maintenance and capital expenditure, rarely available. In addition, it is useful to identify expenditures driven by the need for new services – growth, environmental regulation and pollution control as well as the requirements for providing the base service. This detailed information is seldom readily available; thus some of the estimates given below should be considered as indicative only and within orders of magnitude. The levels of investment and expenditure required for the proper provision of water services are substantial and growing. The role of the international finance community is often crucial for transition and developing economies even where the proportion of required investment may be limited, as it has the ability to leverage local funding to support investment.

Estimates of the future demand for infrastructure services for the first decade of the 21st century, which include water services, have been made based on demand rather than measures of need (Fay and Yepes, 2003). It was noted that water and sanitation have dropped in importance relative to the rest of infrastructure stocks as incomes have increased. In deriving investment needs, account was taken not just of the provision of new infrastructure but also of maintenance needs, estimated at 3% of the replacement cost of capital stock for water and sanitation. Fay and Yepes (2003) estimated that water and sanitation should add up to 2% of GDP, noting that their figure was substantially higher than a previous estimate of 0.4% of GDP for middle-income countries. Adjusting the 2% of GDP to reflect the differences they note between high-, middle- and low-income countries indicates that the amounts to be spent on new infrastructure and maintenance would be 0.4% of GDP for high-income countries, 1.9% for middle-income countries and 2.5% for low-income countries. However, there is some ambiguity in the published figures.

In the following sections examples of the investment requirements for certain OECD and other important countries are discussed on the basis of present trends.

### *United States*

The major factors driving capital investments are regulatory compliance, growth and the age of the infrastructure, accounting for 7%, 40% and 30% of expenditure (Brow, 2001). However, these figures reflect expenditure rather than need. Various estimates of the required levels of expenditure have been made in recent years (Table 5.10). These have included the EPA's periodic "needs survey" of drinking water and wastewater systems, estimates by the Water Infrastructure Network (WIN) and the American Water Works Association, and the Congressional Budget Office. The Water Infrastructure Network report (WIN, 2000) estimated that drinking water utilities need to spend USD 24 billion per year for the next 20 years on infrastructure but that currently the expenditure is USD 13 billion per year. For wastewater systems the figures are USD 22 billion and USD 10 billion per year respectively, leaving an overall gap of USD 23 billion per year over 20 years (Johnson, 2004). These amounts dwarf the existing level of funding, and federal subsidies used to supplement user fees and help finance capital investments are unlikely to address the real causes of inadequate maintenance: the institutional arrangements and managerial practices (Levin *et al.,* 2002). The EPA's own gap analysis, the 2003 Needs Assessment, is in substantial agreement with the WIN and the Congressional Budget Office estimates (EPA, 2005). All indicate that there is a need for substantial investments to upgrade or replace the water infrastructure (Levin *et al.,* 2002) in order to ensure compliance with quality standards prescribed by the Safe Drinking Water Act. The EPA estimated that drinking water utilities will spend USD 154 – 446 billion up to 2019 and wastewater systems USD 331-450 billion over the same period in order to meet the required standards. In addition a further USD 17.5 billion is required to replace lead service pipes and USD 1.2 billion to harden facilities in order to improve security. In addition, there are the operation and maintenance costs that have been estimated at USD 29 billion for drinking water and USD 24 billion for wastewater annually (CBO, 2001). The estimates approximate to a spending of 0.75% of GDP. Affordability ratios for water and sewage services are approximately 0.5%.

Table 5.10. **Estimates of average annual costs for investment in water systems to 2019**

2001 dollars

| Source | Water supply (USD million) | Wastewater (USD million) | Annual amount (USD million) | Total |
|---|---|---|---|---|
| Congressional Budget Office | 12 000-20 500 | 14 900-22 300 | 26 900-42 700 | 538 000-854 000 |
| Water Infrastructure Network | 20 900 | 19 200 | 40 100 | 802 000 |
| EPA Needs Survey | 7 700-22 300 | 16 550-22 500 | 24 250-44 800 | 503 700-1 014 700 |

*Source:* Authors.

Since 1997 a loan programme of USD 1 billion has been authorised annually under the Drinking Water State Revolving Fund for wastewater projects. Concerns about the ability to raise the necessary finances are now leading US municipalities to consider privatisation.

### *United Kingdom*

In England and Wales (privatised) the amounts spent and projected expenditures on provision of water services are shown in Table 5.11 (Ofwat, 2005). The amounts take into account obligations to meet various European Union Directives in future years. In Scotland (public water supply) an amount of GBP 1.8 billion is being invested between 2002 and 2006 with a further GBP 2.1 billion for the period 2006-10 at 2003-04 prices (WICS, 2005). Table 5.10 also shows estimates for the province of Northern Ireland (public). The total corresponds to some 0.72% of GDP at 2005 values. Projected increases are attributable to meeting environmental obligations but the impact of the EU Water Framework Directive is not included, as this will have to be taken into account only post 2010. Estimates for this vary, but are around GBP 30 billion. For the average household the amounts paid for water and sewage services represent an affordability ratio of approximately 1%, in line with European averages; for the poorest however, this can be as high as 10%.

Table 5.11. **Expenditure on UK water services**

GBP millions, 2002-03 prices

| | Region | 2000-05 | 2005-10 |
|---|---|---|---|
| Average annual capital investment | England and Wales | 3 300 | 3 365 |
| | Scotland | 360 | 525 |
| | Northern Ireland | 107 | 114 |
| Average annual operating expenditure | England and Wales | 2 800 | 2 953 |
| | Scotland | 310 | 410 |
| | Northern Ireland | 256 | 227 |
| Total annual expenditure | England and Wales | 6 100 | 6 318 |
| | Scotland | 670 | 935 |
| | Northern Ireland | 363 | 341 |
| | Total | 7 133 | 7 594 |

*Source:* Authors.

Of the capital expenditure, 51% is for the base service, 17% for growth and 32% for quality enhancements.

### *Central and Eastern Europe*

This section is based on a recent report on the EECCA region five years on from the Almaty meeting (OECD, 2005b). The report looked at the costs involved in meeting the MDG in the EECCA countries. Also included were attempts to calculate an all-in cost (referred to as the "total costs") that include O&M and reinvestment costs. The "total costs" were the sum of "MDG costs" over the period 2002-15 (14 years) plus O&M costs of the existing system over the period 2000-20 (21 years), plus O&M costs of new extensions and additional facilities to be built over the period 2000-20, plus reinvestment costs over the period 2000-20 – *i.e.* investment costs needed to maintain the same level of quality/service of the existing infrastructure. The estimate was prepared by COWI (OECD, 2005). The estimates did not include such costs under the "MDG costs", where the level of quality/service is assumed to be improved above the current level. This cost estimate corresponds to an aggregate of costs over two different periods, 14 and 21 years. It is this estimate that COWI uses to explore the feasibility of financing the cost of reaching Target 10, Table 5.12. The annual "total costs" estimates per country are obtained by dividing the "total costs" estimate by 20.

Table 5.12. **Water supply and sanitation estimates for EECCA countries**
Million euros

| | Water supply | | Sanitation | | WSS | | Total as % of GDP |
|---|---|---|---|---|---|---|---|
| | Total | Per capita | Total | Per capita | Total | Per capita | |
| Armenia | 58 | 18.1 | 26 | 7.9 | 84 | 26.0 | 2.49 |
| Azerbaijan | 102 | 12.8 | 87 | 10.9 | 189 | 24.0 | 2.20 |
| Belarus | 211 | 20.9 | 91 | 9.0 | 302 | 30.0 | 1.39 |
| Georgia | 69 | 15.3 | 29 | 6.3 | 98 | 22.0 | 2.59 |
| Kazakhstan | 233 | 16.1 | 100 | 6.9 | 333 | 23.0 | 0.80 |
| Kyrgyz Republic | 80 | 16.0 | 30 | 6.0 | 110 | 22.0 | 6.00 |
| Moldova | 44 | 10.2 | 26 | 6.1 | 70 | 16.0 | 3.02 |
| Russian Federation | 2 408 | 16.6 | 1 254 | 8.6 | 3 662 | 25.0 | 0.32 |
| Tajikistan | 85 | 13.1 | 32 | 4.9 | 117 | 18.0 | 6.26 |
| Turkmenistan | 120 | 22.7 | 32 | 6.1 | 152 | 29.0 | 1.37 |
| Ukraine | 868 | 18.0 | 384 | 8.0 | 1 252 | 26.0 | 1.89 |
| Uzbekistan | 411 | 16.5 | 142 | 5.7 | 553 | 22.0 | 6.28 |
| **Total** | **4 689** | **16.3** | **2 233** | **7.2** | **6 922** | **23.6** | **2.88** |

*Source:* OECD, 2005b.

The report notes that the annual "total costs" estimate of EUR 6.9 billion per year appears out of proportion with the so-called "MDG costs": over a 14-year period, it amounts to nearly EUR 97 billion, more than six times the "MDG costs". This reinforces the contention that the real challenge for the EECCA regions in the years to come lies much more with the O&M of the water supply and sanitation (WSS) systems and maintaining the existing infrastructure at its current level of quality/service than with extension costs or costs incurred to improve the current level of quality/service and bring it to an "MDG Target 10 compliant" level.

The final column reveals what might be considered some anomalous results, in that some appear too low. For example, for the Russian Federation, 0.32% of GDP does not accord well with the situation outlined in Russia's

Endnote Profile at the end of this chapter. Other estimates would appear to be high, perhaps reflecting the scale of the situation to be addressed. As the report noted (OECD, 2005b), the detailed estimates for specific countries show significant discrepancies that can be attributed to a different understanding of the types of costs to be included and to different calculation methods. In addition, the study suggests that even raising the finance to operate and maintain the infrastructure in its present poor state – a much less ambitious challenge than achieving the water-related MDGs – would pose major problems for a number of EECCA countries.

### *Canada*

A report by Infrastructure Canada (2004b) noted that the dearth of reliable, comparable, comprehensive and objective data and information means that it is difficult to estimate that country's infrastructure needs. This has led to discrepancies between the various existing estimates. While a number of studies have reported on the overall deficit of infrastructure in general, fewer address the state of water infrastructure specifically. It is difficult to determine what the total level of current expenditure is for operation, maintenance and new infrastructure. The discrepancies make it difficult if not impossible to arrive at one overarching, comprehensive figure. In reviewing the literature on estimated needs and replacement costs for water infrastructure, Infrastructure Canada (2004a) indicated that the available figures were neither persuasive nor comparable. The report noted estimates of CAD 38-39 billion for the maintenance of existing capital stocks and services, and CAD 88.4 billion for new and upgraded infrastructure over a 15-year period. By 2003 the total was said to amount to CAD 10 billion per year, highlighting the fact that despite the data problems the amounts required would clearly run into billions. The Canadian Water and Wastewater Association reported that an annual investment of CAD 5.8 billion up to 2018 would be required for underground infrastructure. There would also be a CAD 28 billion infrastructure need for municipal water systems and CAD 60.4 billion debt for wastewater systems from 1997 to 2012. This was derived from statistics of the size of the industry, the population served and levels of service provided. The National Round Table on the Environment and the Economy (1996) study found that existing funds are used to address only the critical infrastructure needs, leaving an unmet infrastructure need to ensure that the existing stock is maintained ranging from CAD 38 to 49 billion, and capital costs for the following 20 years would be in the order of CAD 70-90 billion. New capital demand will exceed CAD 41 billion by 2015. Therefore total capital requirements for water and wastewater infrastructure will be CAD 79-90 billion over the next 20 years. This assumes static market conditions; the effect of other measures to curtail demand could reduce the estimates by 10-16%. A Canada West Foundation report (Vander Ploeg, 2003) indicated that some 60% of the estimated shortfall between current and required funding of all municipal infrastructure would be required to bring the water infrastructure up to acceptable standards. Estimates of total infrastructure debt range between CAD 57 billion and CAD 125 billion (Vander Ploeg, 2003), implying amounts of between CAD 34 billion and CAD 75 billion for water infrastructure. Again this does not include current levels of funding but rather the accumulated shortfall.

Infrastructure Canada (2004a) noted the growing difficulties in financing such investments, which is partly due to under-charging for services but also due to an inability to increase municipal incomes and offset falling provincial and federal transfers. This has led to a growing interest in alternative mechanisms for infrastructure financing. Some public-private partnerships of various kinds have been implemented, often attracting considerable opposition (CUPE, 2005). It now appears necessary to address the challenges related to ageing and inadequate water infrastructure. The federal government is aware of the problem and there have been moves to increase funding, for instance through the establishment of the Infrastructure Canada Program, the Green Municipal Investment Fund, the Green Municipal Enabling Fund and the Municipal Rural Infrastructure Fund. The 2003 federal budget allocated CAD 3 billion for investment in infrastructure generally on top of the previous investment of CAD 5 billion announced in 2001. However, according to the Canadian Council of Professional Engineers, this fails to adequately address the burgeoning infrastructure deficit; increased levels of expenditure are required for the modernisation of water and wastewater treatment infrastructure.

Based on the figures presented above, investments of anything between CAD 34 billion and CAD 90 billion could be required over 20 years just to meet the infrastructure deficit. These figures do not include current levels of investment nor operational and maintenance costs. Taking the CAD 10 billion per year figure, this would imply required investments of approximately 0.6% of GDP – an indicative figure given the caveats that various reports have noted.

However, it is important to note that in 2002, with the creation of Infrastructure Canada, the government of Canada formally confirmed that public infrastructure renewal had become a priority of the federal government. The new federal department was established to provide a focal point for the government of Canada on infrastructure policies, programmes and research. Since its inception it has been working with other provinces, territories, municipalities, First Nations, professional associations, non-governmental organisations, researchers and the private sector to improve Canada's physical infrastructure. Through Infrastructure Canada's funding programmes the federal government has made significant investments in public infrastructure, including water infrastructure, over the past few years. To date, the department has announced investments of over CAD 350 million for water and sewage treatment infrastructure under the Canada Strategic Infrastructure Fund, and just under CAD 1 billion under the Infrastructure Canada Program. Significant investments in water and wastewater infrastructure are also being made as a result of the department's CAD 1 billion Municipal Rural Infrastructure Fund announced in 2003. All of these investments are complemented by the funding programmes and other activities of other federal government departments with responsibilities regarding water and sewage treatment infrastructure, including Indian and Northern Affairs Canada and Environment Canada. (For a fuller discussion of the roles, responsibilities and activities of various federal government departments and agencies *vis-à-vis* water, wastewater and related infrastructure, see "Infrastructure Canada: Enhancing Knowledge about Public Infrastructure – Perspectives in the Federal Family", 2002, available at: *www.infrastructure.gc.ca/research*.)

### *India*

The annual requirement for rehabilitating existing infrastructure is estimated to be USD 4.6 billion, while the India Water Vision expects new investments to cost about USD 4.14 billion per year. Annual allocations in the past have been between USD 0.2 billion and USD 3.9 billion a year (Planning Commission, 2002). A large part of the budgeted amounts is spent on recurrent costs for personnel, electricity and subsidies, and not on the needed maintenance. Water Aid (2005) has estimated that the annual financing need for domestic water and sanitation is some USD 5.05 billion but that only USD 2 950 million is actually being spent, leaving a funding gap of USD 2 100 million. However, a serious problem in most developing countries including India is the failure to utilise the budgets already available; often these are some 30-65% of the actual budget. Based on preliminary estimates, meeting the MDG target in urban areas would require an investment of USD 21.8 billion up to 2017 and recurrent expenditures of about USD 21.1 billion over the same period. In the rural areas the figures would be USD 16.5 billion and USD 15.6 billion respectively. It is unclear what these figures imply for the financing needs for water services over the coming decades. A preliminary estimate has been arrived at by using these figures and making some assumptions (Table 5.13).

This total in Table 5.13 is 0.71% of GDP. While this shows a certain consistency with other country estimates above, it is conjectural and a first order estimate. It does, however, indicate the scale of the financing challenge facing the country, given its current levels of expenditure.

The potential for collapse in groundwater for irrigation from the current over-abstraction may also require significant investments if alternatives are to be developed. An obvious option is to better collect monsoon rains, either in river networks or using other local storage options. Investment costs would be substantial; one estimate of the former approaches USD 200 billion. Needs in

Table 5.13. **Estimated annual investment needs in India**

USD millions

| | Rehabilitation of existing infrastructure | New infrastructure investment | MDG urban areas | MDG rural areas | Total |
|---|---|---|---|---|---|
| Capital investment | 4 600 | 4 140 | 1 820 | 1 370 | 11 930 |
| Operational expenditure | 4 370[1] | 3 930[1] | 1 750 | 1 300 | 11 350 |
| **Total** | **8 970** | **8 070** | **3 550** | **2 670** | **23 280** |

1. Using the ratio of 0.95 of capital expenditure derived from the MDG estimates.

*Source:* Authors.

this area are not considered further in this report; however, investments in dealing with irrigation needs if and when these groundwater sources fail will be prodigious.

### *China*

According to the Chinese government, expenditure on what are called environmental goods and services have been rising steadily over the past decade as the country has sought to address the problems associated with water shortages, supply, treatment and pollution. In the 10th Five Year Plan (2001-05) an amount of USD 84.5 billion was budgeted, to be followed in the 11th Plan by USD 157 billion or 1.5% of GDP. In 2003 the estimated expenditure amounted to 1.39% of GDP (China, 2005). However, this covers all environmental goods and services, not just water, and it is unclear what other sums at provincial and municipal level should be included. This needs to be increased, probably to around 2% of GDP for air and water pollution control to 2020, and much greater allocations need to be made for basic capacity building (IBRD/WB, 2001). In the 10th Five Year Plan the budget outlay on water supply and wastewater treatment was USD 33 billion. In the 11th Plan a further USD 12.1 billion has been budgeted for water supply and USD 8.37 billion for wastewater treatment associated with three major water supply and wastewater projects. The 11th Five Year Plan (2006-10) sets as a target access to safe drinking water for 98% coverage of urban residents and 60% for rural residents. Recently the Chinese vice-minister of construction said that urban water supply needs USD 250 billion of investment, although the time scale was not indicated. Half of all wastewater is not treated and around 661 cities have no wastewater treatment systems. An estimated USD 10.4 billion is needed to construct the required facilities to meet these needs (China Economic Net, 2005). If 1% of GDP were to be spent annually on meeting the capital, operational and maintenance requirements, the annual figure would be USD 71.34 billion or USD 356.7 billion over a five-year period. If the amounts given above to be spent on urban water supply and wastewater treatment were spent over the next 10 years on new works, this would amount to approximately

USD 130 billion, implying an amount of USD 220 billion for the maintenance and operation of existing systems. Given that the 2004 total state expenditure was USD 3 425 billion per annum, an expenditure of USD 71.34 billion would represent approximately 2% of the state expenditure, which would seem reasonable.

In order to facilitate this process, reforms of the financing and investment structure of the water industry are under way to encourage a range of investment and participation mechanisms for both local and foreign enterprises. A large proportion of the funds to develop China's water infrastructure are expected to be raised from overseas investment, loans and market financing, despite current low private participation. A key factor in attracting investment will be the reform of property rights and transforming government's role into that of a regulator responsible for quality, price, service, rights and competition rather than a services supplier. There appear to be no readily available figures for the ongoing operation and maintenance funding requirements for the country, although it is reasonable to assume that the budget allocations do include the operational expenditures.

### *Brazil*

According to Almeida and Mulder (2005), public investment in water/ sanitation has fallen over time, from 0.3-0.4% of GDP in the 1970s and 80s to 0.2% during 1999-2002, and 0.1% in 2003. This drop was mainly due to ongoing fiscal consolidation, which affected investment spending more adversely than current expenditure, being relatively harder to retrench. Preliminary data suggest that spending levels have increased in 2004. Investment is also discouraged by the externalities associated with the provision of sewage and water treatment services, and because water/sanitation networks are costly, investment maturities are long, and rates of return are relatively low. More importantly, the drop in public investment has not been compensated by an increase in private investment, which can be attributed predominantly to a lack of clarity about which level of government is responsible for service delivery and regulation in the sector. This is particularly acute in the metropolitan regions, which straddle municipal borders. As a result, no regulatory framework or regulatory agency is currently available for this sector. The National Water Agency (ANA), created in 2001, is responsible for managing and regulating surface water resources but has no purview over water/sanitation services.

### *Water sector investment requirements*

World Bank Research Working Paper 3102 (Fay and Yepes, 2003) suggests that over the period 2005-10 for the developing world an amount totalling the equivalent of 2% of GDP for all developing countries would be required to be invested in the maintenance of existing and new infrastructure, equivalent

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to 0.44% of GDP annually. For the world the equivalent figures are 0.6% of GDP totalled over five years or 0.12% of GDP annually. From Annex II of the same report the calculated percentages of GDP given are set out in Table 5.14.

Table 5.14. **Expenditure on water and sanitation as a percentage of GDP**

| | New infrastructure | | | Maintenance | | | Total |
|---|---|---|---|---|---|---|---|
| | Water | Sanitation | Total | Water | Sanitation | Total | |
| East Asia and Pacific | 0.07 | 0.1 | 0.17 | 0.13 | 0.15 | 0.28 | 0.45 |
| South Asia | 0.21 | 0.19 | 0.40 | 0.36 | 0.26 | 0.62 | 1.02 |
| Europe and Central Asia | 0.02 | 0.05 | 0.07 | 0.10 | 0.18 | 0.18 | 0.25 |
| Middle East and North Africa | 0.06 | 0.11 | 0.17 | 0.10 | 0.16 | 0.26 | 0.43 |
| Sub-Saharan Africa | 0.15 | 0.27 | 0.42 | 0.20 | 0.35 | 0.55 | 0.97 |
| Latin America and Caribbean | 0.03 | 0.05 | 0.08 | 0.05 | 0.08 | 0.13 | 0.21 |
| High income | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.03 | 0.03 |
| Low income | 0.19 | 0.24 | 0.43 | 0.32 | 0.35 | 0.67 | 1.10 |
| Middle income | 0.04 | 0.06 | 0.10 | 0.09 | 0.12 | 0.21 | 0.31 |
| Developing regions | 0.07 | 0.10 | 0.17 | 0.13 | 0.16 | 0.29 | 0.46 |
| **World** | **0.02** | **0.02** | **0.04** | **0.04** | **0.05** | **0.09** | **0.13** |

*Source:* Fay and Yepes, 2003.

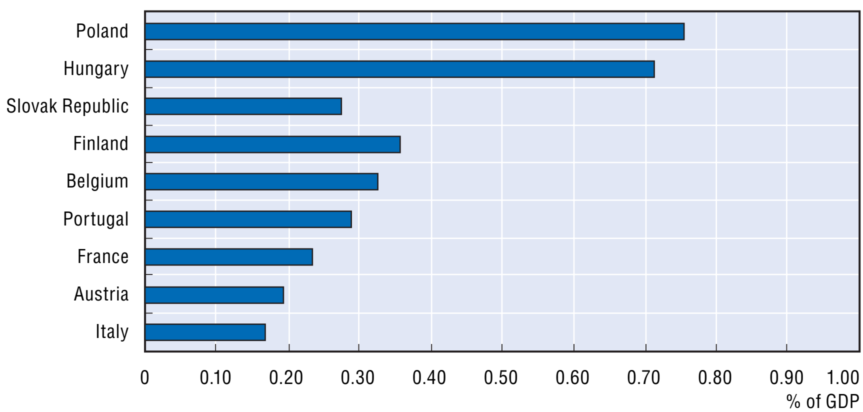
These estimates appear to be substantially lower than the figures reported in the preceding section. Based on detailed estimates of allowed expenditure in the United Kingdom and in the case of the United States on a Needs Survey (EPA, 2005), the equivalent figures were 0.72% and 0.75% of GDP respectively, although in Canada it is about 0.6%. The figure for the United Kingdom is further supported by rough estimates of required maintenance expenditures based on water sector asset values. The value of assets in England and Wales is in excess of GBP 200 billion, based on 3% (Fay and Yepes, 2003) of asset value being spent on maintenance. This implies an expenditure of GBP 6 billion per annum, or the equivalent 0.6% of GDP, excluding new investments and expenditures required for Scotland and Northern Ireland. Thus there is a strong contrast with the figure of 0.03% of GDP for high-income countries given in the table above.

