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ENVIRONMENT DIRECTORATE
ENVIRONMENT POLICY COMMITTEE

Working Party on Biodiversity, Water and Ecosystems

A new era for water management in OECD cities

7th Meeting of the WPBWE, 19-20 February 2015

Action required: WPBWE delegates are invited to provide written comments by 20 February 2015, and to consider endorsing the report for declassification.

The report will also be shared for comments with delegates from the Joint Working Party on Agriculture and Environment, and the Working Party on Urban Policy of the Regional Development Policy Committee. The final report is expected to be released at the WWF7 in April 2015 in Korea.

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NOTE FROM THE SECRETARIAT

This document is the revised draft of the report on Managing Water for Future Cities. This work corresponds to the 2013-14 Programme of Work output 2.3.2.3.1. It is a horizontal project, with contributions from the Environment Directorate (ENV), the Public Governance and Territorial Development Directorate (GOV) and the Trade and Agriculture Directorate (TAD).

The Korean government provided a voluntary contribution and seconded Mr. Kun-Wook Kim, a senior expert from K-Water, to work with ENV. The project also benefited from resources from the Central Priority Fund. These contributions are gratefully acknowledged.

The report builds on the following elements:

- Discussions on the scope and outline at previous Working Party on Biodiversity Water and Ecosystem (WPBWE) meetings, and written comments received before 5 January 2015.

- A presentation and discussion at the meeting of the Joint Working Party on Agriculture and Environment (JWPAE), on 25 November 2014, and at the 4th meeting of the OECD Water Governance Initiative, also on 25 November 2014.

- Two background papers, on *New Modes of Water Supply and Sanitation Management and Emerging Business Models* and on *Barriers to, and Incentives for, the Adoption of Green Water Infrastructure*, shared as background documentation at previous WPBWE meetings [ENV/EPOC/WPBWE/RD(2013)7, ENV/EPOC/WPBWE/RD(2013)8)].

- A report on the governance of water regulators [GOV/RPC/NER(2014)6)], building on a survey to water regulators and discussions in the OECD Network of Economic Regulators (a subsidiary body of the Regulatory Policy Committee).

- A survey on water governance in cities, from a report to be published in 2015 by GOV.

- Case studies on innovative water management drafted by selected OECD cities: Auckland (New Zealand), Fukuoka (Japan), Hamburg (Germany), San Francisco (USA), Suwon (Korea), Tokyo (Japan), Tucson (USA), and four local authorities in South West Kyoungnam Province (Korea).

- Contributions from TAD, based on on-going work on the management of droughts and floods, and groundwater [COM/TAD/CA/ENV/EPOC(2014)43, COM/TAD/CA/ENV/EPOC(2014)42].

WPBWE delegates are invited to provide written comments by 20 February 2015, and to consider endorsing the report for declassification. The report will also be shared for comments with delegates from the Joint Working Party on Agriculture and Environment, and the Working Party on Urban Policy of the Regional Development Policy Committee. The final report is expected to be released at the WWF7 in April 2015 in Korea.

FOREWORD

More than half of the world's population currently resides in cities, and urbanisation is projected to continue increasing. By 2050, 86% of the OECD population will be living in urban areas, with an increasing concentration in large cities with a population of greater than one million inhabitants. There will also be an increasing number of people living in basins under severe water stress.

OECD cities usually benefit from high levels of water security, which derive from a combination of infrastructures, business models and institutional arrangements. It is not clear how such combinations are fit for future challenges.

OECD cities are confronted with significant challenges to protect inhabitants from risks of floods, droughts or deteriorating water quality, which result mainly from urban growth, competition among water users and climate change. OECD cities are also facing particular challenges due to ageing infrastructures and the need to adapt existing assets: most OECD cities need to transition from an era of exploitation of existing infrastructures to one where new assets need to be built and retrofitted in existing environments.

These challenges are particularly tricky when financing capacity is constrained by restrictive budgetary policies and limited affordability for selected users. These challenges will have consequences on the way water is managed across administrative and hydrological boundaries, and urgent attention is needed to address them.

While some cities already gain experience with the management of this transition, more needs to be done to scale up and expedite change. Both local and central governments have a role to play, to make the best use of the initiatives of a variety of stakeholders, including the private sector, households and rural communities.

This report focuses on the challenges OECD cities face regarding water management, and explores policy responses, at both the central and local government levels. The analyses focus on four dimensions which are mutually dependent: finance, innovation, co-operation with the rural environment and governance.

The report builds on OECD work on water economics and governance, in particular financing water management and water services; the diffusion of technical and non-technical innovation in water management; the management of droughts and floods, and groundwater; urban governance; stakeholder engagement; the governance of water regulators.

The report was drafted by a core team composed by Xavier Leflaive, Aziza Akhmouch, Filippo Civitelli, Guillaume Gruere, Julien Hardelin, Celine Kauffmann, KunWook Kim, Hannah Leckie, Kazuki Motohashi and Oriana Romano. Simon Buckle, Anthony Cox, Jane Ellis, Robert Youngman and Karishma Gupte provided comments at various stages.

The report builds on new information collected through:

- a survey on the governance of water regulators; a dedicated report will be released in 2015;
- a survey on water governance in cities; a dedicated report will be released in 2015;
- case studies drafted by selected OECD cities: Auckland (New Zealand), Fukuoka (Japan), Hamburg (Germany), San Francisco (USA), Suwon (Korea), Tokyo (Japan), Tucson (USA), and four local authorities in South West Kyoungnam Province (Korea).

The report benefitted from comments from a wide range of stakeholders, at meetings of several OECD bodies.

ABBREVIATIONS (IN PROGRESS)

EXECUTIVE SUMMARY

OECD cities have not solved water management. While they currently enjoy relatively high levels of water security, OECD cities are confronted with disquieting challenges, including the proven difficulty of upgrading and renewing existing infrastructures, and heightened uncertainty about future water availability and quality. OECD cities are entering a new era, characterised by the need to retrofit existing assets into more adaptable infrastructure, by different combinations of financing tools, and by new roles for stakeholders in water management. The transition to this new era requires co-ordinated action between central governments, local authorities and a variety of private actors.

Emerging challenges for water management in OECD cities

In OECD countries, city dwellers currently have reliable access to safe water and sanitation services. They are protected against risks of too much (floods, heavy rains), too little (droughts), too polluted water, or risks to the resilience of freshwater ecosystems. This remarkable achievement builds on country-specific combinations of institutions, financing mechanisms and technologies. Such combinations may not be fit for the emerging challenges in the water sector.

One of the main challenges relates to increased uncertainty about water availability in the future. First, OECD cities compete with other water users (farmers, energy suppliers, and the environment) to access the water they need, at fit-for-purpose quality. Second, climate change will generate more extreme weather events, increase hydrological variability and uncertainty about water availability.

Another challenge is that of financing the operation, maintenance and renewal of extensive infrastructures, which channel, store, treat or move water. Prevailing financing mechanisms have been able to support the operation of existing infrastructures, while keeping water tariffs relatively low. They have been less successful at financing the upgrade or replacement of assets. Nor have they provided incentives to adapt urban water management to changes in water availability or consumption patterns.

A third set of challenges relates to the way water is governed. Territorial reforms, decentralisation and reallocation of competences affect urban water management, as do emerging changes in regulatory models for the water industry. Water management in OECD cities suffers from several governance gaps, notably fragmented institutions, weak capacity at local level, and tensions between water, energy and land policies.

Four questions to set urban water management on a sustainable path

In this context, OECD cities would benefit from considering four interrelated questions.

What should the water bill cover? The OECD has long argued that there are three ultimate sources of finance for water services: tariffs (revenues from the water bill), taxes (allocations from the public budget), and transfers (transfers from the international community, which have become secondary in most OECD cities). Other sources of finance need to be paid back from a combination of the 3Ts. The context sketched above suggests that the 3Ts should be revisited. In particular, tariff structures and business models may need to be adjusted in order to secure stable revenues in the face of declining water consumption. Governments should consider levying taxes on those who benefit from increased water security (including land and property developers), or who generate higher costs and externalities (e.g. owners of large impervious surfaces, such as roads or car parks).

How to make the best use of innovative approaches to urban water management? Technical innovation is burgeoning in OECD cities, but is not fully exploited. Some innovation is potentially

disruptive, such as smart technologies, distributed systems or green technologies. Disruptive technologies work best in combination with non-technical innovation, such as water-sensitive urban design or innovative business models for water utilities. Cities would benefit from a wide latitude given by other tiers of governments to explore technologies that fit local contexts. Regulatory frameworks can drive the diffusion of innovation, but can also lock cities into suboptimal technical trajectories.

How can cities and their rural surroundings best co-operate? The urban-rural interface can contribute a great deal to OECD cities' water security now and in the future, at least cost for society. For instance, experience with catchment protection from harmful agricultural practices or with the use of farm land as buffer in cases of floods has highlighted the efficacy of such measures for urban water management. On the other hand, rural communities can use a city's runoff or treated wastewater. Incentives and governance mechanisms are required to make use of co-operative arrangements that benefit cities, upstream and downstream communities, and ecosystems.

How to govern urban water management? Three issues deserve particular attention. First, what is the appropriate level of security for a city, how much are city dwellers willing to pay for it and how far are they willing to adjust their behaviour? An adequate response to these questions requires active stakeholder participation in decision making. A second issue concerns the capacity of regulators to adapt their approaches and tools to new issues in the provision of water and sanitation services. Third is the question of scale: water will increasingly be managed at a range of different scales, from catchment to individual buildings, depending on the particular service at issue (protection against floods or droughts; water supply; sanitation; drainage; etc.) and on technological and behavioural sophistication. Metropolitan governance is a consistent trend in OECD cities; it has the ability to combine the different scales and to pool financial and technical resources.

Lessons learned from successful transition towards a new era

Some OECD cities have transitioned towards water management practices that look fit for future challenges. Pragmatic experience with managing change and retrofitting existing infrastructures is particularly instructive.

Most OECD cities have core competencies to manage water in a way that meets future challenges: they are usually responsible for land use, construction and buildings, as well as natural resource management. They are well-positioned to develop solutions that meet hydrological, climatic, social or economic conditions. They can catalyse action by households, local communities and investors.

OECD cities that manage water for future challenges understand that delaying action can increase future costs and limit options to adapt to new water-related risks. They combine a long-term strategy with a pragmatic approach for the renewal of the existing stock of buildings and assets. They deploy a package of technical and non-technical measures that make the best use of water resources, of financial capacities and of the initiatives of a variety of stakeholders.

OECD cities will not be able to respond to all the future water challenges on their own. A number of initiatives taken by other tiers of governments will contribute to urban water management. They are clustered around three categories: regulation (on land use, reclaimed water, or public procurement), the provision of resources (such as information and education) and incentives (financial, or else). Governments can use urban policies and infrastructure finance to promote water sensitive urban design, especially in regions of high risk.

The interplay between national and local initiatives on water management will shape the cities we will live in, including their capacity to thrive and contribute to better lives.

CHAPTER 1. A FRAMEWORK FOR CITY-LEVEL WATER MANAGEMENT

The chapter examines the main water-related challenges that OECD cities face now and will increasingly face in the future. Central to these challenges are the risks of too much, too little or too polluted water, the resilience of water ecosystems and the distinctive ways in which OECD cities have managed these risks so far, through combinations of infrastructures and governance arrangements.

The chapter proposes a framework to analyse policy responses to these challenges that combines four dimensions: financing, innovation, urban-rural co-operation and governance. Each dimension is further explored in subsequent chapters.

Key messages

1. OECD cities enjoy high levels of water security and city dwellers have access to reliable water supply and sanitation services. This remarkable achievement builds on country-specific combinations of institutions, financing mechanisms and technologies

2. However, the prevailing combinations may not be up to future challenges:

- Infrastructures, upon which OECD cities' water security critically depends, are ageing and need to be upgraded. The prevailing business models for urban water management heavily rely on public finance and fail to attract alternative sources.

- Infrastructures and urban water management face emerging pressures such as more stringent health and environmental standards, diffuse pollution, competition to access the resource, increased intensity and frequency of extreme weather (affecting precipitations and evaporation) and, generally, more uncertainty about future water availability and demand. However OECD cities are locked in technical trajectories, and retrofitting existing infrastructure is particularly challenging.

- Water governance in OECD cities is affected by several gaps, such as asymmetries of information, sectoral fragmentation, or limited capacities. In addition, institutional structures are changing, driven by national and international laws and regulations, territorial reforms, decentralisation or the re-allocation of competences across jurisdictions. These changes affect the capacity of cities and other actors to manage water at the appropriate scale.

3. Responses to these challenges combine four dimensions: financing mechanisms and strategies to upgrade and renew existing infrastructures; policies to overcome the barriers that hinder the diffusion of innovative approaches to urban water management; enhanced co-operation between cities and their rural surroundings; governance structures that can manage water at several scales, engage stakeholders, and properly regulate water supply and sanitation services. Alternative scenarios for urban water management illustrate how the four dimensions can be recombined in models with distinctive characteristics in terms of economic and environmental performance and social equity.

4. OECD cities will be affected by water challenges in different ways. They have uneven capacity to take initiatives in the four dimensions mentioned above. Criteria are proposed to cluster cities from a water management perspective. The typology can help cities to situate themselves vis-à-vis other cities facing similar challenges and endowed with similar capacities to respond. It can be used to filter the analyses and options discussed in the subsequent chapters.

Introduction

5. OECD cities are critical to national economic, social and environmental performance. Cities are home to about two-thirds of the OECD's population and account for an even larger share of economic output. They are hubs for job creation, innovation, growth and culture. Yet, cities are also places where governments face acute policy challenges, including infrastructure bottlenecks, high levels of pollution, climate and environmental change, and difficulties in the provision of key services (OECD, 2015, forthcoming).

6. OECD cities are usually well protected from water-related risks: they are protected from floods and droughts, they can treat polluted water; a vast majority of city dwellers enjoy high level of water and sanitation services. When exceptional events occur, OECD cities are usually able to cope and to recover. Water security is essential for cities to continue to thrive and contribute to national (and global) economies.

7. The prevailing level of water security for OECD cities has been achieved via a combination of technical and institutional features (OECD, 2013c; Sitzenfrei and Rauch, 2014), that emerged throughout the 19th century (see Box 1):

- Water infrastructure and water polices are dominated by a focus on water quality and supply, with little or no emphasis on water demand.
- Water security relies on technologies to augment supply, and treat polluted water sources and effluents.
- Water is collected, distributed and treated in large infrastructures that comprise of pipes, taps and meters, and which are centrally organised at city level.
- Users are charged for the service by an operator, below full cost recovery levels; and
- Cities are (relatively) disconnected from their rural environment, as regards water management.

8. This model was sustainable as long as water demand and revenue continued to increase, and new water supplies could meet the growing demand. Public authorities and operators relied on technical innovation to control the pollution of water resources. They knew little about the making or management of the demand, and they had no relationship with their customers beyond billing. This model is being questioned by three sets of challenges: water-related risks; ageing infrastructures; and trends in institutional reforms. The chapter reviews these challenges in sequence and sketches a framework to organise policy responses. It proposes criteria cities can use to situate themselves vis-à-vis others as regards water management.

Box 1. Brief history of the emergence of prevailing models for urban water management

A radical transformation in urban water management took place in the 19th century: the progressive generalisation of water taps and meters allowed quantification of water use, and enabled the distinction between water as a consumptive good, from water as a resource. It shifted the status of water from a common pool resource (non-excludable but rivalrous) into a club good, characterised by freedom to adhere, possibility of exclusion, and equality in tariff setting. The invention of bacteriology, and subsequently of chemical water treatment, supported a further shift of the status of safe water from a club to a public good, which one had to pay for.

This transformation has largely been implemented throughout Europe and other developed countries. Still, a large variety of financing systems co-exist. While economic theory argues that water and water-related services should be priced, and that prices should reflect long term marginal costs, in practice, places remain - including cities - where water supply costs are covered by flat rates, where sewer services are charged through taxation, or where metering is collective (one per condominium) or non-existent.

At the end of the 20th century, the prevailing model for urban water management in developed countries was based on supply-side policies, and cost recovery with minimal subsidies (once the main infrastructures have been built). Urban water is treated to potable standards (Paris is one exception, which has a dedicated network for non-potable water, used for cleaning streets, for instance), even though less than 1% of the water supplied will be ingested by humans, and less than 20% will be in contact with human bodies. This could be viewed either as excessive water treatment; or alternatively as the sensible exploitation of economies of scale (treating all water in a city to the same standard), and application of the precautionary principle (avoiding mistakes that could lead to the consumption of unsafe water).

The invention of both water and sewage treatment works gave additional degrees of freedom to cities vis-à-vis their environment: water abstracted from polluted resources could be made potable, and treated water discharged could have reduced impacts on downstream resources and users. It was only a matter of cost, and for a long period of time, it seemed possible to fund water supply and sanitation (WSS) services from water bills, with the support of some mutual funding mechanisms and government subsidies.

Source: Barraqué, Isnard (2013)

Water-related risks OECD cities face

9. Water security, as defined by Grey and Sadoff (2007), is “the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies”. Similarly, the OECD defines water security as the management of four water risks (see OECD, 2013, for a detailed discussion): too little (water scarcity), too much (floods), too polluted water; and risks to the resilience of freshwater ecosystems. This section reports on recent trends affecting these risks.

Water scarcity

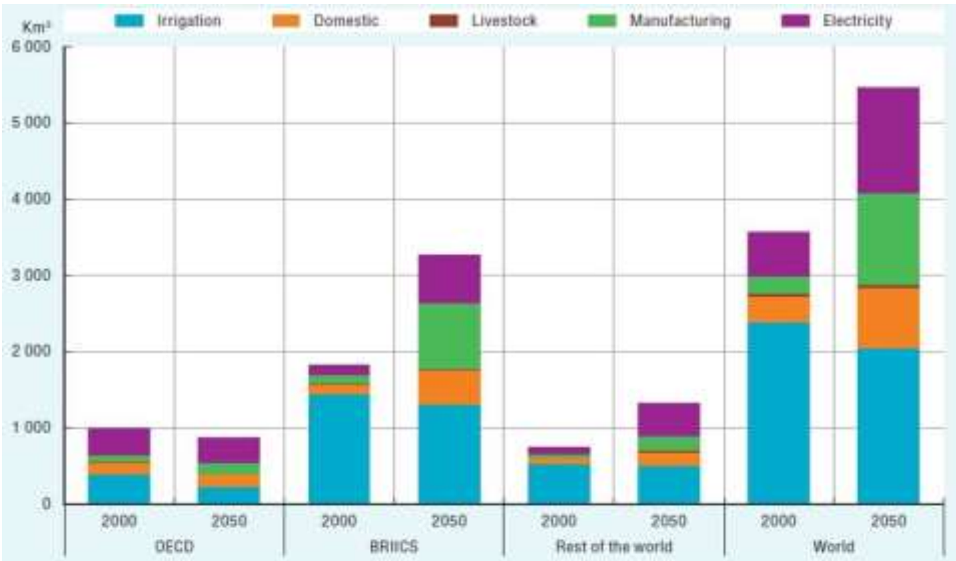
10. OECD cities are projected to increasingly compete with other water users to access the water they need. In OECD countries, future water demand will be driven by energy suppliers and industry, which compete with cities, farmers and ecosystems to access water (see Figure 1). Competition will intensify, as OECD cities will continue to expand (UNDESA, 2009, 2010). Competition will extend further as cities fetch water from ever most distant surroundings: Jenerette and Larsen (2006) measured the surface of land required to supply water to cities with over 750,000 inhabitants. This surface area has grown by 28% between 1950 and 2015, and at increasingly faster rates. European cities stand at the lower end, but as European territory is particularly urbanised, urban water supply actually affects the entire European territory (Jenerette and Larsen, 2006; Bolognesi, 2014). Competition will intensify further as stakeholders realise that basins have their own needs and cities have to pay a higher (economic, financial or political)

cost to meet their needs. For instance, in the Western US, long haul water transfers from one source to a distant city met resistance from local communities (Postel, 1997); as a consequence, future water supply plans mark a return towards local water options.

