Learning from the future: what shifting trends in developed countries may imply for urban water systems in developing countries

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Abstract This study, which is based on reports and articles from various parts of the world, discusses the future development of urban water systems in developing countries. The starting point is the growing need for water and water infrastructure in these countries. Based on an analysis of shifting trends in the water sector in developed countries it is argued that the new infrastructure being constructed runs the risk of soon becoming inefficient and outdated. The first trend is the improvements in domestic water use efficiency; the second is the new sustainability agenda, which places new demands on the water systems. Cities in the developing world have the opportunity to promote domestic efficiency at early stages by laying a strong emphasis on demand management, and to construct more sustainable systems by including sustainability criteria early in the development process.

Keywords Demand management; developing countries; urban water

Introduction

Rapidly growing cities in the developing world are facing tremendous challenges in supplying their populations with adequate amounts of safe water. Improved water access is a prime target for development and as such one of the UN Millennium Development Goals. With growing incomes, increasing numbers of people will aspire for comfortable urban lifestyles similar to those in industrialised countries. This will increase the demand for water-related services, and require the construction of new water infrastructure. However, this paper argues that there is a risk that cities in developing countries repeat mistakes already made in developed countries. The first such mistake would be to build water systems that lead to unnecessarily high consumption. In most developed cities water consumption increased steadily until the 1970s or 1980s after which it levelled out. In recent years, domestic water use has started to decline in many cities, and there is a large potential for further improvements of water efficiency. Efficient appliances, when used together with water demand policy instruments, make it possible for cities in developing countries to meet a growing demand for water services with only moderate increases in water supply; cities in the developing world do not have to develop the same water use patterns as did cities in the developed world.

The second mistake would be for cities in developing countries to put all their efforts into building water infrastructure that may soon become outdated. The broadening of the environmental agenda to also embrace long-term sustainability issues has led to a re-evaluation of the centralised water systems currently used in developed cities. Such systems have limited flexibility and were developed with end-of-pipe solutions; they do thus not match well with the sustainability vision of a society with locally-adapted solutions.
and circular material flows. These recent trends in developed countries can lead the way for the development of new, truly efficient water infrastructure in cities in the developing world.

**Growing cities, growing needs**

The population increase currently taking place in cities in the developing world is not a unique event in history, but the growth rates are much higher than during the urbanisation of developed countries. This high level of population growth, in many cases combined with weak economies, especially insufficient public resources, complicates the construction of efficient urban water systems (e.g. Biswas, 2000). Weak governance structures, lack of management capacity, low levels of education, and political instability add to the difficulties in many countries. The urbanisation literature gives much attention to megacities, but a considerable part of the population increase in the coming decades will take place in smaller cities and urban centres. According to UN forecasts, 40% of the population increase in the period 2003–2015 is likely to take place in towns with less than 0.5 million inhabitants. In many of these provincial centres governance structures and public spending capacity can be expected to be even weaker than in capitals and other large cities. It is a formidable challenge to meet these new urban dwellers’ need for water, while at the same time improving the water access for millions of underserved people already living in urban areas.

Meeting the needs of growing populations is one side of the problem; it is the problem of water scarcity from the perspective of individual households. The other side of the problem is the hydrological water scarcity, the scarcity of easily accessible freshwater in the region where the city is located. These two forms of scarcity are not the same. Even in a water-rich country such as the Congo, large numbers of urban dwellers lack secure access to water. In contrast, most people in the arid northern African countries do have access. Regional water scarcity does not translate directly into water problems experienced by citizens, and vice versa, efforts to improve the water situation of urban households do not automatically lead to hydrological scarcity problems. The link between the two forms of scarcity lies in water management.

**Water management – the need for a demand focus**

In many cases hydrological water scarcity as such is not a problem; it is the increasing economic, environmental and social costs of constructing new water supply infrastructure that become problematic. Showers (2002) analysed the water supply of African urban areas between the 1970s and the 1990s; the study showed how cities in these two decades had become more and more dependent on distant sources and on surface water instead of groundwater. Less accessible water sources are more costly to exploit and there is an increasing risk of social conflict when new dams or well fields are constructed. As the expansion of supply for these reasons becomes less and less feasible, the motivation for improving water use efficiency increases.

