Chapter 13

Urban and industrial water use challenges

Enrique Cabrera
Departamento de Ingeniería Hidráulica y Medio Ambiente,
Universitat Politècnia de València, Valencia, Spain

ABSTRACT: In countries in which agricultural dominates water uses, like Spain, urban and industrial water demand is, from the quantity point of view, a minor issue. Nevertheless, in the last decades this use is gaining relevance, a fact that explains an elemental risk analysis: although even in dry periods the probability of a supply failure is low, the costs associated to that fail are extremely high. In any case, problems linked to agricultural uses are, generally speaking, different of those related to urban and industrial uses. In very few occasions both uses compete, and then the problems are rather decoupled. However, as they share the framework, most of the challenges these uses faces (i.e., to adapt old policies to the current scenario), are common. And because of that, those who are interested in agricultural uses can find in this chapter some interesting ideas on the challenges that urban water faces and on the guidelines to walk towards a more sustainable water management.

Keywords: urban water, urbanization, water prices, population growth

1 INTRODUCTION

The passing of the centuries has not changed human beings' ability to create. Yet as a result of technology, today's customs and lifestyles bear no resemblance to those of just fifty years ago. The solid foundations of knowledge established by our predecessors began to bear fruit in the industrial revolution, in the second half of the 18th century, but this was nothing compared to the technological advances of recent decades which have led to the globalization that currently holds sway. Everything has happened so fast that our present way of life does not resemble that of even a few decades ago. Contrast this with people who lived in the 10th century. Had they been born two centuries earlier, they would have noticed little change.

These advances have taken place in all engineering fields, although a distinction should be made between those with a short, as opposed to a long, history. The former (telecommunications or aeronautics) have evolved in lockstep with their also young socio-economic frameworks. But this is not the case for water engineering. As a result, the technological advance of 20th century water engineering was obliged to coexist with an almost ancestral culture and a rigid and consolidated legal system of rights that has led to significant dysfunctions. To dovetail rapid technological and social change with ancient laws and rights is a complex task, because a rigid framework makes adapting water policy to the contemporary scenario difficult, especially

in countries where the history of water is of great importance. However, rectifying disparities is easier in the case of new engineering fields since progress and frameworks move virtually in tandem.

At present, water administration, training of decision-makers and cultural attitudes of consumers are inadequate to deal with the collateral damage of progress. The required reforms need to be undertaken urgently, because problems are growing with time, and, if the complexity of the reforms continues to frighten those who have to carry them out, the end is already known; a major crisis arrives, forcing them to be implemented painfully.

The current imbalance began with the development of civil, hydraulic and electromechanical engineering in the 20th century. Until then, everything had taken place much more gradually with problems and their solutions going hand-in-hand. However, huge dams and pumps changed the dimensions of hydraulic engineering as it became possible to store large volumes of water and transport it over hundreds of kilometres. This development enabled the achievement of goals that previous generations could only dream of, with millions of hectares of dry land being irrigated and hitherto uninhabitable places (such as Las Vegas) being occupied.

Water engineering had achieved its greatest standing and arrived at its zenith by the end of the 20th century. It was in 1987 when the Brundtland Commission, concerned about the environmental deterioration worldwide, called for more sustainable policies. Since then, the only water policy that humans had implemented (making more resources available) has found its counterweight in a demand management more committed to efficiency. But, as this latter goal has been timidly pursued, the mismatch between supply and demand remains. Inertia hinders progress because the solution chosen first by humans, who tend to be resistant to change, is *business as usual*. Only enhanced environmental education for society can counteract the weight of history, social stress and recession.

2 THE NEW CONTEXT OF URBAN WATER IN THE 21ST CENTURY

Supplying the world's growing population with water of quality is today a complex challenge. Some facts explain why this is so. In order to highlight that the causes of the main problems are rather the same, these facts are presented first in general and afterwards particularised to Spain. Later, as problems are shared, the same diagnosis and the guidelines to follow (see Sections 3 and 4) apply. After that, no other specific mention of Spain is required.