11. Climate change has the potential to exacerbate competition over access to water, especially in mid-latitude and sub-tropical dry zones, or where mountain glaciers store less water than they used to. Climate change is acknowledged as the major socio-economic and environmental factor that will affect water in OECD cities, in the OECD survey on urban water governance (OECD, 2015 forthcoming; see chapter 5 for more details). Cities that rely on surface water will be affected. Cities that rely on groundwater will be affected as well, where they face salinization (e.g. in coastal zones). Groundwater depletion may become the greatest threat to urban water supplies in several regions in the coming decades (OECD, 2012).

12. Cities in several OECD regions already experience severe or recurrent episodes of scarcity. For example, the number of areas and people affected by droughts in Europe went up by almost 20 % between 1976 and 2006 and have cost € 100 billion (European Commission, 2012). In Mexico, increased severity of drought is projected to occur in cities located in the Central, Jalisco and Chiapas regions. In Australia, changes in the frequency of drought will range from -20% to +80% by 2070 relative to present conditions, depending on the location; the largest increase in drought frequency is projected to take place in southwest Western Australia (OECD 2013). In the US, half of the 50 fastest growing cities are in the drought-prone South. Atlanta, the fastest growing metropolitan area in the US, nearly ran out of water in 2007 (Gerrity, Snyder, 2011), and is competing with the seafood industry to secure access to water. In California, global warming and warmer winters are reducing the amount of snow stored in the mountains, and causing snowpacks to melt earlier in the spring. The result is a persistent and exceptional drought (Brewer, 2014), and shortages of water in reservoirs, streams, and wells creating water emergencies.

Figure 1. Projections of future water demand



Source: OECD Environmental Outlook to 2050; output from IMAGE.

13. Analyses of water stress for OECD cities need to factor in infrastructure and traditional adaptation to water shortage. McDonald et al. (2014) argue that hydrological models tend to overestimate the water stress cities face, because they fail to account for canals (to move water from regions where it is abundant to water-stressed areas), reservoirs (to store water when it is abundant to use when it is needed),

and recourse to groundwater. The importance of infrastructure to supply water to cities is illustrated by four detailed case studies developed by Richter et al. (see Box 2).

Box 2. OECD cities' reliance on infrastructure to secure water

Richter et al. (2013) document the sequence of policies adopted by cities in Australia and the US (Adelaide, Phoenix, San Antonio, San Diego) to secure access to water. The case studies highlight striking similarities and successive strategies to secure water supply:

- Cities initially tap their local water supply until it becomes exhausted. Richter et al. (2013) found numerous cases in which a city shifted from groundwater to surface water supply (or vice-versa) as the initial resource became heavily depleted. Building reservoirs contributed to an extensive exploitation of local sources of water.

- Cities next turn to inter-basin transfers of water. However, toward the end of the 20th century, financial, environmental and social consequences were considered more thoroughly, making water conservation more appealing (a low cost, low risk option) than inter-basin transfers.

- Cities then invested in water conservation. This move really started in the 1980s and has since gained traction. And

- Desalination now features in option portfolios, but its development remains marginal and hampered by financial, energy and environmental constraints.

Source : Richter et al. (2013).

14. McDonald et al. (2014) were able to measure cities' reliance on infrastructure to secure water. Building on innovative combinations of data, they calculated that the world's largest cities draw water from almost half of the global land surface, and transport it over a cumulative distance of 27,000 km. Los Angeles is a case in point, as it pulls large amounts of water from sources which lay outside of its watershed (Postel, 1997). When accounting for such infrastructures, 25% of the world's largest cities (above 750,000 inhabitants) are water stressed (McDonald et al., 2014).

15. It follows that cities face a combination of two limitations to access water: geographical (which determines the location, quantity and quality of the nearest water sources) and financial (which drives the capacity to reach out to potentially distant and/or polluted water sources). The first limitation calls for water efficiency and cooperative arrangements, to allocate water where it is most needed. The second limitation calls for innovative financial schemes, and potentially economic growth to generate the resources cities require to invest in water supply infrastructures.

Floods

16. Floods are one of the most costly and damaging disasters, and will pose a critical problem to city planners as they increase in frequency and severity. The latest events of floods (e.g. Genova 2014, North England 2012, New York City 2012, New Orleans 2005), caused by sea-level rise, increased precipitation, inland floods, frequent and violent storms and cyclones, have exposed cities to high costs in terms of recovering from damages, human losses and losses from economic activities. The risk of urban flooding is increasing as a result of climate change and urbanisation, via both rainfall and sea-level rise.

17. The *OECD Environmental Outlook to 2050* (2012) projects that the number of people at risk from floods will rise from 1.2 billion today, to around 1.6 billion in 2050 (nearly 18% of the world's population). The economic value of assets at risk is expected to be around USD 45 trillion by 2050, a growth of over 340% from 2010. This conservative estimate does not factor in the effects of climate change. By region, the increase in economic value at risk is 130% for the OECD, over 640% for BRIICS (Brazil, Russia, India, Indonesia, China, South Africa), and nearly 440% for developing countries.

18. Cities concentrate a large share of these risks and consequences: some are located in coastal zones or flood prone areas; others will be adversely affected by heavy rains, putting strain on drainage systems. Sealed surfaces in cities also alter run-off from rain and storm water, impair the recharge of groundwater aquifers, and increase flood risks.

19. Building on a new set of data, Hallegatte et al. (2013) assessed and projected losses from floods in the 136 largest coastal cities. Average global flood losses in these cities in 2005 were estimated to be approximately USD 6 billion per year. Some OECD cities rank on the top of the list: Miami, New York, New Orleans, Nagoya, Tampa, Boston, Osaka-Kobe, and Vancouver. Due to their high wealth and relatively low flood protection level, three American cities (Miami, New York City and New Orleans) are responsible for 31% of the losses across the 136 cities today.

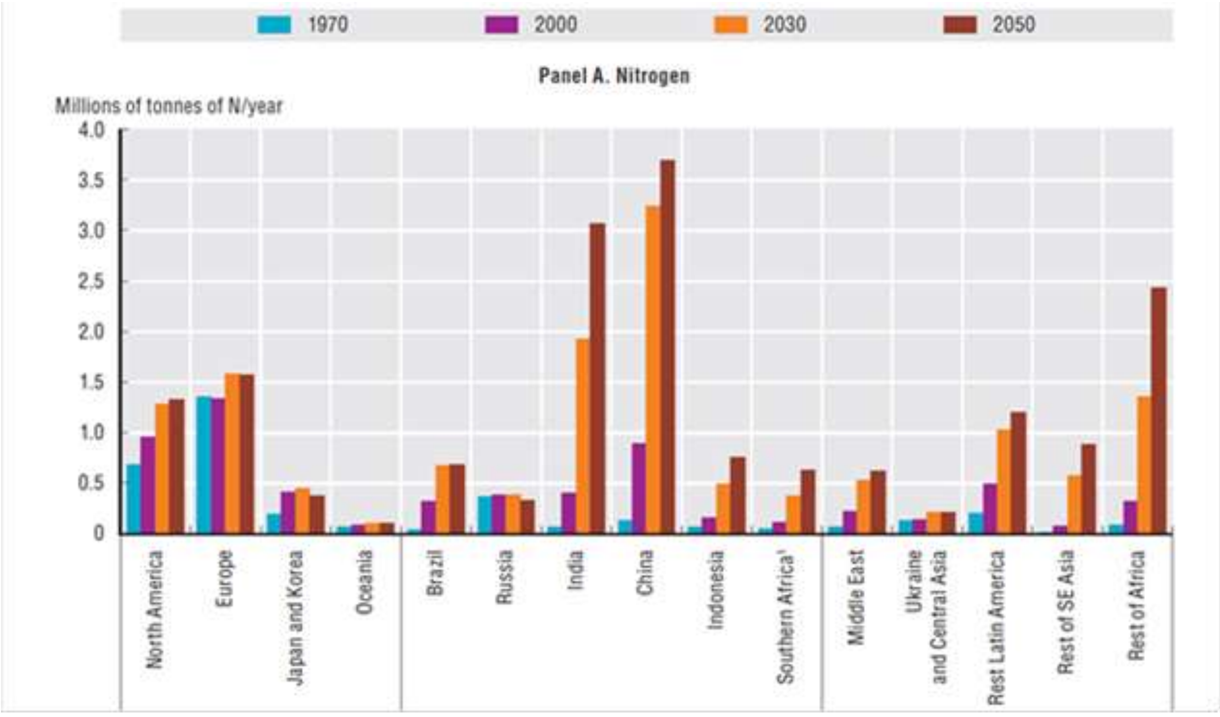
20. The costs can be high: shoreline retreat in the US is projected to cost USD 270 billion to 475 billion for each meter of sea level rise (OECD, 2010d). However, the cost of protection against flooding is minimal in comparison to the cost of inaction. As an illustration, the total costs of flood management in the Netherlands, where more than half of the territory and population and two-thirds of the economic activity are flood-prone, amount to USD 2.0-2.7 billion a year, 0.3% of GDP (Delta Programme, 2013).

Pollution

21. OECD countries have made significant progress in reducing pollution loads from municipal and industrial point sources, by installing wastewater treatment plants and reducing chemical use. As a result, despite increases in population, nutrient levels in wastewater discharge are projected to remain relatively stable in North America and European OECD countries.

Figure 2. Nutrient effluents from wastewater

1970 - 2050



Source: OECD Environmental Outlook to 2050; output from IMAGE.

22. However, whilst improvements in freshwater quality are easy to discern from point sources, such as wastewater discharges, pollution loads from diffuse agricultural and urban sources (fertilisers and pesticides, run-off from sealed surfaces and roads, and pathogens and pharmaceuticals in animal and human waste) are continuing challenges in many countries (OECD, 2012). In nearly half of OECD countries, nutrient and pesticide concentrations in surface and groundwater in agricultural areas exceed national recommended limits for drinking water standards, representing a risk to human and environmental health, and increasing costs for water treatment by cities.

23. Water pollution is affected by shifts in water quantity. Flooding events decrease the performance of storm water treatment, including sewerage overflow, and storm water discharge is contaminated with pollutants from different surfaces, such as heavy metals from road runoff (Mikovits et al., 2014). Drought events decrease the dilution potential of contaminants in point source discharges to surface waters, and additional treatment of wastewater may be required to compensate the lower dilution capacity of the water bodies. In some coastal areas, sea level rise associated with climate change also increases the risk of salt water intrusion in groundwater, which can affect its use for municipal or irrigation purposes.

24. The economic cost of treating water to remove nutrients, pathogens, pesticides or persistent micro-pollutants to meet drinking water standards are significant in some OECD countries, as are the consequences of inaction, such as waterborne disease outbreaks. The expected increase in the frequency and intensity of extreme weather events, and high river flow rates caused by climate change may cause re-suspension of pollutants stored in sediments and exacerbate the problem. Furthermore, the challenge of water treatment to remove contaminants is compounded by the increasing public expectations of infrastructure performance, and human and environmental protection.

Box 3. The costs of unprotected drinking water supplies

In 1993 the largest recorded waterborne disease outbreak in the United States took place when treatment plants in Milwaukee, Wisconsin failed to eliminate Cryptosporidium oocysts introduced into surface waters by runoff from nearby cattle pastures. The incident resulted in more than 403,000 cases of illness (25 percent of the population) and 104 deaths in just two weeks. According to an analysis by the Centers for Disease Control, the total cost associated with the outbreak was $96.2 million (1993 dollars), including $31.7 million in medical costs and $64.6 million in productivity losses (Corso, 2003). Note that these estimates provide only a lower bound on the true economic cost of the outbreak, since they do not consider willingness to pay to avoid the deaths and illnesses the outbreak caused.

Source: USEPA (2013), *The Importance of Water to the U.S. Economy. Synthesis report*, Washington DC

25. A growing source of concern is emerging pollutants and their effects (known or unknown) on aquatic ecosystems and human health (OECD, 2012). The concept of emerging pollutants is not clearly defined. It broadly covers new materials such as nanomaterials, and new chemicals, as well as existing chemicals, for which new adverse effects are still being identified. Emerging pollutants have a variety of uses, such as human and veterinary pharmaceuticals, cosmetics, cleaning agents, pesticides and biocides. Persistent or acutely toxic micro-pollutants in water bodies can generate adverse health and environmental effects, such as interference with the endocrine (hormone) systems of humans and animals leading to cancers, birth defects, and other developmental disorders. One feature of emerging pollutants is that, while their presence in the environment can be measured, their consequences on human and environment health are often unknown (e.g. in case of degradation products), or their individual contribution to the overall health and environmental impact from the combination of chemicals present in surface water is difficult to determine.

26. Such emerging pollutants may raise the future cost of water treatment for potable use and before discharge to the environment. The prevailing model for water management in OECD cities characterised in the opening section is inadequate to mitigate the risks generated by diffuse and emerging pollutants.

The Resilience of Freshwater Ecosystems

27. Cities' water security partly relies on ecosystems and the services they provide. For example, floodplains and wetlands can reduce the impact and occurrence of water–related disasters: they can protect cities from floods and droughts, by absorbing or storing excess water. The natural environment can also filter or dilute pollutants, and improve the quality of the water cities access. Indirect potable reuse is a clear illustration, where treated wastewater returns to water bodies (surface water or aquifers) before it can be used again. Surface water bodies also provide artistic, educational, recreational and spiritual well-being to city dwellers.

28. Cities often alter and degrade water ecosystems and reduce their resilience. It is estimated that 25% percent of the world's rivers no longer reach the sea (Gaffney and Pharand-Deschenes, 2012), as a combination of several malpractices, including from cities. The alteration of natural hydrological systems results in increased runoff rate and volume, decreased infiltration and groundwater recharge baseflow; deterioration of water quality in streams, rivers, and shallow groundwater; and loss of natural habitat and biodiversity. Climate change is also projected to cause adverse impacts on freshwater species diversity and water quality as a result of an increase in water temperature, and changes in physical, chemical and biological properties of lakes and rivers (IPCC, 2007).

29. Such degradation comes at a cost. The Nature Conservancy has analysed 2000 catchments serving over 500 cities over the world (The Nature Conservancy, 2014). It computed that large cities

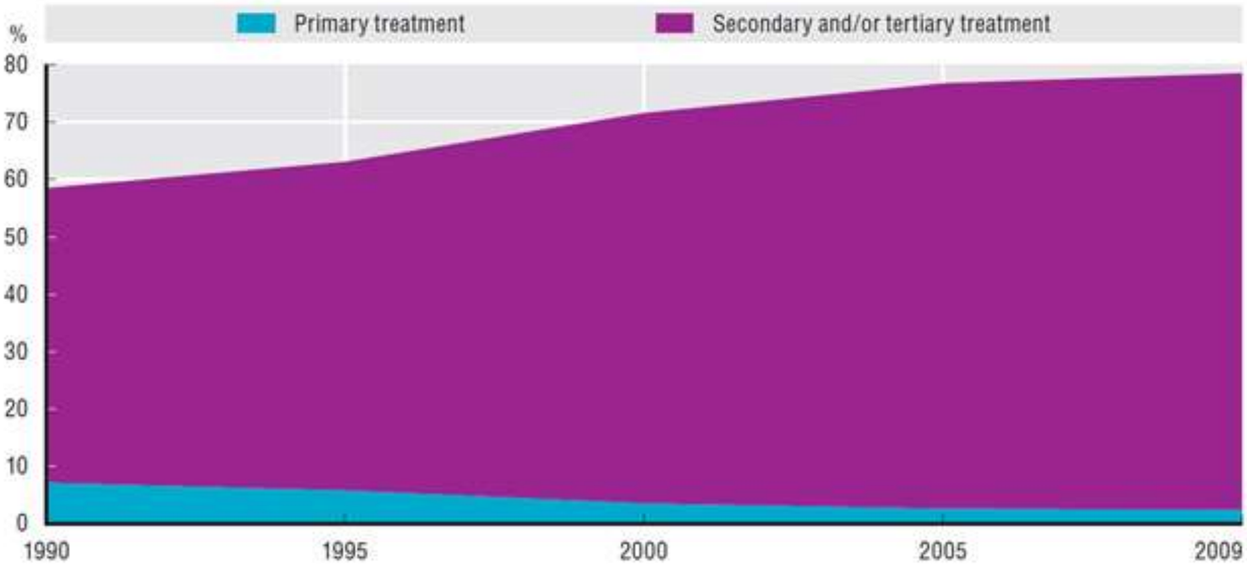
depend on an area the size of Russia to collect, filter and transport water. 700 million people could receive better quality water if cities fully invested in nature. Surveyed water utilities could potentially save 890 million USD a year in water treatment costs through watershed conservation.

Ageing infrastructure

30. OECD cities are usually well-equipped with infrastructures to supply the water they need, to collect and treat wastewater, to protect from floods and heavy rains, and to alleviate the effects of drought. Access to safe water supply and coverage by sewerage networks are distinctively good in OECD countries (OECD, 2012).

Figure 3. OECD population connected to wastewater treatment plants

1990 - 2009, % of total population



Source: OECD (2012).

31. Recent developments have focused on the construction of wastewater treatment plants to improve the quality of wastewater discharge to the environment. For example, European cities have adapted to the requirements of the European Union Urban Wastewater Directive since the nineties. In comparison, renewal of existing infrastructure is lagging behind. The status of WSS infrastructure is not known with accuracy, but converging evidence in several countries suggests that urban water infrastructure requires significant investment to keep up to current and future challenges. Furthermore, networks are ageing and deteriorating; many water networks are nearing, or past, the end of their design life (Davis et al., 2013). For example, 75% of urban water networks in the UK are more than 100 years old (Water UK, 2011); about half of the main water pipes in London are more than 100 years old, and one-third could be even older than 150 years (London Assembly, 2003).