At least, this is what ought to happen, but studies from many parts of the world show that the shift of focus from supply expansion to demand management often is very slow (Basu and Main, 2001; Gumbo and van der Zaag, 2002; Toteng, 2002). In many cities a growing water demand has since long been taken for granted — planners have often extrapolated present trends without analysing possible changes in the underlying factors. An illustrative example of inappropriate planning and inability to anticipate changes in demand is Zurich. Here, water demand had been increasing since the beginning of the 20th century until the 1970s, when suddenly the demand started to drop. More or less at the same time as the demand trend turned downwards, major supply projects were carried
out. As a result, in the end of the 1990s Zurich had a water supply capacity about three times as high as the demand. The high investment costs had left the water utility inflexible. It was locked into a position with high financial costs and little room for new initiatives (Tillman, 2001).

Another example of inadequate demand management is in Mexico City, where the water supply system has for a long time overexploited the main aquifer; water is now pumped to the city from distant river systems. From one of the main sources the water is pumped almost 1000 m of altitude (Hardoy et al., 2001). The energy consumption and costs of this long distance transfer are high, but water is heavily subsidised, so consumers do not experience the true costs of water supply. Consequently the water consumption is high, especially in rich areas where people can use as much as 600 litres per capita day (lpcd). At the same time, approximately 30% of the water is lost through leaks in the piping system, and people living in poor areas often can use only 20 lpcd. Furthermore, in 1997 the water tariffs, which at that time only covered around 20% of the supply costs, were reduced by the city government in an effort to “contribute to better economy for the users” (Tortajada-Quiroz, 2000).

The difficulties of shifting focus from supply to demand is due to a number of reasons:

- The water utility may have technical competence in supply development, but little experience in demand management, which involves ‘softer’ issues related with human behaviour.
- There may be a traditional mental template according to which increasing water demand is regarded as an external factor and supply development as the natural solution.
- New supply projects are more visible and therefore get more media attention. Such projects can thus give more political fame to the decision makers.
- Some demand management measures, such as water metering and increased water tariffs, are unpopular and likely to cause resistance from the citizens.
- Technical consultants may lobby for new supply projects.

Some commentators have used the expression ‘ribbon cutting culture’ to describe the way of thinking common in the water sector. This culture favours new, large and technically-advanced supply expansion projects over the long-term unspectacular reduction of leakage and wasteful usage.

In the 20th century, a strong vision of urban water systems developed. This vision, which is shared by many actors, was one of the reasons behind the success of centralised water systems in the developed world. However, this kind of vision, or system culture, has a tendency to change only very slowly. Such strong cultures are based on a mental template according to which only certain problems get attention and where only a limited range of options are considered. When the surrounding society changes, strong system cultures often have problems adapting. The difficulties of shifting focus from supply to demand are not unique to the water sector. Similar inertia, caused by strong system cultures, has been observed in many other cases, for example in the energy sector (Jonsson et al., 2000; Craig et al., 2002).

There are no reasons to believe that there should be a universal solution to this supply-side bias in the water sector. What can change the situation is if water professionals all over the world are on the alert for inefficient priorities and try to gradually influence the culture of the sector.
**Water efficient households**

In many cities in developing countries a growing middle class has the economic means and the political connections needed to successfully express their demand for in-house piped access to water at a low cost. This can lead to a situation where a growing group of relatively wealthy citizens develop wasteful water use patterns, while poor groups have difficulties meeting their basic needs. It is a risky strategy to allow water use in rich and middle class areas to grow rapidly. Once a high level of water use has become established it may be difficult to reduce. If water is cheap and regarded as plentiful households are likely to buy inefficient water appliances and to develop habits related to high water use.