2.1 Extraordinary and asymmetric population growth

Over the past six decades the world's population has nearly tripled (Figure 1a). While in 1950 the Earth had 2,500 million inhabitants, today there are 7,000 million of us, an impressive increase given that in the previous nine centuries the rise was *only* 1,400 million (from 300 million at the start of the second millennium up to 1,700 million at the beginning of the 20th century). And although the population growth slope

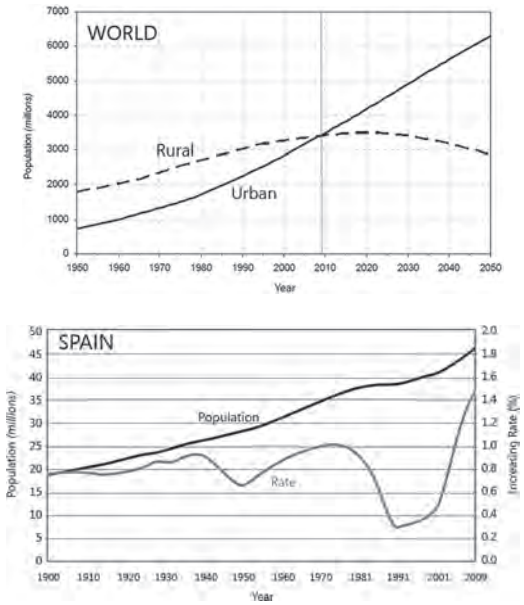

Figure 1 a) World urbanisation prospects (UN, 2010); and b) Spanish population growth in recent decades (BBVA, 2010).

has lessened, the ordinate is increasing so that by 2050 the world's population will reach 9,000 million people.

Yet the figures are even more striking if comparisons are made in terms of urban population. In 1950 only one third of the inhabitants of the Earth (approximately 700 million people) lived in cities. By mid-2009 there were already 3,400 million urban dwellers, accounting for 50% of the world's population, and Spain shows similar trends. Figure 1b depicts both the population growth and the increasing rate, while Table 1 shows the asymmetry.

2.2 Water needs are increasing in an uncertain scenario dominated by climate change

At present in the world, agriculture uses 70% of water resources although forecasts indicate that, in absolute terms, this will decrease slightly (Figure 2), while domestic and manufacturing uses (both urban uses) will increase. In any case it is important to underline, from the food crisis of 2008, that it is believed that food production will have to increase substantially, and that water supply for irrigation will also rise moderately in 2050, adding more pressure to this valuable resource. Spain does not have the official forecasts that should be a substantial part of the new river basin management plans. They still are pending despite the stipulated requirements (*River Basin Management Plans shall be published at the latest nine years after the date of entry into force of this Directive*) in Article 13 of the Water Framework Directive (WFD) published in

Table 1 Distribution of the population in urban and rural areas of Spain (BBVA, 2010).

Year	*Population (total)*	*People P, living in cities P ≥ 50,000*	*People P, living in cities 50,000 > P ≥ 1,000*	*People P, living in rural areas (P < 1,000)*
1900	18,830,649	13.73%	74.16%	12.11%
2001	40,847,371	50.63%	45.53%	3.84%
2009	46,745,807	52.47%	44.31%	3.22%