32. Ageing puts the efficiency of water infrastructure at risk. For instance, leaking pipes generate additional costs : to the environment (as more freshwater is used and lost, and some wastewater returns to the environment untreated), and from a financial perspective (opportunity cost of leakage as well as the cost incurred to treat the water that leaks before it reaches the consumer, which increases the unit cost of treatment). In the UK, the total water leakage has decreased from 30% to 22% during the last 20 years (Ofwat, 2012). Whilst it is technically possible to further reduce the loss percentage, it is not currently

economical (Beal et al., 2012). However, with a consistently increasing demand for water, and a potential reduction in future supply with climate change, it is inevitable that the future value of water will increase, and the further improvement of infrastructure efficiency will become cost-effective (Karaca et al., 2014).

33. In addition to infrastructure inefficiencies and leakage, ageing infrastructure eventually leads to increases in asset functional failures and corresponding increases in the risk of social and commercial disruption, and impacts to human and environmental health (Davis et al., 2013). Failures such as water main bursts or sewage spills can also impose significant costs on both the service provider and the water user (Davis et al., 2013). Furthermore, the risk and consequences of failure are greater with climate change and the rise in frequency and intensity of extreme atmospheric events, coincident with the pressures of further urbanisation. Ageing infrastructures also generate future liabilities, as renewal will be more costly as infrastructures decay. For these reasons, significant investments are required to replace or refurbish ageing and inefficient infrastructure for disaster preparedness, and to increase the structural resilience of water systems (Ray and Jain, 2014).

34. A final point needs to be made on ageing infrastructures in OECD cities. Traditional urban water infrastructure in OECD cities is energy intensive. In a recent communication, Sanders and Webber (2013) note that in the absence of energy-constraints, universal access to a safe and secure water supply would be achievable. However, water requires energy for treatment and pumping. For example, 13% of annual US primary energy consumption is for water services (water treatment consumes a significant part of that energy, but water heating is the primary use of energy). The consumption of energy and cost of WSS services are increasing as clean, gravity-fed surface water sources become over-allocated, and water is collected from increasingly distant, deep, or contaminated sources that require large amounts of energy for pumping and water quality treatment. As easy-access water sources have been tapped first, there is a risk that future water supplies will be more expensive and energy intensive than prevailing ones.

35. In Australia, Kenway (2014) calculated that urban water services indirectly utilise 8% of Australia’s primary energy (13% of electricity, 18% of natural gas use). The largest share of energy consumption through water services related to water use, not water supply. Water used for heating and industrial use were the primary users of energy in urban water, with utilities consuming roughly 10% of energy consumption for water services in Australian cities. Furthermore, energy costs are projected to rise due to increasing demand for energy associated with socio-economic growth. For example, Kenway (2014) notes that the energy demand for water in Australian cities is anticipated to grow by 200–250% between 2007 and 2030. The energy bill for urban water management is projected to multiply by six in most Australian states as a result of this increase in demand for energy.

36. The rest of this section reviews the gap in water infrastructure financing and general trends, based on available data on infrastructure needs and related costs for urban water management. While international data on urban water infrastructures and financing needs is patchy and largely inconsistent, some conclusions emerge. They converge with selected country level analyses, which can be more robust, but difficult to compare across countries.

Global projections for financing needs for urban water infrastructure

37. Infrastructure needs for urban water management are difficult to measure. This is so for two main reasons. First, Lloyd Owen (2011) notes that there is an assumption that WSS infrastructure assets need to be replaced after a fixed period of time: 40 to 80 years for water and wastewater distribution systems; 25 years for mechanical systems (pumping stations and water and sewage treatment works), or 10-15 for some sub-systems and components. However, in reality, asset replacement/refurbishment cycles can be considerably longer than the design life, resulting in a decline of the serviceability and value of the assets. In the North London, Thames Water is facing 30–35% distribution losses from pipes laid 120–150 years

ago (Lloyd Owen 2011). Second, there is no clear optimal level of performance for existing infrastructure. Lloyd Owen (2011) further notes that there is no ideal leakage level. However, leakages above 15-20% do need to be addressed as a part of basic refurbishment and maintenance work, because of contamination issues and loss of opportunity costs. In Germany and the Netherlands, leakage rates of 3-8% can be considered as close to the present realisable limit.

38. With this caveat, there is a strong consensus that global financing needs for urban water infrastructure are significant and rapidly increasing. The results of three different studies on the global capital required for investment in water infrastructure are presented in Table 1 (Box 4 provides more information). Global estimates of required water infrastructure investment ranged from USD 6.7 trillion to USD 22.6 trillion, by 2030 and 2050 respectively. Projected OECD required investment in water infrastructure also varied markedly between the OECD (2006) and the Lloyd Owen (2011) studies. Based on selected country analyses, the OECD (2006) study concluded that the mean level of expenditure on water services for high-income countries was in the order of 0.75% of GDP (from 0.35% in Italy, to 1.20% in France). Of note, global capital needs for full coverage urban WSS services, for the period 2008-2050 were in the range of 7.5 trillion, 15 times greater than rural needs over the same period (Lloyd Owen, 2011).

39. Despite the inconsistencies between the studies noted above, several important messages derive from the attempts to project infrastructure needs for urban water management:

- In OECD cities, the water supply and wastewater system networks are generally the most valuable assets, comprising some 60-80% of the total value of all urban water and wastewater systems. For example, in the United Kingdom, the current value of existing sewage assets alone is some USD 200 billion (OECD, 2006).

- OECD cities are increasingly facing critical future investment needs for water management to upgrade ageing systems and old technologies, and provide resilience to future socio-economic and climate changes;

- Investment needs in water management are large (significantly larger than those required for telecom, land transport, or electricity transmission and distribution), and finances are scarce (OECD, 2006); and

- Although the benefits of investment are likely to outweigh the costs, it does not follow that these projected expenditures will be realised. Indeed, if past experience is any guide, it is unlikely that such investment needs will be met (OECD, 2006).

Box 4. Projections for investment needs in water infrastructure

The three studies referred to in this section build on different definitions and assumptions, and yield different results, with significant discrepancies of up to a factor of three between the projections by Lloyd Owen (2011) and Booz Allen Hamilton (2007).

Table 1. Summary of projected investment required in global water infrastructure

USD trillion

Region	Investment period				
	2005-2015[1*]	2005-2025[1*]	2005-2030[2]	2008-2050[3]	2008-2050[3]
				Basic coverage	Full coverage
OECD	4.74	12.48		2.3	2.3
BRIC	2.98	8.28		2.2	2.8
OECD + BRIC	7.72	20.74		4.5	5.1
Rest of the World				2.2	2.9
GLOBAL			22.6**	6.7	8.0

* Note values are based on average annual estimates over this time period. ** This estimate of USD 22.6 trillion for investment in global water infrastructure compares with USD 9 trillion for energy infrastructure, USD 7.8 trillion for road and rail infrastructure, USD 1.6 trillion for air- and sea-ports, and a total USD 41 trillion for urban infrastructures (Booz Allen Hamilton, 2007).

Sources: 1: OECD, 2006. 2: Booz Allen Hamilton, 2007. 3: Lloyd Owen, 2011.

Some studies focused on water supply and sanitation, while others encompassed water infrastructure more generally. The Booz Allen Hamilton (2007) and Lloyd Owen (2011) studies were global, while the OECD (2006) study focussed on OECD and BRIC countries only. Some studies only measured investment needs, while others included operation and maintenance costs. The Lloyd Owen study (2011) was limited to new infrastructure development because the study was geared towards developing countries, whilst other studies factored in upgrading and renovation of existing systems. Projections by Lloyd Owen (2011) did not factor in climate change, the EU Water Framework Directive, new contaminants, or the presumption of the widespread adoption of desalination and/or water reclamation.

Discrepancies in the studies also derive from the fact that some studies project investment needs, while others measure expenditures (which are likely to be lower than estimated needs). It is also not clear how to deal with refurbishment and replacement: where refurbishment and replacement increases the serviceability levels of assets, it may qualify as capital spending; under other circumstances, it qualifies as maintenance. In any case, there is a high uncertainty about water asset refurbishment and replacement needs, in particular where infrastructure is buried.

Whilst the Booz Allen Hamilton (2007) report does not disclose the basic data on which the calculations are based upon, the OECD (2006) and Lloyd Owen (2011) projections follow distinctive approaches and methodologies:

- The OECD report covers storm water and urban drainage; it has a broader understanding of refurbishment. It is based on the assessment of past expenditures as a share of GDP, at country level. Projected levels were adjusted for a set of drivers which may affect investment needs (including innovation);
- The Lloyd Owen projections are based upon the capital cost of water infrastructure to achieve a set level of coverage and service, and actual costs. Future costs did not incorporate innovation.

Source: Booz Allen Hamilton (2007); Lloyd Owen (2011); OECD (2006).

40. Country level analyses provide additional detail on the status of infrastructures for urban water management. France, Japan, and the United States serve as examples.

France

41. France benefits from a large coverage of water supply and sanitation infrastructures: the networks for water supply are 850,000 km long; the networks for wastewater collection and treatment include 97,000 km of combined sewer, 200,000 km for wastewater only, and 95,000 km for storm water collection. The estimated value of these assets is €150 billion (ONEMA, 2012). Service quality can be assessed based on the indicators below (ONEMA, 2012):

- Compliance with standards for biological quality: 97%[1]
- Compliance with standards for chemical quality: 98%
- Service interruptions[2]: 4.43 per 1000 users
- Leakage rate for urban networks[3]: 21%.

42. Half of the French networks for water supply were built before 1972 (Cador, 2002). The average rate for network renewal is 0.61 for water supply, and 0.71 for wastewater collection and treatment. This means that a full replacement of existing networks would take 160 years for water supply networks, and 140 years for wastewater collection and treatment. However, the average renewal rate is affected by urban-rural disparities; services in high-density urban environments (≥200 habitants per km of network) have a significantly higher rate (1.31), which signals faster renewal. Even so, it would take 80 years to renew existing water infrastructures in densely populated areas, which may be past the design life of the infrastructure.

Japan

43. Historically, Japan has had high investment in water supply services. Since 1955, when Japan entered an age of high economic growth, the development of water supply infrastructures was rapid. A second peak of investment in the 1970s was due to the amendment of the Water Supply Act, followed by a third peak when the “Plan for Fresh Water Supply” and the subsidy for advanced treatment of water were established. However, according to official estimates, there is, and will be, significant future investment required for water infrastructure in Japan (MHLW, 2010). Two primary drivers for future investment in water infrastructure in Japan are: 1) the renewal of the ageing water infrastructure, most of which will need replacement in 20 years; and 2) a need for strengthening of the infrastructure to meet earthquake standards. This investment requirement coincides with a projected decline in available finance, such that 2025, it is projected that the investment needs will exceed the potential available funds for investment (MHLW, 2010). Therefore, there is a critical need to find other sources of capital.

44. The assumptions for these projections are as follows (MHLW, 2010):

- For future investment needs, it is assumed that the water supply facilities nearing the end of their design life will be reconstructed with the same function; and

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[1] Another source (Direction Générale de la Santé; système SISE-Eaux) indicates that 95.2% of the population in France is supplied with water that complies with biological standards more than 95% of the time (2003 data; to be compared with 91.5% of the population, in 1999).

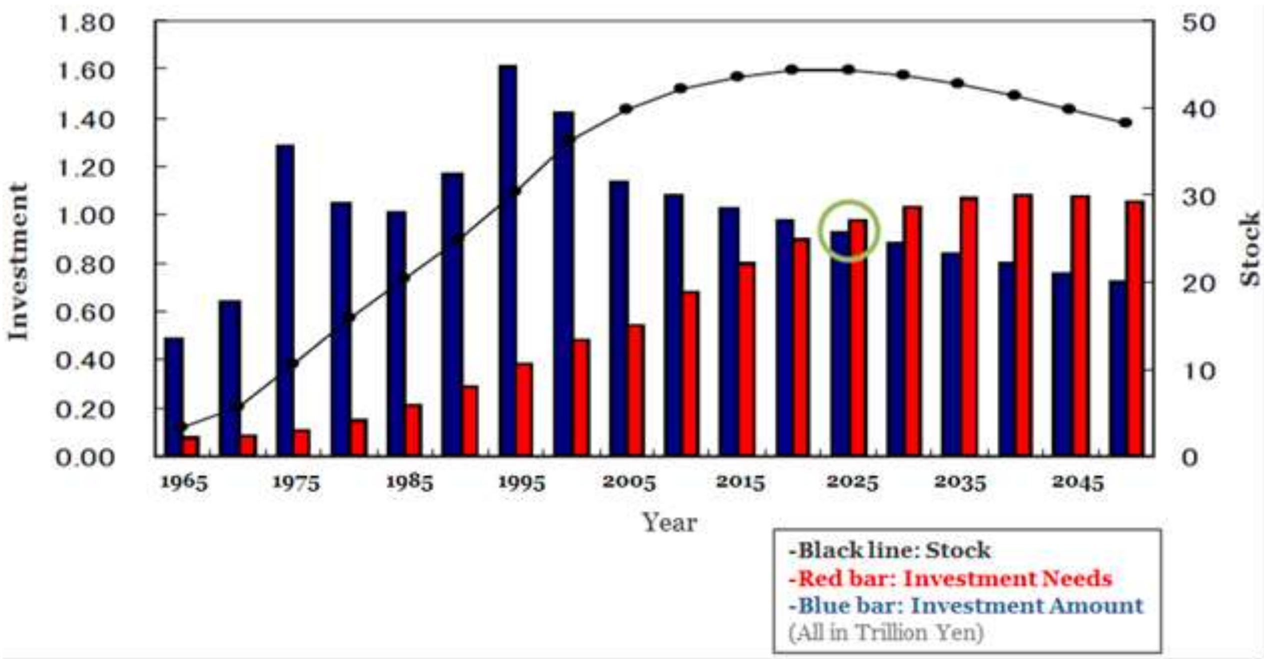
[2] Defined as the number of interruptions in water supply for which water users had not received advance notice.

[3] It is noteworthy that the leakage rate diminishes in regions where the main source is surface water, however surface water often needs costly treatment before it can be used for domestic consumption.

- The investment amount is projected based on the assumption that the annual investment in water supply facilities declines by 1%, compared to the previous year. This assumption reflects the severe financial situation of the Japanese government because the investment capital is largely raised by subsidies from the Ministry of Health, Labour and Welfare (MHLW).

Figure 4. Investment needs in WSS in Japan

trillion yen



Source: Ministry of Health, Labour and Welfare (MHLW) (2010) (http://www.mhlw.go.jp/shingi/2010/02/dl/s0202-8g.pdf) (in Japanese).

The United States

45. The US Corps of Engineers plays a crucial role in the water security for US cities: it provides water supply, supports flood risk management, and regulates the alteration of wetlands. To meet its responsibilities, the US Corps of Engineers builds, operates and maintains extensive and diversified infrastructures for water management.

46. In a recent report, the US Corps of Engineers acknowledged that federal funds over the past 20 years have not been sufficient for adequate maintenance of water infrastructure (National Research Council, 2012). Similarly, local and state funds for water management have been declining. As a consequence, the estimated value of the infrastructure managed by the US Corps of Engineers has declined from USD 237 billion in the 1980s to USD 164 billion in 2010.

47. The funding gap over the period 2000 to 2019 for clean watershed and drinking water capital, operation and maintenance costs is estimated to be over USD 500 billion dollars (USEPA, 2013b), excluding costs of drainage. The investment capital required for the public water system infrastructure to continue to provide safe drinking water to the public, over the period 2011-2030, is estimated at USD 384.2 billion (USEPA, 2013b), excluding expenditures related to raw water dams and reservoirs, projects related primarily to population growth, and water system operation and maintenance costs. Some

commentaries suggest that these figures need to be revised in order to account for adaptation to climate change.

48. Acknowledging that the bulk of required infrastructure has been established, the National Research Council (NRC) provides some recommendations on how the US Corps of Engineers could improve operation, maintenance and rehabilitation (OMR) of its existing water-related infrastructure. These recommendations point towards alternative ways to enhance cities' water security. The NRC (2012) considers that:

- Legislation (in particular the Water Resources Development Act) is geared towards the construction of new infrastructure, and may be maladapted to the present time when the main issue relates to financing operation and maintenance of existing assets;
- There are opportunities for greater involvement of the private sector in the US Corps of Engineers OMR activities;
- Non-structural flood risk management options could be more systematically explored, which "are more efficient, less costly, and provide greater environmental benefits" (NRC, 2012, p.6); and
- There are opportunities to collaborate further with local communities, to lower the costs and share the financial burden.

49. The USEPA (2013b) also suggests that raising public awareness of ageing infrastructure can increase support for the investment required to ensure access to safe and clean water.

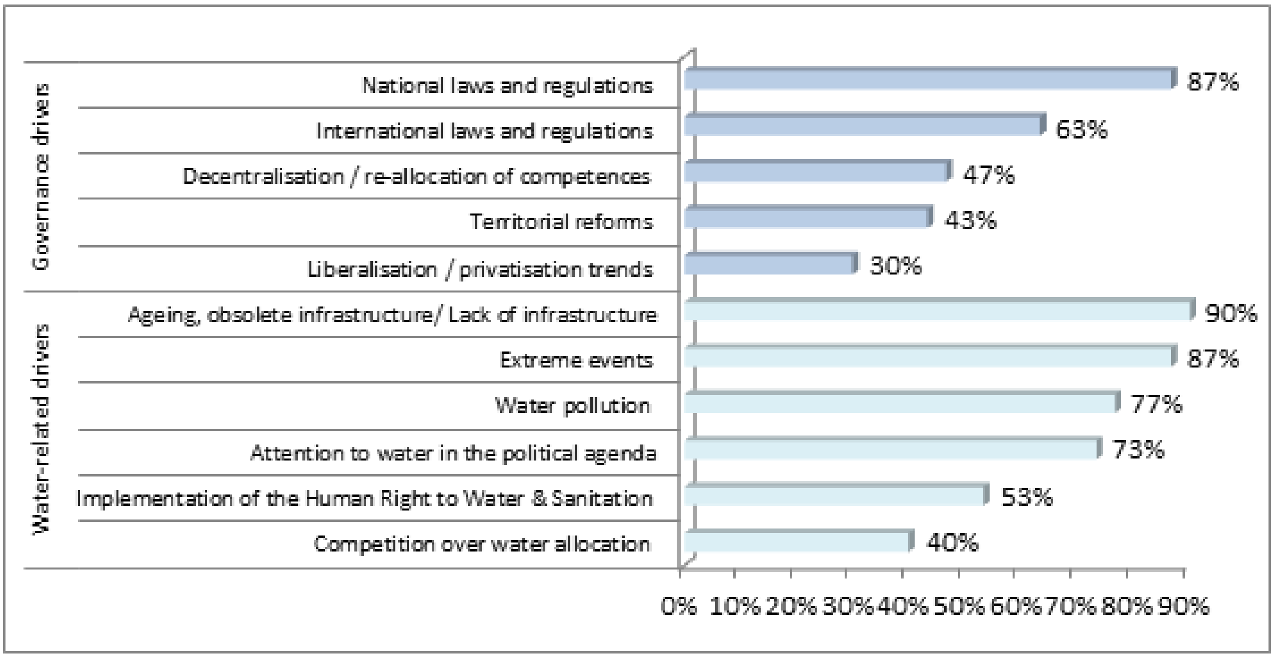
Institutional changes affecting urban water governance

50. Respondents to the OECD survey on urban water governance (OECD, 2015 forthcoming) identified several drivers that have triggered changes in urban water governance (see Figure 5). Some drivers are well established and have been discussed above: climate change and extreme weather events, water scarcity and competition to access the resource, water pollution, lack of or ageing infrastructures. Others are institutional by nature and deserve particular attention: national and international laws and regulations, territorial reforms, decentralisation and re-allocation of competences, and, to a lesser extent, liberalisation and privatisation trends. Even though they do not originate in the water sectors, these institutional reforms affect urban water management.