According to Dangeard (2003): "There are few reliable data on water distribution and water pollution abatement expenses as a percentage of GDP. The figures in international sources depend on the sector covered: does it include urban water or also irrigation? Does it cover services and investments? Orders of magnitude concur on some USD 30 billion per year for developing countries investment expenses, the equivalent figure from Fay and Yepes is USD 13.8 billion per year. Thus, surprisingly, developing countries do not seem to devote a higher percentage of GDP for water infrastructure than industrialised countries. A figure for China's pollution abatement expenses given by the National Environment

Protection Agency is close to 1%, which seems low, although increasing. India's expenditure is believed to be less than 1% of GDP. *In France, water expenses of private sector and administrations are 1.2-1.5% of GDP*" (emphasis added).

There is further corroboration that per capita expenditures on water and sanitation in high- and middle-income countries are greater than the indicated figures in Table 5.14. An analysis of Eurostat data on environmental protection expenditure (public and private sectors) indicates a range of between 0.16% and 0.35% of GDP for high-income (average 0.26%) and between 0.27% and 0.75% of GDP for middle-income (average 0.58%) countries on wastewater (sanitation), see Figure 5.3. Given the limitations of the data sets reported by Eurostat, these figures are likely to under-represent actual expenditures. And they only cover wastewater (sanitation); there are no comparable statistics for water supply expenditures. Assuming that expenditure on water supply mirrors that of wastewater, the range would be 0.32%-0.75% and 0.54%-1.5% of GDP respectively for water and sanitation combined.

Figure 5.3. **Total expenditure on wastewater as percentage of GDP**




*Source:* Authors, based on data from Eurostat.

In 2003 an OECD report stated: "In the OECD countries as a whole the expenditure of the water sector exceeds USD 250 billion per year, taking into account all direct expenditure related to water for domestic, industrial and agricultural use". In the area of pollution abatement and control (PAC), investment and operating expenditure related to water (*i.e.* sewage and wastewater treatment) ranges between 0.3 and 1% of GDP… Most such expenditure is public expenditure, with private expenditure mostly limited to that part of industry and households treating their own wastewater. Water supply and irrigation expenditure are of the same order of magnitude as PAC expenditure.

Table 5.15. **Investment and current expenditure on wastewater pollution abatement and control, selected countries, late 1990s**

| | Total[1] | | | Public sector[2] | | | | Business sector | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Year | Per capita | ‰ GDP | Year | Per capita | ‰ GDP | Investment ‰ GDP | Year | Per capita | ‰ GDP |
| Mexico[3] | .. | .. | .. | 2000 | 1.8 | 0.2 | 0.1 | .. | .. | .. |
| United States | 1994 | 161.8 | 6.0 | 1994 | 105.0 | 3.9 | 1.8 | 1999 | 23.4 | 0.7 |
| Japan | .. | .. | .. | 1999 | 84.1 | 3.3 | .. | .. | .. | .. |
| Korea | 2000 | 116.3 | 6.6 | 2000 | 80.8 | 4.6 | 3.6 | 2000 | 35.5 | 2.0 |
| Australia | .. | .. | .. | 2000 | 36.7 | 1.4 | 0.6 | .. | .. | .. |
| Austria[3] | 2000 | 202.8 | 7.5 | 2000 | 117.2 | 4.3 | 1.9 | 2000 | 47.2 | 1.4 |
| Belgium | 2000 | 111.4 | 4.3 | 2000 | 74.3 | 2.8 | 1.9 | 2000 | 29.6 | 1.1 |
| Denmark | .. | .. | .. | 2000 | 123.0 | 4.3 | 1.6 | .. | .. | .. |
| Finland | 1999 | 81.8 | 3.6 | 2000 | 58.4 | 2.4 | 1.1 | 1999 | 30.6 | 1.3 |
| France | 2000 | 177.9 | 7.5 | 2000 | 100.7 | 4.2 | 2.3 | 2000 | 23.3 | 1.0 |
| Germany[3] | 1999 | 195.4 | 8.3 | 1999 | 168.7 | 7.2 | 3.6 | 2000 | 28.0 | 1.1 |
| Greece | .. | .. | .. | 1999 | 14.3 | 1.0 | 0.9 | .. | .. | .. |
| Iceland | .. | .. | .. | 2000 | 17.2 | 0.6 | 0.5 | .. | .. | .. |
| Ireland | 1998 | 73.6 | 3.1 | 1998 | 58.7 | 2.5 | 1.7 | 1998 | 14.9 | 0.6 |
| Italy[3] | .. | .. | .. | 1996 | 3.2 | 0.2 | 0.0 | 1997 | 6.3 | 0.3 |
| Luxembourg | .. | .. | .. | 1997 | 96.8 | 2.7 | 1.6 | .. | .. | .. |
| Netherlands | 1998 | 144.3 | 5.9 | 1998 | 113.5 | 4.7 | 2.0 | 1998 | 26.6 | 1.1 |
| Norway[3] | .. | .. | .. | 2000 | 81.2 | 2.8 | 1.3 | .. | .. | .. |
| Poland[3] | 2000 | 62.7 | 6.8 | 2000 | 42.0 | 4.5 | 3.7 | 2000 | 20.3 | 2.2 |
| Portugal | 1998 | 58.5 | 3.7 | 2000 | 40.0 | 2.3 | 1.7 | 2000 | 14.9 | 0.9 |
| Slovak Republic | .. | .. | .. | 1994 | 38.3 | 4.9 | 3.6 | .. | .. | .. |
| Spain | .. | .. | .. | 1999 | 46.4 | 2.5 | 2.0 | .. | .. | .. |
| Sweden[3] | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| Switzerland[3] | .. | .. | .. | 1999 | 131.6 | 4.8 | 2.6 | .. | .. | .. |
| Turkey | 1997 | 10.5 | 1.7 | 1997 | 8.7 | 1.4 | 1.2 | 1997 | 1.8 | 0.3 |
| United Kingdom | 2000 | 17.7 | 0.7 | 2000 | 4.7 | 0.2 | 0.0 | 2000 | 13.0 | 0.5 |

1. Public and business sectors and specialised producers of environmental services (not households).
2. Including public specialised producers of environmental services
3. Per capita: in USD per person at current purchasing power parities – ‰ GDP: per 1 000 units of GDP.

*Source:* OECD.

Other reported figures for wastewater for example are for the Netherlands 0.6% of GDP and for France 0.8% of GDP (IWA, 2005). The derived figure of expenditure for India is similar to that of high-income countries at 0.71%, though this appears to be somewhat low. The reported figure for China is 1.4%, compared with the Five Year Plan estimate of 1.5%.

### *Summary*

Based on the evidence cited above, the levels of expenditure on water services for high income countries should be of the order of 0.75% of GDP. The estimations for the EECCA countries would appear to show some broad correlation with the empirical work, although the spread is wide (0.3-6%). The evidence suggests that in the case of low-income countries there will have to be substantial increases in the levels of investment if appropriate levels of water services are to be provided. It is difficult to be definitive given the gaps in data and the uncertainties surrounding the available information. Nonetheless, the following ranges of annual expenditures on water services are proposed, covering capital investment in infrastructure and operational expenditures on water resource development, transmission, treatment, distribution, wastewater collection, wastewater treatment and disposal:

High-income countries 0.35% to 1.20% of GDP

Based on a lower bound (Italy) and an upper bound (France) and including figures from Austria, Belgium, Canada, Denmark, Finland, Germany, Netherlands, Portugal, the United Kingdom and the United States.

Middle-income countries 0.54% to 2.60% of GDP

Based on a lower bound (Slovakia) and an upper bound (Georgia) and including figures from Armenia, Azerbaijan, Belarus, Brazil, China, Hungary, Kazakhstan, Poland, Russia, Turkmenistan, and Ukraine.

Low-income countries 0.70% to 6.30% of GDP

Based on a lower bound (India) and an upper bound (Uzbekistan) and including Moldova, Kyrgyzstan and Tajikistan.

## 4. Key factors driving future demand and infrastructure investment requirements

### *Background*

A set of common trends and eight key drivers that are expected to impact on infrastructure provision in general have been identified and discussed in broad terms in the trends report (Andrieu, 2005). This section considers the significance of each of the eight in terms of their influence on the requirements for and provision of water services. Only the aspects of the drivers that appear to be of a more immediate relevance are examined within the 2025 time scale.

### *Geopolitics*

#### *Non-state actors*

As inter-state relationships have become more complex, states have increasingly sought to establish international mechanisms to facilitate and

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mediate those relationships. In certain areas this has resulted in the assigning of policy and actions to international bodies outside the control of any one state. The European Union (EU) is perhaps the best exemplar of this. The EU plays a particularly important role in the European water sector as it is instrumental in setting standards and requirements that have a significant impact on the required water services and infrastructure to meet these. There has also been a complementary process of devolving responsibility for a range of water service functions away from central government to either local or regional bodies or delegating to state or non-state agencies. This process is the "hollowing out" of the nation state (Jessop, 1995).

The terms of international trade and matters such as subsidies and access to the provision of services and markets are also increasingly being regulated internationally. Such moves will contribute to the further embedment of globalisation and the buttressing of the role of non-state actors, such as trans-national and multinational corporations, which are better able to mobilise access to resources and to project themselves on a global scale in their areas of expertise. This has been under way in the water sector for some time, with a small number of North American and European utility corporations taking on increasing responsibility for the provision of water services across the globe. Paradoxically, these globalising trends are also likely to lead to a rise in locally based initiatives such as partnerships or local affiliates that reflect and capitalise on local circumstances in order to minimise risk.

Both trends are likely to have a significant influence on meeting the demand for and the control and financing of water infrastructure services. An important factor will be the degree to which national governments or agencies will have the ability, power and expertise to exercise oversight of non-state actors.

### *Scarcity and conflict*

Earlier this report highlighted the problems of access to water. According to Alcamo *et al.* (2000), the population living in water-stressed areas could double over the period 1995-2025. By 2030, two-thirds of the world's population may experience moderate to high water stress, mainly in the least developed regions where there is a lack of physical and institutional infrastructure capable of mitigating the impacts. It is the regions of the Middle East, North Africa, Southern Africa, South Asia and China that will be of particular concern, although stress also seems to be increasing elsewhere in countries such as Australia. Forced migration due to water shortages has begun in China, and India could be next (ACNU, 2004). By contrast, wealthier countries will be better able to cope and respond to these challenges through a range of adaptive measures, such as technological solutions, better demand management and long-term planning.

Water scarcity and competition has the potential to create international conflict where there are overlapping national boundaries. Some 40% of the world's population live in the 250 major river basins shared by more than one country. In Africa one-third of all water flows through the Congo, while only a tenth of the population lives within its basin. Economic development in Sudan and Ethiopia will draw on the Nile's waters, making the potential for conflict with adjacent states a real concern. Notwithstanding a number of established international mechanisms for mediating the problems of shared water resources, there is ongoing potential for water-related problems to contribute to regional tensions, such as in the Middle East (surface water resources) and Palestine (groundwater), and these may be exacerbated due to climate change.

Oil and gas resources are of major significance for water services as technologies used for each stage of the process in the main rely on energy and transport. Increasing use of desalination is particularly vulnerable to energy shortages. Security of supply of energy may become problematic with competition in the Middle East. This risk may support both an aggressive approach to maintaining access to energy sources and also new approaches to treating water. Other important resources influencing water services include anticipated shortages of readily available mineral potassium, predicted by some to be exhausted within 50-100 years. This is prompting initiatives for recovery from sewage (Tjandraatmadja *et al.*, 2005) and may require concerted international action.

### *Evaluation*

Both these factors are likely to be of importance in creating and meeting the demand for infrastructure. They will be instrumental in bringing about greater efforts on strategic grounds to develop international institutional agreements in order to reduce tensions and share responsibilities and resources. However, they are unlikely to be primary but rather to be contributory drivers.

## *Security*

### *General*

Threats to security in general appear to be increasing in tandem with globalisation and enhanced communication. Security of water infrastructure has been recognised by governments worldwide and is a major consideration in the United States where new investments have been made and a range of new institutions set up to deal with this and other threats (Copeland and Cody, 2005). Since 2002 for instance, publicly available evidence suggests that the US Congress has provided USD 608 million for studies and passed legislation for vulnerability assessments. This is likely to be an underestimate of actual spend. Threats include physical disruption, bioterrorism/chemical contamination and cyber


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attack. However, for there to be any serious threat to the infrastructure itself it would have to be credible, widespread and sustained in its potential effects, and this would require massive doses of poisons or biological agents. Responses to any threats should ultimately be incorporated in existing contingency plans to deal with emergencies arising from natural phenomena. A few very large plants located in urban areas in the United States supply some 75% of the population, and any attack on these could have major implications. Locally the smaller plants are more vulnerable as security measures are lower, but any consequences of attacks on these would be less widespread. Water infrastructure interdependence on other services, such as ICT, also makes it vulnerable, although there is considerable knowledge following the preparations for Y2K that should help mitigate problems. Nevertheless it is more likely that widespread disruption would be effected more easily via cyber attack, disrupting power, communication and control systems. The effects can be demonstrated by the power failure in northeast United States in August 2003, in which a number of wastewater treatment plants failed. That led to environmental pollution and households being advised to boil water due to failure of water treatment plants (Copeland and Cody, 2005). New technologies are emerging for better collection, analysis and use of information related to infrastructure and asset performance, and as this becomes more sophisticated it may also become more vulnerable to security threats. Instrumentation for water service systems has not been as reliable or effective as in many other areas, and terrorist threats could well encourage more investment in the development of effective instrumentation for water infrastructure monitoring and control. The development of novel technologies that are less vulnerable also may well be forthcoming.

Other potential consequences arise from threats to maintaining adequate functioning of water infrastructure, due to the inability to finance the services provided, unavailability of the necessary expertise, goods and services, and the inability to provide service to meet the legitimate needs of citizens. Threats to functioning could arise from social unrest and inequality, as exemplified during the apartheid era in South African townships; from environmental factors due to climate change; from economic factors that cause affordability problems; or from overloading of systems that results in scarcity and excessive unauthorised and uncontrolled expropriation of supplies.

### *Evaluation*

Security considerations are moving up the agenda and are likely to be aided by the introduction of new technologies and more robust designs, following considerable investment if these are included as part of military perspectives. Organisational security, however, is dependent upon socio-demographic, cultural and economic considerations, and as such is considered to be a manifestation of the consequences of other drivers.

### *Macroeconomy*

#### *Output growth*

Although income per capita will increase, its distribution across countries will be uneven and likely to become more so. Developing countries will face large and persistent income gaps, and the poorest in other countries may become increasingly marginalised. The World Bank has anticipated that the economic gap between developing and developed countries will close as a result of a faster growth in income in the developing countries. This should translate into a proportionately greater ability to pay for water services. However, sub-Saharan Africa is expected to fall behind as its per capita income growth will lag behind, lessening even further its ability to fund water services. Linked with climate change, increasing desertification and droughts, this may provoke massive migration and abandonment of previously inhabited lands.

#### *Globalisation and location of economic activity*

Globalisation as characterised by the increase in trade and capital movements has the potential to be a significant driver for water services, both in developed and developing countries. In developing countries the growth of manufacturing, reflecting rapid industrialisation, will accelerate with a corresponding rise in the demand for infrastructure services to support this growth. Tourism will also continue to place additional and seasonally varying demands on the water infrastructure in some developing countries. At the same time in developed countries, the relative scarcity of and competition for resources (increasing due to climate change) will provide the impetus to reduce reliance in some areas, of which water could well be one.

It is expected that India and China will become major economic powers after 2015. This is underpinned by their growth in prosperity, commitment to education and stable government. Both the United States and European Union will continue to be major players in international capital and influence, and all OECD countries will continue to grow economically.

#### *Economic structure*

It is expected that in most developed countries the labour force will be urbanised, and will either stagnate or shrink due to increasing use of automation. Employment in both agriculture and manufacturing will decline further, adding to the urbanised nature of these societies and their expectations, although in China and India the recent growth in agriculture as part of the economy and reliance on irrigation may continue. Hence in these and a number of other developing countries, although there will be rapid urbanisation and a concentration of economic activity in the cities, agriculture will remain a significant employer and part of the economy. These will also be the areas of the

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highest growth in the labour force. Such changes will underpin the demands for water services and control the types of service to be provided, especially in the urban areas.

### *Public finance, investment and capital markets*

#### *Public finance and privatisation*

In most OECD countries, not only will total tax revenue become harder to raise, but the demands on public spending will increase. This situation will leave less room for discretionary expenditure by developed countries, either on "bail-outs" in their own countries or on direct aid to developing countries.

Privatisation has been seen as an important reform measure enabling improvements to be made to service delivery, especially in the field of infrastructure provision. Shifting the burden of funding from the public to the private sector is regarded as the way forward, especially in public utilities; it is only reasonable to expect this process to continue as a popular option for policy makers. On the face of it the water sector should be an attractive prospect. It is an essential service; it is technologically relatively low risk, and if reasonably well managed offers steady though not spectacular returns. However, some recent examples of problems with the involvement of the private sector from South America, South Africa and the Philippines sound a note of caution, as does a growing reluctance in Europe and Australia to adopt outright the "British Model" of privatisation.

The involvement of the private sector in the public provision of services such as water is likely to grow in importance, especially given the huge engineering and financial challenges to be faced in the provision of new infrastructure and the maintaining of existing assets. The nature of the relationship between the public and the private sector in this regard will have to evolve from the present models in order to gain greater political and social acceptance, especially in developing countries.

#### *Investment*

With private capital flows likely to be increasingly directed towards the fast-growing developing countries, some are likely to be targeted at financing the necessary infrastructure required to underpin economic growth. In contrast, those countries and areas that are perceived as being insecure for whatever reason are unlikely to attract significant foreign direct investment (FDI) – although the lessons from the history of FDI in the 19th and 20th centuries does demonstrate that investors appear to be an inveterately optimistic breed. This situation creates opportunities for companies capable of tapping into these capital flows to create and invest in infrastructure and services in the more attractive and strategically targeted developing countries.

These may well offer better prospects of returns than the developed OECD countries with their tighter sets of controls, regulations and expertise. It is likely though that the majority of TNC/MNCs specialising in the utilities sector will continue to expand their activities across a mix of countries as a way of spreading risk and exposure.

The growing disparity between tax income and the demand for public services will severely challenge the ability of governments to finance infrastructure out of public funds, and will add to the pressure for greater involvement of the private sector. Thus there will likely be increasing participation by the private sector in the provision, financing, operation and maintenance of water services. In those developing countries with weak governance and oversight capabilities it is likely that TNC/MNC will act increasingly independently as a way of offsetting risk, while in rapidly developing countries the relationships will become increasingly aligned to the models adopted in the developed and OECD-centred countries.

### *Demography*

#### *Population growth and urbanisation*

While the world growth in population will continue, that of the developed countries and especially in the OECD, where currently growth rates are around 0.5%, may decline after 2030. The age composition will also change; people will survive longer as health and living conditions continue to improve, with the median age increasing from approximately 38 to 45 by 2030. The implication is that a greater percentage of the population will not be economically active and hence will be more reliant on the services of those who are economically active. In addition, there will be increasing reliance on PCPPs (personal care and pharmaceutical products) that include a wide range of complex synthetic substances that may be persistent, accumulative and toxic if these enter environmental systems via toilet flushing (Kolpin *et al.*, 2002). These and other xenobiotics may impact so significantly on rivers in developed countries that new and more advanced wastewater treatment systems will need to be installed. However, on the positive side, the older population may have more wealth which conceivably could be invested in utilities. By contrast the developing world's population will continue to increase significantly but at a declining rate that is not expected to peak until after 2050. Six countries are expected to account for at least half of the projected increase: the Indian sub-continent of India, Pakistan, Bangladesh; then China, Nigeria and Indonesia. Although the median age in developing countries is likely to increase, it is still substantially lower than in the developed countries; currently it is around 25 and will rise to 33 by 2030. The implication is that this will create a substantial increase in the numbers of the economically active workforce.

Almost all the population growth in developing countries will be accounted for by urban growth – as was much the case in Europe in the 19th century during its period of industrialisation. Urban growth will be driven by inward migration from rural areas as agriculture becomes more commercialised and there is less scope for family-based subsistence agriculture. This migration will be attracted by jobs and services in urban areas, and there will also be increases in the local urban population from those already living there. The rapid population growth in developing countries in the urban areas, coupled with the pressures of economic growth, will give rise to considerable demands for water services both to provide industry with a base resource and also for the survival of the population. Given the low level of income of the majority of the population, the challenge will be to provide and extend a basic level of service to the burgeoning population centres at an affordable cost to both government and citizens alike. In the developed world, given that overall population figures will be stable, the challenges are more likely to arise as a result of the consequences of the ageing population rather than the need for new water services. Indeed the rising expectations and relative wealth of the ageing populations may well result in calls for higher levels and different forms of service from the existing infrastructure.

### *Environment*

#### *Climate change*

A recent report expected that "climate change will have a major impact on water resources in Europe that in turn may require changes in the way that Europeans manage and protect these resources". Drought risks will increase in Central and Southern Europe (Eisenreich, 2005). Globally, water vapour and precipitation are expected to increase, particularly at the higher latitudes all year round. In tropical zones it will increase, but not in subtropical regions. However, there will be an increase in potential evaporation that will generally decrease soil moisture. Nonetheless there will be bigger demands on groundwater and the greatest impact will be on agricultural practices. The extent of climate change and its impacts on the human and natural world will depend on the mitigation measures adopted and the adaptations made. However, given the likely increase in demand for energy and that increase continuing to be met from conventional sources, the consensus is that climate change is likely to become increasingly important. Although varying globally, it is expected that – in addition to the above – it will also contribute to a rise in global temperatures, and thus to major sea level rises and other impacts on the global weather system. As a result climates will become increasingly more erratic, with more droughts and floods affecting the more vulnerable. Food supplies may need to be adapted to use less irrigation water and land use may need to alter where low-lying lands, such as much of Bangladesh, become uninhabitable. As yet, however, the effects on water systems are very uncertain (Bolwidt, 2005; Eisenreich, 2005).

