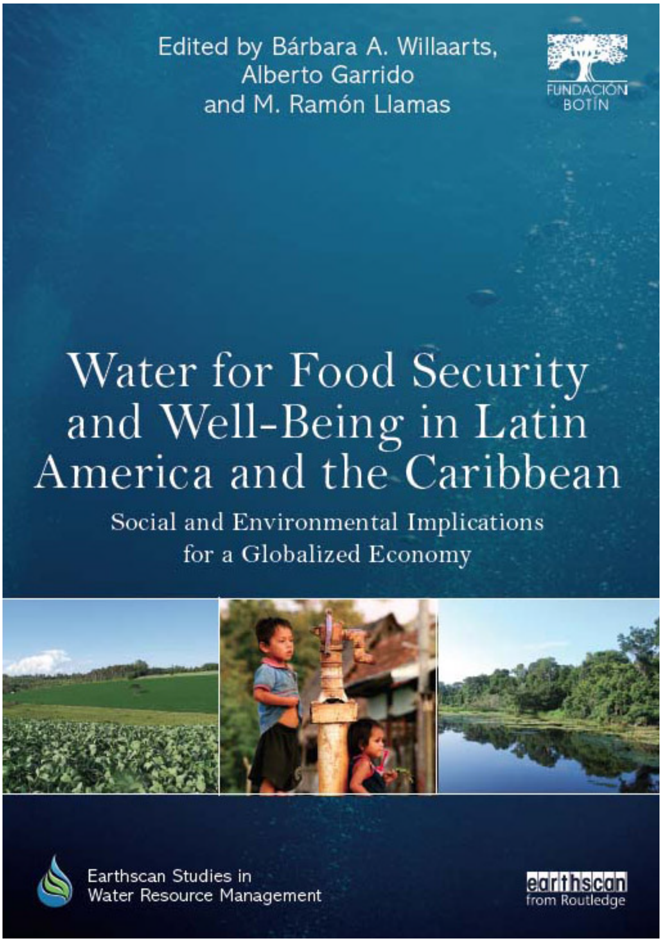

Chapter 8

Water security and cities

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8

WATER SECURITY AND CITIES

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Highlights

- Latin America has achieved good progress in urban water supply and sanitation, although gaps have to be bridged and efficiency has to be improved, especially in what refers to sanitation.
- Urban water supply quality presents deficiencies in some urban areas, some due to poor natural water quality and to inadequate functioning of supply networks.
- A lot could be socially gained by investments in better functioning of urban water supply and sanitation networks.
- Water users have to cover the full cost of urban water supply and sanitation, including maintenance and renovation of infrastructure, most probably the main bottleneck in the way to achive sustainable urban water systems.
- The most deprived population has the right to receive drinking water and sanitation at affordable price for them, but the additional cost has to be covered by the other users and the society in general, without compromising the needed investments.
- The dilemma between public and private water services is not the key issue.

8.1 Introduction

A large and growing fraction of humanity currently lives in urban areas, many of which are, so-called, megacities. Table 8.1 shows some of the most relevant cities in Latin America (LA). In this chapter we consider only continental Latin American countries, Mexico being the most northerly country down to Argentina and Chile in the south. The focus is on water security for large urban areas, with particular emphasis on water services. Various case studies are provided by local experts with short comments on water issues in specific LA large cities. These represent some of the best managed cities in the area, so to some extent the sample is biased. However, what is presented helps to understand the current situation even though they do not necessarily correspond to the general picture of the continent as a whole.

The urban water cycle is a relatively new concept (Cabrera and Custodio, 2013). Even if all early civilizations had large waterworks in order to secure good access to water for their citizens, the generalized establishment of urban supply did not start worldwide until the middle of the 19th century. Thus, available data and studies are based on recent history. In particular, the introduction of water chlorination by English physician John Snow to control water-borne diseases was a real turning point. Although it was not until the early

Table 8.1 Data on some of the largest cities in LA

TOWNS	POPULATION 2011 (millions)	WORLD RANKING IN URBAN POPULATION	SUPLIED SURFACE AREA (km²)	% POPULATION OF LA	PER CAPITA DAILY SUPPLY (L/day/cap)	PER CAPITA DAILY SUPPLY (hm³/cap)
SÃO PAULO	20.6	9	3173	3.43	180	3,702,240
MEXICO D.F.	20.0	10	2046	3.34	360	7,211,520
BUENOS AIRES	13.8	21	2642	2.30	370	5,097,120
RIO DE JANEIRO	12.6	26	4026	1.94	190	2,207,040
LIMA	9.4	30	648	1.57	254	2,387,600
BOGOTÁ	9.0	36	414	1.50	136	1,225,224
SANTIAGO DE CHILE	6.2	53	984	1.03	196	1,209,516
MONTERREY	4.2	88	894	0.70	300	1,266,000
CARACAS	3.3	124	272	0.55	400	1,311,600

Source: own elaboration.

20th century that this technique was widely applied (McGuire, 2013), it is still credited for being the primary cause of last century's increase in life expectancy. In terms of public health, it could be considered the greatest advancement of the millennium.

By the early 20th century most of the world's developed cities had introduced urban water supply networks. However, a few decades later these networks were stressed due to the much higher demand produced by rapid urban growth.

Apart from some pioneering examples of sewage water treatment (the first plant was established in 1890 in Worcester, Massachusetts, USA), they were not at all common in the USA until the end of the Second World War; when in 1948, under the Federal Water Control Act,[1] funds were made available for the construction of treatment plans to ensure water quality. In developed countries, almost 100% of urban and industrial wastewater is currently treated, albeit large improvements can still be made. In Europe the main impetus came from new regulations relating to water quality and pollutants; chief amongst these is the Water Framework Directive (OJEU, 2000). There are still some challenges given that tertiary wastewater treatment to eliminate organic load is still not sufficient to eradicate some worrisome contaminants, which appear in relatively low concentrations.

Latin America has partly followed the path of developed countries, albeit delayed in time and with a long way to go. This is reflected in the America's Water Agenda (Regional Process of the Americas, 2012), a report backed by the Inter-American Development Bank and produced by relevant institutions of the Americas involved in water affairs.

1 www.fws.gov/laws/lawsdigest/FWATRPO.HTML (accessed in June, 2013)

The challenges for America are grouped into fourteen points, of which the first four refer specifically to water supply and sanitation:

- Implementation of the human rights; access to water and sanitation, in response to the July 2010 United Nations resolution A/RES/64/292
- Water, sanitation and service quality deficiencies
- Universal coverage for current urban and marginal areas
- Water and sanitation in rural areas.