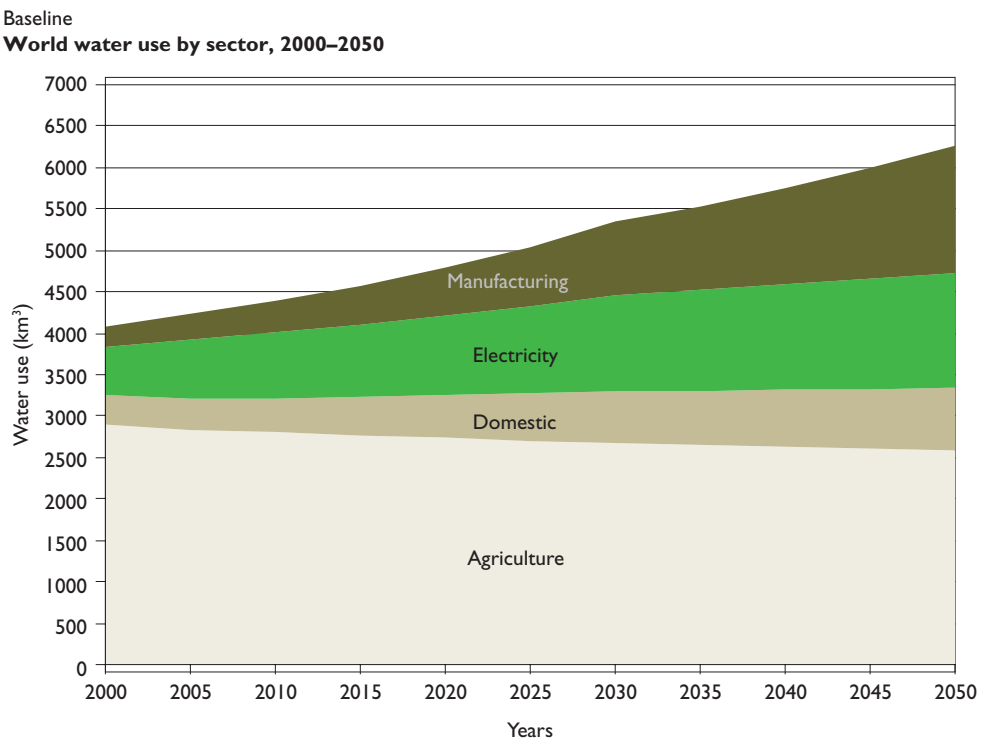

Figure 2 World water use by sector prospects. (Source: OECD Environmental Outlook Baseline 2007).

December 2000. In any case, percentages, over a total water demand of 30,000 hm^3/year [hm^3 = cubic hectometre = million m^3 = 10^6 m^3], are similar to those depicted in Figure 2. In this respect, Spain is rather average and in this context, water resources will suffer a growing stress, mainly taking into account the threat of a global climate change that will (according IPCC models) dramatically affect the Mediterranean countries. As population will follow an increasing trend, the solution must come hand in hand with efficiency.

2.3 The area of land altered and urbanised by humans is growing

Land use changes due to urbanisation affect the hydrological cycle. The creation of impervious surfaces increases runoff, reduces aquifer recharge and gives rise to urban flooding. Its growing frequency and the high economic and, occasionally human, damage it entails, have made this issue one of the greatest concerns for some cities. Then, the urban development of cities, which obviously grows in tandem with population numbers, has a direct impact and increases the complexity of sustainable water management in the world. *It can be stated that a land use decision is a water policy decision as well.*

From this point of view Spain is not on the world's average. The pace of land change during the last decade (1.95%) has been three times higher than the average (0.68%) of the 23 countries that have participated in the European Union (EU) Corine Land Cover Project 2000, which had as its objective to quantify land uses changes between 1990 and 2000. Although the recent burst of the *housing bubble* has provisionally stopped the trend, the problem is already on the floor (Figure 3) and so the study of strategies to minimise its adverse impacts is a crucial issue.

2.4 Water pollution is steadily increasing

Another dramatic change over recent decades has been the deterioration of water quality. In fact, each passing day more expensive and sophisticated treatments are required to make water potable. While in the past irrigation did not bring with it toxic substances, the massive use of fertilisers and pesticides has contaminated many of the aquifers that supply urban areas. These aggressive practices began in the second half of the 20th century and the reaction came in Europe in 1991 when the Nitrates Directive was enacted to become one of the first pieces of environmental legislation in the EU. It marked a turning point and has helped to slightly improve the situation. Yet, it remains one of the issues that cause most environmental concern.

Nevertheless urban (including storm water collection) and industrial uses, due to the pollutants they bring with them, have the highest impact on water quality. Furthermore, the quantity of water polluted and its accumulation in the aquifers is continually increasing due to population and urbanization growth and to the average rise in unit consumption (litres per person per day). Thus, between 1950 and 1990 water used tripled while the population only doubled. Restoring water to its initial quality calls for major investments that many developing countries are unable to afford. Also, what is worse, a long time is required to restore what has been changed (see Chapter 12). Finally, in some cases, once the treatment plants have been built, municipalities cannot afford the operational and energy costs they require.