### *Pollution*

The rapid urbanisation in the developing world, coupled with a substantial rise in economic activity and industrialisation, contributes to increasing levels of pollution in the developing world, and inevitably will continue to do so. Measures to address pollution in these areas and their effectiveness will generally lag behind in terms of priority for these governments despite agreements to international control protocols. Increases in population and economic activity will place further demands on natural resources and their exploitation, also giving rise to pollution. As agriculture becomes more commercialised it is likely that there will be an increase in the use of chemical and biological products to both increase production and prevent (short-term) damage, also contributing to pollution. These trends pose very serious threats to the integrity of water resources, although they will be preferable for human health and welfare.

By contrast, growing public concerns, tighter regulations and the implementation of pollution abatement measures in the developed and some parts of the developing world could bring about substantial improvements in the quality of the environment and decreasing absolute levels of pollution. However, there will be an increasing number and complexity of pollutants as new products and processes are developed.

### *Evaluation*

It is likely that the challenges arising from the environment are going to be substantial. While pollution abatement in developed countries has been successful in arresting decline it has added substantially to the costs of providing the appropriate level of water services. This is now possibly the greatest single driver, particularly in the EU. The full economic cost of these measures is not generally borne by the customer and as fiscal demands on governments increase these will have to be passed on to customers. In the developing world the emphasis is likely to be on the provision of infrastructure to meet basic needs with expensive pollution abatement measures necessarily foregone, although with certain technologies this may be better controlled. Thus there will be a need to develop cheap, cost-effective means of reducing pollution in parallel with appropriate technologies.

Climate change presents some very severe challenges. Not only will the security and certainty of water resources decline but their vulnerability will increase as well. Added to this is the likelihood that infrastructure itself will be increasingly vulnerable to damage arising from sea level rise and flooding, storm damage, flash floods and the accentuation of seasonal effects such as winter flooding and summer droughts. All these pose major challenges to the robustness and resilience of water services and will place increasing numbers

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of people at risk. In agriculture, effective irrigation will be an essential goal. This should be accompanied by changes in the crops being produced in water-stressed areas, in order to minimise the need for the exploitation of new resources; the latter are in any case unlikely to be readily available at a price that agriculture can afford if it bears the economic cost of water services (*e.g.* Vecino and Martin, 2004).

### *Technology*

Technology as a potential driver plays very much a supporting role in that it can make the existing infrastructure more efficient and at the same time lower the cost at which services could be provided. Water services technology will not be able to change the physical facts that water is heavy, ephemeral in nature and expensive and difficult to transport and store. What it can do is impact on the "soft" infrastructure constituting the service component that transforms water from a raw material into an economically important good.

Currently the main perspectives here relate to the inertia of the "traditional" technologies, the application of these from the developed to the developing world, and the movement to utilise more sustainable approaches in the latter. It is still apparent that the large suppliers of water services globally, together with the funders, favour the traditional approaches, perhaps with some new technological components such as membrane filters for the larger conurbations. Aid agencies meanwhile tend to promote ecosanitation and small-scale, easily maintained technology. Reconciling these approaches is the subject of ongoing research and depends on the drivers and urgent imperatives (*e.g.* CSIRO, 2005). For example, desalination technologies are perceived to be appropriate for new breakthroughs using advanced membrane technologies and offering greater energy efficiency. However, water will still need to be transported from coastlines or from areas of brackish water sources to the users.

Water service providers are having to be more innovative and are exploring alternative or new technologies and asset management techniques that can improve their knowledge and understanding of water supply system operation and management, and help deliver these more efficiently. Changes in current practice are required that entail greater use of information and increasing automation while ensuring that human operatives can make decisions about system changes in a "smarter" way. Advances in information technology and communications in other sectors, coupled with space technologies such as earth observation, will revolutionise their everyday use within the water sector, especially as the costs of the acquisition and use of these technologies drop. This could lead to a much greater ability to monitor all aspects associated with service provision, the circumstance and the events surrounding it, in greater detail and to a greater extent than is currently technically possible. However, this has to be coupled with the ability to control and make better use of water and the service infrastructure by being able to communicate in real time between sensors, databases and intelligent system modelling technologies. This would enable supply infrastructure to respond intelligently to changing circumstances as and even before they occur. The increase in computing power at all levels of application will be a key factor in enabling the development of cyber modelling and control. What is done for the water supply infrastructure as it transports water from source to point of demand can also be applied to other areas of activity such as industry, buildings, the home, and in agriculture, where online sensors can be used to balance water needs for irrigation with supplies, getting round practices such as flood irrigation. However, costs and ability to operate these systems will be constrained in developing countries, which is mostly where the biggest users operate.

Biotechnology will have the greatest impact in the areas of pollution prevention, monitoring and remediation. It has the potential to completely revolutionise water treatment processes and may well enable service providers to dispense with conventional treatment plants as they are known today. Much of the treatment would not require a large capital investment for the provision of large fixed infrastructure, as this would be replaced by in-system and on-site processes, tailored to specific circumstances and requirements. It could even lead to the elimination of the distinction between water distribution and sewage systems as it becomes possible to combine them without impacting on public health. In the same way the associated costs and energy consumption would drop considerably, thus substantially reducing the cost of water services. It may be possible to incorporate and deliver bioengineered health products. Bioengineered organisms might be used to recover resources and to produce new sources of energy, raising the possibility that water service providers would also be major energy producers. The application of biotechnology to crops and plants could lead to the emergence of drought-resistant strains, which in turn would reduce the overall demand for water.

In the field of nanotechnology, advances are likely to have the greatest impact on maintaining and enhancing infrastructure performance. This could come about through the use of sensors, smart materials and materials with the ability to self-heal and regenerate. Coupled with ITC advances it could usher in an era of autonomous operation of water service infrastructure (robotics) where the need for human intervention in areas such as dealing with deterioration or breakage would be all but eliminated. The skills mix required would change substantially and could lead to a significant increase in productivity and reduction in the size of the workforce required to operate and maintain systems and infrastructure, also reducing costs.

While much of this could be achieved in developed countries with the necessary resources, it is less certain if the same sort of approaches could be implemented in developing countries. In those with rapidly developing economies that attract substantial FDI, a similar model could well be applied. However, it is unlikely that other developing countries without the skilled resource base will benefit or be able to realise the scale of cost reductions that such technologies could bring. Overall the technological advances would almost certainly bring about the virtual closing of the water cycle in the areas of domestic and industrial use, leading to a potential decrease in the demand on new resources. In agriculture the efficiency of per unit water use would increase substantially through the ability to target and tailor the application of water coupled with an improvement in crop strains.

### *Public decision making*

In both the developed and developing world, decision making is and will become more complex and problematic but for differing reasons, such as the rise in power and influence of some stakeholder groups, particularly the MNIs. This will affect key issues such as how infrastructure will be financed and its location, with nimbyism becoming more prevalent in the developed countries. Ironically, public access to information and measures such as those deriving from the Aarhus Convention in Europe actually may not facilitate access to information about how decisions are really made, due to commercial confidentiality. In the developing world the pattern of decision making will continue to exhibit wide divergence, correlated with economic development and performance and the rise of a middle class. This will determine the role of the private sector, although it is likely that many developing states will seek to maintain some form of control over the provision of water services. Thus partnerships, franchises and concessions could well be the preferred mechanisms for engaging with the private sector, including both local and MNC/TNC. There will be mechanisms for incorporating degrees of local involvement of communities and of accountabilities, but the essential relationships will remain at government level. In the case of those lesser developed countries (LDCs) with poor economic prospects it is anticipated that the role of the private sector in water services will be relatively weak and conversely that of international non-governmental organisations (INGOs) correspondingly important as they enter into partnerships with local bodies, effectively bypassing government in order to provide services to the poor.

In the developed countries the hollowing out of the state will lead to a divergence of modes of decision making. Supranational bodies, such as the EU and WTO, will become increasingly important with respect to policy issues and the terms of engagement. At this level decision making will involve state as well as non-state actors representing a whole range of interest groupings, with business interests having a powerful voice. Below the level of the nation state there is likely to be a greater role for non-state actors such as businesses in the provision of water services but subject to increasing levels of regulation imposed from the supranational arena and overseen by state-sponsored agencies. The greater availability of information and of ITC to citizens will increase their ability and opportunities to become interactive in the field of service provision. Thus new ways of involving citizens in decision making both in the public and private sectors will grow in importance. This will be underpinned by a growth in the rights of individuals as well as the increase in demand-driven schemes where users of a service pay the full economic cost of the provision and maintenance of that service. This implies that localised decision making will become more prevalent as well as easier. It does, however, suggest that decisions regarding regional issues may become more problematic and that large and costly public inquiries may delay investment in major infrastructure where this is proposed.

## 5. Impact of key drivers on future levels of infrastructure investment

### *Introduction*

The purpose of this section is to explore the likely impact of selected drivers on the future demand for infrastructure and the consequent implications for investment. In order to do so the situations outlined in Sections 2 and 3 are taken as providing a baseline against which the possible impacts are judged. Potential future drivers that would have an impact on the demand for and configuration of future water services have been outlined in Section 4. Only the most important of these are considered below.

### *Geopolitics*

#### *Beyond the Nation State*

There are already a number of trans-national organisations that exert varying degrees of influence over the provision of water services at the level of the state and below, such as the World Bank and its affiliates, the WTO, UN bodies, INGOs, the EU and, to a lesser but potentially increasingly important extent, TNCs and/or MNCs (multinational corporations). Of these, the WTO and EU stand out in their ability to set standards, require compliance, take forms of legal action and impose penalties for breaches. Globally it has become apparent that as trade negotiations and frameworks have developed, there has been a greater sensitivity to domestic regulations that relate, among other things, to environmental matters (Oye, 2005). There is a growing potential for conflict due to both increasing trade sensitivity to regulatory difference and increasing uncertainty about the environmental risks being regulated. This is exemplified by regulations that actually advance parochial interests while claiming to target holistic environmental and health protection. In this respect there are perceptions that the stance taken by Europe and that taken by the United States are at odds (Oye, 2005).

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The EU exerts an "arm's length" and overarching influence on water services, not just in the member and accession states but also in countries such as Turkey, Russia and other EECCA states that seek closer economic and political ties as well as trade suppliers from around the world. It is in the area of environmental protection and pollution control that the influence on water services is most marked. The raft of directives includes: Drinking Water, Bathing Waters, Wastewater Treatment, Habitats and more recently the Water Framework Directive. All of these had and continue to have a significant impact on the requirements for and provision of infrastructure to meet their conditions. They have also had an impact on the way services are provided and on operation and maintenance activities. The directives have been instrumental in the re-evaluation of the institutional and organisational structures of water service delivery at the level of the state and local levels and have opened up the industry to greater and varying forms of private sector involvement. Meeting directive requirements, given the backlog of past problems and the scale of their objectives, will continue to be a driver for investment in new infrastructure (*e.g.* Mohajeri *et al.,* 2003). In the United Kingdom some 30% of investments are connected with environmental and quality drivers – approximately 0.25% of GDP; in some countries, given the catch-up required, it could be more.

Other regions of the world have aspired to emulate the European model in one form or another, although none has come to a similar degree of co-operation.

The impact on infrastructure of the WTO is perhaps more indirect; it tends to be concerned with the terms and openness of trade and services, although of relevance are "dispute settlement panels" that attempt to resolve domestic environmental regulatory problems (Oye, 2005). WTO's main role will probably be to encourage greater participation of the private sector and especially TNC/MNC in the provision of water services. As such it would influence the sources, availability and terms of financing of operating and capital expenditures. However, WTO has influenced behaviour by, for example, ruling against provisions in the US clean air act and sea turtle protection, and also against EU, Australian and Japanese environmental regulations, mostly on the grounds that these were disguised trade barriers. The approach is precautionary, which can be extremely stringent without very much proof of consequence and can lead to irreversible and expensive decisions and regulation. This precautionary principle is justification for the forthcoming EU's prescribed substances daughter directive to the Water Framework Directive (WFD) that seems to impose absolute and unreachable standards for prohibiting discharges of certain substances in wastewater, despite environmental background levels being much higher. The consequences of this will be to force EU countries to invest huge sums in wastewater treatment.

The above illustrates that greater participation of international bodies could impact on design, development and other areas that indirectly affect operation and provision of infrastructure. Standards, benchmarking and technology, for example, could have either detrimental or beneficial effects on efficiencies, thus increasing or reducing costs and affecting levels of affordability.

The impacts of moving beyond the nation state will be felt not only in the developed world and OECD countries but also in the transition economies of East and South Asia and Latin America. Impacts are less likely in the low-income, lesser developed countries of Africa, where the challenges are more localised and closely linked with coverage, access and keeping up with basic water service provision.

### *Water and other resources*

The population living in water-stressed areas is set to double over the period 1995-2025, and by 2030 two-thirds of the world's population may experience moderate to high water stress (Alcamo *et al.,* 2000). Regions of particular concern will be the Middle East, North Africa, Southern Africa, South Asia and parts of China. Some countries are already ill-equipped to meet this challenge; as noted above, China's reservoir storage is low in comparison with other countries and India is probably in a similar position. Many of the megacities of tomorrow are located in areas notable for their scarcity of water resources. It is axiomatic that the problem will be most severe in the least developed regions, where there is a lack of physical and institutional infrastructure capable of mitigating the impacts. The most likely response would be to seek to invest in harnessing additional water resources through reservoirs and transfer schemes, such as the Three Gorges and South-to-North projects in China. Such trends have been apparent in Africa. It is often perceived to be easier to address the problems of scarcity through supply-side measures rather than by alternative means of demand management. Thus in transition and developing economies water scarcity will likely prompt interest in new works to harness further water resources. The costs of such projects will continue to escalate, raising questions about their economic viability when compared with other alternatives. Water scarcity may provide the necessary impetus to develop and strengthen institutional means of governing and guiding water resource development at international or river basin level, the development of property rights, and markets in water rights and allocations. This could mitigate the expected pressures for new resources. The losers in all this would be rural water services and agriculture, especially irrigated agriculture, unless there is a strengthening of local rights, possibly through the expansion of Water User Associations (WUA) as advocated by international agencies.

The availability of water resources could become a factor influencing the location of centres of industrial and manufacturing activity as these industries are relocated to transition and developing economies.

In the case of many of the developed economies it is not the scarcity of water resources that will be the problem, as generally water stress will lessen. The balancing out of availability would need to be addressed, and this is linked to predictions of the impact of climate change on resource availability patterns. The rising standards of environmental protection and other factors will drive up energy demands, and it could well be that energy will become a limiting factor in making resources available.

### *Security*

There are increasing concerns over security and terrorism in some countries, notably the United States. That country has already invested considerable sums of money researching the issue and has made budgetary provision to "harden" its water infrastructure against acts of terrorism and sabotage: USD 1.2 billion (EPA, 2005). It is noteworthy that this is less than 10% of the amount allocated to deal with the presence of lead piping in distribution systems. Concerns over vulnerability of water services infrastructure worldwide are likely to result in protection efforts in only a limited number of states that can afford to increase the robustness of their systems, such as the OECD member countries.

Of greater potential influence is the security of electrical and electronic infrastructure that supports the operation of water services. The operation of water and wastewater systems relies on electricity to be able to function. Recent events in the United States have served to underline both the vulnerability and consequences of any failure of the electrical system or even shortages. It is an emerging area of concern, and at this stage the impacts are not well understood. Potentially it could drive new developments and demand for technology in decentralising schemes, and add additional system redundancy in order to increase resilience. It would also spur investment to utilise the embedded energy in water and wastewater as well as advances in new ways of pollution control as a way of reducing operational costs in the long term. As well as recovering energy at sources such as reservoirs and other storage sites, possibilities include turbines in water transmission and distribution systems and in sewers, and energy from solid residuals from treatment processes. There are now several operational examples of the first of these and the latter has been common for sludge from activated sludge plants for decades, but is still often not utilised due to capital and running cost fears.

In a similar way that concerns over Y2K led to developments in software and electronic systems, so threats of terrorism and cyber crime would lead to investment in improving the robustness of these systems. Such developments would not come specifically from the water sector; rather, the sector could draw on the advances made in other business areas, especially with respect to communications, databases and control systems.

In terms of the possible impact on funding and investment it is expected that much of the cost would be absorbed within existing budgets and would not give rise to additional programmes of work requiring special funding streams, although it may facilitate access to military spending sources. These developments could be widely adopted across all but basic service provision, such as for rural water services.

### Macroeconomy

#### Economic growth

World income will continue to grow, rising by 3.1% p.a. to USD 51 800 billion in 2015, with world per capita income also rising but significantly faster than in the past three decades (World Bank, 2005). Also, the income gap between developed and developing countries should shrink given the differences in their rates of growth, with the fastest growth taking place in East and South Asia. This continued economic growth will require substantial upgrading of infrastructure if the development is to be supported. New infrastructure development would mostly take place outside of the OECD countries, while within those countries water systems and services would require maintenance and upgrading in response to the changing structure of economies and increasing societal requirements. The ability to fund and therefore provide water services does depend on continued economic growth. The figures have shown that as an economy develops, the composition of its economic stock and the relative allocation of sectoral investment changes. In these terms, water services decline in importance relative to other infrastructure stocks and proportionally require less investment. Thus as economies grow, the burden of investment decreases and affordability increases – in other words, the whole system becomes more affordable. It also implies that financial investment in water service providers becomes less risky, that stock market performance is less volatile, and that returns are steady and stable but not spectacular. Thus, continued economic growth in developing countries provides one of the means to improve their water service provision and to cope with the increasing demands, especially in the rapidly urbanising areas. The funding gap that is apparent in some countries (WaterAid, 2005) could gradually be addressed.

A slowdown in economic growth would have a severe impact on the ability of countries to invest in and maintain their water services and lead to a widening of the funding gap even in more developed countries. An indication of the consequences could be gained by reference to the experiences of Russia and the former Eastern Bloc countries in the late 1980s and through the 1990s. Investment in new works would be severely curtailed, the required levels of maintenance would not be achieved and regulatory control would be weakened with poor standards prevailing. Service levels and the financial viability of the service providers would decline, leading to increased levels of customer dissatisfaction and localised improvisation as a means to overcome shortcomings. Health concerns and environmental pollution levels would increase. The cost to the economies, on the basis of previous studies, could amount to 3% of GDP or more. There could be increased pressure from some economic sectors for continuing subsidies, for example in agriculture, as these perform a social as well as economic function. Other effects could be the loss of intellectual capital and curtailing of investment in research and development. On a macro scale there could be a limiting of the international communities' ability to provide FDI as well as donor assistance to developing countries, further weakening their position and ability to extend water services provision. The attainment of the MDG for many countries would be considerably postponed. In OECD countries the impact of a slowdown would be less marked but economic difficulties could in Europe prompt a re-examination of environmental and other legislation that would be perceived to be adding considerable costs without the necessary concomitant benefits. This would have a direct effect on the provision and operation of water infrastructure.

### *Globalisation and changes in economic structure*

Globalisation, together with changes in economic structure, will drive the relocation of industrial and manufacturing activity, which in turn will impact on demand patterns. The industrialisation of the developing world will result in increased levels of water demand and consumption, partly as a result of increased activity and partly as a result of a decrease in water productivity. At the same time developed economies will become more service and amenity oriented, placing a higher value on water and so dampening consumptive use. This will reinforce the requirements for increased expansion of water resources and the associated infrastructure in developing countries while in developed countries the need will be to maintain and improve existing systems. As part of the relocation of economic activity there could be a reinforcement of trends towards self-supply of water services, either directly or through the transfer of funds. There is an opportunity here for increased private sector involvement to supplement local services, a trend that may well be reinforced by GATS and could represent a growth area for the water TNC/MNCs, especially if they could mobilise the necessary funding and technical expertise. However, for sound practices it would be necessary to establish property rights and robust legal and regulatory institutions. Such trends are starting to emerge in both China and India, where the state has sought to distance itself from service provision and reconfigure as an enabler and overseer of that service provision. It could also be envisaged as a condition of relocation that such enterprises be required to take on forms of responsibility for extending basic infrastructure and services, modifying the former communist model of enterprises embedded within communities.

### *Public finance and investment*

Between 1993 and 2002 World Bank infrastructure investment lending declined by 50%, partly due to a lack of clarity on the roles of the private and public sectors in infrastructure service provision and underinvestment in country-level analysis. At the same time, private sector investment in the water sector, which accounted for less than 10% of total investment, has also declined (Hall, Iobina and de la Motte, 2003) as the private sector has become more risk-averse in relation to the water sector. Through the 1990s national governments accounted for two-thirds of capital investment in the water sector and are likely to remain the major source of such finance. At the same time there is a need to encourage devolution of responsibility away from central government in order to shift financial burdens away from taxpayers to service users. Such moves should facilitate better access to local capital and financial markets. For the foreseeable future, it is likely that the private sector will be a major source of managerial and technical expertise rather than investors, especially in developing countries (OECD, 2004). There is a need to develop mechanisms to allow greater engagement with the private sector as far as financing is concerned. As has been observed, although reform and innovation are needed in financial architecture, there is not likely to be any paradigm shift and different sources of finance will be needed (OECD, 2004).

### *Demography and urbanisation*

It is expected that not only global population but also urbanisation will increase, so that by 2030 some 60% will live in cities (UN, 2004). Almost all of the increase in population in developing countries will be accounted for by urban growth. The scale of the growth will place enormous pressures on local governments to ensure that there is adequate provision of basic services. In developing countries urban growth will be fuelled by migration out of the rural areas. Thus those constituting the new growth are likely to be relatively less skilled and will add to the burgeoning numbers of urban poor. The manner in which these urban poor are accommodated and the form of urbanisation will have a determining influence on whether and how infrastructure services are provided and their access to them. One of the key questions will be the ability and competence of local government to manage the pace and process of urbanisation and the institutional ability to undertake infrastructure service provision and the levels of funding that can be mobilised. Hence the challenge is not the numbers or rate of urbanisation but rather rate of growth of institutional ability to manage the processes of urbanisation. The major challenges are affordability and revenue generation, the mobilisation of funds and how they are raised. The solution lies in economic growth that enables the required level of funding to be put in place to create the infrastructure and to enable the people to afford the services provided. Thus service level must be linked to affordability (Komives, Whittington and Wu, 2001) – the poorer the household, the less likely they are to access services. The impact of more rapid urbanisation in itself is not the issue; rather, it is how this relates to economic growth and the redistribution of income across society. More rapid urbanisation with commensurate economic growth could in fact be preferable to slower rates of urbanisation with piecemeal development of accompanying infrastructure.

Urbanisation creates problems of water shortage, related to both quantity and quality, as lack of adequate wastewater collection and treatment leads to environmental pollution and deteriorating water quality, thus affecting availability. High levels of water poverty are often associated with poor health and go together with other problems such as poor housing. Evidence from Brazil and other countries suggests that INGOs can play a key role in working with communities in urban areas to extend water services provision (Novy and Leubolt, 2005; Water Aid, 2005; Media Analytics, 2002). In some instances local government has sought to improve coverage by making it a condition of granting leases or concessions to the private sector. Success, however, has been patchy (Bakker, 2005). In sub-Saharan Africa the impact of urbanisation on water infrastructure is problematic in the absence of substantial donor assistance, given the projected continuing economic weakness (World Bank, 2005).