Technology for more efficient water use is available, and this large potential has so far only partly been tapped. Modern fixtures and appliances make it possible to live comfortably with an indoor water consumption of only about 100 lpcd. An example of a city that has made great progress in this direction is Copenhagen where the per capita consumption in 2002 was only 125 litres (KE, 2005). This has been achieved through a combination of increased tariffs, awareness campaigns and active promotion of efficient appliances. The efficiency improvements continue and the goal is to reach 110 lpcd in 2010. In the Netherlands, household consumption has been declining since the late 1980s and it is expected to reach 108 lpcd in 2020 (Miilschlegel and ’t Hart, 2000). A more extreme example of water efficient households can be found in Germany where the 350 inhabitants in the Lübeck–Flintenbreite eco-village use only 77 lpcd (Lübeck, 2003).

Such low volumes, usually require more far-reaching changes in user behaviour and/or water reuse, which might not be acceptable to some users.

The amount of water for toilet flushing, which is often the largest single component of indoor domestic use, depends largely on which technology is used. In 1994, a US regulation that prescribes the use of 1.6 gallons-per-flush toilets (approx. 6 litres) for domestic installations entered into force. Since toilets have a long lifespan, it will take several years until all toilets have been replaced. Therefore, this regulation will continue to influence the trend in domestic use in the US for many years to come.

Washing machines and dishwashers are also replaced at long intervals (approx. 8–16 years), and the difference in water consumption between the average machines in use and the most efficient ones available on the market is usually substantial. For example, the UK Environment Agency estimates that a new washing machine uses about half the water of the average 10-year-old machine. Further technological advances are fully possible, for example, washing machines with internal water recycling and toilets with extremely low water use (3–6 lpcd). Even if these products are not likely to dominate the market, there will probably be a demand for them in niche markets. The examples given show that the trend-shift we have witnessed in some industrialised countries is likely to be only the beginning of a development towards more water efficient homes.

Improvements in water efficiency do not only happen in Europe, North America and Australia. Advanced Asian cities such as Singapore and Hong Kong have developed highly efficient urban water systems, which shows that even in a hot climate it is possible to achieve a good water service with a moderate consumption. In Singapore, flush cisterns of 3.5–4.5 litres are mandatory for new installations (UNESCAP, 1998). In Hong Kong three quarters of the population use sea water for toilet flushing thereby reducing the domestic need for freshwater considerably (Biswas, 2000). In contrast, the water use for WC flushing in Manila is reported to be 60 lpcd (Inocencio et al., 1999). This level corresponds to the flushing use in Australia in the 1950s, almost twice the amount currently used in Copenhagen, or about three times higher than a modern 6/3 litres dual

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flush toilet. The case of Manila is just one example of how old inefficient appliances contribute to high water consumption in city in a developing country.

‘Some for all rather than all for some’ has been a catchphrase for quite some time in the water sector, but if that vision is to be realised a far-sighted and innovative demand management is needed. However, water conservation among rich and middle class citizens does not automatically improve the water access of the urban poor. If water-managing institutions remain unchanged, it is not likely that people with insufficient supply will be better served.

An additional reason to promote household water efficiency already at early stages of water system development is related with the technical problems of declining consumption. Existing systems are constructed for certain flows of water; the dimensions of pipes and pumps, the slope of sewers etcetera are optimised for a projected scale of operation. If consumption does not reach projected levels or decreases, hygienic and hydrological problems may follow. This has become a concern in some European countries where exaggerated water consumption forecasts in the 1960s and 1970s led to the construction of over-dimensioned systems. The same mistake can be made when systems are built in developing countries.

**The new sustainability agenda**

Urban water infrastructure in developing countries should not uncritically be built to mimic the existing water systems in the developed world. In recent years, the sustainability of the centralised water supply and sanitation systems in developed countries has been called into question. A new sustainability agenda has emerged, which calls attention to a broader range of effectiveness criteria. Apart from supplying safe water to consumers at low cost, and to protect recipients from pollution, urban water systems are now also expected to minimise the use of energy and chemicals, to reduce water withdrawals for the benefit of freshwater ecosystems and other water using sectors, and to enable the recovery and recycling of plant nutrients. These new conditions have stimulated the development of water efficient appliances and also generated numerous experiments and pilot projects in, for example, grey-water recycling, rainwater harvesting, waterless toilets, source separation of urine or black-water, and local stormwater management. If recent developments in industrialised countries are not taken into consideration, there is a risk that the design of new water systems in developing countries is based on planning objectives that will soon become obsolete.