A large number of the remaining points also refer to urban water, albeit not so directly, like the 5th point (climatic change), 6th point (governance), 7th point (need for integrated water resources management), 10th point (increasing water contamination, largely due to urban and industrial pollution), and 14th point (creation of a political environment willing to make the necessary investments into urban water planning and infrastructure).

All of these aspects are relevant and important since humans need water to live and yet the way to provide this water is becoming progressively more complex. Towns and the associated water systems expand, while their supporting infrastructures are neither upgraded nor modernized at the same pace, and thus they age and their service quality decreases. This is an issue that must be specifically addressed as often citizens believe that, water being a universal right, the government ought to provide it at no cost to them. This explains their reluctance to pay the true cost of a service that is becoming increasingly costly and complex. As a consequence, politicians responsible for urban water management, who depend largely on citizens votes in many countries, and LA is not an exception, are unlikely to charge the full water service cost. The consequence is that water services often become economically collapsed. The antidote is full, transparent information.

Available documents show that top-down points of view alongside socio-economic and political analysis tend to be prioritized whilst technical aspects are largely disregarded, when they could in fact be the key to better understanding of the problems. To some extent, what follows is an attempt to better understand this discrepancy.

8.2 Water sources for urban supply

Most large cities in LA depend on surface water from river basins (Santiago, Chile, Box 8.1). However groundwater is also important for many of them, occasionally the only source, as is the case of Mar del Plata, Argentina (Box 8.2), or sometimes groundwater is a key complement that cannot easily nor quickly be substituted (São Paulo, Brazil, Box 8.3). At times it is used as a necessary backup as in Lima, Peru, or simply for the supply of fast expanding and poor peri-urban areas (Rio de Janeiro, Brazil, Box 8.4; Lima, Peru, Box 8.5, and Buenos Aires, Argentina, Box 8.6). Mexico City, in terms of urban water management, is one of the most complex ones in the world. It is served by a mixture of imported, local and further afield groundwater resources (Box 8.7 and SACM, 2012). Even though many of the large cities on the continent are near or next to the sea, seawater desalination is seldom employed as an urban water source in LA, with a few exceptions in medium-size towns (e.g. Antofagasta and Iquique, Chile).

Box 8.1 Water supply to Santiago, Chile

[By Joaquim Martí, Aguas Andinas, Santiago, Chile, and Manuel Cermerón, Aqualogy, Barcelona]

Santiago, the capital city of Chile, is located in the Intermediate Chilean Depression, the depression between the Andes and the Chilean coastal range. It receives an annual average precipitation of 320mm mainly concentrated in the May–August period; the summers are long and dry. The population is about 6.5 million inhabitants, of which 95% have their water supply and sanitation needs provided by the Aguas Andinas group, the remaining 5% are served by a municipal company.

Most of the supplied water (86%) is surface water from the Maipo and Mapocho rivers, complemented by some 14% groundwater. To guarantee a continuous drinking water supply, large reservoirs exist, such as El Yeso (220hm^3), Laguna Negra (600hm^3) and Laguna Lo Escañado (50hm^3). Two main plants, Las Vizcachas (15.8m^3/s) and La Florida (4.0m^3/s), produce drinking water alongside twelve smaller plants. The water is then distributed via a 12,094km piping network. Unaccounted water amounts to 29% and includes technical, commercial and measurement components.

The sanitation network covers 100% of the area with 10,501km of sewers. Sewage water is treated in thirteen plants, the two main ones being, La Farfana (8.8m^3/s) and Mapocho–Trabal (6.6m^3/s). All treated waste waters are disposed of downstream from Santiago, in the Mapocho River.

Drinking water price is 0.595US$/m^3, plus 0.465US$/m^3 for sewage service and 0.307US$/m^3 for wastewater treatment. However, low-income citizens may ask for half the price to be covered. All the revenue generated is used to cover the operation, maintenance, replacement and any future works needed to improve the service and ensure water supply security.

Box 8.2 Water security in the supply of Mar del Plata, Argentina

[By Dr Emilia Bocanegra, Universidad Nacional de Mar del Plata, Mar del Plata, Argentina]

The coastal town of Mar del Plata, Argentina, is approximately 450km south of Buenos Aires. It spans an area of 80km^2 and has 620,000 residents, a figure which is doubled during the summer period. The local economy depends on tourism, harbour activities (mostly fisheries), textiles and leather, and fruit trees and orchard agriculture. All water resources are supplied by groundwater coming predominantly from rural areas in the north and northeast of the city but also abstracted inside the urban and peri-urban area. Approximately 129hm^3/yr of good quality groundwater is abstracted from 274 wells. Intensive groundwater abstraction in the urban area has induced seawater intrusion into the aquifer, forcing forty wells to be abandoned. Other wells have also been taken out of service due to high level of nitrates. The limit of 45mg/L of nitrate concentration is exceeded in 117 wells. Water is periodically chlorinated and meets drinking water standards in 96.6% of cases. Some 93% of the population is connected to the distribution network. The network loses 40% and suffers 0.38breaks/km each year. Most residences have tanks to store water since in summer months water pressure may be insufficient to reach some neighbourhoods.

Regarding the sanitation network 92% of population is connected to it, and it suffers 0.17breaks/km each year. Four main servers feed a final pre-treatment plant where solids are separated, dried and aerobically stabilized to produce a soil conditioner that is principally used for ornamental plant cultivation. The effluent is disposed of in the sea.

Drinking water is served at a cost of 0.17US$/m^3, plus 0.12US$/m^3 for sanitation. The joint average yearly charge for connection is 98US$/yr. Commercial and industrial establishments are often metered amounting to approximately 20% of the water provided. The domestic charge is calculated according to the surface area of the dwelling and the area of the city where it is located.

Urban water use rate is high (296L/day/cap). Despite public campaigns to reduce water use, results have not been very effective. In order to encourage water savings there is a surcharge for indoor pools.

The contribution from customers is sufficient for the efficient maintenance and operation of the water and sanitation services. Network expansion and major infrastructure projects are financed by subsidies received from the government. Expansion is planned in the future including the incorporation of a further seventy-four wells into the network in order to supply the western main and the construction of a submarine outfall in order to improve local coastal seawater quality. The municipal company Obras Sanitarias de Mar del Plata (OSMP, Mar del Plata Waterworks) is responsible for supplying water and sanitation services and regulates the different uses under the Water Code of the Province of Buenos Aires thus helping water governance. Currently there is no known conflict between OSMP and rural and industrial users.