In the context of the developed economies and the OECD, the impact of urbanisation will be on the form and level of service, as affordability should not be a problem. Urbanisation affects not just new areas but also the existing areas of urban conurbations. As new areas are developed and other areas redeveloped in line with natural building cycles, there will be opportunities to reconfigure not just the water services infrastructure but also the services themselves. Recent trends are moving towards significant demand management at a local and household scale and the introduction of alternative forms of sanitation and localised forms of service provision aimed at closing the water cycle and thus minimising the input of new resources (WSSTP, 2005). This will require changes to some regulatory controls; it would also entail a redistribution of responsibilities and the rise of localised and specialised forms of service provision, but still within a centralised system. Thus there could also be moves towards integrated utility management and not just water utility management.

### *Environment – climate change*

Climate change could have a number of effects. As well as droughts, it is expected to lead to sea level rise with consequent loss of land areas and increased frequency and scale of flooding, with the attendant risks to human activities and life. At the same time climate zones will shift and the climate will become more unstable (Andrieu, 2005).

The effect of sea level rise will be felt in different places. It will lead to a reconsideration of land use and might in some cases lead to abandonment and relocation of populations. Countries like Bangladesh and some island states would be most severely affected. Such major impacts, although some time into the future, will require the development of additional water resources and the associated infrastructure to transmit and distribute water to the relocated populations, as well as to handle the wastewater and its treatment. Experience of redevelopment on this scale is limited and the closest is probably that associated with the development of the Three Gorges project in China. The uncertainty would be how the process is planned for and managed. Based on the Chinese experience initial expenditures could be anything between USD 50 billion and 100 billion.

Sea level rise could also adversely affect groundwater aquifers due to increased risk from saline intrusion, especially if aquifers are being over-exploited. This could prompt the need to switch to alternative sources of water such as desalination, which at present is energy-intensive and relatively expensive.

A shift in climate zones such as grain belts moving northwards and desert areas increasing in size would not just affect agricultural production and practices. It would also have an impact on urban as well as rural populations. Per capita water use is correlated with climate and to some extent increases as the climate becomes warmer. Any systemic increase in per capita water consumption would offset any gains from water demand management and leakage reduction measures. The consequence could be a need either to develop new water resources or to adopt new, more water-efficient technologies. Either way, additional investment would be required.

More unstable and less predictable weather patterns will mean more droughts and more severe and frequent flooding events. One response would be to do nothing; in fact, some countries may have no option but to seek to live with the consequences as they would be constrained by natural and economic conditions in what they can do. Many countries in the Middle East, North Africa, sub-Saharan Africa and Central Asia may find themselves in this position. Water resources will already be developed and additional resources scarce and costly or beyond further development. In these cases there may have to be a reliance on temporary, unsustainable solutions, or humanitarian assistance and disaster relief, or both. These countries' ability to have introduced mitigation measures such as minimising consumptive use will be constrained by their economic situations and the competing demands on scarce financial resources, as well as the nature of their urban and rural settlement patterns. In middle- to high-income countries it should be possible to introduce mitigation measures, as part of the urban redevelopment cycle discussed above. A number of research projects are already addressing the issues of how to reconfigure existing and urban infrastructure as well new infrastructure to address the impacts of climate change. At the same time governments, certainly in Europe and some other OECD countries, have initiatives looking into the impact of climate change, both from an infrastructure and institutional point of view. Climate change in these countries will add to infrastructure costs, some of which will be borne out of general taxation. These are anticipated to be containable within current levels of expenditure on operation of and maintenance on existing infrastructure.

In the agricultural sector, climate change could trigger major changes in water use patterns as crops and cropping patterns respond to new sets of growing conditions. More effective irrigation will be required, prompting investment. In some areas such as Europe, China and India there will have to be a re-evaluation of the role of agriculture in the economy: is it a purely commercial activity or part commercial, part social?

## 6. Impact of key drivers on the future quality and structure of water-related infrastructure investment

The key drivers likely to impact on the long-term demand for infrastructure in the water sector have been grouped under four broad headings: socioeconomic, technological, environmental and political.

### *Socioeconomic changes*

The way water is managed today is not sustainable; current usages are inefficient and of low perceived value by consumers in most of the developed world (Matsui *et al.*, 2001). The focus needs to be shifted from water as a good to the provision of water as a service. Thus, the emphasis changes from a preoccupation with quantity to considerations of types of use or application and matching quantity and quality with those requirements. For this to happen there will need to be social changes to ensure acceptability and responsibility (SAM, 2004). Current thinking considers water supply, in-house sanitation, water use in agriculture and industry, sewer system, wastewater treatment, and river basin management as parts of an integrated system, although service delivery and regulatory frameworks rarely match this. Thus the integrated overarching system needs to be embedded into the local framework of law and regulation, and into the framework of cultural heritage and concerns. The solution will be the integrated and transparent management of water resources, balancing demand and supply by water saving, increasing reuse and exploiting new marginal sources (WSSTP, 2005; Sommen, 2006). All of these require sociological change as a prerequisite for the adoption of technical innovations.

Globally there is a great deal of diversity in the institutional and organisational forms of water service delivery. Clearly there has been a trend towards the decentralisation of service provision, with central governments gradually delegating operational responsibility downwards, often to the municipal level. The question of the appropriate operational scale is one that depends on context, and there can be no one solution. What is clear is that there is a growing need for effective regulatory oversight however services are provided, and a need for central government to continue to play a strategic role, especially with respect to social, environmental and fiscal policy direction. The potential challenges for regulation are likely to increase as new technology is adopted and organisational forms respond to its deployment. It could well be that responsibilities in the area of service delivery will become blurred, requiring a greater level of governance to protect the public. The interrelationship of different spheres of regulation, safety, economics, quality, environment, consumer protection and perhaps others will become increasingly challenging and complex. The private sector's participation in water services will inevitably grow – and not necessarily as a result of privatisation, as there is only weak evidence that privatisation does actually result in greater investment in water services. Decentralisation and more effective private sector involvement are seen to be the way forward through various forms of outsourcing, as service providers seek to improve efficiencies and adopt technological innovations (Mohajeri *et al.*, 2003). Such factors will have a greater influence on the governance and economics of service provision than any impact of trade liberalisation.

In developing countries such as India and China, there will likely be an increasing trend toward forms of partnerships between local and international enterprises. This would make technological advances more readily available and create bigger, more globalised markets and at the same time localise their application. Important factors in enabling such partnerships to flourish would be the strengthening of property rights, a sound judiciary, legally enforceable contracts, the removal of barriers to the formation of joint enterprises and the formation of local capital markets to provide access to the necessary funds. A key issue in the funding of water services will be full-cost recovery and revenue collection. Only if there is certainty over the income stream can there be adequate planning for and provision of services. Decentralisation of responsibility would imply a similar decentralisation of revenue generation and a lesser level of reliance on central forms of funding. Achieving a balance between central and local forms of revenue generation and its allocation will continue to exercise the minds of policy makers. Technological changes and better ICT will enable there to be more sophisticated forms of revenue raising, tailored to more individual requirements and consumption patterns. This does mean, however, that there will be a great deal more interaction between customers, consumers and service providers in ways that are not immediately apparent today, albeit a lot of this may be "virtual" and there might need to be moves towards individual accounts management.

Many of the changes, whether in the developed or developing world, will depend for success on trust and the management of expectations. In this the role of the service providers but also of stakeholder groups representing ranges of interest will be important. Trust will also be important in respect of how growing forms of social risk are managed and accommodated. These risks would be associated with climate change effects, such as drought and flooding, security of supply, the security of the services and the ability to support economic growth.

Overall, socioeconomic changes are expected to increase unit costs of water service infrastructure delivery into the foreseeable future. This will be due to the following, singly and in combination: population growth; population profile changes; rising unit demand and expectations for water services; more extensive service provision; and increasing use of private sector services with risk costs.

### *Technological changes*

Water infrastructure technology in developed countries exists in its present form in large measure due to strategic decisions made in the past. Hence these systems are "path dependent". Fundamental strategic choices have been made in the past without proper critical evaluation, but dictate paradigms of delivery for long periods (Juuti and Katko, 2005). Current approaches to water supply and sanitation, developed over the past 150 years, are time-consuming to install and expensive, and generate environmental problems such as traffic congestion, dirt and noise. But there is actually no need to rely entirely on these traditional solutions, due to the fact that scientific developments have paved the way for alternatives as effective, reliable and robust as the traditional solutions, but less costly and less time-consuming to install and operate (WSSTP, 2005).

Technological change presents the opportunity to challenge some but not all of the ways in which water services are provided. The key question is the extent to which technology can bring about the closing of the water cycle such that the requirement for the input of new resources is minimised. It must do so in a way that is cost-effective, appropriate for those who must use it, and capable of widespread adoption. There will be technological requirements to enable localised cycles to be closed, and at the same time technological needs to manage the wider systems within which the localised systems are embedded. This may be supported by enhanced techniques for desalination in the near future, benefiting arid countries in particular.

There will be increasing requirements for real-time monitoring and control at every point in the water cycle. For developing countries, small-scale decentralised systems need to be better developed; that will require a range of new technological innovations, including new ICT systems that can ensure the secure operation and continuous monitoring of these systems. Although the systems will be "on-site", technologies for their remote monitoring and control will become feasible. Their uptake will depend on a shift in the perspective of the large operators, from a current "obsession" with large end-of-pipe and centralised systems to this service market.

Intra-local technological needs would include the increasing use of local on-site systems, and better control and management of all forms of water quality at less cost and with greater reliability than at present. This would involve biotechnology applications coupled with ITC and nanotechnologies that can deliver water fit for purpose in context, including reuse and local harvesting in all forms. Moving away from the idea that water is a conveyor of waste is core to the concept. This will require the integration of technologies for monitoring, controlling and removing diffuse and point pollutants; they will need to give timely warning of and react to pathogens and pollutants – at all stages of the water cycle, with ecologically degradable products (sustainable chemistry). They will also need new sensors integrated with new ICT tools to communicate both on-site and between sites. New approaches to dealing with bio-solids for other uses are also required. Overall the new technologies should produce less waste and use fewer resources. Smarter operation of all assets will require the deployment of sensors integrated with robotics to reduce the risks associated with long-lasting below-ground assets failing and optimising interventions. Low maintenance or self-maintaining systems are needed. The operation and maintenance of such systems holds implications for the organisational structure of how such services are delivered, charged for and regulated. However, even in developed countries there would be problems for some sections of the population associated with their economic status and the "digital divide". Thus the introduction of such technologies and placing in the hands of individual consumers greater control over the service provided to them will require careful development and capacity building, as well as access to and choice of alternatives.

While it would be possible to envisage such schemes at the household or small community scale, this might not be appropriate in the context of developing economies or in expanding megacities. It should however be possible to scale up such applications such that larger populations at suburb level could be served as in the "on-site" wastewater treatment systems now being utilised in the United States (USEPA, 2001) and Australia (WSAA, 2005).

There will still be a need for interconnectivity between local systems, akin to the present distribution systems, as well as the resource, distribution and treatment systems, referred to here as inter-local systems. New biotechnologies present the possibility of using what were previously marginal quality waters – *e.g.* brackish, grey and black waters – as potential resources, reducing the demand for new resources. Remote sensing and monitoring technologies with GIS would allow for the micromanagement of nutrients in agriculture, and ecosystems would allow timely response to changes in runoff water quality. Coupled with this, satellite technology and GIS would provide early warning for extreme weather and other conditions, allowing the preparation and implementation of appropriate responses. The operation and maintenance of transmission, distribution and collection systems would also benefit from advances in nano- and biotechnology. Service providers would be presented with the opportunity and ability for in-system treatment, self-monitoring and automated robotic maintenance that optimise interventions, bio-/nanofilm coatings and waste products, along with energy and resource recovery. Where there are large water/wastewater treatment plants these would move from being consumers to producers of energy and resources (residual solids will be used for, *e.g.,* building).

However, placing an increasing reliance on remote and automated systems increases the risks and consequences of failure, as without due regard such systems can be fragile and when they fail, they fail in a catastrophic manner. The deployment of technological innovations on this scale would be dependent on acceptability and society's as well as institutional capacity to handle and live with it. Thus it would not be appropriate in all situations.

Better technologies for monitoring, controlling and removing diffuse and point pollutants – at all stages of the water cycle, with ecologically degradable products (sustainable chemistry) – also need new sensors integrated with new ICT tools. Also required are new approaches for dealing with bio-solids for other uses. Overall there is a need for new technologies that produce less waste and use fewer resources.

Security is a growing concern in some countries, and as support systems become more sophisticated the vulnerability of the infrastructure increases. Technical failure for whatever reason could lead to widespread impacts, pollution, health-related problems and lack of service provision for extended periods of time. While water systems are for the most part robust, they do rely on other services outside of the water service providers' control; electricity, telecommunications, transport, etc. are all vulnerable. Thus it could prove necessary to develop redundant or duplicated infrastructure, physical or otherwise, in order to increase resilience. An increasing dependency on automated systems, controlled at a distance or with their own AI, potentially poses some serious risks; any future installations of this kind might be required to have back-up or fail-safe mechanisms in place much the same way as in nuclear power generation. There may be regulatory requirements put in place for additional monitoring and reactive systems to be developed that are capable of triggering emergency responses similar to the way immune systems work.

Overall, it is expected that technology will help to attenuate the overall increasing costs of water services. This will be due to: new techniques (scientific, sensor and ICT) and better ways of managing information and hence performance, resulting in smarter ways of operating new and current systems; greater energy; and resource efficiency (net surplus). This presupposes continuing investment in R&D at current levels. One slight concern is that with increasing private sector involvement, R&D may become more internalised, possibly constraining major advances in technology. Hence a modest benefit has been assumed in the analysis below.

### *Environmental changes*

Climate change in its impact on weather patterns will have a noticeable impact on water resources, albeit one as yet uknown (Bolwidt, 2005). The greater climate variability and uncertainty will increase the vulnerability of resources across the globe. This will also occur in those countries and regions where there is not expected to be an increase in demand for withdrawals. Two potential but not mutually exclusive responses may be envisaged to increase the security of supply. One is through storage projects such as dams and reservoirs; however, it is not expected that this provision will be adequate to completely mitigate the effects of climate change (Bolwidt, 2005). Indeed the World Bank and ICD envisage continuing activity in this direction, although it has to be questioned how long the trend can be supported given the high costs and environmental and social impacts. Dual usage for energy generation may, however, maintain its momentum, as hydropower is a sustainable energy source. As global temperatures increase, and especially in those countries where there is already a scarcity of resources, the efficiency of surface water storage will decrease and the marginal cost of development will continue to increase. As yet there has been no widespread use of artificial storage recharge (ASR) due to a variety of constraints; these are mainly related to concerns about pollution, although a large-scale groundwater recharge scheme using sewage effluent is under development in Perth, Australia. However, with new biotechnologies that can begin addressing concerns over pollution and water quality, ASR offers a means of at least partially controlling pollution and so

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better minimising losses. Resource development might well continue to be a preferred solution in many instances, especially in the developing countries. In high-income countries, maintaining and even increasing the amenity value of water and the environment that it supports is becoming increasingly important. This will not only mean greater competition between different, competing uses but also could change the essential character of "artificial" water bodies. For example, there are many examples of storage reservoirs in the planning phase meeting with vociferous resistance from environmentalists and subsequently being designated as Sites of Special Scientific Interest. This shift from "water mines" to ecological and recreational resources then leads to restrictions on use and constraints on their management for the original purposes. Other options such as desalination could become cost-effective for some countries that have the economic and energy resources to support them, but as a solution they would currently be deployed only in limited circumstances unless new technologies emerge.

The alternative response is to use existing resources more effectively through the application of demand management and recycling/recovery of water, to increase the intensity of its use. This is already happening, with industry in OECD countries such as Australia, Japan, the United States and Europe leading the way. However, this has been on the back of existing technology and systems configuration. For this approach to make any impact there has to be a step change in the intensity with which water can be reused. For that to happen, not only will new technologies that address problems of pollution and pollutant removal have to become widely available but physical infrastructure will also have to be adapted.

While demand-side management offers the possibility of making a unit of water work harder, in a global context water for urban and rural domestic consumption as well as that for industry will constitute only some 40% of total demand. Agriculture represents the biggest potential area for improving resource availability, in terms of both quantity and quality. The greatest impact could be felt in the area of biotechnology – with the possibility of engineering more water-efficient cultures – and ICT, which would bring about more effective water use in agriculture. Improvement could also come from a greater acknowledgement of the need to better manage the role of "virtual water" (water used to produce products), with changing crop production (in developing countries) and import patterns (in developed countries) (*New Scientist,* 2006). (Global estimated use of virtual water is some 1 000 $km^3$ per year.) It is also expected that new "water trading" initiatives will emerge, in which cities will be able to acquire agricultural allocations much more cheaply than new sources, expensive desalination or other systems (*e.g.* WSAA, 2005).

Environmental pollution brought about by economic activity will continue to be a problem, more especially in the developing and rapidly industrialising/

urbanising economies. It is unlikely, given the nature of legislation, regulation and its application, that levels of pollution will be significantly reduced anywhere other than in countries with well developed and applied pollution control measures, despite the attempts by WTO to act as an arbiter on internal behaviours. This stresses the likely importance of developments in technology that would allow for the detection and remediation of pollution before it gets into water service systems. There will be a continuing challenge of more complex, persistent and toxic materials that accompany technological development. The other concern will be pollution arising from extreme climatic events (droughts as well as floods) or as a result of systems failure (accident or sabotage). These problems require back-up and robust responses – perhaps necessitating redundancy in water service systems, as these may be minimised but cannot be entirely eliminated.

Overall, the environment is likely to be the greatest driver for adding costs to the future delivery of water services and managing the infrastructural impacts. The main factors are climate change and responses to this that may require large new infrastructure; expectations about security of quality and contaminant control to protect ecosystems; increasing uncertainties and the need to develop systems with in-built redundancy; and interactions across sectors such as water and energy.

### *Political changes*

With the increasing trend towards decentralisation and more effective private sector involvement in water service provision, there will be political challenges. Many of these will be related to what the relationship between the centre and the local state is to be and how responsibilities are to be allocated. They involve accountability and governance in both the public and civil spheres. Regulatory frameworks, sets of obligations, and (especially) how the services are financed and revenue collected are all political matters. Change, however, has a tendency to be incremental and adaptive by nature in the face of institutional inertia and powerful élites rather than radical, except in the face of crisis (Hay, 1999). Given the potential technological changes outlined above, the probable increasing role of private sector participation in all aspects of water management will require a profound re-examination of the regulation institutions in all countries.

Continuing urbanisation will put a strain on local political institutions as they struggle to come to terms with increasing demands; finding the necessary financial and human resources to meet those demands; and the allocation of those resources – all this at a time when raising tax revenues is increasingly difficult. The nature of urbanisation will require a greater openness about the appropriateness, setting and achievability of levels of service and their sustainability. Institutions in the developing countries will have to adapt to cater for large numbers of poor people; part of the solution will lie in partnerships with civil society to deliver services. Transparency will be an important element that must go together with forms of public involvement and participation. Given these developments there could be a tendency towards centralising local control – forms of paternalism, when in fact the situations require the opposite course of action. The possible future configuration of water services provision will involve debates about the role of the state in the ongoing development of paradigms for the way in which water is seen and used (*e.g.* Hassan, 2001).

Overall, political changes are expected to increase the relative costs of future water service delivery, principally due to: planning, land use and urbanisation control processes; effectiveness of governance up and down the process; the forms and needs of revenue collection (which may not improve due to political will); increasing service levels to "be the same as everyone else", driving infrastructure performance up.

## 7. Possible changes for the sustainability of current business models

In reflecting on the possible implications on business models, a distinction is drawn between a generalised situation in OECD countries, transition economies such as Russia and developing economies such as China and India. As already pointed out, there exists a wide variety of business models with varying degrees of private sector participation. This reflects the differing local historical and socioeconomic trajectories as well as the local physical context. The term business model should be understood in this context as referring not just to the actual business of service provision, but also to the institutional context within which it operates.

In OECD countries there is a relatively mature and stable business model in place, one that is increasingly looking for opportunities to market its knowledge and expertise within its economic sphere as well as outside. The principle of full-cost recovery is accepted and is increasingly an integral part of the regulatory framework. Affordability of the service is such that for most households, water services are invisible. The setting of tariffs is done in reference to other social objectives; thus water service providers could be given a greater degree of flexibility in their setting, in conjunction with regulators. That might also allow for other forms of revenue raising, so as to avoid basing everything on user fees. This could be of importance when it comes to raising income to meet wider societal requirements, such as mitigating the effects of climate change or risk provision – aspects that present a society with wide risk. Raising funds and investment in the light of growing needs will be a challenge. How this is undertaken will depend on the degree of autonomy that central government accords the decentralised service providers as well as the maturity of the financial markets. In this respect the OECD countries are well placed. The relatively stable political and economic conditions should facilitate the process of tapping into a range of financial instruments. The efficiency of revenue collection will make an increasing contribution to its performance. In general the one area that requires attention is that of regulatory oversight, which often does not provide the level of scrutiny required to ensure that the performance of water service providers can be benchmarked and provided with the necessary incentives to ensure business efficiency. This is particularly important as most services are delivered in a monopolistic way; competition is not the same as for most other types of service. Water service providers also need to strengthen their ability to engage with governments at a policy level in order to ensure that legal requirements – and, in the case of the European Union, directives – are practical and do not entail excessive costs. The ability to respond to and adopt new technologies and to implement them to best effect will be constrained by other factors, not just the capabilities within the service provider. Much will depend on planning policies and the ability of service providers to interact with and influence new urban and rural landscapes. Thus current business models are likely to become more sustainable and be well placed to cope with the identified trends.

In transition economies, affordability and the efficiency of revenue are matters of concern, together with the ratio of revenue to costs. These present problems for the continuing viability of business in those economies. The institutional and regulatory capacity will require strengthening, especially if there is to be a greater reliance on the involvement of the private sector. This appears essential in order to ensure that social and environmental objectives are met and there is adequate consumer protection with business-driven services. Investment and raising finance is likely to continue to present problems as, given the economic conditions, there will be structural constraints on the availability of funds and also the ability to tap into alternative sources of funding. The involvement of the international financing institutions will continue to be important. Much more support will be required in order to ensure the viability of the emerging business models.

In developing countries such as India and China, the key to success will depend on the forming and evolution of partnerships between local authorities, service providers (national and international) and civil society. While the problems between developing and transition economies are similar, the scope for India and China to overcome these is probably greater, given the size and pace of development of their economies. This economic growth should continue to stimulate interest in these countries, and their sheer size and diversity should be seen as positive assets. This reinforces the message that

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public-private partnerships will be both desirable and possibly even essential. It would be premature, however, to pass any definitive comment as to the viability and sustainability of their business models, as these are still emerging.

## 8. Summary and conclusions

Estimates of projected expenditure on water infrastructure have been made for the United Kingdom, the United States, India, Russia, China and Brazil, with other EECCA countries as outlined in Section 3. The baseline used for current expenditures has been estimated from the proportion of GDP allocated to water services, varying from 0.3% to 2%, although specific EECCA countries apparently have much higher rates, up to 6%. This gives a current global figure of USD 576.4 billion invested annually. In the future for the high-income countries, an investment rate of 0.75% of GDP has been assumed until 2015. For Russia, the OECD (2005b) figure of 0.32% of GDP seems an underestimate, but this has been used nonetheless to 2015. For China, 1.5% has been taken from the Five Year Plan (Section 3) and for India, the figure derived was 0.71%; for Brazil, Almeida and Mulder (2005) give an estimate of only 0.20%, which seems rather low but has been used. The projected GDP growth rates (World Bank, 2005) for EU countries to 2015 are assumed to average 2.3% p.a. overall, with US growth as 2.5% p.a., China 5.3% and India 4.1% p.a. For some countries there may appear to be seemingly high GDP growth rates adopted here. As noted earlier, in adopting broad figures the report has been informed by the available literature, which will tend to underplay individual circumstances. In the particular case of Mexico, for example, given the strong ties with the US economy, it is likely that the country will be influenced by US performance for the foreseeable future, potentially providing support for the projected growth.