51. Cities' governance structures affect natural, capital, and human resources available to manage water, the role of local authorities (regulator, facilitator, or service provider) as well as the way cities deal with interdependencies across institutions, places and sectors. Governance arrangements can particularly foster coordination across levels of government, possibly reducing fragmentation. Attention to water in the international political agenda and the implementation of the Human Right to Water and Sanitation call for special attention to disadvantaged people, even in developed countries[4].

[4] For example in France, access to safe water and sanitation services remains an issue for 200,000 homeless people and 3 million inhabitants with unhealthy housing conditions in urban areas.

Figure 5. Key drivers affecting urban water governance



Note: Results based on a sample of 30 respondents who indicated the governance drivers as "critical" and "Important".

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

52. This section discusses institutional drivers. Particular attention is paid to national and international regulations, administrative and territorial reforms, and trends in the water industry.

National and international regulations

53. Local governments and citizens play an active role in the implementation of national and international laws regulating several aspects of urban water governance. An example is the European Water Framework Directive, for which the involvement of local actors and citizens is key for managing water in a sustainable way, better co-ordinating public action across levels of government and reducing conflicts at the local level. National governments regulate the activities of local authorities, and monitor and control their performance to ensure compliance with international human rights obligations, as well as the relevant national legislation, regulations and policies (de Albuquerque C., 2014). The recognition of access to drinking water and sanitation as a basic human right (United Nations' resolution 64/292 of July 28, 2010) stimulated initiatives, such as the European Citizens' Initiative "Water a Human Right" that collected 1.9 million signatures across Europe.

54. Two additional items can be used as illustrations. The first one is environment and health standards, which drive the costs of water security and water services. For example, the European Union Directive on urban wastewater treatment 91/271/CEE, identifies a total of 72.8% of EU-27 territory as sensitive areas/catchments that require more stringent wastewater treatment before discharge to water bodies in order to reduce the risk of eutrophication[5]. The surface area of catchments considered sensitive

[5] According to the definition in the European Directive on wastewater treatment, a sensitive area is a water body where further treatment than that prescribed in article 4 of the UWWTD is necessary either because it is eutrophic or at risk of becoming eutrophic in the near future, or because such treatment is necessary to fulfil other Council Directive(s).

increased by 4.8% between 2011 and 2013 (European Commission, 2011). The EU Directive 91/271/CEE also establishes a timetable, which Member States must adhere to, for the provision of improved urban wastewater collection and treatment systems. A review in 2011 indicated that more stringent treatment installations were already in place for 77.3% of the total generated wastewater load of big cities. The Swiss Federal Office for the Environment recently mandated that the largest 100 wastewater treatment plants in the country add a fourth step in the treatment process, thereby reducing the micro-pollutants in Swiss rivers and lakes by half. The estimated cost of this additional water treatment is 1.2 billion Swiss Francs (FOEN, 2012).

55. A second item is technical standards. Urban water management in selected countries may be biased towards high-cost options. For example, Lloyd Owen (2011) flags that Austria and Germany have adopted a high-cost, arguably over-engineered approach towards provision of WSS services. Such a strategy is driven by national, as well as EU, imperatives. It may be argued that another driver of urban water management is industrial policy, to support domestic engineering and construction sectors. During the period of 1990 to 2010, England and Wales financed a major catching up exercise due to under-spending in the 15 previous years, as well as accepting EU directives which had previously been contested (Lloyd Owen 2011). For example, during 1990 to 2010, England and Wales spent £90 million renewing a dilapidated network, and Germany spent EUR110 million on a network (in the former West Germany) that was considered to be in materially better condition (Lloyd Owen 2011).

Administrative and territorial reforms

56. Administrative and territorial reforms across OECD countries are radically changing the municipal landscape. In 2007, Denmark reduced the number of municipalities from 271 to 98; in Turkey, the number of municipalities was reduced from 3,225 to 2,950 after a reform in 2008 and further decreases (from 2,950 to 1,395) are expected by the end of 2014. In 2007, Finland started restructuring local government and services (the “PARAS reform”), encouraging municipal mergers and municipal cooperation for public service delivery on a voluntary basis (OECD 2013a). In the Netherlands the number of municipalities has been reduced by more than half following several mergers and reorganisations in the last six decades, and ongoing discussions are targeting a threshold of 100,000 inhabitants per municipality (OECD, 2014). Other territorial reforms are in place in Australia, Canada, Germany, Iceland, Norway, Switzerland and the UK (OECD 2014b).

57. The current context of crisis and tight budget policies have given such reforms a further impetus, with municipal merger policies picking up as austerity measures bite. For many governments, the economic and financial crisis has been an opportunity to step up the movement towards reorganising municipalities, with the goal of rationalising and pooling resources to increase the efficiency of local public action.

Trends in the water industry

58. In parallel to these territorial reforms, the water industry in a number of OECD countries is also experiencing deep reforms towards the consolidation and corporatisation of water operators. In Italy for instance, there were 3,704 water services operators and 4,278 wastewater service operators (Marques 2010) before the reforms of 1994 and 2006. Since then, consolidation is under way: there were some 2,000 operators in the water sector in 2014, and the number is expected to shrink to 91 operators. In Ireland, the consolidation of the water industry is very recent or still on-going (see the example of Ireland in Box 5).

Box 5. Consolidation of the water industry in Ireland

Irish Water is Ireland's new national water utility that is responsible for providing and developing water services throughout Ireland. Incorporated in July 2013, as a semi-state company under the Water Services Act 2013, Irish Water will bring the water and wastewater services of the 34 Local Authorities together under one national service provider. Irish Water will gradually take over the responsibilities from these Local Authorities on a phased basis from January 2014. It will take approximately five years for Irish Water to be fully established, at which point it will be responsible for the operation of public water services including management of national water assets, maintenance of the water system, investment and planning, managing capital projects and customer care and billing. As well as responsibility for public water services, Irish Water will also be making capital and investment decisions regarding the country's water infrastructure on a national basis. Irish Water will be accountable to two regulatory bodies – the Commission for Energy Regulation (CER) who is the economic regulator for the water industry, and the Environmental Protection Agency (EPA) who is the environmental regulator.

Source: OECD (2015 forthcoming c), The governance of water regulators; based on www.water.ie/about-us/company/about-irish-water/

59. The management of water service and the consolidation of the water industry are bringing about changes in water service delivery in cities. Lloyd Owen (2013) documents trends in private sector participation for water supply and sanitation globally. The number of people served by private operators continues to grow globally. It is estimated to be above 1 billion people. Lloyd Owen has identified 313 new contracts for the 2010-2013 period. At the same time, opponents to private sector participation claim some gains. More than 86 cities among OECD and non OECD countries re-municipalised water services during the last 15 years[6], either by shifting from private to public ownership of assets or companies, or by changing from outsourced services to direct provision by a public authority. After the re-municipalisation in Paris in 2010, citizen-initiated campaigns have pushed for a similar move in cities such as Marseille and Lyon. A referendum carried out in Italy in 2011 questioned private sector participation in the country. In May 2014, citizens of Thessaloniki (Greece) expressed their strong opposition to the privatisation of the public water company (out of 218,000 people voting, 98% said no to privatisation[7]).

60. The most relevant trends may relate to the change in the industry and in the contracts awarded. Lloyd Owen (2013) documents a shift in private sector participation from long-term towards shorter-term contracts and the emergence of service contracts, in particular performance-based contracts. In the same review, Lloyd Owen also notes the shift towards fewer combined water and wastewater service contracts and more specific contracts addressing one part of the water cycle. Sewerage treatment and water reuse contracts are the most dynamic segments.

[6] http://www.waterjustice.org/uploads/attachments/41_PSIRU_REMUNICIPALISATION_86%20cities%20LIST.pdf
[7] http://europeanwater.org/news/press-releases

Box 6. The Italian referendum on water services

A country-wide consultation was held on 12-13 June 2011. Two of the issues concerned water management. The first question was whether an article in a 2008 law, which required water supply to be managed exclusively by companies in which private investors held at least 40%, should be repealed. The second question was whether an article in the 2006 Environment Code, which guaranteed a minimum remuneration of 7% on capital costs in the calculation of water tariffs, should be repealed.

Several months of intense, often ideological campaigning preceded the referendum, much of it focusing on the principle of private sector participation in the provision of water services. The “yes” campaign argued that water was “a public and common good to be publicly managed.” The “no” campaign argued that private participation in the water sector was necessary to drive efficiency and provide much needed investment.

More than 95% of voters (with a 55% turnout) voted yes all four questions. By restricting the return on capital, the referendum limits opportunities for water utilities (public and private) to raise capital for investment in capital markets. The plans of a number of privately operated utilities to upgrade parts of Italy’s water network have been shelved. Some public utilities may be able to resort – in the short term – to taxation to repay loans, but this option is not available to private operators, including utilities jointly operated by the public and private sector.

Despite the results of the referendum, most municipalities still apply the pre-referendum rules and allow the private sector’s continued involvement in water provision. Supporters of the referendum have asked the Constitutional Court to force these municipalities to comply with referendum outcomes. The decisions taken by the regulator, AEEG, may also have a bearing on this issue. The way in which future tariffs, and the associated rate of return on capital, are defined could influence investment decisions. It is clear that current policies have created considerable uncertainty and are an important impediment to investment in the water sector.

Source: OECD (2013), *Environmental performance reviews: Italy*, OECD Publishing, Paris.

A new role for stakeholder engagement

61. Stakeholder engagement deserves a particular attention as it is expected to play a larger role in urban water management. It is likely to require innovative governance arrangements, to consult with a variety of stakeholders and to leverage their capacity to take initiatives and manage water.

62. OECD work on water security argues that setting an appropriate level of security is not merely a technical exercise: perceptions matter and they can best be factored in via stakeholder consultation. Moreover, OECD city dwellers are puzzled by the fact that conservation policies drive unit costs of water up: efforts to minimise water consumption do not translate in cheaper water bills (see Chapter 2 for further developments). Finally, as Chapter 3 will argue, innovation in urban water management often relies on actions taken by water users (e.g. conservation practices, investment in water-saving appliances). It follows that stakeholder engagement is likely to play an increasingly critical part in urban water governance.

63. Overcoming current and future water-related challenges in OECD cities will require effective governance frameworks, which pay particular attention to stakeholder engagement. Chapter 5 will focus on selected dimensions, building on recent developments of the OECD Water Governance Initiative.

A framework for urban water management

64. This section sketches an analytical framework that helps achieve a certain level of water security for OECD cities, at the least cost for society. The framework brings together four interlinked dimensions, which OECD cities can explore to enhance their water security now and in the future. Financing is one, as OECD cities rely on extensive infrastructures, which need renewal. Innovation (both technical and non-technical) can lower the costs of water security. Some innovations, in particular green infrastructures or

services rendered by ecosystems, require co-operation between cities and their surroundings. Institutional arrangements matter, to combine the different scales at which cities manage water, regulate urban water services, and to engage with stakeholders, who have their say in the level of water security they deem appropriate, how much they are willing to pay to achieve it, etc.

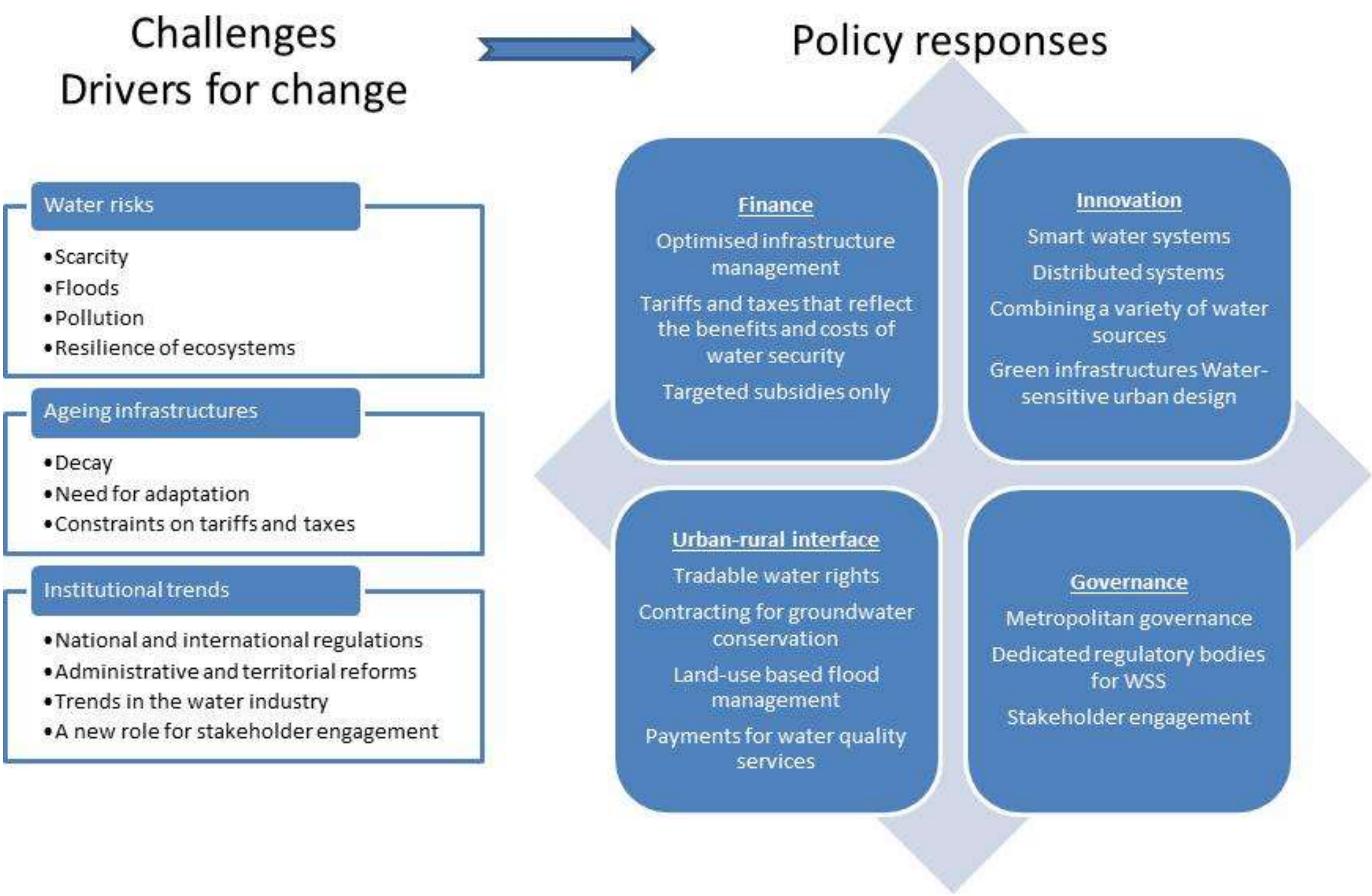
- Financing: what are the options to lower the cost of responses to water challenges (e.g. via enhanced asset management, or exploiting low-cost water sources)? How can traditional sources of finance (in particular tariffs and taxes) be best mobilised? What are the options for harnessing additional sources of finance (e.g. new sources of revenues for water utilities, or private capital)?

- Innovation: which technical (e.g. smart water systems, distributed systems) and non-technical innovations (e.g. water-sensitive urban design) can contribute to water security and affordability in OECD cities? Which barriers hinder their diffusion in OECD cities and how they can be overcome?

- The urban-rural interface: what are the benefits of improved co-operation between cities and their rural surroundings? How can such co-operation be put in practice?

- Governance: how can urban water governance be fit for future challenges? Particular attention will be paid to the combination of different scales for urban water management, stakeholder engagement and the regulation of water supply and sanitation services.

Figure 6. A framework for city-level water management



65. The case study of Auckland illustrates the complex interactions between the four dimensions. It shows a most interesting combination of measures dealing with financing and business models (harnessing property developers, offsetting), technical innovation (storm water management, multipurpose green infrastructures), non-technical innovation (water sensitive urban design, catchment and aquifer accounting), scale (amalgamation, urban-rural co-operation), governance (stakeholder engagement, long term vision reflected in spatial planning).

Box 7. A multi-facetted approach to urban water management - the case of Auckland, New Zealand

Auckland's sub-tropical climate – an average of 1240 mm of rain falls per annum – and location between two sensitive and highly valued harbours make storm water management a core feature of the Auckland Council's role.

Auckland's most pressing water management issues derive from its rapidly growing population and expanding urban footprint. Wherever Auckland has expanded into greenfield areas in the past, freshwater and highly valued marine receiving environments have been degraded. The newly introduced requirement to manage within nationally prescribed bottom lines for freshwater quality elevates the importance of freshwater management as a driver of urban form and design in Auckland, and makes it a key factor in the council and government's plans for managing growth and meeting urban growth demands.

In 2010, Auckland reformed its governance arrangements with the objective to deliver an agreed regional vision and build the economies of scale to deliver it. The region's seven district councils (responsible for managing land and delivering council services) and the Auckland regional council (responsible for managing the environment and regional strategy) were amalgamated to create a single unitary authority.

Amalgamation served to centralise the council's research, investigation and monitoring functions, which has allowed the council to develop a centre of excellence for science, generated the scale necessary to complete high quality work and ensured that policy advice and political decision-making is underpinned by the best quality evidence available.