In developed countries the rationale of urban water systems has shifted over time, and a widening range of problems have become included in what these systems are expected to deal with. This development can be summarised as follows:

- **Supply clean water.** Water in cities was getting too dirty. Bad smell.
- **Protect local environment.** Dirty beaches. Mechanical treatment.
- **Protect aquatic ecosystems.** Knowledge about eutrophication. Chemical and biological treatment.
- **Contribute to sustainable flows of matter and energy.** Recycle nutrients through land application of sludge or source separation systems. Energy conservation and limited use of chemicals.

Even if the development of urban water systems has not been this straightforward (phases have overlapped) the general tendency is clear: the scope has broadened and new tasks to solve have been added over time. Generally, the new demands have been possible to meet by adding technical end-of-pipe solutions. However, the growing emphasis laid on
sustainability has led to a critique of the centralised structure of these systems. Although
centralised systems are efficient in a narrow technical sense, their ability to contribute to
a sustainable development is now being called into question (Gleick, 2002).

The building of large-scale centralised urban water systems was part of the project of
modernisation. The modernistic vision was a well-planned city where the needs of the
citizens could be anticipated by administrators and catered for by technical professionals.
Through a functional division of labour citizens’ lives should be made safe and comfortable.
In this planning paradigm, citizens were regarded as passive clients with similar
needs; all they had to bother about (in connection to the water system) was to pay the
fees and turn the tap. However, in later years this vision has gradually given way to more
pluralistic approaches to city planning where locally-adapted solutions and small-scale
systems with various degrees of user involvement are gaining ground.

Today’s centralised systems suffer from a lack of flexibility. System components
depend on each other to function properly; so that once the system has been built it is dif-
ficult to change. Technological, institutional and economic lock-ins make the systems
inflexible. Melosi (2000) concludes his analysis of how urban water infrastructure devel-
oped in the United States that these systems built in “permanence but not resilience”. They
may therefore not be well suited for meeting future challenges, for example,
changes in demographic patterns and water consumption levels, pollution from non-point
sources, and altered conditions caused by climate change.

**Efficiency – a moving target**

When studying water scarcity and conflicts Ohlsson (2000) identified three stages of
water management; when resources get increasingly scarce, the focus of management
will shift. Based on Ohlsson’s typology of scarcity situations it is possible to define effi-
ciency in three different ways:

- To meet citizens’ water demand in a reliable and cost effective way.
- To meet the demand for water services without unnecessarily increasing withdrawal.
- To allocate water to the most important uses without causing social conflict or eroding
  trust in the water managing institutions.

History shows that efficiency has to be understood as a moving target. As discussed in
relation with the new sustainability agenda, the criteria of efficiency for urban water sys-
tems have shifted, as the result both of technological and scientific progress, and of
changes in societal priorities. These changes, together with the three levels of efficiency
described above, show that the evaluation of water systems’ efficiency is indeed a com-
plex task. What efficiency actually means cannot be finally fixed: the concept has to be
open to reconsideration and renegotiation.

**Conclusions**

Growing urban centres in the developing world are facing formidable challenges in secur-
ing all their citizens access to safe water. In the coming decades, large investments are
needed for this purpose. This paper called attention to the risk that some of these invest-
ments may be used inefficiently if recent trend-shifts in the water sector in the developed
world are ignored.

The first risk lies in building systems with unnecessarily high capacity. By managing
water demand at early stages of development, cities can avoid future investments in
supply systems and lower the risk for future conflicts. This paper provided some evidence
of the efficiency improvement potential of modern water technology for domestic appli-
cations and stressed the need for cities to actively prevent the development of wasteful
usage patterns.
The second risk lies in making the systems inflexible and not well adapted to meet the sustainability challenge. Systems based on large-scale central distribution, collection and treatment were developed in an earlier era when linear flow systems and end-of-pipe solutions were prevalent. Growing cities should not regard a central water system as the only option but investigate how such systems can work in combination with other solutions to build an infrastructure that is flexible enough to comply with future criteria of efficiency, aiming at sustainability.

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