Fay and Yepes (2005) proposed a general figure of 2% that has been adjusted slightly for middle-income countries, such as Poland and the Czech republic, to 1.9%, in line with the different sectoral allocation of investments between countries.

The potential effects of the main drivers that have been reviewed in Sections 3-7 have been considered in relation to each OECD country and others given in Table 5.16. The relative significance of each of the drivers in terms of how they are likely to influence the investment in water infrastructure in the ten-year period to 2015 has been qualitatively evaluated for each country and used to adjust the baseline estimates of proportion of GDP investment over the period. In 2005, the figures are assumed to be those initially defined as above, gradually changing to the adjusted figures by 2015. Beyond 2015, some of the lower- and middle-income countries will have moved to the high-income band and rates of investment have been adjusted accordingly (downwards as a proportion of GDP).

In estimating the changes in investment profiles as a result of the four main drivers, the effect of technology has been assessed as reducing the costs by some 6.66% on baseline. This has referred to an increase on typical current figures for efficiency gains for the England and Wales service providers at just less than 3%, but is estimated to be potentially some 6% by the economic regulator. For the other drivers, the costs have been assumed to increase by a total of some 33% as a consequence of environmental drivers (current UK estimates). The greater need to attract private sector participation and funding will mean that risk premiums will be higher, with more account of profit margins. Hence the increase for socioeconomic drivers has been taken to be some 25%; with the effects of internal politics it is slightly more than half of this figure at 15%.

It should be noted that the projected investments represent an estimate of what in an ideal world would be required to provide and maintain adequate levels of water infrastructure services for all sectors of a countries' economy and population. The projections illustrate the scale of the challenge that faces those at all levels responsible for planning for and providing water service needs, indicating that there is no room for complacency. Furthermore, it is unlikely that there will be any significant tail-off in investment requirements over time; rather, priorities will switch from infrastructure investment to infrastructure maintenance. Earlier it was suggested that the potential benefits in health terms alone have been estimated at USD 84 billion per annum, just for meeting the MDG – and this is simply for bare minimum provision of water services. Improving water infrastructure services would significantly reduce the costs of health care, lost productivity, loss of resources and other problems imposed on governments, the environment and on industry by water-related pollution. It has been estimated for China alone that the cost of pollution amounts to as much as 2% of GDP (Turner *et al.*, 2003). Globally the figure is not known, although it might be expected to be somewhat lower than this. In addition, water services are an essential part of any economy; without them, economic activity would be severely curtailed. Although the benefits are likely to outweigh the costs, it does not follow that these projected expenditures will be realised. Indeed, if past experience is any guide, it is certain that they will not be achieved.

Table 5.16. **Projected expenditures on water and wastewater services**

| | GDP ($ billion) | GDP/cap ($) | GDP growth (%) | Current exp. on water infrastructure ($bn) | Class | Projected expenditure on water infrastructure as % of GDP | | Average annual investment ($ billion) | | Main Drivers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | By 2015 | By 2025 | By 2015 | By 2025 | Socio-economic | Technology | Environment | Political |
| Australia | 602 | 29 893 | 2.3 | 4.515 | HI | 0.75 | 1.08 | 6.86 | 9.95 | M | H | H | L |
| Austria | 254 | 31 254 | 2.3 | 1.905 | HI | 0.75 | 0.89 | 2.59 | 3.91 | L | H | H | L |
| Belgium | 309 | 29 707 | 2.3 | 2.318 | HI | 0.75 | 0.69 | 2.75 | 4.38 | L | M | M | L |
| Canada | 1 050 | 32 921 | 2.3 | 7.875 | HI | 0.75 | 0.83 | 10.27 | 15.74 | M | H | M | L |
| Czech Republic | 187 | 18 370 | 2.3 | 3.553 | UMI | 1.9 | 0.85 | 3.12 | 2.83 | M | H | H | M |
| Denmark | 178 | 33 089 | 2.3 | 1.335 | HI | 0.75 | 0.89 | 1.82 | 2.74 | L | H | H | L |
| Finland | 152 | 29 305 | 2.3 | 1.140 | HI | 0.75 | 0.69 | 1.35 | 2.15 | L | M | M | L |
| France | 1 724 | 27 738 | 2.3 | 12.930 | HI | 0.75 | 0.83 | 16.86 | 25.84 | M | H | M | L |
| Germany | 2 391 | 28 988 | 2.3 | 17.932 | HI | 0.75 | 0.83 | 23.38 | 35.84 | M | H | M | L |
| Greece | 224 | 20 362 | 2.3 | 1.680 | HI | 0.75 | 0.81 | 2.17 | 3.34 | H | M | L | L |
| Hungary | 152 | 15 546 | 2.3 | 1.140 | HI | 0.75 | 1.37 | 2.02 | 2.79 | H | H | H | M |
| Iceland | 10 | 33 269 | 2.3 | 0.075 | HI | 0.75 | 0.69 | 0.09 | 0.14 | L | M | M | L |
| Ireland | 152 | 37 663 | 2.3 | 1.140 | HI | 0.75 | 0.69 | 1.35 | 2.15 | L | M | M | L |
| Italy | 1 620 | 27 984 | 2.3 | 12.150 | HI | 0.75 | 0.92 | 16.83 | 25.23 | H | M | L | M |
| Japan | 3 817 | 29 906 | 1.9 | 28.627 | HI | 0.75 | 1.26 | 46.98 | 63.41 | H | H | H | L |
| Korea | 10 30 | 21 419 | 2.3 | 7.725 | HI | 0.75 | 1.23 | 12.76 | 18 | H | H | M | H |
| Luxembourg | 28 | 63 609 | 2.3 | 0.210 | HI | 0.75 | 0.64 | 0.24 | 0.39 | L | H | M | L |
| Mexico | 1 006 | 9 887 | 2.4 | 190.114 | UMI | 1.9 | 0.85 | 167.78 | 153.65 | H | M | L | M |
| Netherlands | 477 | 29 332 | 2.3 | 3.577 | HI | 0.75 | 1.08 | 5.43 | 7.88 | M | H | H | L |
| New Zealand | 97 | 239 43 | 2.3 | 0.727 | HI | 0.75 | 1.13 | 1.14 | 1.63 | M | M | H | L |
| Norway | 184 | 40 005 | 2.3 | 1.380 | HI | 0.75 | 0.64 | 1.58 | 2.55 | L | H | M | L |
| Poland | 475 | 12 452 | 2.3 | 9.025 | UMI | 1.9 | 0.85 | 7.93 | 7.18 | M | H | H | L |
| Portugal | 194 | 18 503 | 2.3 | 1.455 | HI | 0.75 | 0.88 | 1.96 | 2.97 | M | M | M | L |
| Slovak Republic | 81 | 15 066 | 2.3 | 1.539 | UMI | 1.9 | 0.85 | 1.35 | 1.22 | M | H | H | M |

Table 5.16. **Projected expenditures on water and wastewater services** *(cont.)*

| | GDP ($ billion) | GDP/cap ($) | GDP growth (%) | Current exp. on water infrastructure ($bn) | Class | Projected expenditure on water infrastructure as % of GDP | | Average annual investment ($ billion) | | Main Drivers | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | By 2015 | By 2025 | By 2015 | By 2025 | Socio-economic | Technology | Environment | Political |
| Spain | 971 | 23 627 | 2.3 | 7.282 | HI | 0.75 | 1.06 | 10.97 | 15.96 | H | M | M | L |
| Sweden | 254 | 28 205 | 2.3 | 1.905 | HI | 0.75 | 0.69 | 2.26 | 3.6 | L | M | M | L |
| Switzerland | 230 | 31 690 | 2.3 | 1.725 | HI | 0.75 | 0.64 | 1.97 | 3.19 | L | H | M | L |
| Turkey | 530 | 7 503 | 3.5 | 10.070 | UMI | 1.9 | 0.85 | 9.33 | 9.66 | M | M | L | M |
| United Kingdom | 1 736 | 28 938 | 2.3 | 12.499 | HI | 0.72 | 0.86 | 19.14 | 27.96 | L | H | H | L |
| United States | 11 724 | 39 496 | 2.5 | 87.930 | HI | 0.75 | 0.64 | 101.65 | 167.63 | L | H | M | L |
| Russia | 1 449 | 10 179 | 3.5 | 4.637 | UMI | 0.32 | 0.85 | 11.49 | 26.41 | H | M | L | H |
| India | 3 291 | 3 080 | 4.1 | 23.366 | LI | 0.71 | 2.50 | 74.8 | 108.31 | H | M | L | M |
| China | 7 334 | 5 642 | 5.3 | 110.010 | LMI | 1.5 | 1.90 | 182.1 | 247.18 | H | M | L | L |
| Brazil | 1 462 | 8 049 | 2.4 | 2.924 | LMI | 0.2 | 1.90 | 19.8 | 32.02 | H | M | L | H |
| **Total** | | | | **576.42** | | | | **772.12** | **1 037.83** | | | | |

*Source:* Authors.

## *Bibliography*

ACUNU (2004), AC/UNU Millennium Project: Global Challenges, *www.acunu.org/millenium/ch-02.html*.

Alcamo, J., T. Hendrichs and T. Rosch (2000), "World Water in 2025: Global Modelling and Scenario Analysis for the World Commission on Water for the 21st Century", Kassel World Water Series Report No. 2, Centre for Environmental Systems Research, University of Kassel, Germany.

Alegre, H., W. Hirner, J.M. Baptista and R. Parena (2000), *Performance Indicators for Water Supply Services*, IWA Publishing.

Almeida, E. and N. Mulder (2005), "Enhancing Brazil's Regulatory Framework for Network Industries: The Case of Electricity, Oil and Gas, and Water and Sanitation", OECD Working Paper No. 425, OECD, Paris.

Bakker, K. (2005), "Global Trends in Private Sector Participation", *www.geog.ubc.ca/~bakker/globaltrends.htm*.

Barlow, M. and T. Clarke (2004), "The Struggle for Latin America's Water", North American Congress on Latin America, *www.globalpolicy.org/socecon/gpg/2004/0704waterprivatization.htm*.

Birrell, B., V. Rapson and F. Smith (2005), "Impact of Demographic Change and Urban Consolidation on Domestic Water Use", Occasional Paper No. 15, Water Services Association of Australia, Melbourne, June.

Bolwidt, L.J. (ed.) (2005), "Climate Change: A Challenge or a Threat for Water Management?", *Wat. Sci.Tech*, Vol. 51, No. 5. p. 149.

Brinkhoff, Th. (2004), "Die grössten Agglomerationen der Welt", *www.citypopulation.de*.

Brisco, J. (2005), *India's Water Economy: Bracing for a Turbulent Future*, World Bank, Washington, DC.

Brow, C. (2001), Funding America's Drinking Water Infrastructure: From Public to Private, WISE, Washington, DC.

Brubaker, E. (2003), "Public Goals, Private Means: Why the Private Sector is Uniquely Capable of Providing Water and Wastewater Services to Ontario's Municipalities", presented to Public Goals, Private Means Research Colloquium, Faculty of Law, University of Toronto, 2 October.

Butler, D. and F. Memon (eds.) (2006), *Water Demand Management*, IWA Publishing.

California Coastal Commission (2006), "Seawater Desalination in California", *www.coastal.ca.gov/desalrpt/dchap1.html*, accessed 18February 2006.

CAS (2000), "Analysis of Water Resource Demand and Supply in the First Half of the 21st Century", China Water Resources, *www.chinawater.net.cn/CWR_Journal?200001/*.

Castelan, E. (2001), "Water Management in the Mexico City Metropolitan Area: The Hard Way to Learn", Proceedings from the Symposium Frontiers in Urban Water Management: Deadlock or Hope?, UNESCO Technical Documents in Hydrology IHP-V, No. 45, pp. 260-268.

China Economic Net (2005), "Infrastructure Urged to Open More to Foreign Investors", 24 September.

China (2005), see *www.chinaembassy.org.in/eng/szyss/t189436.htm*.

Copeland, C. and B. Cody (2005), "Terrorism and Security Issues Facing the Water Infrastructure Sector", Congressional Research Service Report for Congress Order Code RL32189, April update.

Cosgrove, W J. (2003), "Water Security and Peace", IHP-IV Technical Documents in Hydrology, PC→CP Series No. 29, UNESCO /IHP /WWAP.

Cosgrove, W.J. and F.R. Rijsberman (2000), *World Water Vision: Making Water Everybody's Business*, World Water Council, Earthscan Publications, London.

CSIRO (2004), *Water for a Healthy Country,* ISBN 0-643-09100-9.

CUPE (2005), "Who Benefits – Corporations or Communities? The Clear Choice about Water", *www.cupe.ca*, accessed 27 January 2006.

Dangeard, A. (2003), "Economics of Affordable Systems in Urban and Outlying Areas", Conference on Market Development of Water and Waste Technologies through Environmental Economics, 30-31 October, Delhi, India.

Dean, A. (2005), Introductory remarks: The OECD Survey of Brazil, 2005, Seminar, Rio de Janeiro, 1 March.

Dieterich, B.H. (2004), "The Unfinished Agenda", *www.imtd.org/current_water_article.htm*.

Earth Policy Institute (2006), "Pouring resources down the drain", *www.earth-policy.org/*, accessed 18 February.

EBRD (2004), *Sustainability Report 2004*, EBRD, London.

Eisenreich, S.J. (ed.) (2005), "Climate Change and the European Water Dimension", European Commission – Joint Research Centre, EUR 21553 EN.

Elizabeth Economy (2005), "The Case Study of China", Council on Foreign Relations, New York, *www.library.utoronto.ca/pcs/state/china/chinasum.htm*.

Environment Canada (2005), "Did You Know?", *www.ec.gc.ca/water/en/info/facts/e_quantity.htm*, accessed 27 January 2006.

Estache, A. and A. Goicoechea (2005), "How Widespread Were Private Investment and Regulatory Reform in Infrastructure Utilities During the 1990s?", World Bank Policy Research Working Paper 3595.

European Commission (2002), *Water Accounts – Results of Pilot Studies*, ISBN 92-894-4526-2.

EUROMARKET (2005), *www2.epfl.ch/mir/page18246.html*.

Eurostat (2003), "Water Use and Waste Water Treatment in the EU and in Candidate Countries", in Ulrich Wieland, *Environment And Energy Theme 8 – 13/2003,* Catalogue No. KS-NQ-03-013-EN-N, European Communities, *http://epp.eurostat.cec.eu.int/cache/ITY_OFFPUB/KS-NQ-03-013/EN/KS-NQ-03-013-EN.PDF*.

Eurostat, *http://europa.eu.int/estatref/info/sdds/en/milieu/exp_sm.htm*.

Fankhauser, S. and S. Tepic (2005), "Can Poor Consumers Pay for Energy and Water? – An Affordability Analysis for Transition Countries", EBRD Working Paper, No. 92, London.

FAO (2000), *AQUASTAT,* FAO, Rome.

Fay, M. and T. Yepes (2003), "Investing in Infrastructure: What Is Needed from 2000-2010", World Bank Working Paper, No. 2545, World Bank, Washington, DC.

FCM (2001), "Early Warning: Will Canadian Cities Compete? A Comparative Overview of Municipal Government in Canada, the United States and Europe", Federation of Canadian Municipalities, Ottawa.

Ferrier, C (2001), "Bottled Water: Understanding A Social Phenomenon", Report to WWF (available from: *www.earth-policy.org/*, accessed 18February 2006).

Gleick, P.H. (2004), *The World's Water 2004-2005*, Island Press.

Gleick, P.H. (1998), *The World's Water 1998-1999: The Biennial Report on Freshwater Resources,* Island Press, Washington, DC.

Hall, D., E. Iobina and R. de la Motte (2003), *Public Solutions for Private Problems? Responding to the Shortfall in Water Infrastructure Investment*, PSIRU, London.

Hall, D. and V. Popov (2005), *Privatisation and Restructuring of Water Supply in Russia and Ukraine*, PSIRU, Greenwich.

Harding, R. (2006), *Ecologically Sustainable Development: Origins, Implementation and Challenges*. Desalination 187 (2006), pp. 229-239.

Hassan, F.A. *et al.* (2003), "History and Future of Shared Water Resources", SC-2003/WS/42, IHP-IV Technical Documents in Hydrology, PC→CP Series No. 6, UNESCO/IHP /WWAP.

Hassan, F.A. (2001), "Water: The Mainstream of Civilization", 2nd IWHA Congress, 8-13 August, Bergen, Norway.

Hazin, L.S. (1996), "Towards More Efficient Urban Water Management in Mexico", *www.gdrc.org/uem/water/mexsaade.htm*.

Hay, C. (1999), "Crisis and the Structural Transformation of the State: Interrogating the Process of Change", *British Journal of Politics and International Relations*, 1, No. 3, pp. 317-44.

Hoornweg, D. (2004), "Public Private Partnerships and Sustainable Development", Address to Globe Conference, 31 March 2004, unpublished.

Hua, M. (2000), "Towards a Recycling Society: A Case Study on the Successful Implementation of the Pilot Ecological Sanitation Project in Dalu Village, China", Proceedings from the Symposium "Frontiers in Urban Water Management: Deadlock or Hope?", UNESCO Technical Documents in Hydrology IHP-V, No. 45, pp. 161-167.

Hugo, G. (2003), "Urbanisation in Asia: An Overview", Conference on African Migration in Comparative Perspective, Johannesburg, South Africa, June.

Hutson, S., N. Barber, J. Kenny, K. Linsey, D. Lumia and M. Maupin (2005), "Estimated Use of Water in the United States in 2000", *US Geological Survey Circular 1268*, Reston, Virginia.

IBRD/WB (2001), *China: Air, Land and Water – Environmental Priorities for the New Millennium*, The World Bank, Washington, DC.

India Resource Centre (2003), "Private Water, Public Misery", *www.indiaresource.org/issues/water/2003/privatewaterpublicmisery.html*.

Indian Planning Commission (2002), *India Assessment 2002: Water Supply and Sanitation,* Planning Commission, Government of India.

Infrastructure Canada (2004a), *Water Infrastructure: Research for Policy and Program Development*, Infrastructure Canada.

Infrastructure Canada (2004b), *Assessing Canada's Infrastructure Needs: A Review of Key Studies*, Infrastructure Canada.

ISO/TC 224/WG 2 (2004), "Service To Users", Working Draft – WG2/N17 V.3, 30 April 2004.

Ivanov, S.G. and E.S. Shalukhina (2005), "Russian Water Supply and Sanitation: Key Issues", *IWA Year Book*, *http://2006.sibico.com/?content=list&section_id=66*.

Jingrong, L. (2003), "Water Supply and Demand Imbalance Sharpens in China", *www.china.org.cn/english/2003/Sep/76069.htm*.

Johnson, J.N. (2004), Testimony on Ageing Water Supply Infrastructure, Subcommittee on Water Resources and Environment, US House of Representatives.

Juuti, P.S. and T.S. Katko (eds.) (2005), "Water, Time and European Cities – History Matters for the Futures", WaterTime project, EU Contract No. EVK4-2002-0095, *http://europa.eu.int/comm/research/rtdinf21/en/key/18.html*.

Kolpin, D.W., E.T. Furlong, M.T. Meyer, E.M. Thurman, S.D. Zaugg, L.B. Barber and H.T. Buxton (2002), "Pharmaceuticals, Hormones and Other Organic Wastewater Contaminants in US Streams, 1999-2000: A National Reconnaissance", *Environmental Science and Technology*, 36, pp. 1202-1211.

Komives, K., D. Whittington and X. Wu (2001), "Infrastructure Coverage and the Poor: A Global Perspective", School of Public Health, University of North Carolina.

Lee, T., J.L. Oliver, P.F. Teniere-Buchot, L. Travers and F. Valiron (2001), "Economic and Financial Aspects", in C. Maksimovic and J.A. Tejada-Guibert (eds.), *Frontiers in Urban Water Management – Deadlock or Hope*, pp. 313-343.

Levin, R., P. Epstein, T. Ford, W. Harrington, E. Olson and E. Reichard (2002), "US Drinking Water Challenges in the Twenty First Century", *Environmental Health Perspectives*, Vol. 110, Supp. 1, pp. 43-52.

Lundie, S., N. Ashbolt, D. Livingston, E. Lai, E. Kärrman, J. Blaikie and J. Anderson (2005), "Methodology for Evaluating the Overall Sustainability of Urban Water Systems", The University of New South Wales Centre for Water and Waste Technology, Report for the Water Services Association of Australia (confidential), June.

Mainardi, S. (2003), "Water Availability and Infrastructure Development: Cross-Country Econometric and Neural Network Estimates", *Desalination*, 158**,** pp. 241-254.

Matos, R., A. Cardoso, R.M. Ashley, A. Molinari, A. Schulz and P. Duarte (2003), "Performance Indicators for Wastewater Services", *IWA Manual of Best Practice*, International Water Association.

Matsui, S., M. Henze, G. Ho and R. Otterpohl (2001), "Emerging Paradigms in Water Supply and Sanitation", in C. Maksimovic and J.A. Tejada-Guibert (eds.), *Frontiers in Urban Water Management – Deadlock or Hope*, pp. 229-263.

McGill University (1996), Report on the State of Municipal Infrastructure.

McGill (1999), "Sustainable Water Resources Management in Beijing and Tianjin Region: Water Demand Estimation", School of Urban Planning, McGill University, Montreal.

Media, Analytics (2002), Brazil's Water Industry, *www.researchandmarkets.com/reportinfo.asp?report_id=302980*.

Mirza, S.M. and M. Haider (2003), *The State of Infrastructure in Canada: Implications for Infrastructure Planning and Policy,* Infrastructure Canada.

Mohajeri, S., B. Knothe, D.N. Lamothe and J.A. Faby (2003), *Aqualibrium: European Water Management between Regulation and Competition*, European Commission.

Mulford, D. (2005), "Economic Reform and Infrastructure", Remarks by US Ambassador to India at FICCI's India Infrastructure Conference, New Delhi, 28 March.

National Round Table on the Environment and the Economy (1996), "State of the Debate on the Environment and the Economy: Water and Wastewater Services in Canada", *Canadian Journal of Economics*, Vol. 32, No. 3, pp. 688-704.

*New Scientist* (2006), "The Parched Planet", 25 February, pp. 32-36.

NIC (2000), Russia's Physical and Social Infrastructure: Implications for Future Development, Conference Report, *www.cia.gov/nic/confreports_rusfuturedev.html*.

Nie, L. and W. Schilling (2000), "Development of Sustainable Water Management in Beijing, China", Proceedings from the Symposium "Frontiers in Urban Water Management: Deadlock Or Hope?" UNESCO Technical Documents in Hydrology IHP-V, No. 45, pp. 279-284.