Amalgamation gave the council and Council Controlled Organisations the necessary scale to tackle issues that were previously beyond the capacity of individual councils. Since amalgamation the council has been able, for instance, to substantially upgrade the region's two key wastewater treatment plants and progress the NZ $950 million 'central interceptor' project that will reduce overflows from the Auckland isthmus' combined waste and storm water system.

The council is currently initiating a "Greenways" programme to align council actions and investment across a range of policy and operational units with the aim of delivering multiple freshwater-, biodiversity-, transport-, urban design-, and storm water-related outcomes from the same investment. To support this the council is developing the necessary capability to convene and support cross-council 'virtual teams' that bring together experts from different backgrounds with community and stakeholder groups to tackle common issues and promote integrated and location-specific outcomes.

While this integration holds the promise of significantly improved and more cost-effective outcomes, the council recognises that it is unlikely this action alone will suffice to meet statutory bottom lines for fresh water quality, especially in already degraded urban catchments. By maximising the integration of council planning, programmes and investment, and catalysing collaboration with community and private sector providers the council is hoping to catalyse innovative responses to complex and emergent water quality issues.

Source: the case study was developed by Andrew Schollum and Grant Barnes, Auckland Council, for the OECD project.

66. The section reviews the four dimensions in more details. It sketches three sets of scenarios for future water management in OECD cities, which illustrate how distinct combinations of the four dimensions lead to alternative futures.

Financing

67. Financing is an essential feature of future water management in OECD cities. As argued above, OECD cities need to upgrade, renew and possibly adjust the infrastructures on which they rely to manage water risks and deliver water services.

68. Infrastructure renewal has been postponed for several decades in a number of countries and cities. Asset management policies have been driven by cheap water that reflects neither the opportunity cost of the resource nor the cost of upgrading existing infrastructures. Underinvestment in infrastructure has resulted in a decline in asset value and an increase in the risk of functional failures, social and commercial disruption, and negative impacts to human and environmental health. Further postponing investment may generate higher damages or costs of transition. It can also minimise the risk of inadequate adaptation of infrastructure to changes in water availability and demand (as uncertainties regarding climate change and population dynamics are reduced), and give access to new and more efficient technologies or practices.

69. Critical to the sustainable provision of sustainable water services is an appropriate combination of revenues from water tariffs, taxes, and transfers from the international community (OECD, 2010). Additional sources may be available to bridge a financing gap, but will be repaid through a combination of tariffs, taxes and transfers. Each of these sources of finance is, and is likely to remain, severely constrained. Therefore, financing water management in OECD cities will increasingly require efforts to: a) minimise the costs of ensuring future water security and provision of water services; b) revisit tariffs and taxes; c) diversity revenue streams; and d) access private finance.

70. The role of financing in achieving water security, including the provision of WSS services, is discussed in Chapter 2.

Innovation

71. Innovation can minimise operating costs of water management and postpone renewal to a certain extent. OECD cities would benefit from two sets of innovation:

- Technical innovation can enhance water security. For example, refined membrane technologies can treat water and wastewater to higher quality grades. Investment will be required, to fit such innovative tools into existing networks. Other innovative technologies can increase efficiency and save costs. For example, methane can be captured in wastewater treatment plants and utilised as a source of energy, thereby minimising energy costs.

- Non-technical innovation matters as well. Innovative business models for water utilities, water-sensitive urban design can minimise the cost of water security and avoid future liabilities. Contractual arrangements between municipalities and water users can share the risks related to water management and the financial burden of achieving water security.

72. Green infrastructures deserve particular attention. They provide ecosystem service benefits, and are an emerging planning and design concept to mitigate urban water risks. There is a range of green infrastructure options to enhance water security, and they can often be more cost effective than traditional engineered approaches. Alternative techniques will bring different combinations of water, energy and land and city managers will need to address trade-offs between these three resources.

73. Innovation takes place in the context of either new greenfield developments[8] (as cities expand or build new areas or facilities, such as a hospital or an airport), or brownfield projects. In OECD cities, the deployment of innovative techniques and practices will often require retrofitting existing infrastructures and reforming prevailing practices. Retrofitting generates particular challenges, which deserve attention.

74. Issues related to the diffusion of innovation for water management in OECD cities are discussed in greater detail in Chapter 3.

The urban-rural interface

75. Co-operation between cities and their rural surroundings allows for more effective water management at the river basin scale. This is because both the drivers of the problems, and the consequences of the chosen policies, have significant effects across different areas, jurisdictions and economic sectors.

76. Urban-rural cooperation can help OECD cities enhance water security. For example, compensating farmers when their land is flooded can be more cost-effective than building dykes, which run the risk of being maladjusted in the long term. Similarly, compensating upstream farmers for attaining water quality objectives (by reducing the use of fertilisers, pesticides and herbicides) can be more cost-effective than treating polluted waters downstream for potable use[9]. Co-operation with other water users in the river basin can also mitigate competition to access limited water resources, particularly during periods of drought. Cities can also contribute to enhanced water security in their environment by minimising sealed surfaces and utilising water-sensitive urban design to recharge aquifers and limit groundwater and surface water contamination.

77. Potential synergies between urban and rural areas will only materialise when appropriate incentives and tailored arrangements are in place: what does it take for farmers to embark in sustainable agricultural practices to protect a catchment, or to accept that their property be flooded to protect the city downstream? How can governments, national and local, create the appropriate collaboration and outcomes?

78. The role of the urban-rural interface in achieving water security is discussed in Chapter 4.

Water governance

79. Multi-level governance gaps are manifold in the way OECD cities manage urban water. Some are compounded by the emerging challenges noted above (e.g. administrative, policy or funding gaps). Others are stemming from the change in the "governance climate" and the call for more inclusive and bottom-up policymaking (e.g. accountability, information and capacity gaps). Moreover, the dimensions sketched above require adjustments of urban water governance. Three issues deserve particular attention:

- How can the different scales be reconciled at which water has to be managed, from buildings (in the case of decentralised systems) to catchment (when cities co-operate with their surroundings)?

[8] Greenfield developments are defined as creation of planned communities on land not yet converted to development (typically on green surroundings of cities). They contrast with brownfield developments, which take place on previously developed land.

[9] Such a practice can be compatible with the Polluter Pays principle when compensations are attached to concrete objectives regarding the improvement of water quality and the sustainability of particular services.

- How does the establishment of dedicated regulatory bodies answer the critical issues faced in the regulation of urban water supply and sanitation services?

- How can stakeholders contribute to the design and implementation of effective urban water management?

80. Future developments in urban water governance are explored in Chapter 5.

Alternative scenarios for urban water management

81. Three scenarios for urban water management help illustrate how the four dimensions outlined above can be combined, prefiguring alternative modes to manage urban water, with distinctive economic and environmental performance and social equity. The scenarios have been developed in the research project Eau&3E (see Barraqué, Isnard, 2013, for a synthesis). The project focussed on France, but most of the lessons learnt are relevant for OECD countries.

82. A first set of scenarios stay within the limit of the prevailing model for urban water management: revenues from water bills remain the main source of finance; technological trajectories remain the same; and environmental and health regulations are basically unchanged. This situation is likely to lead to a rapid decline of service quality (in terms of the quality of water supplied and of treated wastewater), to additional pressure on water resources, and to severe affordability issues. Some adjustments could take place: on tariffs, to reflect social concerns and to incentivise water efficiency; and on infrastructures, to rely on pipe-less technologies where networks reach their limit. However, these adjustments do not translate into better sustainability of urban water management. A more aggressive attempt to control demand is an option, but may trigger resistance from water users and generate dire financial consequences.

83. A second set of scenarios lead to a radical revamping of the prevailing model. Alternative sources of finance are explored, based on a revision of the public good dimension of selected elements of the water cycle - wastewater treatment and protection against fire are financed by taxpayers. Alternatively, cross-subsidisation of water services could be considered, or mutualisation of some support functions, leading to a reorganisation of water services. The existence of a unitary service could be questioned, and dual water treatment could be explored, with basic services provided as universal ones, while parts of the city could access an improved service, at a higher cost. These options can contribute to financial sustainability, but raise other concerns, such as political acceptability and equity issues.

84. A third set of scenarios recombine the management scale of water services. Urban water can be managed at a larger scale, to mutualise access to the resource, benefit from economies of scale, and provide some territorial solidarity. At the same time, urban water systems may reach diseconomies of scale, as they extend to supply distant urbanites. They can be managed at smaller scales, combining both piped and non-pipe technologies where appropriate. Such approaches can be driven by central states, leading to territorial reorganisation. Alternatively, they can result from initiatives between urban and rural communities, such as payment for ecosystems services, whereby downstream cities pay upstream farmers for preservation of natural ecosystems to secure water (in terms of both quantity and quality). A third option cannot be excluded, where cities rely on themselves to secure the water they need, in isolation from their environment, by desalination and systematic water reuse.

85. The three sets of scenarios highlight that urban water management can evolve in different directions. They reflect social preferences in terms of the appropriate level of water security, solidarity across territories and user groups, or relative values attached to water, land or energy. While such preferences may be implicit, the scenarios help anticipate some of their consequences and prefigure the cities and societies we will live in.

Clustering cities as regards water management

86. The section proposes a working definition of cities, based on previous OECD work. The point is that administrative boundaries are inadequate to account for the challenges cities face and the initiatives they take. Other criteria are relevant to approach urban issues. In addition, a typology is sketched to cluster cities as regards water management.

A working definition of cities

87. The OECD has traditionally used thresholds based on population density (the ratio between population and the total area of the administrative unit) to classify regions as either urban or rural. While this approach has the obvious benefit of simplicity and performs well for several applications, it has clear limitations when applied to the analysis of urbanisation patterns and their effects on the economy, the environment and social relations.

88. While the concentration of people in dense urban centres of "established" OECD cities has slowed down or even decreased in some cases, other agglomerations of varying sizes including London, Milan, Tokyo, Manchester and Lyon have not stopped changing. Such changes are often changes in form, in what constitutes a city's geographic footprint, rather than increases in population density. Some urban areas are evolving from monocentric agglomerations to more complex systems made of integrated urban centres (cores) and sub-centres. In other territories, a number of cities and towns are increasingly linking up, forming polycentric integrated areas. This changing spatial organisation of cities and the wider territories within which they are located directly affects the quality of life of their inhabitants, the demand for transport infrastructures, the surrounding landscape, the directions of human and capital flows, and the global environmental footprint of urbanisation.

89. The OECD (2012b) notes that monitoring urbanisation and comparing the performance of urban areas require new definitions based on economic function rather than administrative boundaries. A definition of urban areas as functional economic units can better reflect these changes and guide the way city governments plan infrastructure and services. The concept acknowledges:

- The growing consensus that public policies should be concerned not only with the scale of urbanisation, but also with its geographic shape. The functioning and efficiency of linkages between cities, and those between urban and rural areas, can lead to important changes in how and where economic production takes place.

- The role of large metropolitan areas in the global economy and their capacity to realise the benefits of economic agglomeration, industrial clustering and innovation.

- The potential of medium-sized cities to drive more sustainable urban development, without the costs and inefficiencies associated with mega-cities.

90. The OECD in collaboration with the EU (Eurostat and EC-DG Regio) has developed a harmonised definition of urban areas as "functional economic units", thus overcoming previous limitations linked to administrative boundaries. The functional approach better fits the dynamism of urban contexts, using population density to identify urban cores and travel-to-work flows to identify the hinterlands whose labour market is highly integrated with the cores (OECD, 2012b). It facilitated identification, for each OECD country, of all urban systems with a population of at least 50,000. We return to this in Chapter 5, when discussing institutional arrangements to manage water in OECD cities.

A typology of OECD cities for water management

91. Cities will be exposed and affected by water challenges differently. Their capacity to respond will also vary. A typology of OECD cities is sketched below, which is relevant from a water management perspective. The typology combines two sets of criteria: a) challenges cities face regarding water management; and b) cities' capacity to respond to these challenges, which depends on exposure to water risks, features of the urban environment, and the institutional architecture. OECD cities would benefit from the possibility to situate themselves vis-à-vis other cities facing the same water-related challenges and endowed with similar capacities to respond.

92. Similar attempts found in the literature pave the way. Box 8 captures relevant groupings developed by Fernandez (2014) and SWITCH (van der Steen, 2011).

Box 8. Types of cities as regards water management

Applying the concept of urban metabolism[10], Fernandez (2014) proposes a global typology of cities. The typology builds on the consumption of major categories of material and energy resources including total energy, electricity, fossil fuels, industrial minerals and ores, construction minerals, biomass, water, and total domestic material consumption. It consists of five types of cities:

- *Developing regions*: The most challenging cities in developing regions consume small quantities of materials and resources.
- *Significantly industrializing economies*: Cities with access to abundant resources consume little electricity and score higher on other dimensions. Some OECD cities belong to this category, including Istanbul, Mexico and several Japanese cities (Nagoya, Osaka, Tokyo, Yokohama).
- *Transition economies*: Cities where consumption of industrial minerals and ores is low, while all other consumption categories are medium to medium-high. OECD cities in this category include Barcelona, Budapest, Lisbon, London, Madrid, Milan, or Rome.
- *Mining and coal-fed economies:* Mining and coal-fed economies have a specific pattern, and are characterised by a high consumption of fossil fuels and lower consumption of biomass, construction minerals and domestic materials. The OECD cities of Athens, Berlin, Dublin, Prague, Santiago, Tel Aviv, and Warsaw fall in this category.
- *Low density and high affluence cities:* Low density and high affluence cities consume high levels of material and energy sources; some of which face challenging climates. OECD cities in this category include Boston, Denver, Detroit, Melbourne, Phoenix, Sydney, and Vancouver.

Water is not a discriminating factor in Fernandez's typology. This suggests that urban water management is affected by dimensions that are not specific to the water sector. Such dimensions include endowment in energy and material resources. This endowment will affect technology choices for urban water management and incentives for energy-efficient water services.

Van der Steen proposes a typology of cities that is relevant for urban water management, based on features that combine water issues with governance capacity: affordability issues; capacities in the water sector; rainfall patterns (tropical, moderate, affected by climate change); scarcity of water resources; potential for reuse of treated wastewater. Combining these distinctive features, van der Steen clusters cities into three broad categories:

- Type 1 - Water management driven by basic service issues;

[10] Urban metabolism is defined as the study of the physical flows required to serve the urban economy.

- Type 2 - Water management driven by water scarcity; and
- Type 3 - Water management driven by climate change effects on rainfall patterns, flooding and water quality.

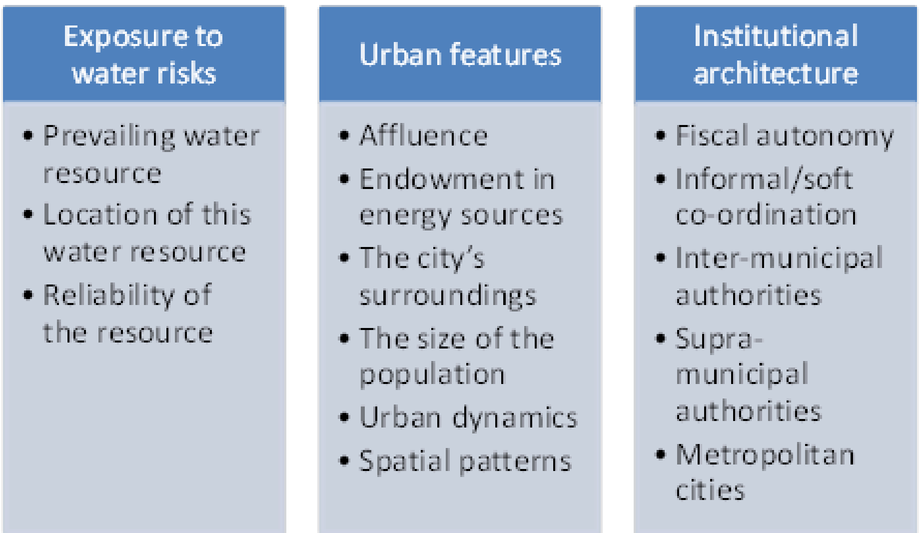
Source: Fernandez, J. E. 2014. Urban Metabolism: City Typologies, Presentation at 2014 MIT Europe Conference. Brussels, Belgium. Steen P. (van der) (2011), Application of Sustainability Indicators within the Framework of Strategic Planning for Integrated Urban Water Management, SWITCH Deliverable 1.1.7

93. The typology sketched below draws on considerations developed in this chapter and on OECD work on urban development and territorial indicators. It combines three dimensions:

- exposure to water risks: too much, too little, too polluted water and risks to the resilience of ecosystems;
- distinctive urban features: affluence, energy endowment, surroundings, size, urban dynamics, spatial patterns; and
- the institutional architecture.

94. Figure 7 brings the different dimensions together. The rest of the section explains the dimensions and the criteria to capture them in more details.

Figure 7. Criteria to cluster OECD cities as regards water management



Water risks

95. Water risks have been discussed in detail in this Chapter. Relevant criteria to characterise a city's exposure to water risks include: **the prevailing water resource** (surface vs ground water); **the location of this water resource** (local vs distant - distant sources require infrastructure to transport water and are more

likely to face potential conflicts with other distant users); and **the reliability of the resource** (renewable vs non-renewable source; level of water stress).

Urban features

96. Several urban features affect a city's exposure to water risks and its capacity to respond. These include:

- **Affluence**. It drives water consumption and demand from city dwellers, infrastructure design, and financing capacities. It also affects the value of assets at risks. A simple criterion to measure affluence would be GDP per capita (above vs below average for OECD urban areas).

- **Endowment in energy sources**. It affects construction and operation costs and can drive trade-offs between water, energy and land. It may be difficult to identify a simple metrics. Fernandez' work provides preliminary data (see Fernandez, 2014).

- **The city's surroundings**. The surrounding can be a source of risks (coastal zones) and be vulnerable to human impact. It can also provide ecosystem services. Appropriate categories are urban vs rural; coastal zones and deltas.

- **The size of the population**. It affects exposure to risks and raises issues of scale. Large cities have more opportunities to collect revenues and invest in water security; they accumulate expertise and technical capacities, to plan, manage and operate water infrastructures. Small cities face lower competition with water users, discharge less wastewater runoff, and impact less on the resilience of freshwater ecosystems. In Chapter 5, cities are clustered in the following categories: i) below 500,000; ii) between 500,000 and 1.5 M inhabitants; iii) between 1.5 M and 5 M inhabitants; and iv) above 5 M inhabitants.

- **Urban dynamics**. Growing cities will have opportunities to invest in greenfield developments and new infrastructures, and to raise additional revenues (including local taxes). However, planning and investment in water security and water services need to keep a pace with population growth. There is a risk that rapid urban development generates future liabilities. Shrinking cities may be trapped with oversized infrastructure, and fail to generate the revenue required to operate and maintain them. Urban dynamics can be measured by the city population growth rate, compared to the average population growth of OECD cities (OECD metropolitan database).