Box 8.3 Water security in the metropolitan area of São Paulo, Brazil: the key role of groundwater

[By Ricardo Hirata, CEPAS-Universidade de São Paulo, São Paulo, Brazil]

The megacity of São Paulo, including the surrounding thirty-five municipalities, reunites 20.6 million inhabitants. They are located in the Alto Tietê Watershed (ATW), which has a surface area of 5,720km^2. The public water supply system is operated by SABESP, a state-owned company that provides 2,144hm^3/yr (68m^3/s) of water coming from eight surface water sources, half of them imported from another water basin. More than 95% of the total population is provided for in this way. Additionally, a total of 347hm^3/yr (11m^3/s) of water comes from approximately 9,000 privately owned tube-wells. Even though this supply is only 17% of total demand, if it fails due to water contamination or excess of abstraction, it will seriously compromise water security in the ATW. SABESP currently has no more water resources available to substitute for this groundwater use. Water transfers from further water basins, although planned, will not be available in the near future. Average groundwater abstraction in the area is about 32% of total recharge (400mm/yr), including rainfall infiltration (45%). Losses from the supply and sewage network are 55%. However, abstraction is irregularly distributed in the area and concentrates especially in the central area of Penha-Pinheiros sub-basin where abstraction exceeds 80% of the recharge.

Water supply security in the ATW is also a concern with regard to well conditions as 60–70% of them lack operation permits and, as a consequence, there is no control on them. Well drilling and construction does not follow acceptable standards, so the wells and the aquifer itself are under risk of contamination. More than 50% of declared contamination cases in São Paulo State are located in the ATW. This is the result of intense industrialization and unplanned, dense and rapid urban expansion.

Box 8.4 Water security in the metropolitan area of Rio de Janeiro, Brazil: groundwater, the unknown resource

[By Gerson Cardoso da Silva Jr, IGEO, Universidade Federal do Rio de Janeiro, Brazil] The Metropolitan Area of Rio de Janeiro (MARJ), Brazil, with a land area of 5,292km^2 plus 400km^2 of the Guanabara Bay, comprises seventeen municipalities with approximately 12.6 million inhabitants. The significant demographic and economic growth in recent decades is the cause of a notable increase in the consumption of water resources. The Hydrographical Region of Guanabara Bay (HRGB) includes the MARJ and other territories, but predominantly, river headwaters. About 50m^3/s are transferred from the Paraíba do Sul River to the Guandu Water Plant, the main source of water for public supply. The price for the final user is approximately 0.65US$/m^3 which includes sewage treatment. This is complemented by water from other minor sources, groundwater being approximately 2% of the total. In general, high-quality water is supplied by the water plants. The gross revenue accounts for financial costs and investments, as well as for operational and maintenance costs. Water losses due to leaks in pipelines and 'social losses' (e.g. unpaid water for shantytowns) represent 30% of the total distributed water.

In many situations a significant use of groundwater resources as a supplementary source of water in the region is made, even though the aquifer characteristics are poorly known. Most wells lack any kind of register or permit. The Rio de Janeiro State has implemented in recent years a programme for well legalization, raising the number of permitted wells from a few hundred to thousands in the last five years alone, although official federal statistics point to approximately 0.5 million shallow wells in the area, which are mainly used by low-income populations as a complementary source and sometimes as the sole water source. Aquifer overexploitation is not reported. Groundwater quality is sometimes poor due to pollution or salinity.

About 44% of sewage water (13.2m^3/s) is treated, and most of the remaining discharge flows to the sea through a pipeline or to the Guanabara Bay. In general the situation is improving.

Box 8.5 Urban water in Metropolitan Lima, Peru

[By Javier Dávara, Aqualogy-CEDAPAL, Lima, Peru, and Manuel Cermerón, Aqualogy, Barcelona]

The metropolitan area of Lima, which comprises Lima (Peru's capital) and Callao (main Peru's harbour) has approximately 9.4 million inhabitants. It is in an arid zone which depends fully on river water from the high Andes Range. Urban water supply is tapped from two of the three local rivers and the local aquifer. In this arid area aquifer recharge is through river and urban water infiltration.

The state-owned Servicio de Agua Potable y Alcantarillado de Lima (SEDAPAL, Lima's Drinking Water and Sanitation Service) fully supplies forty-three out of the forty-eight city districts and partially two others, with 83% of surface water and 17% of groundwater, which is treated in three plants. Some 89% of the inhabitants are supplied through 13,700km of pipes, and 85% of sewage water is collected through 12,000km of sewers, 20.6% of which is treated in seventeen plants.

Water prices are 0.67US$/m^3 plus 0.29US$/m^3 for sanitation. There is fixed base rate plus a charge proportional to the volume of the water supplied, with different rates for domestic, commercial, industrial and state demands.

Box 8.6 Urban water in the city of Buenos Aires, Argentina

[By María Josefa Fioriti, Under-Secretariat of Water Resources, Buenos Aires, Argentina]

The water supply and sanitation of the Autonomous City of Buenos Aires, the capital of Argentina, and its seventeen neighbouring administrative areas ('partidos') is the responsibility of AySA (Agua y Saneamientos Argentinos S.A.). The very flat area covers over 18,11km^2, it has 10.2 million inhabitants, of which 90.6% receive drinking water and have sanitation. 4.53hm^3/day of surface water from the Rio de la Plata and 0.25hm^3/day of groundwater from 238 wells is supplied, about 600m^3/day/cap. The water supply network exceeds 18,000km. Supplied water quality complies with the fifty-eight values of the Regulatory Framework, which is based on the Argentinean Food Code and Word Heath Organization recommendations.

Some 62.6% of population is served by the 10,600km sewage water network and five treatment plants, discharging to an outfall that takes and diffuses the 2.25hm^3/day of effluents to a point near the end of the estuary of La Plata River, 2.5km offshore.

Water is charged to domestic, commercial and industrial establishments, and non-occupied land according to the metered volume for those who have a water meter and according to building or house characteristics for the other ones. Social tariffs are applied to low-income citizens and also they participate in local water management affairs as regulated by national authorities.

The Director Plan Framework for water aims to have 100% coverage by 2018. This will require a new drinking water treatment plant, modernization of the existing networks, five new sewage water treatment plants and the enlargement of four of the existing ones.

Quality of service, the protection of human rights and the delivery of concession conditions to the water company depends on the Water and Sanitation Regulatory Entity (ERAS). Water planning for water service and sanitation works depends on the Planning Agency (APla).