Novy, A. and B. Leubolt (2005), "Participatory Budgeting in Porto Alegre: Social Innovation and Dialectical Relationship of State and Civil Society", *Urban Studies,* Vol. 42, No. 11, pp. 2023-2036.

NSW (2004), "Meeting the Challenges: Securing Sydney's Water Future", The Metropolitan Water Plan, New South Wales Government.

OECD (1999), *The Price of Water: Trends in OECD Countries,* OECD, Paris.

OECD (2000), Global Trends in Urban Water Supply and Waste Water Financing and Management: Changing Roles for the Public And Private Sectors, CCNM/ENV(2000)36/FINAL.

OECD (2001), *The Price of Water: Trends in OECD Countries*, OECD, Paris.

OECD (2003), *Environmental Performance Reviews – Water, Performance and Challenges in OECD Countries,* OECD, Paris.

OECD *et al.* (2003), "Facing a Crisis of Confidence in Private Sector Participation in the Water Sector", Proc. Conf. Private Sector Participation in Municipal Water Services in Central and Eastern Europe and Central Asia, Vienna, July.

OECD (2004), *Financing Water and Environmental Infrastructure for All: Some Key Issues*, OECD, Paris.

OECD (2005a), *Economic Survey of China 2005*, OECD, Paris.

OECD (2005b), Issue Paper: "Financing Water Supply and Sanitation in EECCA", Conference of EECCA Ministers of Economy/Finance, Environment and Water and their partners from the OECD, 17-18 November, Yervan.

Oye, K.A. (2005), "The Precautionary Principle and International Conflict over Domestic Regulation: Mitigating Uncertainty and Improving Adaptive Capacity", *Wat.Sci.Tech.,* Vol. 52, No. 6, pp. 59-64.

Planning Commission (2002), "India Assessment 2002: Water Supply and Sanitation", Planning Commission, Government of India.

Radio Free Asia (2005), Pollution: A High Price for Growth, *www.rfa.org/english/news/2005/04/21/asia_environment*.

Ramirez, L. (2005), Water Shortages Are a Potential Threat to China's Growth Stability, *www.voanews.com/english/2005-03-18-voa41.cfm?renderforprint=1*.

Ray, K. and A. Dzikus (2000), "Water Demand and Management: The Experience of the Water for Africa Programme", Proceedings from the Symposium "Frontiers in Urban Water Management: Deadlock or Hope?", UNESCO Technical Documents in Hydrology IHP-V, No. 45, Addendum pp. 3-15.

Renzetti, S. and D. Dupont (2003), "Ownership and Performance of Water Utilities".

Rosengrant, M.W., X. Cai and S. Cline (2002), *Global Water Outlook to 2025: Averting an Impending Crisis*, IFPRI, Washington, DC.

Ross, D., A. Thornton and K. Weir (2004), "Priority Hazardous Substances Trace Organics and Diffuse Pollution (Water Framework Directive): Treatment Options and Potential Costs", UKWIR Report Ref. No. 04/WW/17/5.

Roth, E. (2001), "Water Pricing in the EU: A Review", European Environment Bureau, Brussels.

SAHRA (2006), Sustainability of semi-arid Hydrology and Riparian Areas, [*www.sahra.arizona.edu/about/*] (accessed 18 February 2006).

Saleth, R.M. and A. Dinar (1999), *Water Challenge and Institutional Response: A Cross-Country Perspective*, World Bank, May.

SAM (2004), *Precious Blue: Investment Opportunities in the Water Sector*, Sustainable Asset Management, Zurich.

Schramm, E. (2004), "Privatisation of German Urban Water Infrastructure in the 19th and 21st Centuries", International Summer Academy on Technological Studies – Urban Infrastructure in Transition, Institute for Socio-Ecological Research, Frankfurt am Main.

Secrest, T. (2001), "A Review of World bank Assessments of Water and Wastewater Programs in Central and Eastern Europe", PNWD-SA-5595, Advanced International Studies Unit, Pacific Northwest National Laboratory.

Shadananan Nair, K. (2004), "Strategies to Meet Increasing Water Demand for Agriculture Associated with the Needs of Increasing Population – A Key Development Issue in India in the Coming Decades", Centre for Earth Research and Environmental Management, Kerela.

Shiklomanov, I. (1999), "World Water Resources and Their Use", SHI/UNESCO, St. Petersburg, Russia.

Sommen, J. van der (2006), "Europe, Water and the World", Europe's contribution to the 4th World Water Forum, February.

Stedman, L. (2006), "Market Movements on Arsenic", *Water 21*, February, pp. 31-32.

Stephenson T. (2001), Problems of developing countries, in C. Maksimovic and J.A. Tejada-Guibert (eds.), *Frontiers in Urban Water Management – Deadlock or Hope*, pp. 264-312.

TERI (2002), *State of India's Environment (A Quantitative Analysis),* TERI, New Delhi.

Thames Water (2005), "Thames Tideway Strategic Study", Steering Group Report, February.

*The Economist* (2005), "Private Worries", 11 August.

*The Guardian* (2003), "Water Boards on Alert", 1 December.

Tipping, D.C., D. Adbm and A.K. Tibaijuka (2005), "Achieving Healthy Urban Futures in the 21st Century", UN-Habitat, 25January.

Tjandraatmadja, G., S. Burn, M. McLuaghlin, S. Burn and T. Biswas (2005), "Rethinking Urban Water Systems – Revisiting Concepts in Urban Wastewater Collection and Treatment to Ensure Infrastructure Sustainability", *Wat. Sci.Tech.,* Vol. 5, No. 2, pp. 145-154.

Turner, J., F. Wu, H. Hsieh and T. Hildebrandt (2003), "Challenges for Financing Infrastructure in China", Woodrow Wilson International Centre.

Twort, A.C., D.D. Ratnayaka and M.J. Brandt (2000), *Water Supply,* 5th Ed., Arnold and IWA Publishing.

United Nations (2003), *Water for People, Water for Life – UN World Development Report* (WWDRI), UNESCO and Berghan Books, UK.

United Nations (2000), Resolution adopted by the General Assembly [without reference to a Main Committee (A/55/L.2)] 55/2, United Nations Millennium Declaration, September, *www.un.org/millennium/*, *www.undp.org/mdg/basics.shtml.*

UNEP (2002), International Source Book on Environmentally Sound Technologies for Wastewater and Stormwater Management, *http://unep.or.jp/Ietc/Publications*.

UNESCO (2004), *Eliminating Unhealthy Water/Providing Clean Water for All,* UNESCO.

United Nations (2002), *World Urbanization Prospects: The 2001 Revision Data Tables and Highlights*, Department of Economic and Social Affairs, Population Division, United Nations, New York.

United Nations (2004), *World Population Prospects: The 2004 Revision and World Urbanization Prospects*, Population Division of the Department of Economic and Social Affairs, New York.

UNRISD (2005), "An Assessment of Water Sector Reforms in the Indian Context: The case of the State of Maharashra".

US Embassy, Beijing (2002), "Clearing the Muddy Water: China Centralizing Water Management Authority, Beijing".

USAID (2002), "Brazil: Making Cities Work Urban Profile", April.

USEPA (2002), *Onsite Wastewater Treatment Systems Manual,* EPA/625/R-00/008.

USEPA (2005), "Drinking Water Infrastructure Needs Survey and Assessment: Third Report to Congress", Office of Water, 4606, *www.epa.gov/safewater/needs.html*, Washington.

USHR (2004), "Ageing Water Supply Infrastructure", Subcommittee on Water Resources and Environment, US House of Representatives.

USITA (2005), "Water Supply and Wastewater Treatment Market in China", United States Department of Commerce, International Trade Administration.

Vahala, R. (2005), "Challenges, Vision and the Following Research Needs", Address to Water Supply and Sanitation Technology Platform, Budapest, October, 2005

Vall, M.P. (2001), "Water Resources, Abstraction and Use in European Countries", Eurostat, European Community, ISSN 1562-3106.

Vandemoortle, J. (2001), *Are the MDGS Feasible?*, UNDP, New York.

Vander Ploeg, C. (2003), "A Capital Question: Infrastructure in Western Canada's Big Six", Western Cities Project Report No. 27, Canada West Foundation, Calgary.

Vander Ploeg, C. (2004), "No Time to be Timid: Addressing Infrastructure Deficits in the Western Six", Western Cities Project Report No. 30, Canada West Foundation, Calgary.

Vecino, J.B. and C.G. Martin (eds.) (2004), *Sustainability of European Irrigated Agriculture under Water Framework Directive and Agenda 2000* (WADI), EC EUR 21220 EN, Office for Official Publications of the European communities.

Warner, D. (1997), *Drinking Water Supply and Environmental Sanitation for Health*, WHO, Geneva.

Water Aid (2005), Getting to Boiling Point, *www.wateraid.org/in_depth/in_depth_publications/getting_to_boiling_point/6230.asp*.

WSAA (2005), "Testing the Water", Water Services Association of Australia Position Paper, No. 01, October.

Water Management Consultants Ltd. (2004), "Small Scale Private Sector Participation in the Rural Water Supply Sector", R8335 *Knowledge Review* February, 1788/R1, Prepared for UK Department for International Development.

WCD (2000), "Dams and Development Final Report", World Commission on Dams, London.

WDM (2005), "Dirty Aid, Dirty Water", World Development Movement, February.

Werner *et al.* (2004), "An Ecosan Source Book or The Preparation and Implementation of Ecological Sanitation Projects", 3rd draft, Version: February, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

WHO (2004), *Guidelines for Drinking-water Quality Volume 1: Recommendations*, 3rd Edition, pp. 515, WHO, Geneva, Switzerland.

WHO/UNICEF (2005), "Water for Life: Making It Happen", Joint Monitoring Programme for Water Supply and Sanitation, ISBN 92 4 156293 5.

Wieland U. (2003), Water Use and Wastewater Treatment in the EU and in Candidate Countries, Eurostat, European Community, ISSN 1562-3106.

Wolf, A. (*undated*), Summary: The History and Future of International River Basins, Report to UNESCO, PC→CP [post 2002].

World Bank (2001), *China: Agenda for Water Sector Strategy for North China*, Washington, DC.

World Bank (2002), *Bridging Troubled Waters: Assessing the World Bank Water Resources Strategy*, Washington, DC.

World Bank (2005), *World Development Indicators 2005,* World Bank, Washington, DC.

*World Development Report,* 2004.

WHO (World Health Organization) (1992), *The International Drinking Water Supply and Sanitation Decade*, Geneva.

WHO (2001), Access to Improved Drinking Water Sources: Mexico, WHO/UNICEF joint monitoring programme for water supply and sanitation coverage estimates 1980-2000, September.

WIN (2000), "Clean and Safe Water for the 21st Century: A Renewed National Commitment To Water And Wastewater Infrastructure", Water Infrastructure Network, Washington, DC.

WSSTP (2005), Water Research – A Necessary Investment in our Common Future, Water Supply and Sanitation Technology Platform, Strategic Research Agenda, Version 5, Draft 17 October.

*www.environmentalindicators.com/htdocs/indicators/6wate.htm*, accessed 3 October 2005.

*www.environmentalindicators.com/htdocs/indicators/7muni.htm*.

# * *Endnote Profile: Past Trends in Selected Countries*

## Mexico

Agriculture accounts for over 80% of water abstraction and 66% of total groundwater use. Groundwater also supports 70% of domestic and industrial water needs (Saleth and Dinar, 1999). By 1996 nearly 50% of the total public irrigation system had been transferred to water user associations. In the urban sector there have been reforms aimed at decentralising urban water supply away from central government to state and municipal governments and encouraging private investment. Central government retains responsibility for regulation, monitoring and enforcement, thus separating the management of resource issues from use and distribution. Urban access to drinking water was estimated at 96% in 2000, compared with 69% in rural areas (WHO, 2001); sewage and sanitation services had much lower coverage rates. Improvements in coverage between 1995 and 2000 were due to a national water programme, but this did not address the problems of low levels of maintenance and deterioration of assets. Water distribution is heavily subsidised by the government, which encourages overexploitation of resources and the under-financing of services. Only some 10% of wastewater is treated, despite effluents also being used for irrigating crops.

In 1989 the National Water Commission was set up at federal level to deal with water management by integrating water resource planning and management and co-ordinating efforts across the three levels of government (national, state, local). It acts as regulator at local level to finance and provide water infrastructure but not to operate it. This is the responsibility of municipalities and other local bodies; the private sector can also be involved (Hazin, 1997). In 1995 over 70% of water services were provided by municipalities. Levels of indebtedness are high among municipalities, with most public investment coming from the central government: 84% in 1994 (Hazin, 1997). This weakness is compounded by both a lack of technical and administrative capacity and lack of funds to cover operating expenses other than staff and administrative costs; the latter becomes more marked as the population size served by a municipality decreases. In an effort to address these problems there has been a programme to modernise water management companies, supported by funding from central government as well as from the World Bank, IDB and EBRD. As a result there has been an upsurge in agreements and concessions between municipal authorities and private water companies covering some 70% of the urban population (Barlow and Clarke, 2004).

The Mexico City metropolitan area holds over 20% of the country's population (22.5 million by 2010). The water supplied to users is heavily subsidised; the wealthiest benefit the most. Seventy-six per cent of the population live on low incomes. There are some 20 million houses, of which only about 51% have taps; 1.5% rely on public taps and 18.2% are supplied by private tankers, for which the charges are 500 times those of the domestic users. Bottled water demand is increasing by some 15% per year. The water system loses some 1.9 billion cubic metres every year due to leakage (UNESCO, 2004) and relies on groundwater for 80% of its supplies. Due to over-abstraction planners are now considering using sources up to 200 km away. To do this, the unit cost of water would have to rise from USD 1.34 to USD 5.36 per $m^3$, potentially making it unaffordable (Castelan, 2001). In addition, there are serious water quality concerns. Although there are 13 water treatment plants, many dating from the mid-1990s, they are frequently not in use due to either a lack of operating funds or a lack of water. In 1993 the water delivery system was subdivided among four water MNCs, which has led to charges of escalation of tariffs, high disconnection rates and underinvestment. In 1997-2000 the World Bank invested in a Master Plan for water for the city. Unfortunately, although there have been some improvements, there are cultural problems, with lack of commitment, limited institutional capacity and high costs of solving the major problems militating against substantial improvements. A major success has been the programme for water recovery (leakage management), which has recovered some 5 $m^3$/s at an investment cost of USD 50 million. This has offset the need for many of the major water transfers planned at a fraction of the cost (10%).

## Australia

Australia, while seemingly very arid, has high localised rainfall (1 100 mm per year in the Sydney catchments) compared with other countries (the East of England has 450 mm per year). It has water infrastructure that in places is some 100 years old, but low leakage rates (10%). Due in part to high immigration and a series of droughts (the 1980s prompted action), efforts have been made to place water supply issues high on the government's agenda (*e.g.* CSIRO, 2005). Because of these pressures and responses and the existence of traditional Western technology, Australia may provide a good example of how provision and management of infrastructure in Europe – and possibly the United States and other OECD countries – may be delivered in the future, when climate and demographic changes start to force a reappraisal of the way current services are delivered.

It is believed that there is already evidence of climate change in Australia, with droughts in the west and east and a longer-term reduction in rainfall in these areas of about 10%. Reduced rainfall is also responsible for a 50% reduction in observed river flow volumes.

Agriculture, which includes substantial areas of irrigated land, accounts for some 67% of total water use despite comprising only some 4% of GDP output (WSAA, 2005). Household use comprises some 9%, and 16% is used in various industries. There is major tension between the acute urban area needs for water, where abstraction costs are some AUD 1 000/megalitre, and farming needs, where charges are only AUD 40/megalitre. The other major challenges are to restore "environmental flows" to waterways that have been degraded due to over-abstraction and to meet increasing customer expectations regarding service levels.

Responsibility for water resources and management lies with each state and with local city and urban authorities, although central government has considerable influence controlling finances. In the 1980s a system of water licences was introduced, changing the way water was perceived and priced, and allowing water charges to be increased. Following rejection of the UK privatisation model in the early 21st century, reforms have introduced a hierarchy of organisations and delineated the respective spheres of influence for various government layers and water sector stakeholders; community involvement is very high and there is a mix of regulatory and economic instruments. In 2005, arrangements were introduced to allow third party access to the provision of water services. As yet there have not been any inset arrangements; it is thought that these would "cherry-pick" the profitable opportunities, placing a strain on the incumbent (public) suppliers. At the local level, corporatisation and privatisation of water undertakings in the urban and irrigation sectors have taken place, which has served to improve the sustainability of the systems.

All cities in Australia have water systems now facing problems of deterioration and the impact of urban development, especially on storm and wastewater management. This is in spite of the systems being well managed and maintained. Although Australian per capita consumption has been declining over the last two decades, due to the decline in industrial use and very effective water demand management, this trend has been and continues to be offset by demographic changes. For example, Melbourne's population is expected to grow by more than 1 million in the next 20 years. The country is becoming increasingly urbanised with growth rates of 2% or more, and at the same time the number of households is increasing. As a result, the projected increases in water demand based on four scenarios for 2001-31 indicate that in some cases increases of up to 70% could occur (Birrell, Rapson and Smith, 2005). The expectation is that by 2020 most of the cities will be at full service capacity.

Currently there is a federal fund of some AUD 1.7 billion to finance a "National Water Initiative" and a number of major research programmes, such as the "Water for a Healthy Country" initiative (CSIRO, 2005). The reforms since the 1980s have produced savings in water use by demand management, recycling, reuse and the introduction of rising block tariffs. There have also been efficiencies in operational expenditure of some 20%. Other initiatives have seen water-efficient labelling and subsidisation (to the customer) of white goods and the introduction of "water trading". Across the country there is a diverse range of approaches, based on the idea that sustainability comes from resilience and diversity and avoiding "lock-in" to large-scale asset construction and use. There have been very detailed whole-life and sustainability studies (unparalleled globally) and the development of new technologies (*e.g.* NSW, 2004; Lundie *et al.*, 2005). Notably, there has been the move away from large end-of-pipe systems to more local and on-site management of water and wastewater. Desalination has been seen as a major option and a new plant is under construction to serve Perth. However, objections to the high energy use and concentrated wastes discharged have recently blocked similar plans for a desalination plant to serve Sydney (NSW, 2004; WSAA, 2005).

## Brazil

Brazil is the fifth largest country in the world and as a country of almost continental size its climate and water resources vary. Water scarcity is acute in areas of population concentration and economic importance. With the majority of the population living in urban areas, the Brazilian economy is essentially non-agriculturally oriented; just 5% of the estimated usable cultivated area and 10% of irrigation potential are so far developed. In urban areas the coverage rate for access to water supply and sanitation services were 90% and 56% in 2000 respectively, while in rural areas they were 18% and 3% respectively. Those percentages are for a population of 170.1 million (USAID, 2002), although this national figure masks wide disparities between regions. Less than 20% of collected wastewater is treated. Coverage rates reflect the predominance of the large urban centres of Sao Paulo, Rio de Janeiro and others. Some 81% (138 million) of the population live in urban areas, many from rural areas. Water services have a number of different providers, including: state companies, of which there are 25 supplying some 95.1 million people with water supplies and sewage services to 39.8 million people; municipal providers and private providers to 40 municipal areas, mostly concentrated in the southeast region in midsize cities. Until the mid-1990s, 85% of the investment in water services was provided through the government, but since the 1990s this has begun to change. Both the federal government and states have privatised many of their assets including the enterprises responsible for water supply and sanitation services;

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this has shifted the burden of investment away from direct government involvement. In general, privatisation has proved easier at the municipal level where there are fewer legal constraints on actions such as granting concessions, which states cannot do (Media Analytics, 2002). Many of Brazil's publicly owned water companies have modernised and now operate on a corporatised basis, allowing them better access to credit and financing. A national water sector regulatory body set up in 2001 has started to take action to improve the long-term efficiency of irrigation. River basin committees are setting up water agencies to act as private or state-owned enterprises responsible for water resources development and management. These are in addition to the water services functions provided by or through state and municipal authorities. There remain, however, areas of concern such as co-ordination among all levels of government over water issues, addressing water pollution and water scarcity, and increasing cost recovery for services. In its 2005 economic survey, the OECD commented that "private investment in water and sanitation continues to be constrained by a lack of clarity over the assignment of regulatory powers across different levels of government. This has held back much-needed investment" (Dean, 2005). Overall, the water sector appears to be in a good position to strengthen its institutional foundations. However, recent construction projects to improve sewage treatment by building large new facilities in Porto Alegre, Greater Sao Paulo and other major conurbations have had problems due to financing and are proceeding in a "stop-start" manner.

Elsewhere in South America the situation is similar, with virtually no sewage treatment in El Salvador and Paraguay and highest levels in Nicaragua and Brazil. Where treatment exists, system performance may be poor, unmonitored or badly regulated. Waterborne diseases are thus endemic in a number of countries, such as Colombia. Citing a review in 1991, UNEP (2002) reports that the major issues in Latin America are: poor political support for wastewater treatment, linked to lack of environmental policies; financing, including a lack of indigenous institutional capacity and the form of financial models imposed by international agencies; and the need for more appropriate technologies.

## Canada

Canada's water resources are considerable. It has an estimated 7% of the world's renewable water supply, the third highest percentage after Brazil and Russia. Almost 9% of its land area is covered by freshwater, including some 25% of the world's wetlands. However, for a country of just over 31 million people in 2003 and with a per capita GDP of CAD 29 700 (putting it in the top 15 in the world), it is not without water problems. Some 85% of the population lives within 300 km of the southern border with the United States while 60% of the country's freshwater drains northwards. The amount of water used in Canada has increased by nearly 26% since 1980, causing greater ecological stress and raising the costs of maintaining adequate water infrastructure (*http://environmentalindicators.com*). In 1999, about 26% of Canadian municipalities reported water availability problems within the previous five years (Environment Canada, 2005).

Just under 95% of Canadians have access to adequate water supplies and sewage services. Of that share, some 97% had primary and 78% secondary or tertiary wastewater treatment. However, while it is safe to say that infrastructure in western parts of the country is generally newer than infrastructure in the east, it is difficult to make further regional generalisations. For example, while Calgary has a water treatment system that is state of the art, the City of Victoria, also a western city, has no water treatment system at all. In fact it remains one of the only cities in Canada that dumps untreated sewage directly into the ocean. The discrepancy among different municipalities is partly a result of how sewage and water treatment is regulated in Canada: generally, it falls under the jurisdiction or authority of many different levels of government. National, provincial, municipal and in some cases even international laws and standards apply to sewage treatment (*www.environmentalindicators.com/htdocs/indicators/7muni.htm*).

The vastness and diversity of the country's geography also has a significant impact on infrastructure financing needs, and one of the most striking examples of this exists in Northern Canada. Communities in the North already face tremendous infrastructure challenges as a result of the relatively small tax base and physical remoteness of many communities, but also due to the logistical and technical difficulties of building on permafrost and withstanding extreme climate conditions. Water infrastructure in particular can be very different in the North than in the rest of Canada, with many communities relying on trucks rather than pipes to deliver freshwater and dispose of wastewater. Additionally, climate change, which is being experienced most acutely in Northern Canada, is having direct impacts on infrastructure in the North. Melting permafrost, erosion, and the unpredictability of the ice-road season are creating increased demands for investment in new and innovative infrastructure in order to adapt. At the same time, the unpredictability of climate change is making it difficult to identify when and where these investments need to take place.