- **Spatial patterns**. OECD cities can be distinguished in terms of compactness or sprawling (see OECD 2012a for more information). Compact cities seem better able to conserve land resources for agriculture, recreation, and water and energy provision. They can also save costs to connect city dwellers to water services. However, compactness can make retrofitting existing urban water infrastructures more costly and affects the water – energy – land trade-offs. Urban sprawl can affect ecosystems, when natural habitats are destroyed or fragmented by developed land. A relevant criterion is the sprawl index, which enables classification of cities according to the measure of the growth in built-up areas, adjusted for the growth in a city population[11] (see Chapter 5 for an application to a selection of OECD cities).

[11] When the city population changes, the index measures the increase in the built-up area relative to a benchmark where the built-up area would have increased in line with population growth. The SI index is equal to zero when both population and built-up area are stable over time. It is bigger (lower) than zero when the growth of built-up area is greater (smaller) than the growth of population, i.e. the city density has decreased (increased). (OECD Metropolitan database).

Cities by institutional architecture

97. The institutional architecture can affect urban water management in several ways. It can facilitate (or hinder) co-operation at the appropriate geographical scale; co-operation across policy domains; and autonomous decision making on issues that affect water security, depending on how responsibilities are shared. Metropolitan and hydrological boundaries rarely match and stakeholders in the basin have to be accounted for when it comes to aligning views, interests and motivations. Similarly, metropolitan boundaries can encompass several municipalities, even in the absence of metropolitan authority (OECD, 2011b).

98. A first criterion that drives the capacity of a city to take initiative and respond to water challenges, is **fiscal autonomy**, i.e. the capacity to raise revenues affected to the city's own policies. This capacity dictates whether the city has some capacity to adjust revenue streams to needs, or depends on fiscal transfers from a central budget. It can be used as a proxy for political autonomy as well.

99. In addition, OECD (2013) work on urban governance highlights four types of institutional architecture, which are relevant for water governance:

- **Informal/soft co-ordination**. It takes the form of lightly institutionalised platforms for information sharing and consultation;
- **Inter-municipal authorities**, sharing costs and responsibilities across member municipalities;
- **Supra-municipal authorities**. An additional layer above municipalities can result either in a directly elected metropolitan government, or in upper governments setting up a non-elected metropolitan structure; and
- M**etropolitan cities, a special** status for largely populated cities, which puts them on the same footing as the next upper level of government and gives them broader competencies.

100. We return to this in Chapter 5. The typology sketched above can be used to tailor analyses and policy options to specific situations. Chapter 6 in particular signals potential fits between water risks and specific options cities may wish to consider.

References

Allan, T (1997), Virtual water: a long term solution for water short Middle Eastern economies. http://lwrg.org/water-food-and-trade.html. British Association Festival of Science - Water and Development Session, 1997 Leeds, United Kingdom. University of Leeds.

Barraqué B., L. Isnard (2013), Les recherches sur la ville durable : l'exemple de la gestion durable des services d'eau, in *Urbanisme et services publics urbains : l'indispensable alliance*, ASTEE

Beal, S., Trow, S. & Haywood Smith, B. 2012. Environment Agency, Ofwat, Defra Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning. Contract 26777. Northumberland, UK: Strategic Management Consultants,.

Bhatia, R., M. Falkenmark (1993), Water resource policies and the urban poor: innovative approaches and policy imperatives, *Water and Sanitation Currents*, The World Bank, Washington DC

Bicheron P., Defourny P., Brockmann C., Schouten L., Vancutsem C., Huc M., Bontemps S., Leroy M., Achard F., Herold M., Ranera F. and Arino O. (2008), *GlobCover 2005 – Products description and validation report*, Version 2.1,. Available on the ESA IONIA website (http://ionia1.esrin.esa.int/).

Bolognesi T. (2014), Analyse structurelle des systèmes hydriques urbains en Europe: aspects organisationnels et défis patrimoniaux, *Revue d'économie industrielle*, n°147, pp.51-86

Booz Allen Hamilton 2007. Lights! Water! Motion! *Strategy+business magazine (Booz & Company)*, Spring 2007, Issue 46.

Brewer, M. 2014. *U.S. Drought Monitor: October 21, 2014* [Online]. Lincoln, Nebraska: National Drought Mitigation Center. Available: http://droughtmonitor.unl.edu/ [Accessed 30/10/ 2014].

Clothier, B., Collins, D., Heiler, T., Jenkins, B., Mowat, A., Pyke, N., Saunders, C. & Thomas, J. 2009. Virtual Water: Emerging Issues. *The Royal Society of New Zealand*, September 2009.

Davis, P., Sullivan, E., Marlow, D. & Marney, D. 2013. A selection framework for infrastructure condition monitoring technologies in water and wastewater networks. *Expert Systems with Applications*, 40**,** 1947-1958.

European Commission 2012. Water Scarcity & Droughts – 2012 Policy Review – Building blocks Non-Paper. Brussels, Belgium: European Commission.

FOEN (2012), *Mikroverunreiningungen: Spezialfinanzierung für ARA-Ausbau in der Vernehmlassung*.

Frone, S. & Frone, D. F. 2014. Challenges in Analyzing Correlation between Water Infrastructure and Economic Development. *Procedia Economics and Finance*, 10**,** 197-206.

Gaffney, O., F. Pharand-Deschenes (2012), Water in the Anthropocene. Welcome to the Anthropocene: A planet transformed by humanity. http://www.anthropocene.info.

Gerrity D., S. Snyder (2011), The economic value of water in metropolitan areas of the United States, *Water Policy*, 13, pp.443-458

Grey, D. & Sadoff, C. W. 2006. Water for Growth and Development. In: Thematic Documents of the IV World Water Forum. Mexico City: Comision Nacional del Agua.

Grey, D. & Sadoff, C. W. 2007. Sink or Swim? Water security for growth and development. *Water Policy,* 9**,** 545-571.

Grimsey, D. & Lewis, M. K. 2002. Evaluating the risks of public private partnerships for infrastructure projects. *International Journal of Project Management,* 20**,** 107-118.

Hallegatte S., C. Green, R.J. Nicholls, J. Corfee-Morlot (2013), Future flood losses in major coastal cities, *Nature Climate Change,* 3, 802–806

Hunger, M. & Döll, P. (2008), Value of river discharge data for global-scale hydrological modelling, *Hydrology and Earth Systems Science*, 12(3), 841–861

IPCC 2007. Climate Change 2007: Synthesis Report. *An Assessment of the Intergovernmental Panel on Climate Change: Fourth Assessment Report.*

Jenerette D., L. Larsen (2006), A Global Perspective on Changing Sustainable Urban Water Supplies, *Global and Planetary Change*, vol. 50, pp.202-211

Karaca, F., Raven, P. G., Machell, J. & Camci, F. 2014. A comparative analysis framework for assessing the sustainability of a combined water and energy infrastructure. *Technological Forecasting and Social Change,* In press.

Kenway S. (2014), Lessons from the Australian Millennium drought, and emerging frameworks and management tools, communication at the *Energy for Water Workshop*, organised by KAPSARK, Paris, 15 September

Lloyd Owen D. (2011), *Infrastructure Needs for the Water Sector*, unpublished paper commissioned by the OECD in the preparation of the OECD report *Water Security for Better Lives*, OECD Publishing, Paris

London Assembly (2003), *London's water supply*, a report by the London Assembly's Public Services Committee

Lorrain D., F. Poupeau (2014), Ce que font les protagonistes de l'eau, *Actes de la Recherche en Sciences Sociales*, n°203, pp.4-15

Marsden Jacob Associates (2006), Securing Australia's Urban Water Supplies: Opportunities and Impediments. A discussion paper prepared for the Department of the Prime Minister and Cabinet (available at http://www.environment.gov.au)

McDonald R.I., K. Weber , J. Padowski , M. Flörke , C. Schneider , P. Green , T. Gleeson, S. Eckman, B. Lehner, D. Balk, T. Boucher, G. Grill, M. Montgomery (2014), Water on an urban planet: Urbanization and the reach of urban water infrastructure, *Global Environmental Change*, Volume 27, 2014, 96 - 105

Ministry of Health, Labour and Welfare (MHLW) (2010), (http://www.mhlw.go.jp/shingi/2010/02/dl/s0202-8g.pdf) (in Japanese)

Mikovits, C., Rauch, W. & Kleidorfer, M. 2014. Dynamics in Urban Development, Population Growth and their Influences on Urban Water Infrastructure. *Procedia Engineering,* 70**,** 1147-1156.

National Research Council (2012), *Corps of Engineers Water Resources Infrastructure: Deterioration, Investment, or Divestment?*, Washington, DC: The National Academies Press.

OECD (2006), *Infrastructure to 2030. Telecom, Land Transport, Water and Electricity*, Paris

OECD (2010d), *Cities and Climate Change*, OECD, Paris.

OECD (2012), *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD Publishing, Paris.

OECD (2012b), *Redefining "Urban": A new way to measure metropolitan areas*, OECD Publishing, Paris

OECD (2013), *Water Security for Better Lives*, OECD Publishing, Paris.

OECD (2015, forthcoming), Framework for Urban Policies, Paris.

OECD (2015 forthcoming b), *Water Governance in OECD Cities*, OECD Publishing, Paris

OECD (2015 forthcoming c), *The governance of water regulators*, OECD Publishing, Paris.

Ofwat. 2012. *Distribution input and supply pipe leakage for England and Wales: Dataset for 1992/93 to 2010/11* [Online]. Available: http://data.gov.uk/dataset/distribution-input-and-supply-pipe-leakage [Accessed 31/10 2014].

ONEMA (2012), *Observatoire des services publics d'eau et d'assainissement. Panorama des services et de leur performance*, Paris

PBL (Netherlands Environmental Assessment Agency, 2014), *Towards of World of Cities in 2050. An Outlook on Water-Related Challenges*, background report to the UN-Habitat Global Report,

Postel, S. 1997. *Last Oasis: Facing Water Scarcity*, New York, N.Y., Worldwatch Institute.

Ray, C. & Jain, R. 2014. Chapter 7 - Water Infrastructure Development for Resilience. *In:* JAIN, C. R. (ed.) *Low Cost Emergency Water Purification Technologies.* Oxford: Butterworth-Heinemann.

Richter B.D. (2013), Tapped out: how can cities secure their water future?, *Water Policy*, 15, pp.335–363

Sanders K., M.E. Webber (2013), The Energy-Water Nexus: Managing Water in an Energy Constrained World, *Earth Magazine*, July

Sitzenfrei, R. & Rauch, W. 2014. Investigating Transitions of Centralized Water Infrastructure to Decentralized Solutions – An Integrated Approach. *Procedia Engineering*, 70**,** 1549-1557.

The Nature Conservancy (2014), *Urban Water Blueprint*

USEPA (2013), *The Importance of Water to the U.S. Economy. Synthesis report*, Washington DC.

USEPA (2013b), *Drinking Water Infrastructure Needs Survey and Assessment. Fifth Report to Congress*, Washington DC

Water UK (2011), *Sustainability Indicators 2010-11*, London

CHAPTER 2. ADDRESSING THE FINANCIAL CONUNDRUM

This chapter examines the challenges related to financing urban water management. Several factors drive financing needs up while traditional sources of finance are constrained. For example, revenues from water tariffs are affected by declining water use per capita in several city centres; taxes are constrained by fiscal consolidation. The chapter screens options that cities can explore to minimise costs (e.g. green infrastructures), make the best use of tariffs and taxes, diversify revenue streams, or access private finance. The role of financiers, property developers and other private actors is considered.

Key messages

101. Keeping up with current levels of water security in OECD cities will require sustainable financing, to upgrade and renew existing infrastructures and eventually to build new assets. At the same time, prevailing sources of finance for urban water management are severely constrained and are likely to remain so: revenues from water tariffs are affected by the decline of water consumption per capita in several city centres; public budgets available for investment in infrastructures are affected by fiscal consolidation; and international solidarity mechanisms are unlikely to benefit OECD cities.

102. Robust financing strategies for water management in OECD cities combine four elements. First, they minimise operating costs and investment needs via targeted maintenance; efficiency gains, for instance by amalgamating water services at the right scale; or use of low-cost water sources. Each option requires specific institutional arrangements. For instance, amalgamation requires the organisation of deliberative and technical bodies at the appropriate scale.

103. Second, robust financing strategies explore tariff structures that contribute to water resources management (in particular water conservation) and to the financial sustainability of water services. Three inter-related questions deserve renewed attention:

- How to compensate declining water demand? The chapter reviews innovative tariff structures that partially decouple revenues for service providers from the volumes of water sold, and performance based contracts, that reward the attainment of specific objectives such as reduction in non-revenue water, or water or energy conservation.

- How to address affordability issues? The distributional effects of sophisticated tariffs need to be analysed thoroughly to avoid financial losses and unequitable consequences. The chapter reviews several responses, which combine targeted support to those who need it and encouragements to use water-saving appliances.

- Who should pay the water bill? Those who benefit from urban water management or who generate additional costs should be identified and harnessed to foot the bill. Fiscal instruments can redress externalities associated with land development or with impervious surfaces.

104. Third, revenue streams for water management can be more diverse, when cities consider new fiscal instruments (land taxes, or taxes on impervious surfaces), or when utilities develop new services. Finally, OECD cities can tap into new sources of capital. The private sector, including financiers, property developers and small entrepreneurs, is gaining experience in financing discrete facilities at different scales (desalination or wastewater treatment plants; distributed infrastructures). Experience accumulates with public utilities recycling some of the capital tied up in water infrastructures, to generate cash that can be used for new projects. National and local governments need to explore innovative ways to jump start and leverage private investment, where needed.

105. Innovation around these issues abounds in OECD cities. Some institutional barriers need to be addressed so that it diffuses more systematically. Selected barriers include preference for incumbent technologies, cheap water (that fails to recognise negative externalities such as poor maintenance or degrading performance of water services), political interferences (e.g. micromanagement of the service; suboptimal and unstable pricing policy; biased or incomplete definition of performance for water services). The three subsequent chapters address some of these barriers.

Introduction

106. This chapter analyses how financing needs for urban water management in OECD cities can be met. It first documents trends in traditional sources of finance for urban water services, including the 3Ts (Tariffs, Taxes, Transfers) and repayable finance. It then explores strategies OECD cities can use to cover their financing needs. These combine options to minimise costs (through targeted maintenance, or amalgamation of services, for instance), innovative tariff structures and additional sources of finance (such as innovative business models for water utilities and taxes that harness beneficiaries of enhanced water security). The chapter covers both investment in, and operation and maintenance of urban water infrastructure and services.

107. The chapter highlights the connections with innovative technologies to manage water, and the potential benefits of co-ordination with the rural environment. It further identifies requisites that can facilitate the exploration of innovative and financially sustainable options for urban water management. These include regulatory policy, institutional arrangements and stakeholder engagement.

108. The Republic Korea illustrates some of the main points developed in the chapter. Supporting evidence is appended, which confirms that: a) as coverage by water infrastructure develops, operation and maintenance represent a significant and rising share of total costs for urban water management; this raises specific financing issues; b) heavy reliance on public finance is not sustainable, in particular in the context of the economic and financial crisis, where public finance is scarce and competition to access it is fierce; c) at the same time, revenues from water bills are affected by stable, or declining water consumption; and d) new sources of finance can be explored, reaching out to those who benefit from investment in wastewater collection and treatment.

Constraints affecting sources of finance in OECD cities

109. Orthodox economic theory argues that revenues from user charges should cover all the costs related to the service: O&M costs, capital costs and the opportunity costs of using the resource (which can be significant where there is competition to access water sources). The OECD has a distinctive approach, as it acknowledges three sources of funds that ultimately finance water services and infrastructures: revenues from user charges (tariffs), subsidies and transfers from public budgets (taxes), and transfers from the international community: the 3Ts. Other sources of finance can be considered to cover upfront investment: repayable finance, including loans, bonds and equity, but they will be repaid, by a combination of the 3Ts.

110. This section reviews general trends in sources of finance for water services and infrastructures. It zooms in on the 3Ts, and on repayable finance (essentially bank loans and private equity). General barriers to international investment, such as regulatory, currency and corruption risks, apply in the water sector but are not covered in this report.

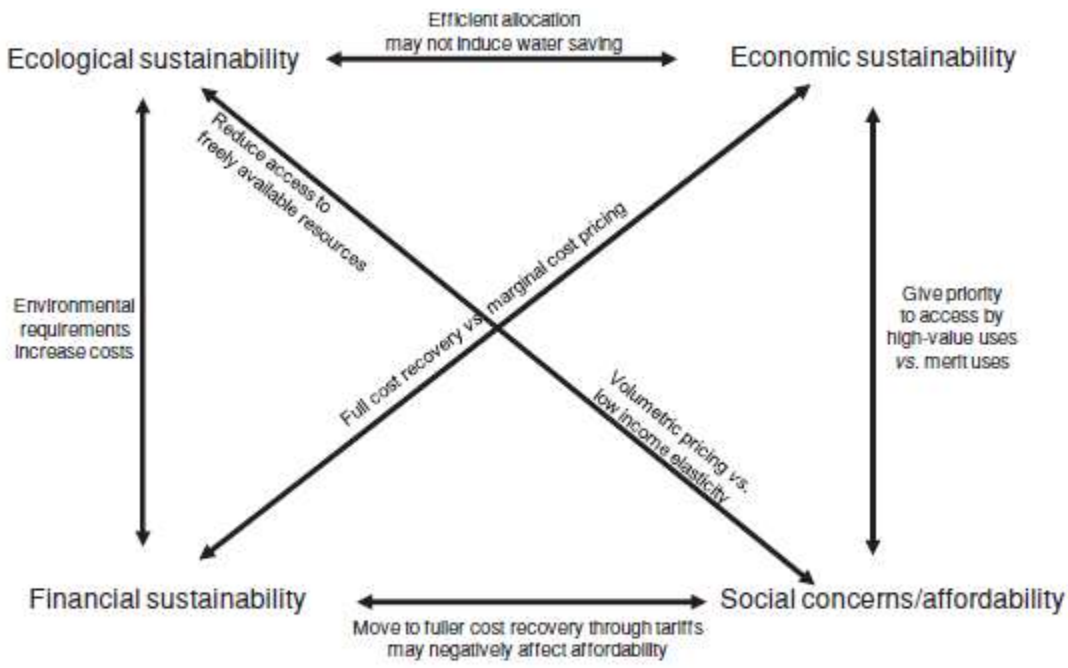
111. The section argues that OECD cities face increasing limitations to access the revenues and capital they need to invest in water-related infrastructures. These trends are not limited to large cities. In New Zealand for instance, small towns experience equal hardship due to population declines and aging infrastructure, leaving a lesser rate base (local taxation) that affects local government’s ability to fund, operate, and maintain infrastructure.