As all over the world, during recent decades Spanish water bodies have received many sources of pollutants (urban, industrial and agricultural), and (although people only react if the pollution is clearly perceived, such as when it affects public spaces like beaches) society is sensitive to contamination, so the response has been effective to some extent, although with two weak points. First, most of the money devoted to these investments came from Brussels (EU). But this time is gone. Second, most of the small cities and rural settlements do not have waste water treatment plants. In Catalonia, for instance, 34.57%

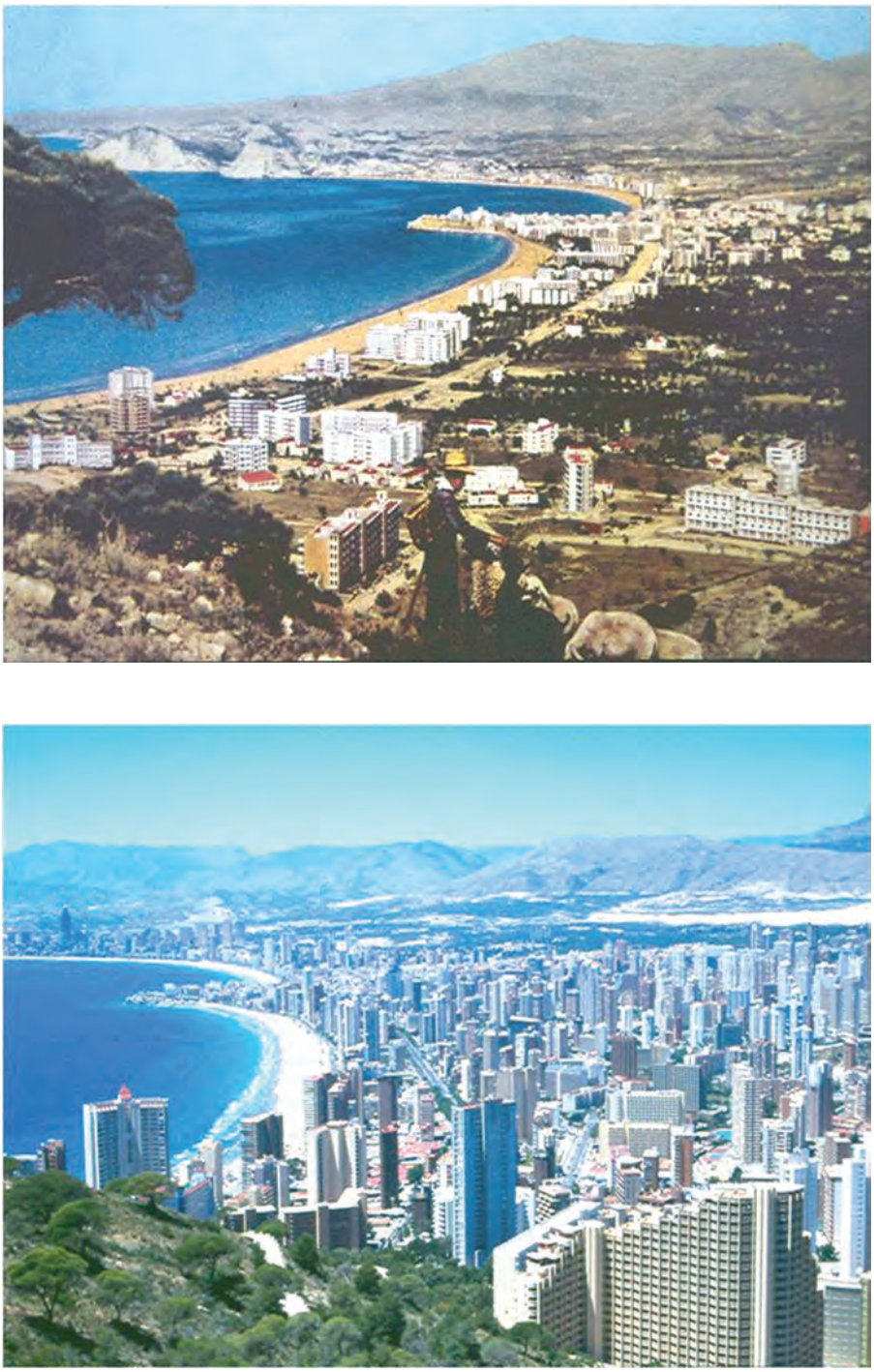

Figure 3 Land use change. The city of Benidorm in the early 1960s and today.

of the municipalities (hosting just 4.59% of the population), do not have such a facility, and as water is subsidised, the main body responsible for its management (the Catalan Water Agency) supports a deficit of 2,500 M€. In any case, it must be underlined that Catalonia is not the worst region of Spain. It is in a better position than others.

2.5 The current economic crisis

We are living in turbulent times with few developed countries, if any, not affected by the global crisis. One of the biggest problems is the result of excessive borrowing by governments that now must reduce their deficits. That means that in forthcoming years they will manage tight budgets. This will hamper what has hitherto been standard practice in many countries: paying for this infrastructure with public money. To put it another way, subsidies will gradually be withdrawn. Although banned since 2010 in Europe by the WFD, many countries have so far been ignoring it.

The probable end of subsidies, in addition to leading to an increase in prices, will make it necessary to seek alternative funding and to reduce costs. The need to attract private capital will reopen the perennial debate about public-private management which, irrespective of their pros and cons, is a subject that should be discussed from a pragmatic standpoint far away from the political arena. In addition, the need to reduce costs will foster efficiency and a search for economies of scale. In short, the current economic crisis will, in all probability, mark a turning point from subsidies to full urban water cost recovery. Spain, with unemployment over 21%, an external debt over the 160% of the Gross National Product (GNP) and a public deficit of around 9%, should start to think about it. Otherwise, this *hydric bubble* will burst soon.

2.6 Investment has been huge – the challenge now is to maintain infrastructures and renew them