Heightened concerns about flooding and drought as a result of climate change are also affecting investment needs in water system infrastructure. For example, Infrastructure Canada recently committed CAD 120 million to expanding the Winnipeg Red River Floodway, which has saved the city from flooding over 20 times since it opened in 1968, but which in recent floods has been filled almost beyond capacity. There is also growing interest in developing innovative regional water distribution systems for rural and agricultural communities.

In 2001, Canadians used 335 l/c/d, and at least half of this amount is "unnecessary and wasteful" (Environment Canada, 2005). Canada's per capita consumption is 65% above the OECD average; only the United States has a higher per capita consumption. As the 1987 Federal Water Policy observed, water is the most undervalued and neglected of Canada's natural resources. Municipal water use accounts for some 12% of all water withdrawals, slightly less than manufacturing at 14%. Although manufacturing has reduced overall gross water use through recycling, consumption rates have gone up as the economy has grown. In addition, at least 40% of discharges are untreated.

Although much of the water infrastructure was built in the first half of the 20th century, the development of the country is reflected in the diversity of water infrastructure statistics. According to McGill University (1996), in 1995 the average age of municipal sewage treatment infrastructure in Canada was just under 25 years; the average age of municipal storm sewers was about 32; and municipal sanitary and combined sanitary and storm sewers was about 41. However, in Toronto for example, 17% of water mains are 80-100 years old and 7% are even older. High population growth has been focused on a limited number of large metropolitan centres. About two-thirds of the population live in these areas; the largest seven account for 45% of the total population. Water infrastructure was well maintained until the 1970s, due to good economic conditions and the fact that many of the facilities were built after 1945 and so relatively new (Infrastructure Canada, 2004). Most agree that since then there has not been the required investment in the maintenance of the infrastructure. As a result, deterioration of water infrastructure has become a significant problem. It has been estimated that to repair Ontario's water mains costs CAD 40 million a year, that water losses are around 40%, and that 25% of the water system must be replaced and 50% restored over the next 60 years (Infrastructure Canada, 2004). According to a 1996 survey of 167 Canadian municipalities, 59% indicated that water distribution infrastructure was in need of repair. The situation for wastewater infrastructure was worse: 68% of the sewer systems were reported to be in need of repair. For example, in Ontario in 2002, 61% of water treatment works failed inspections and in 2001, 101 sewage treatment works violated provincial laws or guidelines (Brubaker, 2003). At the same time, new standards, design requirements, regulatory demands and stricter environmental and health regulations have increased both the need for upgrading and capital and operational costs. Three decades of deferred maintenance work have created a situation where deterioration will escalate exponentially if no action is taken (Mirza and Haider, 2003).

Local government capital spending has been on a downward trend for the past two decades (Vander Ploeg, 2003). Charges for some water services do not cover the costs of municipal water and wastewater services, such that use is being subsidised with only half of the operation and maintenance costs being recovered in some communities. The tightly controlled fiscal framework limits the ways in which municipal authorities can raise funds and increase revenues. This has contributed to the increasing infrastructure deficit and has led to a growing preoccupation with how to finance infrastructure (FCM, 2001; Infrastructure Canada, 2004a; Vander Ploeg, 2004). However, in western cities the water and wastewater infrastructure is often in a better position, ascribed to the relative youth of those cities. Also, such services are more frequently paid from user fees, making the financing of infrastructure improvements easier than it would be if it depended on the municipal tax base (FCM, 2001).

Under Canada's Constitution Act (1867), responsibility for water is divided between the federal and provincial governments. Provinces are the "owners" of water resources, while the federal government has specific responsibilities with respect to such matters as fisheries and navigation. The 1970 Canada Water Act entrusted the federal government with providing national leadership in freshwater management. Since 1987 the Federal Water Policy has provided a framework for water-related activities of all federal departments. Contributing to the complexity of water governance is the fact that local agencies such as municipalities and water management agencies also play an important role, but are creatures of provincial governments. Overall, provincial governments are responsible for long-term as well as day-to-day management of water resources. This includes policies, regulations and strategies covering drinking water supplies, the protection and conservation of water quality and quantity, and aquatic ecosystems. In order to promote better management many are moving to integrated ecosystem and watershed management approaches, and several have created institutions that focus on specific water issues such as apportionment. At another level there are also collaborative bodies that link specific federal, provincial and territorial spheres of interest – for example, the Canadian Council of Ministers of the Environment, which developed water quality guidelines.

## China

Only 47% of the Asian population have improved sanitation coverage, by far the lowest of any region of the world. Asia has 80% of the global population without access to improved sanitation, and almost two-thirds do not have access to improved water supply. With just 31% coverage, the situation is much worse in rural areas than in urban areas, where coverage is 74%. Water supply coverage is 81%, the second lowest after Africa. Like sanitation, coverage is lower in rural areas (73%) than in urban areas (93%). Currently, approximately two-thirds of the Asian population live in rural areas, but by 2015 the urban population is projected to represent 45% of the region's total, and should reach just over one-half by 2025. This population growth and shift will place enormous strains on already overburdened urban services. If adequate provision for sanitation in large cities is taken to mean a toilet connected to a sewer, there is a lack of adequate provision in cities throughout Asia.

Not only is China the world's most populous country, but its geographical sweep is huge. There are thus major differences between regions, and any generalisation can be very misleading. Renewable water resources have been estimated as being 2 711 billion $m^3$ from surface and 829 billion $m^3$ from groundwater; respective withdrawals have been estimated at 425 billion $m^3$ and 86 billion $m^3$. Water availability is unevenly spread over the country and China is prone to both floods and droughts. The north and northeast have over 40% of the population and 60% of the cultivated land but only 15% of the water resources. Added to this are concerns about groundwater mining from the North China Plain aquifer, an important grain-producing area and source of water for several major cities; were it to fail the consequences could be catastrophic (World Bank, 2001). Agriculture accounts for some 73% of water use, with 10% domestic and 17% industrial. The growth in irrigation needs is 0.5% as compared to 5% for non-irrigation needs. Of the total water consumed, 80% comes from surface water sources and the remainder from groundwater and reuse. Of particular concern are the shortage of water supply in some 600 cities, mostly located in the economically important northern part of the country, and water pollution. Already some 400 cities face water shortages, mostly due to environmental pollution (RFA, 2005), and some 600 million people risk drinking contaminated water. The total shortfall has been estimated at 6 billion $m^3$ (Jingrong, 2004). Beijing, for example, has experienced difficulties since the 1970s, with predicted shortages of up to 1.64 billion $m^3$ (annual rainfall 10 billion $m^3$) by 2010. The city has recently been considering new sources up to 1 000 km away, together with further development and control of local surface and groundwaters, and a lot of new small and local interception dams. This will also help with water reuse for irrigation. In addition, some 2.45 million $m^3$ of drainage from urban areas is seen as a potential for reuse following treatment. Locally, water saving measures and storm water storage is being introduced into the city (Nie and Schilling, 2000).

In 2002, per capita consumption in urban and rural areas was 219 l/h/d and 94 l/h/d, respectively (USITA, 2005). China expects the net increase in water demand to reach 40 billion $m^3$ by 2005; over half will be needed in cities and towns, where at present there is 77% network coverage. Supply systems built in the 1950s are experiencing serious deterioration. Agricultural demand is expected to stagnate or decline as a result of improving efficiency and technology. Wastewater treatment is set to rise from an estimated 20% to 45% by 2005 and to 60% in the larger cities (USITA, 2005). In 2002 only 310 out of 660 cities had municipal wastewater treatment works, with none in most of the 17 000 towns. There are over 61 000 industrial wastewater works, owned by the enterprises that treat 85% of discharges (USITA, 2005). Only in areas of severe water shortage is there any concerted attempt to reuse wastewater. A 1993 ESCAP study found industrial water use to be highest in the Yangtze River Basin (including Wuhan), where 25% of all water extraction was for industry. The highest urban water use was in the Hai He-Luan He basin (which includes Beijing). Almost 9% of the total water use was for urban supply. While most of the water is used for agriculture, the increase in agricultural water consumption has been low. The Nanjing Institute of Hydrology and Water Resources estimated that from 391 billion $m^3$ in 1980, agricultural use by 1993 was 406 billion $m^3$ (50% of all water used) and 394 billion $m^3$ in 2002. Use for irrigation declined by over 4%, from 358 to 337 billion $m^3$. However, an increasing amount of this water was from the ground. Of the 1.3 billion population, some 80% were living in rural areas in 1999. The use of human wastes for fertiliser for agriculture is widespread and has been practiced for more than a millennium. However, poor practices meant that in 2001 some 50% of the rural population were infected by ascariasis and 63% with helminth. Although more than 85% of the total population has access to some form of latrine, less than 15% of these facilities were considered safe in a UNICEF survey in 1999 (Hua, 2000). New initiatives are needed to promote the uptake of properly planned ecosanitation systems.

Industrial water use in southern China has shown the biggest increase (in percentage terms) from 1980 to 2002; urban water demand grew by 470%, from 6.8 to 32 billion $m^3$.

In 2002, China began a massive south/north diversion of water, with three canals planned to link the country's four main rivers, including the Three Gorges project. Much of this is scheduled to be in time for the 2008 Olympics. The total cost is estimated to be USD 22 billion, with the construction of the west route cost at USD 36 billion. A limited liability company will oversee the main work and there are plans to establish provincially based companies for the associated auxiliary infrastructure. Such water diversions are causing reductions in river flows, a 26% loss of wetlands and the drying up of 2 000 lakes, affecting the Yellow River (Ramirez, 2005).

Between 1950 and 2000 the urban population increased by over 500% and now accounts for some 40% of the total (UN, 2002), with 72% of growth by rural migration. By 2030 about 60% of the population – some 883 million people – will be urbanised (Hugo, 2003; OECD, 2005). Such growth is placing enormous burdens on urban water supply and sanitation systems. The economic growth rate over the last 20 years has averaged 9.5% and is expected to continue at high rates (OECD, 2005). In 2003 China was the largest recipient of FDI, at USD 53 billion. The private sector is now a major force in the economy and is one of the main engines of jobs and growth; with further urbanisation it could add to the reduction of inequalities. A major challenge is to reduce the pollution accompanying urbanisation. Although there are an increasing number of wastewater treatment works, only a third are functioning well. This is due to a combination of low funding and fee collection and insufficient government monitoring and law enforcement (Turner *et al.,* 2003; McGill, 1999). Pollution monitoring and law enforcement are poor due to weak institutional capacity at all levels. There are also problems in raising the required finances, mainly through the use of enterprise bonds and other mechanisms such as public-private financing partnerships (Turner *et al.,* 2003; McGill, 1999). Although government policies have contained levels of pollution generally, water pollution remains high and the extensive use of resources such as water is beginning to pose problems for economic development (OECD, 2005). One-third of the major water basins are classed as highly polluted and 75% of the water flowing in urban areas is unsuitable for drinking. At the same time there is considerable scope for improving efficiency in the use of irrigation water (OECD, 2005).

China it is still a politically centralised system, although there is now a considerable degree of decentralisation of power at national, provincial, prefectural, county and community levels. Legislative and regulatory powers as well as planning and development are the responsibility of national government but the management and maintenance of water systems are the responsibility of the various lower tiers. Municipal governments are primarily responsible for providing water and wastewater services; they own and manage more than 60% of water capacity. Responsibility for the water sector is split between the Ministry of Water Resources and the Ministry of Environmental Protection. Although the administration is vertically integrated there remains a substantial degree of functional specialisation and management decentralisation across government layers. This decentralisation causes conflict across government and is further complicated by the presence of state-owned water enterprises, which have their own agendas. There have been a number of legal instruments passed to strengthen powers in this area, including clearer lines of responsibility and financing; bridged gaps between environmental protection, water supply and pollution; demand management; and property rights. An increasing number of policy initiatives aim at adopting economic instruments, in some cases making government funding contingent on introducing full-cost pricing. But given that prices for services in general are held below full cost, this imposes financing constraints on the provision of services (OECD, 2005). Tighter budgetary constraints may, however, lead to some hard choices.

In 1997 private and non-governmental organisations were allowed entry to the water sector, and all public water projects were supposed to be run along commercial lines. There are requirements for local governments to draw up integrated water management plans; municipal undertakings have been reformed and government has separated service delivery from regulation. Emphasis has been on economic growth and devolution of authority. This has resulted in institutionally weak environmental protection and corruption at all levels. Reforms have strengthened the financial position of the state, contributed to a rising standard of living and the growth of per capita water use, and increased water pollution and competition for the dwindling water available (Elizabeth Economy, 2005). If these trends continue there could be up to 30 million "environmental refugees" forced to migrate because of lack of water for arable land, searching for work in the cities.

Between 1981 and 1993 the annual investment in urban public water facilities increased from USD 45.6 million to USD 743 million. There are efforts to encourage development outside of the existing economic growth areas through the central government's "Go West" programme. The areas targeted lack the necessary water infrastructure and require investment in improving supply, sanitation and wastewater treatment as well as institutional strengthening. One such endeavour is being supported by the World Bank with a loan of USD 180 million out of the total estimated cost of USD 280 million. This is being complemented by the Asia Development Bank's initiatives in the poorer inland provinces in the water and wastewater sectors.

## India

India is the second most populous country in the world and in terms of land area the seventh largest. Agriculture accounts for 84% of water use, with domestic supply accounting for only 5% and industry the remainder. It is expected that non-irrigation demand will quadruple due to population growth, urbanisation and economic development, although India is likely to remain essentially an agricultural nation for some time to come. Between 1950 and 2000 the urban population increased by over 350% and now accounts for some 30% of the total (UN, 2002), or approximately 280 million people. By 2030 some 40% of the population will be urbanised, accounting for some 575 million people (Hugo, 2003), living in over 4 378 towns and cities and contributing in excess of 60% 0f the country's GDP. The population is expected to stabilise at an estimated 1.5 billion by 2050. Of the urban population, 90% had access to clean drinking water in 2002 (Planning Commission, 2002) compared to 85% in 1993, although the corresponding figures for the rural population are 78% in 1993 (WRI, 1995) and 70% in 2002. Some 19% of rural households have a toilet compared to 80% in urban areas (Planning Commission, 2002). Sewage systems are present in only 70 out of the 300 major cities, and only 30% of wastewater generated in municipal areas is treated (Planning Commission, 2002), and not necessarily to a good standard.

Between 1950 and 2000 the gross irrigation potential increased from 19.5 to 95 million hectares, and further increases are expected. India has a wide range of geography and climate that influences water resources, utilisation

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and agriculture. In general, agriculture relies on the seasonal monsoon rainfalls: 50% of precipitation falls in just 15 days and over 90% of rivers flow in just four months, a variability that brings both drought and flood. Most of the interior is arid though fertile, meaning that agriculture could be expanded. In India's 2002 national water policy, drinking water was given the top priority in water allocation ahead of irrigation, which has significant implications for future water sector development. Nonetheless, some 21 million farmers now use underground water for irrigation of two-thirds of India's crops, and this takes out some 250 $km^3$ of water per year that is only being renewed at a rate of 100 $km^3$ per year (New Scientist, 2006). Currently it is estimated that around one million new groundwater pumps are installed annually to increase crop irrigation. Not only are there no data on the distribution of the pumps, but they are entirely uncontrolled as well as being subsidised by government.

There are associated problems between states over the management of transboundary water resources; these are expected to worsen in the future, with a growing disparity between supply and demand for water (Shadananan Nair, 2004). There are further problems connected with the overexploitation of groundwater, brought about by the increasing use of small motorised pumps. In 2000, India's 81 million land-owning families had some 20 million tube wells and pump sets, a figure that grows by 500 000 per year. Unregulated use and cheap electricity has depleted aquifers, which has meant ever deeper wells and increased costs. This also poses severe problems for rural water supply, as these wells are the major source of drinking water. In addition there is concern over leachates from agriculture causing increasing aquifer pollution. The pollution and deterioration of groundwater in many areas is a matter of increasing pubic health concern, as is the quality of many of the rivers used by municipal authorities for drinking water supply, which are heavily polluted (TERI, 2002).

Although there is a strong central government, the lack of constitutional powers makes it weak with respect to the co-ordination of the water sector. That leaves the sector and its institutions relatively constrained in what they can achieve in terms of planning and water management (Brisco, 2005). National water supply and sanitation strategies are set out in successive five-year plans. The nodal agencies for rural and urban water supply and sanitation are the Rajiv Gandhi National Drinking Water Mission and the Ministry of Urban Development and Poverty Alleviation. Urban infrastructure facilities are provided by local urban bodies that depend on central and state governments for grants and loans. Other problems are the negligible user charges, corruption, high staffing levels and an enormous backlog of deferred maintenance (Brisco, 2005). Budgetary allocations to the water sector are falling, as are payments by users. The situation has to an extent been alleviated by the "era of individual coping strategies". For rural populations it is the tube well that taps local aquifers; for the middle classes and industry there are other self-provision strategies. For the urban poor there is only the water vendor. Progress in introducing sectoral reforms after 1999 remains slow, though there has been some localised progress (Saleth and Dinar, 1999). Central Government has identified the need to reform the way infrastructure development is governed if it is to meet the target of 100% coverage of the urban population with water supply facilities and 75% with sewage and sanitation by 2007. The funds required for this purpose are estimated at INR 53 000 crore, the majority of which would come from the states (*http://indiabudget.nic.in*). How this translates down to states and to local bodies remains to be seen.

Following reviews by the World Bank and the government of India, interest in privatisation has been increasing and some states have created autonomous corporations to mobilise private funding. Over the past ten years the World Bank has been working with the Ministry of Urban Development to promote private sector participation. Success has been somewhat mixed, with many proposals failing and 25 large and small contracts being abandoned after starting. A recent report noted some successes, however (UNRISD, 2005). For example, in 1999 the urban centres of Madras, Poona, Bangalore and Hyderabad were successful in attracting private participation in the form of management contracts and concessions in the water sector. This trend has been continuing, with many other examples of the private sector gaining concessions to supply municipalities, industry and even rural areas in spite of sustained vocal opposition (India Resource Centre, 2003). There are concerns that the controversies surrounding the involvement of the private sector are hindering the search for solutions to the chronic water shortages experienced in most cities and urban areas. In Delhi for example, only 2.9 million $m^3$ of water are supplied intermittently, as against a demand of 4.2 million $m^3$ per day, to the 60% of the people who have water connections. For the rest they rely on illegal connections, tankers, standpipes or handpumps. Delhi's water board is planning to let pilot management concessions costing an estimated USD 246 million, retaining the right to set tariffs. However, in 2004 revenues covered only 60% of operating costs. To raise tarrifs would require accurate and reliable water meters – which have not so far been installed (*The Economist,* 2005). India has demonstrated that it can improve its water sector but this requires removing the obstacles to water being priced properly and developing a private financial infrastructure that can fund developments (Mulford, 2005). The government has acknowledged that financing will have to be based on user charges, and has introduced a range of incentives to encourage the private sector to participate and municipal corporations to make use of bond issues, although so far on a limited scale (*http://indiabudget.nic.in*).

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## Europe

In Europe the overall abstraction and consumption of water resources is believed to be sustainable, although there are marked regional variations and the effects of climate change may challenge distribution. During the 1990s there were decreases in water abstracted for almost all uses in most parts of Europe, the decrease being most marked (30%) in the Central EU accession countries. However, in Southern Europe seasonal water shortages are becoming more acute as agricultural and tourist demand for water increases. The southern European countries have the most land under irrigation and are also among the most inefficient in their agricultural usage (Vecino and Martin, 2004). On average, 33% of total water abstraction is used for agriculture, rising to 50% and more in southern European countries. It is also these countries that have the greatest area of irrigated land, with an average usage of 7 000 $m^3$/ha, which compares to figures of between 500 and 2 000 $m^3$/ha in other parts of Europe. By contrast, urban use accounts for some 16% of all water abstracted and industry 11%, with energy production (cooling) being the most extensive user of abstracted water. Per capita urban water use has shown a small decrease since 1990 although the actual amounts vary across Europe according to factors such as climate, the levels and efficiency of public water supply, water use habits and how water is paid for. Some of the falls in usage have been the result of an increased focus on water savings measures and the introduction of water charges and tariffs (*e.g.* Butler and Memon, 2006). However, loss of water from water systems remains a serious problem.

Absolute water use has increased as a result of more people being connected to water supply systems through demographic changes, such as more households and increased wealth and standards of living. In Europe the percentage of the population connected to a public water system is generally over 90%, although there are regional differences. In Eastern Europe the proportion of urban households connected to piped water supply is generally over 80%, with coverage in the rural areas ranging from 10% in Romania to 90% in Slovenia and Bulgaria. In the former eastern bloc, urban water use has decreased as a result of industrial decline, tariff increases and improvements to the supply systems. In contrast, Bulgaria and Romania have high water use per capita as a result of poor supply systems and all the problems that attend these. Per capita household water use varies from a high of between 224 and 265 l/capita/day in Spain and Norway to lows of between 85 and 115 l/capita/day in Lithuania, Estonia and Belgium.

Across Europe, there are major differences in subsidiarity traditions, and thus the role of local governments. According to Juuti and Katko (2005), this difference is crucial for the evolution of and strategic decisions concerning the management options for water and sewage services. Most significant is the role of the private sector in delivering these services. Clearly this is now strongly related to the globalisation and diversification of a relatively small number of large corporations that are major actors in water service provision.

The development of water services in 29 cities across Europe has been examined in detail by Juuti and Katko (2005), reporting on the EU WaterTime project. The historical factors creating demand for water services are varied; the most important were: the state of the service providing business; fire protection; lack of readily accessible water; poor water quality; environmental protection; public health; industrial needs; regional perspectives; and tourism. These demands can be exerted at different times in the development of each city. The strong role of fire fighting and associated insurance services is cited as a primary driver for a number of cities.

In each country studied, it was found that although private finance initially provided water services (in a less than comprehensive way), subsequent responsibilities were taken over by municipal provision by the beginning of the 20th century. Interest in environmental protection for receiving waters did not develop until the 1960s-70s although most countries had some form of wastewater treatment by then. After the Second World War most of the Eastern European systems were managed under centralised state control, rather than at a municipal (city) level. In the latter part of the 20th century, most European cities introduced separation between the storm and sanitary drainage systems, although due to historical instillation, most sewers in Western Europe are still of the combined type; only new systems are separate. Few countries – the Netherlands and many cities in the United States are notable exceptions – are attempting to retrofit systems for the separation of storm and sanitary wastewater. In London for example, there are plans for a new combined storage sewer at a cost of USD 3 billion, which uses essentially the same technology as for the originally constructed interceptor sewers in the 19th century (Thames Water, 2005).

Renewed interest in private operation and ownership of water services emerged in Europe in the 1980s-90s. Despite this, the only fully privatised services for water and sewage in Europe are in England and Wales; in the other constituent countries of the United Kingdom, these services are provided differently. Various other forms of private involvement exist, ranging from simple contracting services to partnering and municipal or state-owned dedicated companies. Even state operation can be varied, with federal operation in some countries, municipalities in others and segregation between the various water service components (water, sewage, storm water) in others. Mohajeri *et al.* (2003) provide a comparative review of private sector involvement within the water sector across the (then 14) member states. Diversity is and will remain a main principle of the EU, and these various forms of service provision are likely to continue but with dynamic shifts and partnering across and within service groups. There is strong evidence of multi-utility presence in many EU countries, with perhaps fewer and fewer major players in the water market over time. Reconciling the delivery of the Water Framework Directive with the need to better engage stakeholders and also to ensure that they pay the full economic cost for water services – and within a very short timescale (2015-17) – will be challenging for Europe and inevitably allow more of the experienced and larger private companies to engage in the market and operational opportunities. The needs to upgrade water infrastructure are the greatest in the newest European countries, but it is also in these countries that the economic challenges are likely to be greatest (Fankhauser and Tepic, 2005).