Revenues from water tariffs

112. OECD (2010a) argues that water tariffs serve four objectives, which may conflict with one another: financial sustainability, economic efficiency, environmental sustainability and social concerns. Trade-offs between the four objectives and the capacity to address them evolve over time: income

improvements may enable a low-income community to face the prices needed to obtain services that were previously unaffordable; technological improvements may reduce costs; more effective institutions may emerge; social learning processes may enable the community to accept previously unacceptable solutions (*e.g.* pricing). It follows that pricing strategies would benefit from recurrent assessments and revisions.

Figure 8. Policy objectives and trade-offs that affect price structures for water services



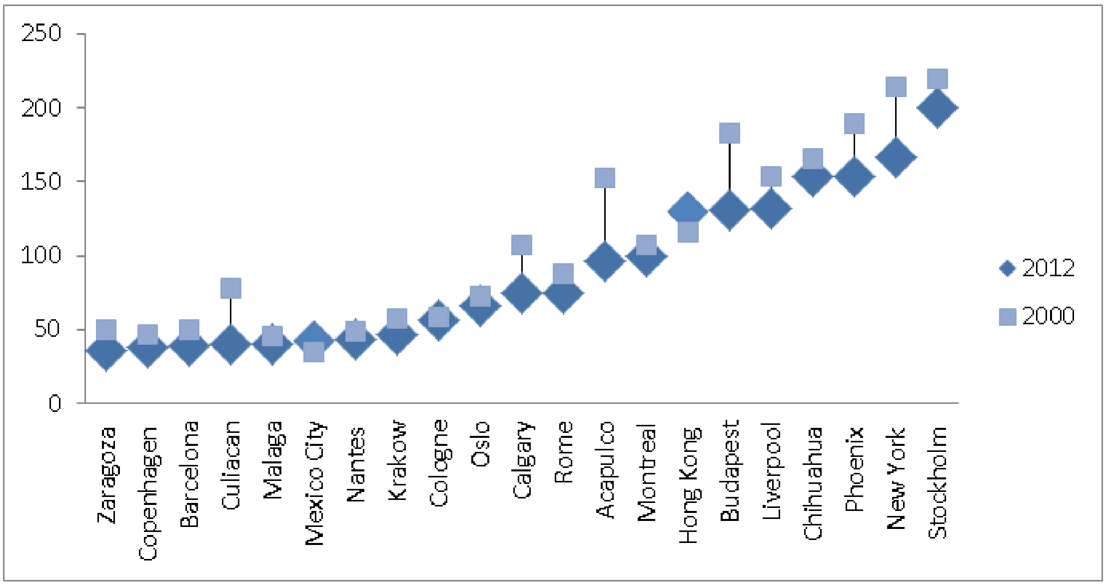
Source: OECD (2010a), based on Massarutto, A. (2007b), "Abstraction Charges: How Can the Theory Guide Us?", presentation made at the OECD Expert Meeting "Sustainable Financing for Affordable Water Services: From Theory to Practice", November.

113. Revenues from user charges are based on the volume of water used and/or wastewater collected (or a proxy thereof) and rates per unit of water used or treated. They are affected by urban water use per capita and by inefficiencies in the tariff setting process, especially when a disproportionate part of costs incurred by service providers is fixed. Note that the share of variable costs is higher when utilities procure bulk water from wholesalers.

114. Per capita water consumption is declining in OECD cities. It declined by 25% in Paris over 15 years; by 16.5% in Berlin between 1995 and 2005 (Poquet, Maresca, 2006); by 31% in Nantes (France) between 2003 and 2008. The OECD (2014) survey on *Water governance for future cities* confirms this trend. Over the last ten years, water consumption generally declined, but it sharply decreased in cities like Acapulco, Budapest, Culiacan, New York and Phoenix. Compared to their respective levels in 2000, only Mexico City (and Hong Kong) shows a slight increase in water consumption. It follows that reduced water consumption per capita becomes the "new normal" in OECD cities. This decline sometimes contrasts with consumption trends in peri-urban areas, driven by urbanisation.

Figure 9. Water consumption in selected cities

2000-2012; m3/inhabitant/year



Note: the sample includes cities that provided data for 2012 and 2000.

Source OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

115. This trend is driven by a combination of factors. In France, domestic water consumption per capita has been declining since the turn of the century (1% per annum, since 2000; ONEMA, 2012), driven by relatively fewer industrial activities in urban contexts; water demand management in collective buildings, to minimise costs; innovation and new appliances, which are more water efficient; higher water prices; and households attitude vis-à-vis the environment and wastage.

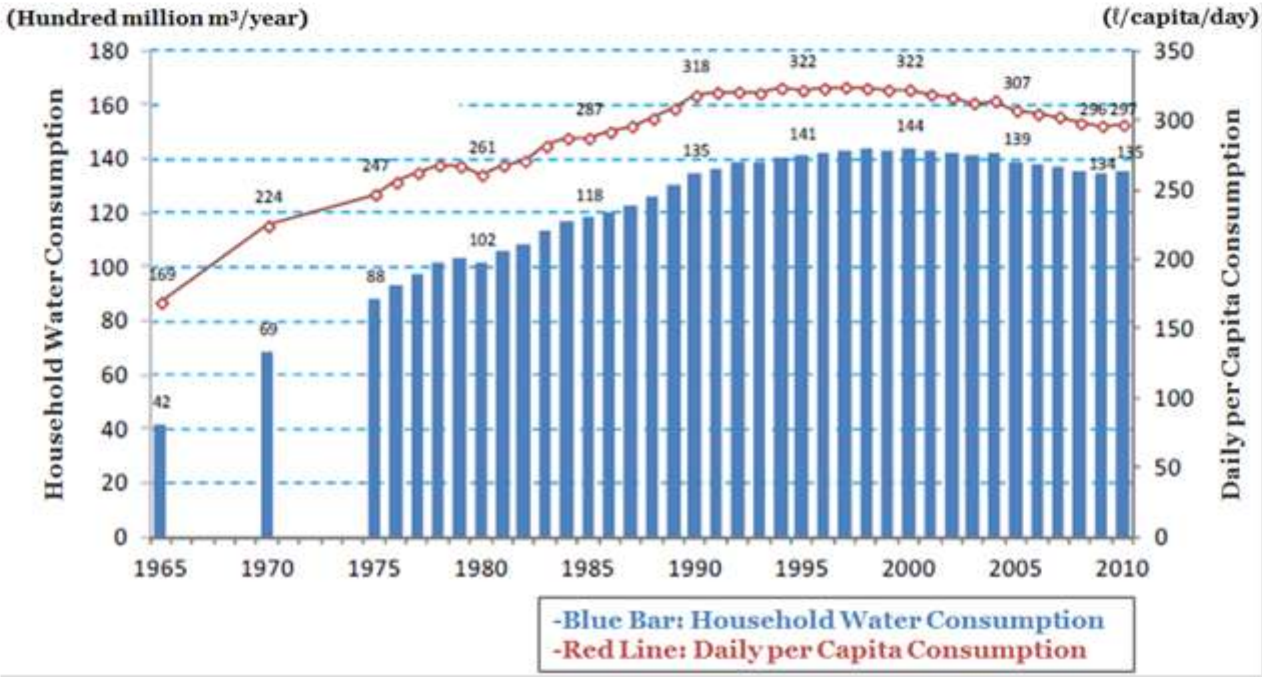
- Industrial uses decline, driven by efficiency gains and the shift away from industries towards services. Similarly, hospitals and schools tend to reduce their water consumption.

- Households reduce their consumption as well (see Figure 10, on Japan). Decreasing water use per capita initially stemmed from outdoor uses. It now hits indoor uses as well (in the USA, chiefly toilet flushing and washing machines; see de Oreo, 2010).

- A growing number of operators are facing an additional decrease in consumption due to households finding alternative water supply solutions, like rainwater harvesting and private well drilling (a point made by Barraqué; see OECD, 2013c): the motive can be environmental (local solutions to reduce the energy footprint), or economic (water bill considered too expensive). These households usually remain connected to the main infrastructure, and in some cases discharge in the sewer water they have not purchased, free riding on the sewer service.

- Authorities contribute to this trend, when they encourage users to conserve water. In California, for instance, the 2009 Water Conservation Act requires the state to achieve a 20% reduction in urban per capita water use in California by the end of 2020.

Figure 10. Domestic Water Consumption in Japan



Source: Ministry of Land, Infrastructure, Transport and Tourism "Water Resources in Japan" (2013) (in Japanese)

116. It is unclear whether per capita water consumption in OECD cities has reached its lower limit or will decline further. Projections on future water demand in OECD cities do not always anticipate the shifts in actual water consumption. The Oxford Water Futures group, looked at 21 projections for future water supply needs in England and Wales made between 1949 and 2009 and plotted them against the actual amount put into supply over the years. In the mid-1970s, the utilities were supplying some 13 billion litres each day. Two projections in that decade foresaw a requirement of 28 billion litres per day in 10-20 years' time; two other projections anticipated a requirement of 24 billion litres and one projection plummeted to 20 billion litres. In fact, supply peaked at 17 billion during those decades and today is back to 14 billion (quoted in Lloyd Owen, 2011).

117. Declining water consumption has ambivalent consequences (Conseil national de l'eau, 2013). On the one hand, it relieves pressure on the resource and allows for coping with future uncertainties without additional investment. On the other hand, it raises technical, social and political issues:

- Declining water consumption slows the water flowing in pipes, and generates water quality risks.
- Declining water consumption affects the revenues of utilities (public or private) when revenues are based on the volumes of water sold or treated. As water services are characterised by a high share of fixed costs (up to 80%), a disproportionate price increase is required to compensate lost revenues from enhanced water conservation[12]. The city of San Francisco has experienced this spiral of drought-triggered conservation measures, driving volumes of water consumption down; as a response, rates for water supply increased by 5.9% in 2014.

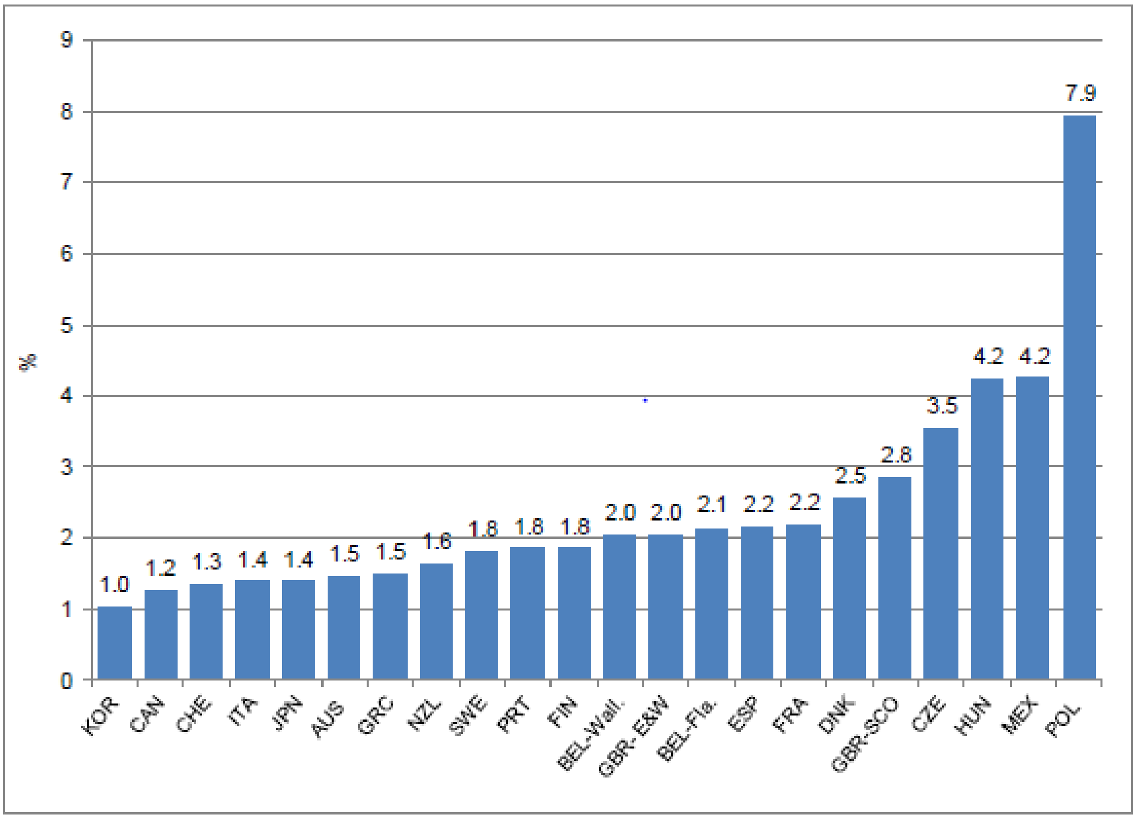
[12] A later section of this chapter will discuss how two-part tariff structures can address the issue (while raising others).

118. The ambivalent consequences of declining water consumption explains why the city of Hamburg has ceased to promote water efficiency and conversation: technical and financial concerns about further decreases in water consumption override the potential benefits of water saving. It follows that conservation measures should be experimented first in areas where water scarcity or growing water needs have brought existing infrastructure to full capacity, and where additional water supply would be very costly.

119. One option to compensate declining water consumption in OECD cities is to raise tariffs. However, this generates two issues. First, there are limits to water price increases. While the vast majority of city dwellers in OECD countries could afford larger water bills, rising water tariffs have made countries such as England and Wales discover the problem of the water poor. The OECD survey on water pricing (OECD, 2010a) establishes that water bills represent 3%[13] or more of households' budgets for the lowest decile of the population in several OECD countries. This is the case for 2 million French households. In England and Wales, the amount of water payments in arrears increased remarkably after privatisation of the water supply system. Even though the larger part of bad payers is not paying on principle rather than from a lack of means, some bad payers can't afford to pay. In the last section of the chapter, we discuss tariff structures and other measures that can compensate declining water demand and conservation policies while addressing affordability issues.

Figure 11. WSS bills as a share of disposable income of the lowest decile of the population

Selected OECD countries. Average income of the lowest decile of the population, 2008



Source: OECD (2010a), *Pricing Water Resources and Water and Sanitation Services*, OECD, Paris.

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[13] 3% is acknowledged by the international community as a threshold for the share of households' budget allocated to water bill. This figure however remains debatable. It could be further disaggregated to reflect the situation of distinct groups (by size, revenues, etc.).

120. Second, higher tariffs associated with declining water consumption can confuse customers: they may be perceived as a punishment for virtuous behaviour. This can explain why political entities tend to avoid raising rates to recover lost revenues. For instance, in France, price increases do not fully reflect the decline in the volume of water sold. This can be explained by productivity gains and by declining financial burden for utilities (as former loans have been repaid; Conseil national de l'eau, 2013). It is not clear, though, how the decline in revenues affects service quality, maintenance of the infrastructure and investment flows.

121. The trends analysed above put the business model of urban water management in question. It is widely accepted that the costs of the service should be covered by the water bills[14] (OECD, 2009, 2010a). However, questions arise about the sustainability of this model, as costs increase and volumes of water sold diminish. Moreover, the model may not comply with core principles of financing water services (see OECD, 2012). For instance, some beneficiaries of improved quality of water services may not contribute to covering the costs which is a limitation; or the water bill may cover expenditures generated by other users. This is the case, for instance, when water bills cover the costs of rain water management, or the treatment of diffuse pollution in groundwater. In that context, OECD cities are encouraged to revisit what should be paid by the water bill. We return to this in the subsequent sections of the chapter.

Taxes (transfers from public budgets)

122. Taxes are the other main source of finance for urban water services essentially to balance costs and revenues at the national and/or sub-national levels. Access to public budgets is severely constrained, in particular since the financial crisis has triggered fiscal consolidation policies. Kaminker et al. (2015 forthcoming) note that the economic and financial crisis has constrained government budgets in many OECD countries, putting downward pressure on public sources of investment financing for infrastructure. Furthermore, the fiscal consolidation efforts to reduce the share of government debt in GDP have been accompanied in some countries by pressure to reduce support to urban infrastructure. It is noteworthy that Ireland's recent shift from a model where water services were paid by taxpayers to a model paid by industry and households was part of the IMF-EU bailout programme to save public finance and face important investment needs.

123. In this context, two avenues are being considered for financing urban water services. One is to optimise the leverage effect of public finance. For example, in the US, federal support for water infrastructure has gradually changed. In the 1970s, the federal government provided large grants to finance sewage treatment plants. Through the 1980s, grants were superseded by the state's rotating loan programme called the Clean Water State Revolving Fund, authorised in 1987 and the Drinking Water State Revolving Fund in 1996. Since their inception and as of the end of 2011, the funds have helped finance 111 billion USD infrastructure projects (Congressional testimony in December 2011, referred to in Walton, 2012). Since 2011, local governments cover nearly all the capital cost of water infrastructures.

124. In the current context, however, this strategy faces limitations. Donnelly and Christian-Smith (2013) note that, while historically, municipal bonds were a relatively inexpensive way to finance new infrastructure, today, credit rating agencies are increasingly downgrading municipal water systems. Donnelly and Christian-Smith quote a report by Ceres, which argues that the most common cause for these downgrades is that water tariff increases have not kept pace with spending on system maintenance or debt service coverage.

[14] The Netherlands has a distinctive approach, as wastewater is financed by a separate institution (regional water boards) which collects revenues on a large scale.

125. Another avenue, which attracts attention, is to arrange public support in a way that does not translate into public debt. See Box 9 for an illustration in the US.

Box 9. Innovative Public Finance Support in the United States

In the US, Congress is considering a water-only loan programme (currently a draft, as accessed on October 2014): the Water Infrastructure Finance Innovations Authority would provide low interest loans repaid at long term US Treasury rates. This could be used to make loans for large infrastructure projects, which can hardly be financed by State revolving funds, thus lowering the cost of access to capital for water utilities.

This would have little effect on US public debt, as only the money considered at risk of default is counted as federal expenditure, and default in water projects is very low.

Source : Circle of Blue, America's Water Infrastructure shows its Age (last accessed February 2014)

Transfers from the international community

126. In OECD cities, transfers from the international community play a marginal role in financing water management. One notable exception is structural and cohesion funds in Europe, which have played a role to upgrade urban infrastructures for new member countries, or countries facing difficulties to meet European regulations. EUR 8 billion in total funding is provided for reducing leakage rates, connecting to water supply, generating additional supply and improving infrastructure. For disaster prevention, EUR 7 billion is available. The Solidarity Fund (EUSF) provides funds for disaster relief in member states. Around EUR 1 billion is allocated each year.