Box 8.7 Urban water in Mexico City

[By Ramón Aguirre Díaz, Director General of Waters Systems, Mexico City, Mexico]. The metropolitan area of Mexico City exceeds 20 million inhabitants and is located in the Valley of Mexico, a closed basin 2,240m above sea level. Current water outflows from the area are artificial. Water availability is 160m^3/yr/cap, while for the whole country is 4,090m^3/yr/cap. The main water source is the aquifer, which has been over-drafted by a factor of two for more than a decade. This is a non-sustainable situation. Some studies indicate that the aquifer could be completely exhausted in two or three decades. Complementary water supply from the Cutzamala water surface dams is not enough in the event of a serious drought. About 10% of the population receives water once or twice per week, another 15% will suffer from low water pressure during five to six hours per day and 5% does not receive good quality drinking water. Current average urban water use is 530L/day/dwelling, which is a very high figure under current circumstances. This is the result of water prices being well below the real cost of water and the almost non-existent water meters in the dwellings.

To deal with this huge and concerning problem and to take care of the future generation, an Integrated Water Resources Management Program (PGIRH) has been prepared and launched, for the coming twenty years. Among the many actions, 225 new wells, the protection of 111 springs, the substitution of 5,700km of pipes to reduce leakages, 1,326km of new pipes, seventy-four improved or new drinking water treatment plants and the use of reclaimed treated sewage water for non-drinking uses are included. Aquifer recharge with reclaimed sewage water treated up to drinking water quality is foreseen to increase storage and to control subsidence problems, especially where thick clay layers exist. The programme aims at raising water prices to cover real cost and to install in-house water metering to reduce water use, but considering social tariffs for the more deprived. Although the programme is very ambitious and involves very high investment of 13 billion US$ investment in twenty years, it is feasible and it is what the City of Mexico requires to achieve a sustainable, quality water service.

Water quantity is not generally a limitation in LA (see per capita consumption in Table 8.1). However, per capita consumption is often high, particularly in Argentina and Mexico. The limitations come mainly from the needed infrastructure associated to water storage and transport. Sometimes water transportation may involve important energy consumption when natural barriers have to overcome, as in Peru for the transport of water resources from the water-rich and relatively low-lying upper Amazonas basin to supply the arid western coastal area, where most of the large urban areas are located. Mexico City and other urban areas at high altitude require costly water pumping from low-lying areas. Furthermore conflicts with local residents arise as they compete for the resources or do not accept wastewaters for agriculture in exchange of handling over the water resources they already have. Here groundwater plays an important role but it is also a source of conflicts with other users. Deeper wells are drilled in order to tap up-to-now little exploited aquifers and offered as a new water resource when it is in fact part of the same system and their exploitation will only worsen current problems of over-draft and also serious land subsidence in some areas.

The water quality of urban supply sources is often an important issue, and will be more in the future. Buenos Aires (Argentina) takes a large part of its water from the urban and industrially polluted Rio de la Plata, which can suffer large quality fluctuations. The urban areas in Colombia and Venezuela cannot use the numerous local rivers, lakes and aquifers due to intense pollution from important urban, industrial and mining areas upstream. Groundwater is commonly of enough good quality, but there are important exceptions. In coastal urban areas seawater intrusion has forced the closure of part of the supply wells (Mar del Plata, Argentina; Recife, Brazil). High natural groundwater salinity due to aridity is found in northern Chile and Peru, and in parts of northeastern Brazil. An excess of nitrates is also a common groundwater quality problem, mostly caused by the activity of the urban area itself, for example when collective sanitation is insufficient (Conurbano Bonaerense, Buenos Aires, Argentina, and Lima, Peru) and in some cases of agricultural origin, although this does not occur as intensely as it does in North America and Europe. This last aspect is important around urban areas in Mesoamerica (Costa Rica, Nicaragua, and Guatemala). Unwanted and noxious solutes, such as relatively high concentrations of fluoride and arsenic, can be found in groundwater. Although this problem rarely affects people in large cities connected to public water supply, it is a serious issue in many rural areas of Argentina, Paraguay, Chile, Peru and Mexico. Some large towns do often have to blend the different water sources in order to dilute waters that do not meet the standards or take out of service some others – an often-used situation when sanitary authorities intervene or use them only as backup in emergencies. Blended water may not always be available to all citizens. Treatment for natural poor water quality is not common in LA, where looking for new water sources is preferred, even if this is more expensive.

8.3 Current situation of urban water services

The initial euphoria at establishing water services throughout the 20th century, their advantages being so obvious, made sure that the funds needed to initiate the projects were provided. However, this euphoria has not been maintained, and in fact many water services are currently in dire need of modernization. This and the great population growth, especially in urban areas, are responsible for the existing problems, which are especially pronounced in LA. The most important of them are presented below.

8.3.1 Insufficient water service cover

Reducing the percentage of people lacking water services is one of the main Millennium Development Goals, which also include halving by 2015 the number of people lacking drinking water. The World Summit for Sustainable Development in Johannesburg in 2002 added sanitation to these goals (GTAS, 2003). These goals have been globally accomplished and exceeded for water supply, but not for sanitation that is likely to fall 85% short of the objective (Regional Process of the Americas, 2012). Prospects are good for LA (ONU, 2011; UNICEF/OMS, 2012), although in rural areas the situation is not as positive since 20% of these populations do not have adequate water supply and 50% of them lack appropriate sanitation (Pearce-Oroz, 2011) (see Chapter 6 for a detailed presentation of these indicators).

8.3.2 Lack of urban and industrial wastewater treatment

This seems to be the main mid-term problem to be addressed by developing countries and by LA in particular. By prioritizing the Millennium Development Goals to increase water supply and sanitation networks, wastewater treatment has been put to one side. The Americas' Water Agenda report (Regional Process of the Americas, 2012) highlights the effect of increasing water contamination but does not deal with the causes; the problem is simply considered a service deficiency. The IV World Water Forum of Mexico (CNA/WWC, 2006) provided the impressive figure that more than 86% of wastewater is disposed of into the environment without any treatment, and irrigating with untreated wastewater is a common practice, highly risky for citizens' health.

Good wastewater treatment before disposal is a key component of sustainable water management, even if it requires costly investments, expensive maintenance and modernization of the existing network. After a global analysis avoiding contaminated water in the urban environment, treatment is much cheaper than importing water resources from elsewhere. However, in the real world short-term goals overcome the mid- and long-term points of view. This problem will never be solved if water prices do not allow a reasonable cost recovery since Governments do not have enough economic resources to subsidize water treatment, especially for a population that is polluting more and more and increasingly using more household polluting chemicals.

8.3.3 Economic unsustainability

Economic sustainability is a necessary although not sufficient condition to solve the above mentioned problems. Efficient management needs not only technological capacity to identify the best cost-benefit actions, but also economic resources to carry them out. Without them the system advances towards economic collapse, as too often happens in LA urban water services.

In practice, the efficient and accurate administration of economic resources is difficult, as dealt with extensively in the OECD (2012) report, although this will be not addressed here. Up to seven key coordination gaps are identified for better water governability: administration, information, policy, capacity, financing, objectives and accounting. Economic resources are needed and they should be wisely managed.