The 20th century, particularly in its early decades, witnessed the building of large water structures, mainly in semiarid countries or regions, like Spain or California. As part of a water policy geared towards mobilizing more water resources, water engineering structures were an excellent driving force for an economy which had to grow after the Great Depression and World War II. Furthermore, at that time governments were not burdened by current debt levels, and these were popular projects that enhanced quality of life and were therefore political vote winners. And since their environmental impacts were not well known, no one, or few persons, objected to them.

But that is now over, especially in developed countries where water management needs are much more necessary than water development. The water engineering structures and systems of the past now have to be preserved, if not replaced, including millions of kilometres of urban pipelines. Yet this is not attractive to the public at large who assign little value to those policies, unless they are obviously necessary. Nor is it attractive to politicians (renewing pipelines means *burying* money). However, since the need is obvious so as not to further jeopardise future generations, it cannot be delayed. Civil society must react and act.

In Spain, urban water infrastructure assets can be summarised in very few (although impressive) figures: some 200,000 km of water supply pipes, around 70,000 km of sewer pipes and roughly 5,000 water treatment plants. An important part of these

assets is, or will soon become, old. But current urban water tariffs do not fully allow for maintaining or, when necessary, replacing them. Hopefully, still there are some few years of margin to react. Most of the water treatment plants have been built in the last decade and they still show acceptable performances. But as the return period of these infrastructures is shorter than most of the other urban water assets (pipes, reservoirs, tanks, etc.) the time to react is rather short.

3 ON THE NEED TO ADAPT DECISION-MAKERS' TRAINING TO THE NEW SCENARIO

The problems to be tackled are consequently formidable, Mexico City being a catalogue of the most significant ones. With over 20 million inhabitants, its urban water comes mostly from its aquifers because the surface resources in its surroundings are scarce. However, the city's unremitting growth and the degradation of its aquifers, severely affected by urban activity, made it necessary to find resources in neighbouring basins, and this generated serious social problems for the farmers who, until then, had been using this water. There is, indeed, a high leakage level that can only be remedied by huge investment, which will in turn require raising prices with all the social problems that this generates for the poorest people. In short, what had previously been only a one-dimensional engineering problem is now multidimensional. Technology, although important, is playing today a secondary role.