The Watertime project provides an illustration of the changing water consumption patterns for some of the European cities investigated, as shown in Annex Figure 5.A1.1. These results are believed to be an underestimate of the actual water usage. Several reasons are given for the general decline in consumption since the 1990s: the energy crisis in the 1970s and charging for sewage treatment linked to it; the decline in industries using centrally supplied water; general water efficiency awareness and drive; and metering.

Forms of revenue raising are also crucial for meeting demands for water-related services. In some countries water services are provided using revenues from general or local taxation, whereas in others it is the "customer" who is directly charged for the water used. Where properties are metered there should be a greater awareness of the need to conserve water (although not for the wealthiest), yet evidence suggests that typically less than 10% of demand can be cut by retrofitting water meters (Butler and Memon, 2006). Declining water use has a knock-on effect for tariffs, with lower income for suppliers. Hence a number of structural changes were instituted in a number of the Baltic countries in order to ensure supplier viability.

Additional data suggest that there has also been a decline (less marked than in Annex Figure 5.A1.1) in billed domestic water consumption in nine of the cities studied in the Watertime project. Notwithstanding these results, a separate review of domestic water use across Europe (Wieland, 2003), had slightly different results to what may be interpreted from Annex Figure 5.A1.1 in terms of whether or not demand was declining, as given in Annex Table 5.A1.1.

The table possibly underestimates domestic usage, as in some countries consumption is determined based on the total domestic supply divided by the total population, and a significant number of households may not in fact be connected to "public" supplies. For example, in 2002 only some 54% and 72% of Romanians and Estonians respectively were connected, although supposedly almost 99% of Bulgarians are and have been connected since the early 1990s (Eurostat). Table 5.A1.1 shows that in a 15-year period demand has fallen in the new countries (where there are more private supplies) and risen in Nordic countries. The highest demand was found to be 214 l/h/d in Finland. In Germany, Belgium, the Netherlands, Austria and Denmark, water charges were relatively high and hence water use is lower.

Most water in Europe is abstracted from surface water sources (70-90%). An exception is Denmark, which is entirely served by groundwater. Public water supplies represent less than 20% of total overall demand and predominantly originate from groundwater, although trends now show that there is an increasing reliance on surface supplies. The highest overall abstractions in the EU region for all uses are in Greece, Portugal, Spain and Italy; the highest demand for public supplies is in Belgium, Iceland and Norway. Data on distribution system leakage rates are sparse. In England and Wales leakage currently stands at 150 l/h/day (2004-5), representing some 20% of piped supply and the average per capita daily consumption of one person. Households and small business users of public water supplies are classed as "domestic". In Finland, these users consume all of the supply in this sector, whereas in Bulgaria only some 34% of the public supply goes to domestic uses. Annex Table 5.A1.2 shows that across Europe, domestic usage can be viewed through three groups, and compared with uses in the EFTA countries. There is no correlation between domestic use and the proportion of the population connected to public supplies.

Water supply quality is heavily regulated across Europe, with the Drinking Water Directive covering the primary standards.

Europe has a wide variety of institutional arrangements for water resource management and water supply, ranging from direct public management to delegated public management, delegated private management and direct private management (EuroMarket, 2005). In the Netherlands, 20 corporatised water utilities run the water supply system while wastewater remains a municipal function. In France there are some 16 300 water suppliers, mostly controlled by three large private concerns operating under franchise agreements with local authorities who own the assets. They supply some 75% of the population and 52% of all sewage services (Renzetti and Dupont, 2003); the rest are served by municipalities.

Spain also operates a system of delegated management but to a lesser extent than France, with 37% in private hands and with the state having an interventionist role, particularly with regard to agricultural water supply. In some parts of Germany, public-private consortia act as service providers while in other parts supply is managed by municipalities. For example in Bavaria, one of Germany's 16 Länder, there are over 3 000 municipal water works. In the United Kingdom, arrangements include private water companies, corporatised public provision and provision by a government department. In

Italy there have begun to be changes to the public provision of water services, partly brought about by the Water Framework Directive. Private water concessions to consortia (often headed by the big international water undertakings) by municipal authorities are being implemented under a 1994 law. In addition, corporatised municipal enterprises are beginning to operate beyond their own home territories. The trend in private sector participation has gradually increased over the past decade in southern member states (EuroMarket, 2005). The predominant model of water supply and sanitation, not only in Europe, is in one form or another of state-owned utilities fulfilling that function. Less than 10% of all people globally get their water from privatised or part-privatised businesses (SAM, 2004). Overall in Europe 48% of the population is served by water supply systems under public management, 15% by public water companies (Germany and the Netherlands), 20% by delegated private management (mostly France and Germany) and only 1% by direct private management (England and Wales) (Bakker, 2005).

Throughout Europe water tariffs have been increasing at between 2% and 6% per annum (OECD, 2001) although the levels of water prices are lower than the cost recovery levels. There are few examples where tariff structures have been designed to aid demand management (Roth, 2001) and often those few include substantial subsidies. Although over the last 10 to 15 years there have been moves to better cost recovery, it is only in the case of domestic use that any real improvement has been made, partly supported by greater metering coverage. There are, however, marked differences in approach across the EU. While more countries have introduced volume-based charges, in southern countries social concerns and equity are important and so systems such as block tariffs are more prevalent. In the industrial sector 75% of water used is not drawn from the public system and even where it is little information is available on price levels (Roth, 2001) but it would appear that cost recovery is below that for domestic supply. With respect to agriculture there is a marked divergence in tariffs between Northern and Southern Europe. In the south, equity considerations predominate; in the north, water use is almost always charged by volume used.

A common feature that emerges is that the water infrastructure systems built since the 19th century have been provided by the state (national, regional or local) as these could not have been financed privately. As a result of this public investment, the degree of access to water services and the level of coverage achieved has been very high. Over the past 20 years the main driver behind water services has not been the need to extend the services provided. Rather, at present the need for capital-intensive investment in water infrastructure arises from the need to meet new standards and requirements or from new developments. Apart from this, all water service providers in Europe are facing similar problems. Modernisation of the existing systems is overdue;

they are ageing and deteriorating, and in doing so are creating problems with respect to both water quantity and quality of supply. Apart from the key issue of maintenance associated with deterioration of assets, the other overarching factor influencing the water sector activities are EU directives and particularly the Water Framework and associated directives. Meeting directive obligations has in the past been a key driver of effort and expenditure, including research and development. Many of the directives are associated with environmental quality and (to a lesser extent) social concerns. These and especially the WFD will continue to require substantial investments and expenditures on the part of all EU member states. For example, a recent estimate of the cost to the United Kingdom of the Priority Hazardous Substances Directive is some USD 10 billion (Ross, Thornton and Weir, 2004).

A review of water and wastewater programmes in Central and Eastern Europe (Secrest, 2001), identified a number of common issues to be addressed. Infrastructure was severely degraded due to age, a situation exacerbated by lack of maintenance, lack of performance incentives, high costs, low cost recovery and low levels of service. Tariffs generally did not reflect the full cost of the service, and the presence of cross-subsidies tends to favour domestic consumers. In many cases revenues only cover 60% of operational costs, leading to a downward spiral of poorer service. In addition, the low level of service and low tariffs reduced the incentives for customers to conserve water, and high non-payment rates (20-30%) were common, often due to the small number of industrial customers who comprise a large part of the revenue stream. As a result the projects studied aimed to improve the operating performance of the water systems and at the same time develop the institutional base of the utilities through a range of sectoral legislative, regulatory and institutional reforms. The slow progress in reform at municipal level is seen as the biggest obstacle to the improved provision of water services (OECD, 2005b). A step-wise approach to upgrading – contingent on what customers could pay for – was adopted, aiming at full cost recovery and at full revenue collection (Secrest, 2001). The review indicated that in many cases these objectives had been met. It has been estimated that in a good number of these countries USD 15-34 per capita per year of additional finance would be needed if the present infrastructure is to be properly maintained and renewed (OECD, 2005b).

The debates concerning the future of water services may in fact be reduced to the question of how, given the rising demands on state budgets, the funding problems are to be resolved and what bodies will be responsible for securing the necessary funding. The problems of maintaining networks are bound up with the question of what future networks will look like (Schramm, 2004). The challenges that the current models of service provision – in particular, public provision – are facing may lead to the adoption of new forms of organisation, operation and ownership of water infrastructure.

## United States

The Constitution provides an overall framework for property rights, while state regulatory commissions oversee the operation of privately owned local utilities and local governments regulate public utilities. With the growth of cities between 1800 and 1900, water provision was dominated by the private owners. By 1900 over half of the concerns were in public ownership due to contractual problems between municipalities and companies, principally over water for fire-fighting. In the United States water and sanitation assets are devolved to local governments. Where local governments have been carved up into smaller political jurisdictions and individual water works are impractical, privately owned companies have emerged to provide regional services covering several local governments. There are approximately 54 000 community water systems, of which some 43% are publicly owned, 33% privately owned and 24% classified as ancillary systems that supply very small communities (Bakker, 2005). Together these systems provide 90% of US tap water; approximately 3 000 provide more than 75%. In addition there are 21 400 non-profit non-community water systems, according to the US Environmental Protection Agency (USEPA). The privately owned water systems are in the main small, user-owned or local investor-owned rather than publicly traded corporations; they supply only some 13% of households. In contrast, public water systems serve 86% of households across America. Private companies are subject to rate-of-return regulation by state public utility commissions, which also oversee the publicly owned utilities.

The estimated water use in 2000 was 1 544 million $m^3$ per day; use has varied by less than 3% since 1985 as withdrawals for irrigation and power generation have stabilised (Hutson *et al.*, 2005) down from a peak in 1980. Irrigation remains the largest consumptive user; since 1950 it has accounted for 65% of total water withdrawals. Over this period proportionally more water has been withdrawn from aquifers, increasing to 42% of the total in 2000. Irrigated areas more than doubled between 1950 and 1980, remaining stable until 1995; since that year there has been a 7% increase in response to drought conditions, standing now at some 61.9 million acres (Hutson *et al.*, 2005). However, irrigation application efficiency has increased. In 2000, 85% of the population obtained their supplies from public suppliers, up from 62% in 1950, with a corresponding drop in self-supplied domestic usage. Public water supply withdrawals account for some 11% of the total. By contrast, industrial water withdrawals have been decreasing since 1985 (24%), reflecting the changing pattern of industrial activity and the impact of pollution control legislation. California, Texas and Florida accounted for a quarter of all withdrawals, reflecting their usage for irrigation and power generation.

It has been estimated that there are some 1 440 000 km of water mains in the United States; on average there are 238 000 water main breaks each year; and, on average, water systems lose between 20 and 30% of supply, and in the case of older systems as much as 50% (USHR, 2004). Leakage is a serious economic burden. In Detroit for example, there is water rationing and pressure problems in midsummer, and lost water is valued at USD 23 million per year – added to which there are other associated economic costs and health-related issues. There are problems nationwide with the need to replace lead service pipes and measures to reduce their health impact. The cause of the problems is said to be the change in design standards over the years. In the 1890s, systems had design lives of 100 years plus; by the late 20th century this had decreased to between 30 and 50 years (USHR, 2004). Thus many systems are past their sell-by date, as the American Water Works Association observed:

> Considering the huge wave of aging pipe infrastructure created in the last century, we can expect to see significant increases in break rates and therefore repair costs over the coming decades. In the utilities studied by AWWA, there will be a three-fold increase in repair costs by the year 2030 despite a concurrent increase of 3½ times in annual investments to replace pipes. (USHR, 2004)

On top of this there are increasing problems arising from sewers and stormwater. Added to that are the pressures to extend systems and provide additional capacity for supply and sewage systems to cope with growth and the additional operation costs this implies (USHR, 2004). Since 1996, grants for water supply have been made through Congress under the Clean Water State Revolving Loan Funds, which in 2004 amounted to USD 7 billion. Approximately 40% is provided for treatment needs, 30% for transmission and distribution and the remainder for storage, source development and other needs. The amounts are based on USEPA's Drinking Water Needs Survey, carried out every 5 years for the documented needs for the next 5 to 20 years.

The Water Infrastructure Network (WIN) report estimated that drinking water utilities need to spend USD 24 billion per year for the next 20 years on infrastructure, but that currently the expenditure is USD 13 billion per year. In respect of wastewater systems, the USEPA estimated needs in 1998 as requiring a spend of USD 140 billion as part of an assessment for the Revolving Loan Fund programme (UNEP, 2002). More recently the figures given were USD 22 billion and USD 10 billion per year respectively, leaving an overall gap of USD 23 billion per year over 20 years (Johnson, 2004). These amounts dwarf the existing level of funding and federal subsidies used to supplement user fees and help finance capital investments, and are unlikely to address the real causes of inadequate maintenance: the institutional arrangements and managerial practices (Levin *et al.,* 2002). USEPA's own gap analysis, the 2003 Needs Assessment, is in substantial agreement with the WIN and the Congressional Budget Office's estimates (USEPA, 2005). All indicate that there is a need for substantial investments to upgrade or replace water infrastructure (Levin *et al.,* 2002) in order to ensure compliance with quality standards prescribed by the Safe Drinking

Water Act, even though municipal authorities face funding constraints. The current state of water municipalities and increasing public awareness will force federal agencies to implement corrective action at a faster pace. USEPA estimated that drinking water utilities will spend USD 154-446 billion up to 2019 and wastewater systems USD 331-450 billion over the same period in order to meet the required standards. In addition, a further USD 17.5 billion is required to replace lead service pipes and USD 1.2 billion to harden facilities in order to improve security. It has been indicated that in order to meet these demands there will have to be rate increases coupled with increased government funding, as well as more efficient use of water and resources.

Water rates are in the majority of cases insufficient to cover full cost recovery, and their revenues are not hypothecated for reinvestment in water services. Very few utilities have adopted pricing policies that encourage water conservation, such as block tariffs. The number of utilities and the decentralised nature of the industry are also seen as a problem, as they lead to duplication of effort and sub-optimal management of resources, and do not allow for economies of scale to be realised. In recent years there has been an increasing debate about the need to restructure water supply, particularly in light of the forecast needs for high levels of capital. But the evidence on whether public or private provision is better is inconclusive, although private utilities are said to be more successful in raising investment funds (Levin *et al.*, 2002). Land use pressures and economic and social changes will pose challenges to water supply and sanitation systems. The provision of services has prompted massive population transfers to more arid areas and at the same time contributed to increasing per capita rates of consumption, putting further pressure on water resources. There is rising concern that the lack of clean water is becoming a limiting factor for industry; at the same time many communities do not have the ability to pay for the mandated improvements (USHR, 2004). Government loans provide about 10% of the overall infrastructure investment with the remainder provided locally, a situation that is exercising increasing congressional concern over how funding could be more effectively applied (USHR, 2004). Further concerns relate to a severe lack of investment in research and development for the water sector; asset management practices that lag behind other developed countries by some 10-15 years; the need to move towards integrated water resource management in order to address emerging resource and supply issues; and the need for an overhaul of federal financial support mechanisms (USHR, 2004).

## Russia

The water sector in Russia is experiencing problems associated with the deterioration of its assets, a lack of management capacity, and weak public finance mechanisms. Many of these problems can be traced back to the late 1980s, when investment in the sector all but stopped. In the last 20 years replacement rates have nowhere exceeded 25% of that needed (Ivanov and Shalukhina, 2005). Water losses between abstraction and consumption are in excess of 50% due to the lack of investment and maintenance. Municipalities are a leading source of water pollution, discharging some 52% of non-compliant wastewater into the environment as some 69% of the systems lack the capacity to treat the current flows. In 1997, 10% of the wastewater requiring treatment was treated to the required standards (NIC, 2000). Urban sprawl from unregulated developments is posing an increasing threat to water sources, especially in Moscow. Drinking water supplies are often contaminated, such that in the 1990s there was a marked increase in water-related diseases. One estimate put the cost imposed by water pollution at 1% of GDP, about USD 13 billion. With only 30% of water consumption metered, revenue collection and conservation is extremely limited, per capita consumption rates are between 450 and 500 l/capita/day. Weak institutional arrangements and a lack of regulation compound the physical problems. In the Soviet era, water services were largely funded from central budgets and industry often provided such services free to the communities around them. Responsibility has now shifted to local governments and public utilities, which lack the ability or political will to generate the necessary revenues. Revenue payments by public entities are often ignored, with the result that the utilities cannot cover operating costs and have to defer still further maintenance and upgrading work (NIC, 2000).

In more recent years the situation has begun to improve with support from the international finance community and the emergence of Russian-owned companies, set up by "oligarch" groups that create joint ventures with municipalities to provide water services (Hall and Popov, 2005). In part this might be the result of legal changes that placed responsibility on local governments for the organisation and development of water services as well as tariff-setting. By mid-2004 private Russian operators controlled 50 large utilities and other municipalities were in the process of negotiating leases or concessions for periods of up to 50 years. Such contracts are subject to minimal controls, which increase the risks to all parties – and most especially consumers – considerably. Increasingly, finances such as loans are being provided by international organisations such as the World Bank, EBRD, EU and the International Finance Corporation. An example of such initiatives is the EBRD support for the St. Petersburg sewage plant to treat effluent from 77 000 people; as a result only 15% of the city's wastewater is now untreated, contributing to tackling the environmental pollution of the Baltic Sea. The EUR 138 million project was supported by a loan of EUR 35 million from the EBRD and EUR 50 million donor funding from the EU. Most of the international agencies' efforts are focused on promoting the introduction of the private sector or corporatisation and thus include sectoral reform as well as infrastructure upgrading as part of the project finance (Hall and Popov, 2005). Major water MNCs have generally not entered the Russian market for a variety of reasons, though a number have contracts to build and operate works. These include the risks to returns, local opposition and legal obstacles. They have however been increasing their co-operation and partnerships with Russian companies in the sector, providing engineering and consultancy expertise.

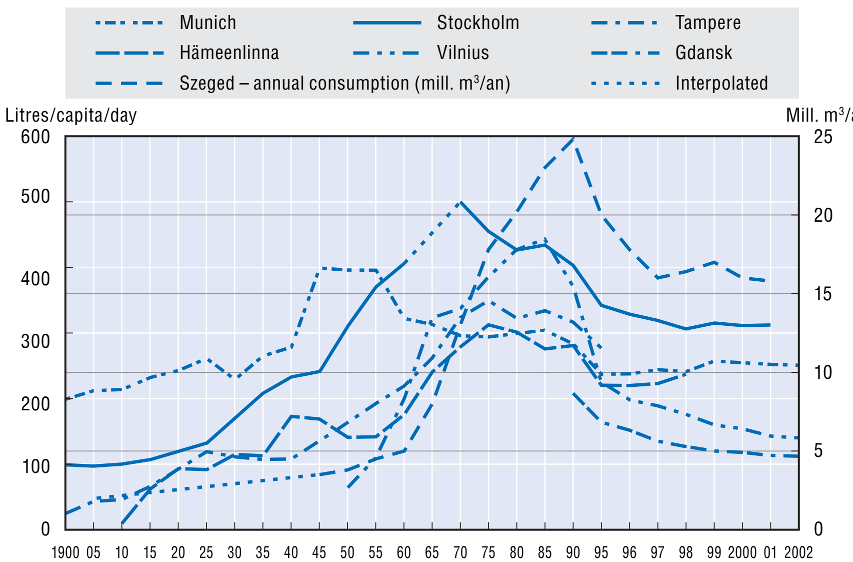
The estimated investment required to replace water works and installations runs at USD 10 billion. To be able to cover such expenses over ten years would require tariff increases of 4 times present levels. In view of such high amounts other sources of funding need to be identified. For full water meter penetration an amount of USD 200 million has been estimated along with USD 50 million annually to service such a system. It has been anticipated that in the medium term there could be up to ten large local companies managing water services to the majority of Russian towns and cities.

## Africa

Africa has the lowest proportional coverage of the population with access to improved water supply of any region of the world. The situation is much worse in rural areas, where coverage is 50% compared with 86% in urban areas. Sanitation coverage in Africa is also poor, although Asia has even lower coverage levels. Currently, only 60% of the African population has sanitation coverage, with 80% and 48% in urban and rural areas respectively. In global terms, the continent houses 27% of the world's population that is without access to improved water supply, and 13% without access to improved sanitation. The African population is expected to increase by 65% over the next 25 years, with the greatest increases in urban areas. The urban population is expected to triple, from some 138 million in 1990 to 500 million in 2020, with 20% of the population – some 200 million – living in a few megacities. In 1990 the largest megacities (25 million) accounted for half or more of the GDP. Meeting the 2015 MDG targets will require tripling the rate at which additional people gained access to water between 1990 and 2000, and quadrupling the rate at which they attained improved sanitation. Whereas 86% of urban dwellers have "improved" supplies, more than half have inadequate provision if the definition is to mean a house connection or yard tap. In most of the largest cities in Africa, less than 10% of the inhabitants have sewer connections. Tens of millions of households, especially in informal settlements, only have access to overused and poorly maintained communal or public toilets. Supplying the burgeoning cities is placing increasing strain on hinterlands, with many cities already outgrowing the local resources. In addition to deleting water resources, associated resource stripping has resulted in excess runoff, soil erosion and subsequent receiving water sedimentation and contamination. Water-stressed areas already exist in several major river basins, *e.g.* the Nile, Tana, Limpopo and Niger. Many of these are also experiencing problems due to trans-boundary issues between countries, as is Lake Victoria (Ray and Dzikus, 2000).

# ANNEX 5.A1

Figure 5.A1.1. **Water consumption patterns for some European cities – total water supplied per capita**




*Source:* P.S. Juuti and T.S. Katko (eds.), *Water, Time and European Cities*, Figure 17, p. 232.

Table 5.A1.1. **Changes in household water use for EU countries**

Litres/head/day

| Country group | Mid-1980s | End-1990s-2000 |
|---|---|---|
| Nordic | 175 | 195 |
| Southern | 180 | 178 |
| Western | 140 | 147 |
| All member states | 148 | 150 |
| New (then) accession countries | 125 | 108 |

*Source:* Wieland, 2003.

Table 5.A1.2. **EU Domestic water consumption per capita per year ($m^3$)**

Data from late 1990s and 2002

| Comparative use | Countries | Domestic use | % population connected to public water supply |
|---|---|---|---|
| Highest users | Finland, Italy, Spain, Portugal, Greece | 64-78 | 85-100 (some countries not known) |
| Mid-level users | Denmark, Luxembourg, Austria, Sweden, Romania | 55-60 | 54-97 |
| Lowest users | Belgium, France, Netherlands, Germany, Slovenia | 41-47 | 91-99.9 |
| EFTA users | Iceland, Norway, Switzerland | 75-108 | 89-95 |

*Source:* Vall, 2001; Eurostat.