Water service economic unsustainability refers not only to the lack of funds needed to improve the facilities and systems of the fast growing cities – they may come from international organizations in the case of poor countries – but also to the more complex problem of obtaining the funds needed for the correct functioning of the existing, expensive infrastructures. These funds ought to be secured from the water services users themselves. This opens two permanently debated points: 1) tariffs that allow for cost recovery, which is a complex matter in countries with deep social inequalities, and 2) corruption, which is especially concerning in LA. In poorly consolidated democracies corruption is a rather frequent temptation in front of the increasing economic resources being used and attracted, as shown in an OECD website[2] on this topic.

8.3.4 Ageing of existing water infrastructures

The ageing of water infrastructures is a very serious problem that passes almost unnoticed due to the more conspicuous problems commented above. This problem even affects the USA, the richest of all the American countries, as underlined by the EPA (Environmental Protection Agency). In 2007 the EPA estimated that 334,800 million US$ has to be invested during twenty years in order to modernize drinking water supplies (EPA, 2009). In other recent studies it is estimated that about 1,600,000km of drinking water pipes have to be modernized in the USA, which means about 3000 billion US$ over the coming twenty-five years (AWWA, 2012). Figure 8.1 depicts the magnitude of this great problem by showing the evolution of the median age of the infrastructures and the median age of the population in the USA.

In LA this problem is even more serious. This is a direct consequence of the economic unsustainability mentioned previously, worsened by the fact that most new investments are for new infrastructures to progressively extend water services and approach the MDGs, while existing infrastructures are poorly maintained. Some of them are many decades old. All of them have an expiry date. Maintenance, rehabilitation or replacement failures will have serious consequences in the long term. In some way they are the main cause of the deficient quality of supplied services (Regional Process of the Americas, 2012).

2 www.oecd.org/corruption/latinamerica

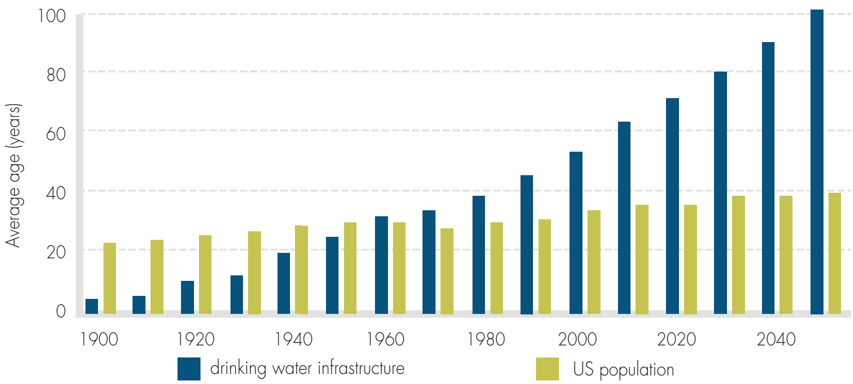

Figure 8.1 Median age of population and of water pipes in the USA. *Source: Buchberger (2011)*

8.3.5 Poor quality of water services

This is the natural consequence of economic unsustainability, caused by poor maintenance and the lack of infrastructures renewal. The Regional Process of the Americas (2012) report explicitly highlights the most relevant deficiencies to be insufficient water disinfection, poor surveillance of water abstractions, discontinuous service, insufficient pressure, high leakage percentage and the low wastewater treatment degree. These are big challenges.

The problems identified by the Regional Process of the Americas (2012) report can be grouped into water quality (treatment and monitoring) and distribution (pressure, leakage, continuity of service). Something similar has been identified by Aqua Rating, a project sponsored by the IDB with the help of the IWA (International Water Association). The project aims at developing a system to qualify water and sanitation suppliers (Krause et al., 2012). For water service quality the project considers drinking water quality, water distribution for use and consumption, wastewater collection, and care of the users (this last point being more commercial than structural).

8.4 The enormous cost of poor water service quality

In any country urban water services should and can be economically, environmentally and socially sustainable. In spite of the big financial resources required, scale economies in cities allow to provide these water services at a reasonable cost, which is more difficult in rural areas (Pearce-Oroz, 2011). This is not discussed here. Sustainability demands governance and long-term vision, which is the bottleneck of implementing these systems. The other aspects are easier to solve. The fact that providing a low-quality service is more costly to citizens than attaining the adequate standards needs to be clearly shown and argued. This can be easily understood from a social point of view by showing the savings that would be obtained if the individual no longer had to support the failings of the poor-quality service. However, the supplier will always look to their own short-term economy if not pushed to do otherwise by well-informed and organized citizens.

Each of the six deficiencies described below is accompanied by the associated costs, which are seldom considered and often transferred as a burden for future generations. However when all these costs are included, good management of the water service is much cheaper. The problem comes down to the need to involve society much more in the water services through appropriate institutions.

8.4.1 Insufficient disinfection and drinkability

According to the World Health Organization (OMS, 2002), inadequate water and sanitation are the main causes of illness, such as malaria, cholera, dysentery, schistosomiasis, infectious hepatitis and diarrhoea, which are related to 3,400 million deaths in the world and LA is not an exception. Inadequate water and sanitation are also a main cause of poverty and of the growing gap between the rich and the poor. Figure 8.2 shows the close link between child mortality and access to improved water and sanitation (Robinson et al., 2006).

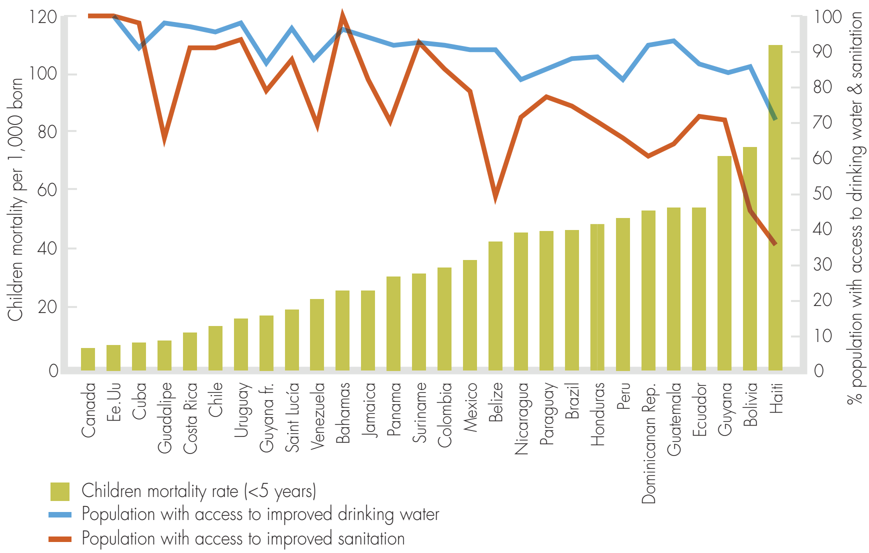

Figure 8.2 Access to water and sanitation (%) and child mortality (deaths per 1,000 born) in different American Countries. *Source: Robinson et al. (2006)*

8.4.2 Lack of quality control

There is a long path through pipes from the drinking water plant to the citizen's tap. The pipes may be sometimes over one hundred years old. Even if at the inflow point to the system water quality is guaranteed, along the distribution path it deteriorates, especially when the residence time in the distribution network can be up to several days. A control of water at the outflow of the drinking water plant is needed but is not sufficient as the water quality will deteriorate, the older the network is.