Profound changes have happened in just a few decades that require adapting both the training of decision-makers and the mindset of the citizens to this new scenario. Solutions will only be acceptable when they harmoniously combine all standpoints on the problem. *Integration* should therefore govern the decisions made about future water policies, especially in urban areas with serious social implications. Water is a very transversal issue and sustainable solutions require integration of all interests and points of view. This calls for a cultural change, particularly in terms of the major players, ranging from decision-makers to all stakeholders. In short, there is a need to map out new curricula which both bring the training of those who will be the leaders of the future into closer contact with reality and also take into account the three areas (political, managerial and technical) in which decisions are made. The training will prepare the future leaders for the role they are to play, and all will have a common knowledge of the issues to be tackled in order to be familiar with the viewpoint of the other positions. Only through integration can sustainable solutions be found.

Yet, training for those who make the decisions is not enough on its own. The administration must be as professional as possible in order to avoid political interference in technical decisions. Last, but not least, the general public has to be educated about the environment as there will always be a conflict between what is good in the short term and what is good in the medium-to-long term. This is because while politicians make their decisions with an eye on the next election, solutions are sustainable only if they take into account the interests of future generations. Yet, political interests and sustainability can be made compatible by educating the public. If most voters support an unpopular decision because they understand the need for it, their political representatives will only become visible in the medium-to-long term.

The need to deal with problems using an interdisciplinary approach is obvious, and perhaps as a result it has become increasingly prominent. Experts are now beginning to take the idea on board, and it is already present in international forums. This interdisciplinary approach has not yet been put into practice, and this is one of the major outstanding issues. Hence, unless the training of decision-makers and society is adapted to the new scenario, it will be virtually impossible to ensure in the near future that most of the people living on the planet (hopefully all of them) will have enough water in their homes and drinking water of quality at a reasonable price.

Once more Spain is a paradigmatic example because it is crucial to adapt the water culture of the citizens and the administrative structure to the new scenario. When framework changes and new challenges arise, there appear inconsistencies between the traditional institutions and the emerging needs. In Spain, ballasted by historical water rights, that becomes evidence of the need for change.

4 THE BIG CHALLENGES

Today the major challenge facing urban water is to achieve the Millennium Development Goals set at the 2002 Johannesburg Summit, one of which is to provide access by 2015 to water and sanitation for billions of people in developing countries who at that time did not have it, and to reduce by half the percentage of people without. But this formidable task (its solution requires a Herculean effort) is out of the scope of this chapter. Attention is paid now to those general issues, arising from the rapid changes in recent decades, discussed above, which call for new approaches, a process that has begun in some countries.

This can be highlighted by the differences in the price of 200 m^3 (the volume corresponding to the yearly demand of a family) of tap water (excluding urban drainage and sanitation) around the world. The wide divergence between some of the world's largest cities is hard to understand. According the last International Water Association report on this matter, the highest price is US$ 765 in Copenhagen while the lowest one, in Milan at US$ 33, is not even 5% of the Copenhagen rate. This disparity can only be explained qualitatively by historical reasons and quantitatively by costly structures and quality of delivered water. Hence analysing which terms of the water costs are taken into account leads to an understanding of what at first sight seems very difficult to justify. Yet while part of the bill is subsidised and some costs, especially environmental ones, are ignored, the differences will continue to exist. However, because water is of great social interest, decision-makers are not prepared to break with ancient customs.