Much attention has been paid to this aspect in the last two decades in developed countries. One example is the EPANET programme for analysis of water networks, sponsored by the US Environmental Protection Agency (Rossman, 2000). It is a free access programme aimed at facilitating the study of water quality evolution through pipes.

Urban water quality is of great concern in all developed countries (Kastl et al., 2003; MHLS, 2010) due to trihalomethane generation, which is a carcinogenic compound resulting from the progressive interaction of organic matter in water – mostly that from surface resources – and chlorine (Aieta and Berg, 1986). This is the reason why in some countries, like The Netherlands and many areas in Germany, the use of chlorine as a disinfectant has been abandoned and substituted by other disinfection processes, which do not impair the taste, but they are often more expensive. As a result, these countries have drastically reduced the consumption of bottled water (den Blanken, 2009).

8.4.3 High percentage of losses

Unreliable or inadequate pipes for the soils in which they are laid, careless assembly, lack of maintenance and scarce – sometimes, inexistent – network rehabilitation or replacement are the main factors that cause the water distribution system deterioration. Water supply reliability depends on pipe proofing, which decreases progressively over time.

Network water losses in LA are often very high. According to ADERASA (Association of Regulating Entities for Drinking Water and Sanitation of the Americas) the average value is 42% (Figure 8.3), and this value is possibly quite conservative as it refers to a set of the best managed towns in the area (ADERASA, 2012). According to the Cooperativa Andina de Fomento (Andean Cooperative for Enterpreneny, CAF, 2011) losses are 40%, which is also quite optimistic as it is estimated from data contributed by the own water distribution utilities. In a later publication (CAF, 2012) the fraction of unaccounted water (real leakage, measurement errors and thefts) had risen to 50%. Consequently, it seems that in LA about half of outflow water from drinking water plants does not get to the users, which is economically, environmentally and socially unsustainable, even if the water resource is not entirely lost for later use.

The consequences of high network losses are well known. The most relevant are:

- Existing infrastructures (pumps, drinking water plants, reservoirs, networks) become insufficient to secure the water supply and they have to be enlarged. This means doubling current capacity in LA.
- High probability of pathogenic intrusion into the water network. If water pressure drops below atmospheric pressure in a network – something that happens often when water service is not continuous – leaked water may get back into the system (Kirmenyer and Mantel, 2001). This poses a more serious problem than quality deterioration during distribution.
- Water supply may be intermittent in dry periods, when less water is available. This has a series of other drawbacks that will be commented upon below. Should the water losses be small, there is no need to interrupt water supply. There are other more reasonable methods to save water without recourse to temporal interruption of the supply (Cabrera, 2007).
- Water users' poor trust in the water utility, thus reducing willingness to pay.

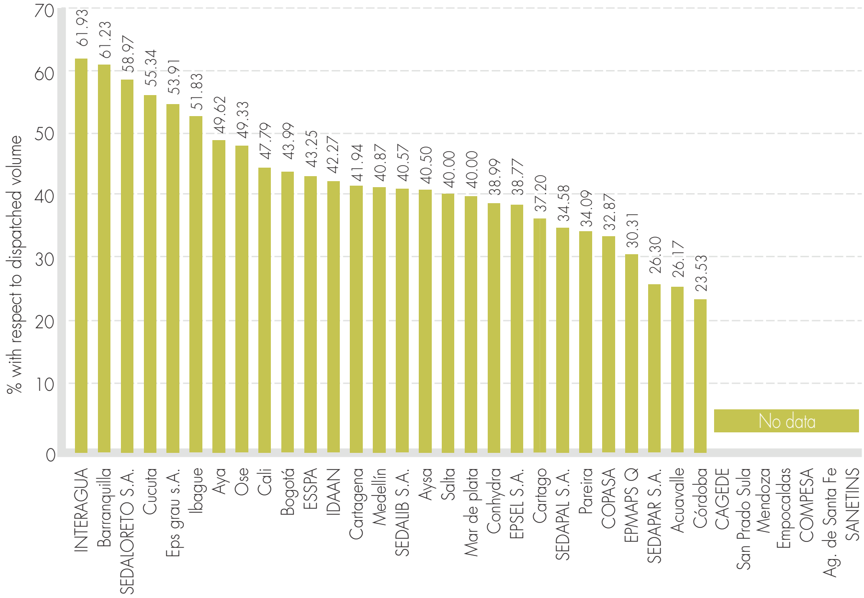

Figure 8.3 Water network losses in representative urban areas in LA. *Source: ADERASA (2012)*

8.4.4 Low water supply pressure and domestic storage tanks

Leakages aside, a network becomes insufficient if it cannot supply the demanded flow at water demand peaks at the established pressure – at least approximately 20m of water head (two atmospheres) – when water demand peaks. Problems appear when the network does not improve its capability at the same rate as population growth. Often pipe diameters are those required by the city before a significant increase of connected people. In order to solve supply problems the manager of an insufficient network forces or recommends the construction of domestic water storage tanks and butts, to decouple water demand from users from actual supplied water. They store water when demand is low (e.g., from 0:00 to 6:00 am) and release it in peak hours. The method has clear disadvantages:

- Water quality can be significantly affected due to storage time, mostly because storage time is unknown, but also to the high possibility of a pathogenic intrusion as pressure – the guarantee against intrusion – is lost. Besides, tanks and cisterns are barely protected and cleaned; this contributes to a worsened water quality guarantee, as shown in the experimental studies carried out in Tiquipaya, Bolivia (Schafer and Mihelcic, 2012).
- Energy is wasted since water is depressurized to later be pressurized again for the users.
- From a more technical point of view, water demand timing is quite distorted and the system loses a great deal of its characteristics, thus making it more difficult to conduct mathematical simulation and leakage surveys.

Temporal water service interruption shows that the network is clearly inadequate to supply a growing population. Looking globally at the problem, this implies a very important economic loss (Cabrera et al., 2013): the money the system manager saves by not investing is much less that the set of expenses transferred to all connected customers.

8.4.5 Intermittent service

Often inefficiency – high leakage – and insufficiency – lack of pressure – go together and then the water supply manager has no other recourse than intermittent service by interrupting water supply periodically. This is frequent in LA, where it has been observed in almost 30% of the systems (CAF, 2012). The most serious drawbacks of water quality loss and the causes of the system becoming no more secure are well documented (Yepes et al., 2001; Totsuka et al., 2004). One of the most serious problems is faster network deterioration as a result of alternatively pressurizing and depressurizing the network, which leads to increasingly more frequent and lasting breakdowns and water losing points. According to Charalambous (2011), the number of pipe breaks each year triples with respect to a continuous water supply.

8.4.6 Lack of wastewater treatment

In LA most urban and industrial water discharges lack treatment, and this has important consequences due to the serious sanitary, environmental and the not always fully recognized economic consequences. If the town pollutes the near-by waters, it has to look for more distant water supply sources and consequently more expensive ones. Looking for water sources further afield is not a new phenomenon: in 1890 in order to supply Paris, it was proposed that water be taken from Lake Leman, 450km away (Barraqué, 2004). What at that time was a fashion, declined by end of the 19th century and beginning of the 20th century after the discoveries of Pasteur and Koch that lead to disinfection thus allowing the use of local water. However, in some of America's large cities, importing water seems a real necessity, as is the case of Mexico City (Perlo and González, 2009), and probably of Lima.

8.4.7 Conclusion on poor water quality supply

From any point of view, making use of economies of scale is the most logical and feasible solution to provide a good quality urban water service to the citizen at the lower possible cost when all involved costs (e.g. the bottled water to substitute for tap water, see Box 8.8) and a mid- and long-term economic balance are considered (Cabrera et al., 2013). However, this needs a good administrative structure and political support, in addition to a large capacity for leadership amongst decision makers. Currently, most or all urban water cycles in LA are unsustainable.

Box 8.8 Bottled water and soft drinks for domestic consumption

In many LA countries the production of bottled water and soft drinks is not only quite developed but has a special economic and social relevance, with the trade mostly in the hands of a few large firms. Mexico is a leading country. One of the main drivers seems to be the once unreliability and poor quality of in-house water supply, without guarantee of being pathogen free, or too saline, or containing an excess of toxic natural solutes for sustained consumption, such as fluorine or arsenic. This is the case in many rural and small urban areas of Mexico, Argentina and Paraguay, most of them using groundwater without adequate hydrogeological studies. Large efforts are devoted to better understand the origin of these natural pollutants and on practical means to reduce economically their content. Interruptions in domestic supply in the past, as explained in the main text, can be considered the main cause of the widespread use of small domestic storage tanks on the roofs of the houses, as can be seen in many of the low-rise residential areas of several towns in LA. Some water-related diseases are not uncommon, often with mild results to locals, not always to travellers; there is a real risk of epidemic spreading. Another important driver of bottled water and beverages consumption is the increasing living standards. Drinking bottled products is often considered a sign of affluence, which becomes a social issue and a display of personal status. This is widely propagated by effective advertising by large companies and good distribution logistics. Even though this represents a large part of income to individuals and to society, it is difficult to be reversed.

Production of bottled water and drinks uses about two to three times the water in the final product and about 25% of its volume as fuel consumption. These amounts include the water used to produce the bottles and the fuel to distribute them which has to be added as well as that needed to produce the additives. Furthermore used plastic bottles is becoming a serious environmental problem.

Bottled water price in the market ranges from 500 to 5,000 times higher than the average tap water price. It is one of the main hidden personal, social and environmental costs of a deficient water supply.

8.5 Causes of the current water services situation

After describing the main problems of urban water services and the associated serious consequences, the present situation is taken into account in order to define measures aimed at improving it. This is a complex task. Economic and social–political causes have been described in detail by some organizations (CAF, 2011; Regional Process of the Americas, 2012; OECD, 2012) as well as by some authors that have a great wealth of knowledge about LA (Jouravlev, 2004; Hantke-Domes and Jouravlev, 2011), and will not be repeated here. As an overview, key phrases from three of these works that explain current situation are given opposite.

In the report 'Water Governability in Latin America and the Caribbean: A multilevel point of view', the OECD (2012) concludes that [translation from Spanish]:

> Key challenges are institutional and territorial fragmentation and badly managed multi-level governance, as well as limited capacity at the local level, unclear allocation of roles and responsibilities and questionable resource allocation. Insufficient means for measuring performance have also contributed to weak accountability and transparency. These obstacles are often rooted in misaligned objectives and poor management of interactions between stakeholders. (p.15)

The report on Americas' Water Agenda (Regional Process of the Americas, 2012) provides a similar diagnosis:

> It is important to emphasize that in contrast to the institutional strength and stability in Canada and the USA, the social perception studies on the role of public institutions in Latin America and the Caribbean (LAC) demonstrate low credibility. Different factors not always attributable to the institutions have had an influence on this: the magnitude of the challenges faced, institutional weakness, the scarcity of economic resources, preconceived judgments and ideological notions with respect to the role of the State, the regulation and participation of the private sector, the weakness of civil society organizations, the perception of seizure of the institutions by interested sectors and the problems associated with globalization.(p.6)

Some years before, the same problems were pointed out in Jouravlev (2004) on the status of drinking water and sanitation services on the 21st century [translation from Spanish]:

> Despite the differences to be expected in a region that is home to many different countries, reforms have many common features, such as; institutional separation between the roles of sectorial policymaking, economic regulation and the management of the systems; the deepening and consolidation of decentralization in the provision of services; the general interest in promoting private participation, the development of new regulatory frameworks, and the demand, born out of the 1980s crisis, that services should aim to be self-financed, and when in place, subsidy plans should be set up to help low-income groups.

These coinciding diagnoses can be summarized as weak governance and a lack of leadership. In short a public urban water service for a big city is a project common to all its inhabitants and can only be carried out successfully with sound governance and leadership. Given that water and the nature of human beings are the same regardless of country boundaries, the differences between national water policies depend on the strength of their governing institutions and political structures as well as on other cultural and economic factors. From a strictly technical point of view the problem is not unduly difficult in the big cities, however, the story is different in rural areas where a priori scale savings are not possible to make water supply economically feasible.

In order to easily overcome these handicaps, some existing problems have to be solved, the difficulty of which will vary according to the country, although some already have plans in place. Even when plans exist, it helps in taking into account these handicaps, which are reviewed over.