In the light of the foregoing, a natural transition demands both educating decision-makers and users. Thus, the former will learn how much is at stake and will not hesitate to drive change, while the latter will bear the sacrifices they are asked to make because they understand the need for the decisions. This will be a gradual change based on the following five points:

i A cross-cutting approach and breadth of vision. Actually water issues are located in a multidimensional space. Decisions should consider and balance at least the three key axes of that space (economic, social and environmental).

ii Integration with other environmental policies. Water decisions influence and are influenced by other environmental policies. As noted above, water/land is the most important but by no means the only nexus. For instance the energy/water pairing has come much more to the fore over the last ten years.

iii Joining science and politics. At present there is a lack of common ground in all matters relating to the environment because while science follows the pace of events in real time, politics usually thinks only in the short term.

iv Administration, the gradual driving force behind progressive change, must be adapted to the current context. That includes competent and free public servants, far away from the political arena. If water policy reforms are not gradually implemented, a water crisis will finally force the changes abruptly. Society's awareness will make these changes easier.

v Enhancing demand management as the best option to mitigate water stress and to be sustainable. This entails improving efficiency, encouraging saving and promoting reuse. With growing demand for water in a scenario of climate change, the future asks for a more efficient water use. Four key actions are necessary:

a Passing on all the costs of water services to users encourages saving and efficiency. Some countries (e.g. Germany) have been passing costs on into the bills of users for over a decade. This is done by dividing the drainage fee into two blocks: one, the stormwater fee (proportional to the water drained by the property, a function of the paved land) and another for wastewater treatment (water use dependent). As rainwater drainage requires high investments, this *stormwater utility fee* has become significant and independent of the blackwater fee (see Table 2). As a matter of fact, in Berlin it has risen up to 1.90 €/m^2/year [http://www.bwb.de].

The full cost recovery principle is questioned on the grounds that water is a universal right, which justifies subsidies. Here it should be noted that progressive rates make it possible to subsidise the poorest without having to do so with the whole service. An analogous case is the taxation in a country. It can be designed, or not, to protect low rents. However, no one disputes that a country needs to balance its income and expenditure. The question is how to do so.

Finally, it must be ensured that all the money users pay is invested in maintaining and improving these services.

b Renewing infrastructures, some of which are now very old.

c Commitment to provide a quality supply. The relentless rise in the consumption of bottled water, with all its environmental drawbacks, needs to be halted

Table 2 Urban drainage rates in Germany in 1999 (BUNR, 2001).

	Drainage fee (divided into two blocks)		*Drainage fee, €/m^3 (one block)*
	Blackwater (€/m^3)	*Rainwater (€/m^2/year)*	
Germany	1.79	0.77	2.28
Old West Germany	1.72	0.78	2.23
Old East Germany	2.39	0.59	2.54

soon. As a matter of fact, global bottled water sales have increased dramatically over the past several decades. Total revenues of bottled water are in Spain higher than those of all water utilities. Its unitary cost is hundreds, even thousands, of times higher than that of tap water, and nobody argues that this commodity is too expensive, while it is socially very complex to adapt the price of public water to its real costs.

d Improving knowledge to continue moving forward. Research should take into account the concerns of industry professionals.

In this list of challenges the technical ones have not been included (e.g. water for human use should be of the highest quality, and the importance of promoting grey water reuse or water harvesting). They all can arrive in a natural way, once the *structural barriers*, to which we have paid all our attention, have been removed.

5 CONCLUSIONS

Addressing the supply of quality water to a growing population in a world that is changing at breakneck speed is one of the biggest challenges facing society in the 21st century. And although their magnitude very much depends on the starting point of each country, on their water awareness and, for sure, on the specific socio-economic characteristics of each country, the main guidelines are rather the same all around the world. Spain is, indeed, a representative case of this general picture.

REFERENCES

BBVA (Banco Bilbao Vizcaya Argentaria) (2010). *Población 51: La población en España: 1900–2009* [Spain's Population: 1900–2009] Fundación BBVA, Madrid, Spain.

BUNR (Bundesminiterium für Umwelt, Naturschutz und Reaktorsicherheit) (2001). *Water Resources Management in Germany*. Federal Ministry for the Environment, Bonn, Germany.

OECD (Organization for Economic Cooperation and Development) (2007). *OECD Environmental Baseline 2007*. OECD, Paris, France.

UN (United Nations) (2010). World *Urbanization Prospects. The 2009 Revision. Highlights*. Report ESA/P/WP/215. United Nations, New York, USA.