8.5.1 Lack of professional capacity of political decision makers

Decision makers, besides applying common sense and being honest, must give priority to sound solutions for citizens and especially for future generations. They ought not to be guided by short-term goals and self-interest, but will require training and good foundations on which to build. With this in mind they will boldly identify decisions for the future, abandoning the short-term visions that have become commonplace, and will strive for mid- and long-term solutions.

8.5.2 Lack of training for managers and engineers

In the urban water cycle three different decision levels exist: political, managerial and mechanical. These last two refer respectively to those controlling finances and human resources and those carrying out technical decisions. However, current training opportunities for staff are not sufficient to deal with the complexity of urban water supply. Since economic resources are often lacking, these managers and engineers with little training have to identify optimal cost-benefit solutions. This is highlighted in the OECD (2012) report, in which it is said that in two-thirds of the LAC countries studied, the capacity gap is a big handicap to the effective implementation of water policies.

8.5.3 Lack of environmental knowledge amongst citizens

State financing of large water infrastructures and the principle that water is a public good have fostered the belief amongst citizens that they have a universal right to good-quality tap water at little or no expense. Water as such has only an environmental and opportunity cost, but the infrastructures needed to carry the water to the citizen has high economic costs which must be paid by water users. Without this, recurrences continue to happen: a progressive deterioration of the infrastructure that benefits nobody. Another aspect to be considered is that the tariffs ought to be progressive to help the economically weakest gain access to water they need with any loss in water quality.

The lack of public knowledge about real water costs makes the need to increase water tariffs a poorly understood issue. This is regrettably part of a political debate when it should be a 'state' affair given that the survival of the city is at stake. The average citizen is intelligent and, if given the right information, is likely to be able to see the difference between opportunistic and self-interest policies, and those which are honestly beneficial to the population. This is of crucial importance in order to separate water from the political arena as much as possible.

8.5.4 Allocating responsibility

Fragmented institutions, with diverse points of view of the same issue, make for difficult decision making. This problem is highlighted in all reports where water problems are analysed in any detail. As water is such a key issue, all politicians try to include it in their agendas, or avoid it as much as possible in the case of serious conflict. Drinking water's increasing complexity has favoured an increase in the number of government departments involved in managing the issue: water, environment, health, industry, mining, etc. This makes for cumbersome and bureaucratic governance. More nimble and operative structures are needed in order to solve the plethora of water problems.

Involving users in water affairs may be an interesting approach. An approach is that adopted in Buenos Aires, where AySA has had considerable success doing specific work with lower-income sectors, through the methods of 'participatory models of governance' (MPG) and the 'Water+Work Plan' (Plan agua más trabajo), and to a lesser extent to 'Sanitation+Work Plan', which is reflected by joint action with neighbourhood communities, municipalities, government agencies, and social organizations. The company performs most of the financing of projects and provides technical supervision and neighbours help with labour, receive technical training, participate in workshops on proper use, and receive a discount on their bills (Lopardo and Lentini, 2010).

8.5.5 Lack of water service standards

In order to have a good-quality water service, objectives are needed and have to be made explicit. Management indicators (Alegre et al., 2006) allow them to be set with relative accuracy. For example, when defining the minimum water pressure that has to be guaranteed at demand peak, one must take into account the acceptable percentage of losses. This is needed to evaluate the present situation and set future targets. Independently of objectives set by financing organizations (Krause et al., 2012), which are establishing water service quality evaluation systems, the corresponding country authority (or regulator if it exists) should be the one to set the detailed objectives.

8.5.6 Unclear pay rules when the service is externalized

The public–private urban water management debate is intrinsic to the service and continues to cause debates. In 1875, the city of Birmingham (UK) bought the service from the private enterprises that had started them, arguing that 'the quantity and quality of water to be supplied to the public are matters of greater importance than making profits and should be controlled and managed by representatives of the people and not by private speculators' (Thackray, 1990). Shortly afterwards the story was repeated. In 1898 the city of Amsterdam bought the private company because of problems with financing the necessary extensions to the network arguing that the private company was more interested in making profits than in supply' (Swemmer, 1990). After more than a full century the debate continues, with those who defend public involvement bringing forward similar arguments.

Circumstances in LA have made the above commented issue a conflictive one (Castro, 2007; Ducci, 2007; ISF, 2008). At the same time that public management is preferred, there is also a need to attract and obtain private investment. This explains why prestigious institutions revisited the problem and proposed guidelines for developing reasonable agreements (Solanes and Jouravlev, 2007; OECD, 2009). This will not be elaborated upon further here, but will undoubtedly continue to be debated in all countries for many years to come (Jones et al., 2004; Boland, 2007).

8.5.7 Political prices and criteria

The lack of clear criteria used to establish the final price to be paid by citizens for the water service is probably the largest Achilles' heel of the urban water cycle. Since not all costs are recovered, a large part of the infrastructure has to be financed with public funds of diverse origins or with subsidies. Since this means large money sums passing through a few hands it is not rare that corruption occurs (Solanes and Jouravlev, 2005). Thus, clear criteria for self-financing are needed, in such a way that the sustainability of these water services is guaranteed by honouring the cost recovery principle as promoted by the Water Framework Directive in the European Union (OJEU, 2000), and also with an equitable tariff system to protect the weakest, without compromising efficiency. This equity is crucial given the large inequalities in LA.

8.5.8 Poor transparency in urban water management

Since water is a public good that is essential for life, it has to be flawlessly managed. There is an ethical obligation for transparent management, and this is even more serious for water supply. Countries have to establish the means needed to accomplish this goal. It would be recommendable that all money coming from urban water should be invested in water, and not be used for other needs, as often happens due to biased political interference. An efficient regulation service is one of the best ways in which to accomplish this goal, much as efficiency is a key strategy in order to reach a more sustainable future (BNA, 2012)

8.6 Conclusions

Providing a quality drinking water service, adequate sanitation and correct treatment of wastewater is a very complex problem, especially in LA where the population, especially in urban areas, has expanded rapidly. It is even more difficult considering that the current situation is far from desirable. The root of the problem is neither economic (scale economies allow for the provision of good quality and sustainable water services at a reasonable cost) nor technical (current engineering can deal with the most complex problems). The handicaps to be overcome are a severe lack of governance and of institutional leadership which are currently unable to deal with the rapid evolution. Since the path to be followed is well known, it is hoped that improvement of the current situation and avoidance of the serious consequences of not doing anything could be seen in the near future. LA citizens deserve the best quality service at the lowest possible cost though the differing characteristics of each country must be taken into account before any plan is implemented.

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