127. Other international mechanisms may emerge as potential sources of finance for urban water management. Carbon finance already finances investment in wastewater treatment in non-Annex 1 countries, via Clean Development Mechanisms. Water gains traction in national and international climate policies; it is increasingly acknowledged that more attention needs to be paid to adaptation to a changing climate and that water is the primary vector for it. However, it is not clear how climate finance can be mobilised for water management in OECD cities.

128. Recent OECD work on water in adaptation to climate change established that financing for adapting water systems has yet to be adequately addressed in most OECD countries. The adaptation strategies and plans of most OECD countries only briefly address financing issues, if at all (see OECD, 2013d, for more information on national plans). A few OECD countries have relied on international funding mechanisms to support adaptation activities. For example, Chile has received support to develop activities related to climate change from the Global Environment Facility (GEF), its implementing agencies and bilateral development co-operation partners. In 2010, the World Bank approved a USD 450 million loan for Mexico to develop public policies aimed at supporting the Mexican government's efforts of promoting the adaptation of its water sector to climate change. The loan was intended to support government policies to contribute to the country's preparedness to confront the growing impacts of climate change through programs by the National Water Commission (CONAGUA).

Repayable finance

129. Urban water management is struggling to attract private capital. As noted in OECD (2006), the profile of urban water investment projects typically involves a high initial capital outlay, followed by a very long payback period from long-lived assets. As a result, the risk of repayment default is high relative to many other projects. The information asymmetry between governments and water utilities, and the

political sensitivity of water pricing, leave the sector vulnerable to *ad hoc* politics and social criticism. As a result, the sector often suffers from a high level of political interference, and a confusion of its social, environmental and commercial aims.

130. Recent trends in private finance make access to public funding to finance urban water management even more challenging. In the wake of the economic and financial crisis, corporate (e.g. utilities) and financial sector sources of investment financing face significant constraints and all may continue to diminish in the coming years.

131. Utilities have insufficient capacity to expand their investment in water infrastructures. The utilities' balance sheets are constrained by the negative impacts that any increase of debt could potentially have on their credit rating and cost of capital. Industry leaders (Veolia, Suez Environnement) have radically revised their approach to investment in new contracts, as is reflected by their renewed preference for management contract (instead of concessions) wherein they do not have to invest their own capital for infrastructure development.

132. The capacity of cities and utilities to access loans from banks is unevenly spread across countries. This capacity has decreased in many OECD countries as a consequence of the 2008 financial crisis: the financial crisis has prompted banks to reduce investments across illiquid asset classes and shorten the term or duration of loans (Kaminker et al., 2015). Local authorities are particularly affected, where governments set limits on how much a city can borrow. Access to credit becomes a distinctive feature of private and public operators. Under specific circumstances, access can be easier for private operators, making the case for management contracts or PPPs. Under other circumstances, access can be favourable to public authorities and discourage private operators. It is essential that access to credit does not pre-empt decisions on the status of the operator.

133. In that context, private investors will be even more selective when considering urban water management projects. As any other infrastructure projects (see Kaminker et al., 2015 forthcoming, for a more detailed discussion in the renewable energy sector), urban water projects will only attract private capital if they can provide sufficient collateral, probability of success and predictability of future cash flows to secure investors' future income. Trends in revenues from water tariffs, analysed above, indicate this can be challenging. However, developments documented below confirm that water projects do attract private funds, including from pure financial investors.

Options to minimise costs

134. Chapter 1 highlighted that OECD cities have had a marked preference for grey infrastructures that protect against different water risks, often managed at municipal level. Reservoirs and dykes have been built to protect against risks of droughts and floods. Extensive piped networks have been built to supply water, collect rain- and wastewater and treat them.

135. Alternative modes of urban water management exist, which require less capital investment and/or are less costly to operate and maintain. This section envisages options to minimise costs for urban water management. Some are technical and rely on enhanced infrastructure management, alternative and cheap sources of water or alternative technologies. Others relate to the organisation of urban water management, particularly its geographical scale. Some of these options rely on co-operation between cities and their rural environment. They require adjustments in the organisation and governance of urban water management. These linkages are revisited in subsequent chapters.

Tapping efficiency gains in asset management

136. Increased efficiency in the operation and maintenance of existing assets can be a cost-efficient way to improve water security and services. Rigorous infrastructure management has multiple benefits. It can lead to sustainable financing schemes, precise contracts between the authority and the operator, and fiscal optimisation.

137. Increasingly, urban utilities in developed countries rely on computer tools, inspection robots and GIS to gain a precise knowledge of the state and performance of their assets, in particular the parts buried underground (see illustrations in Box 10). This knowledge in turn allows a better phasing of maintenance and renewal investments to improve the system' reliability (in particular the repair of damaged pipes). Innovative tools help enlarge the scale and scope of infrastructure monitoring, and extend the time horizon and budgeting needs for asset management.

Box 10. Advanced asset management - Illustrations from selected OECD countries

The case study provided by the city of Auckland signals the use of GIS to overlay actions and investments that have a direct or indirect effect on fresh water quality, including those scheduled in the:

1. storm water asset maintenance, renewal and development programme;
2. cycleway and road construction programme;
3. network infrastructure development programme (e.g. broadband rollout).

The case study highlights the potential benefits of advanced asset management. It also suggests additional benefits that derive from co-ordination across sectors (road construction, broadband rollout).

The Massachusetts Water Resources Authority, in the United States, for example, developed a predictive maintenance strategy based on condition monitoring and the probability and consequences of failure of each component. The programme increased equipment availability to 99%; it achieved cost savings by eliminating unneeded and low-value preventive maintenance work, and shifting the freed-up resources to predictive tasks and actual maintenance work.

In the UK, an advanced pressure management system that combines software, sensors and controllers is used to detect leakages early on; it has reduced water loss by 1.5 million litres per day.

Sources: case study developed by Andrew Schollum and Grant Barnes, Auckland Council, for the OECD project; Case Study – Massachusetts Water Resources Authority. WERF Org; quoted from WEF (2014); i2O (2012)

138. Advanced asset management methods can be combined with a multidimensional definition of performance for water services, from basic physical condition to service quality, business risk and sustainability. Tools to assess the state of infrastructure are followed by decision support systems to design financing strategies taking account of the impact of costs on water prices, and the consequences of environmental, social and economic disruptions.

139. Where the operator and authority have a clear vision of the assets and renewal needs, together with improved forecast on water demands, they can develop rigorous planning of operation and maintenance, together with investment. They can sign precise and secure contracts that reduce information asymmetries and rent seeking behaviour from either party (OECD, 2009b, 2010b). Furthermore, rigorous asset management entails precise depreciation, which in turn leads to improved self-financing capacities, reduced debts, and access to cheaper loans (because the utility is more creditworthy).

140. Where asset management is delegated to a private operator, the operator can contributet through sharing knowledge and capacity. Private sector participation is encouraged by a clear definition of roles and responsabilities, a definition of performance and contractual arrangements that promote efficiency.

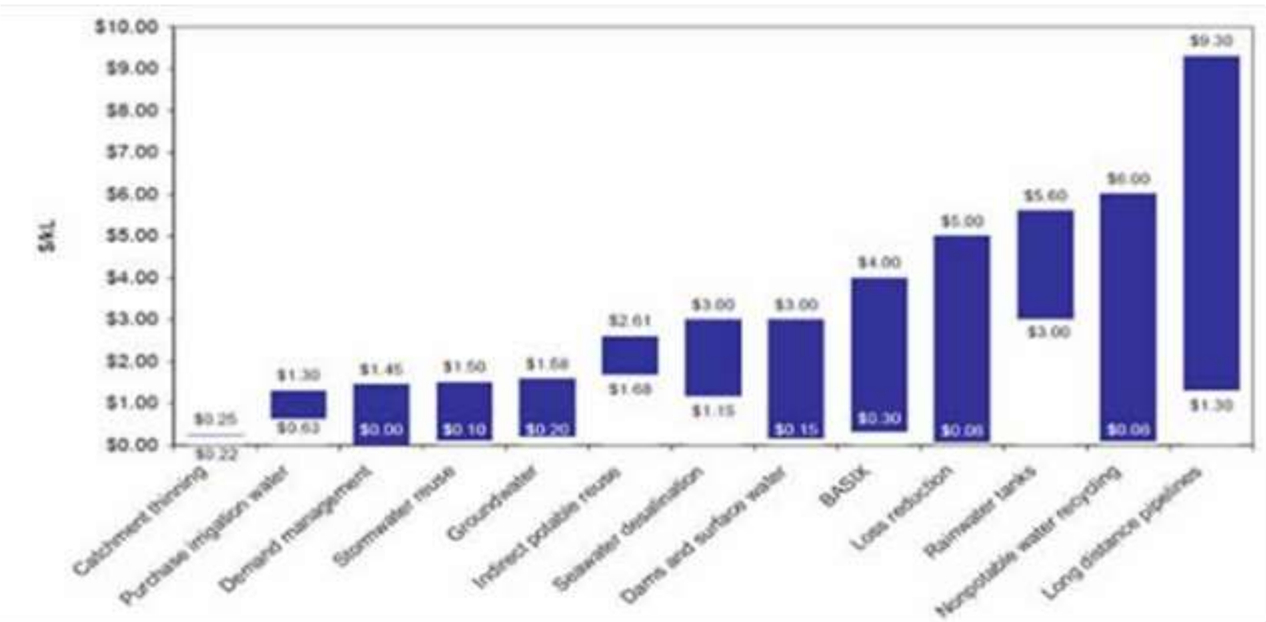
Exploiting low-cost water sources

141. Marsden Jacob Associates (2006) analyses the costs of major supply and demand options available to Australian cities (see Figure 12). The study dates and costs certainly need to be updated. The main message remains: all things being equal, contextual features determine the cost advantage of any option:

- most options have very low cost in favourable locations and situations (e.g. catchment thinning, purchase irrigation water);
- many options have very high cost (>$3.00/kl) in unfavourable locations and situations (e.g. rainwater tanks, long distance pipelines);
- the costs of pipelines and pumping have a dominating influence where water needs to be transported over long distances.

142. The driving force of transport costs has several consequences on infrastructure design and management. First, it explains why urban services meet diseconomies of scale at the far end of existing infrastructures (Barraqué, 2003). Second, it suggests that wastewater reclamation will be more cost effective when treatment facilities are located close to potential users, be they industrial, agricultural, or municipal ones. Therefore, on the one hand, major new water reuse initiatives are frequently comparable with, or more expensive than desalination due to long transportation distances. On the other hand, decentralised systems have an advantage when wastewater is treated and reused close to where it is collected, saving on transport costs and using less infrastructure and energy.

Figure 12. Direct costs of alternative water supply options



Source: Marsden Jacob Associates (2006).

143. As will be discussed in Chapter 3, innovative ways to manage water in OECD cities can reduce costs of urban water management. Green infrastructure in particular can avoid or postpone the costs of building new or extending existing grey infrastructures. For instance:

- Building new dams and rainwater harvesting facilities would cost US$ 0.04- 0.06 per cubic metre (m3), whereas rehabilitation of existing infrastructure would only cost about US$ 0.02/m3; demand-side measures would be far cheaper (2030 WRG, 2009).

- The proposed eco-friendly "sponge-like" water system in Philadelphia (US), involving new forms of drainage (green roofs, wetlands, repaving with porous materials) would be less than half the cost of a conventional upgrade of the current system of pipes and basins (Cardno, 2013; quoted from WEF, 2014); achieving a similar level of service through an additional wastewater treatment plant would be 4 or 5 fold more expensive (8-10 billion USD, as compared to 2 billion; Walton, 2012).

- In Australia, a pilot project funded by Queensland Urban Utilities in partnership with SEQ Catchments has repaired 500 metres of eroded riparian corridors near the Beaudesert Sewage Treatment Plant in the Logan River catchment can achieve the same level of environmental performance as upgrading the treatment plant, as a lesser cost.

- The East Bay Municipal Utilities District in California uses methane from waste to power generators; it has become one of the first wastewater treatment facilities in the US to be a net-energy producer (USEPA, 2013a).

144. Similar attention should be paid to costs related to avoiding water quality degradation. We touch on this in chapter 4, when arguing that catchment protection from diffuse pollution can be a cost effective way to manage water quality.

Amalgamating urban water management

145. Non-technical options exist to minimise costs. For instance, many OECD countries have aggregated (or consider aggregating) small utilities, to generate economies of scale and make the best use of large infrastructures. Heavy investment costs and the phasing out of government subsidies have urged local utilities to turn towards concentration at upper levels of government, for part or all of the tasks to provide and deliver WSS services (OECD, 2013c; see chapter 1 for selected illustrations).

146. The case study of Auckland, New Zealand, illustrates how amalgamation of several councils gave the Auckland Council the necessary scale to tackle issues that were previously beyond the capacity of individual councils. For instance, since amalgamation, the council has been able to accelerate the modernisation of the region's antiquated wastewater treatment systems, substantially upgrade the region's two key wastewater treatment plants and progress the NZ $950 million 'central interceptor' project that will reduce overflows from the Auckland isthmus' combined waste and storm water system. Similarly, the Korean case study on cities in the Kyoungnam province documents cost-efficiency that can derive from amalgamation of urban water services.

147. Because the size and cost of sewer pipes is usually higher than water supply infrastructure, concentration of sewerage units is more limited (OECD, 2013c). Amalgamation may occur for wastewater treatment, where economies of scale exist for some complex treatment processes.

Box 11. Amalgamation of water services - the case of Kyoungnam Province, Korea

A large number of Korean municipalities are having a hard time managing their own waterworks. The problems are mainly attributed to a lack of revenue by low water tariff, which lead to financial constraints regarding renewal of existing water infrastructures. Aging water infrastructures, in particular, aging water mains are the predominant cause of water leakage, driving production costs and water tariffs up.

In order to solve these issues, the central government supports and encourages municipalities to amalgamate water supply services and consign amalgamated services to specialised water agencies.

4 local governments in South West Kyoungnam Province amalgamated their water supply systems and consigned the operation of water supply system to K-water. Each local government retains ownership of its water supply system and remains responsible for the provision of the service and for setting tariffs. It is also responsible for planning and extending water mains, to increase access to tap water. Tasks devolved to K-water include water abstraction and treatment; distribution of treated water to customers; notifying and collecting water tariffs.

K-water has installed an integrated remote-control centre, which aims at monitoring and controlling all water sources, treatment plants, and reservoirs of each municipality. A majority of facilities have no staff, except facilities located far from city centers. Operators of the integrated remote-control centre monitor water pressure and manage facilities 24/7. They are available at all times to respond immediately to calls from a facility. Engineers working for a local service center are requested to be able to reach the facility within 30 minutes, through a network of emergency contacts in case the systems are out of order.

K-water covers upfront capital costs for renewal and upgrades of aging infrastructures, in order to enhance operational efficiency. K-water charges each local government for the operating expenses, including recovery of investment, on a monthly basis. The contract specifies the amount of operating expenses and recovery of investment to be paid by the municipality, providing municipalities with the ability to plan expenditures in advance.

The project is receiving good reviews from central government and municipalities involved. The project is expected to cut costs by 240 hundred million won (17.4 million €) over the contract duration (between 20 and 30 years), compared with business as usual. The volume of accounted-for water increased in the new system; increases range between 17.1 and 41.3%.

Table 2. How amalgamation affects consignment charges

Name of municipalities	Consignment charge[15] under individual consignment	Consignment charge under Integrated consignment	Difference of Consignment charge	cost-cutting effect(%)	Note
Sacheon	749 won/㎥	727 won/㎥	22 won/㎥	2.9	30 years average
Geoge	416 won/㎥	391 won/㎥	25 won/㎥	6.0	20 years average
Goseng	652 won/㎥	628 won/㎥	24 won/㎥	3.7	20 years average
Tongyoung	529 won/㎥	495 won/㎥	34 won/㎥	6.4	20 years average

Table 3 compares the full operation costs of separate systems, with the full operation costs of the amalgamated system. The benefits of economies of scale vary, driven by such factors as municipalities' access to local source of water, distance between municipalities in the project, and status of services in each municipality. Therefore, municipalities considering amalgamation would benefit from examining feasibility in details

[15] Consignment charge includes operation cost, repayment of invest and commission, which is given to K-water.

Table 3. Comparison of full cost of operation before and after amalgamation

Classification	Unit	Total	Sacheon	Geoge	Tongyoung
Production cost before project (a)	Won/㎥	-	1,139	1,185	1,192
Production cost after project (b)	Won/㎥	-	1,002	1,133	1,102
Difference(c= a-b)	Won/㎥	-	(-)137	(-)52	(-)190
Estimated volumes in sales/year (d)	Million ㎥	42.2	13.7	16.7	11.8
Total saved cost (e=c×d×f)	billion won	118.4	5.6	17.4	44.6
Average saved cost	Won/㎥	50	19	9	22
Contract period (f)	Year		30	20	20

Source : K-water internal reports.

148. Amalgamation eventually results in the combination of different services at different scales. In Ile-de-France, there is a 3-tier management system: street sewers are municipal, interceptors and storm sewers are run by the counties (4 *départements*), sewage treatment is operated by a joint board between counties (almost regional level). In several countries, the production of water or treated wastewater was separated from delivery of the service to customers:

- In Boston, Massachusetts, a metropolitan authority consolidates water production and sewage treatment, leaving member municipalities in charge of the systems' management.

- In Portugal, the government created a national water company in 1994. Municipalities in the same area were offered to jointly manage treatment plants, while communes kept responsibility for the operation of water and sewer mains.

- In Australia, the 1994 reform planned by the Council of Australian Governments mandated the unbundling of former urban water monopolies, with bulk water production plus sewage treatment organised at regional level (one public company) and retail water services at more local level (several water distribution companies). This choice paved a way for alternative water supply technologies (recycling, desalination).

Water tariffs that contribute to water resources management

149. In theory, the price charged to water users is an effective tool to promote water use efficiency, thus contributing to water security where water is scarce. Price-based approaches to water conservation are more cost-effective than non-price approaches. The gains from using prices as an incentive for conservation come from allowing households to respond to increased water prices in the manner of their choice, rather than by installing a particular technology or reducing particular uses, as prescribed by non-price approaches.

150. In practice, empirical evidence shows that demand for urban water is relatively inelastic to price. In France, a marginal price increase by 50% would reduce water demand in a given territory by 10% (see meta-analysis compiled by A. Thomas, 2013). On average, in the United States, a ten percent increase in the marginal price of water can be expected to diminish demand in the urban residential sector by about 3 to 4 percent (Olmstead, Stavins, 2009). As a consequence, pricing alone is usually not enough to reach urban water policy objectives. Pricing can be effective in the medium to long term; non-price regulation is more effective in the short term.

151. OECD governments and cities are struggling to design tariff structures that promote wise water use, while ensuring financial sustainability of service providers. OECD (2010) has shown that few OECD countries reflect water scarcity in water prices. Water prices reflect long term marginal costs of the provision of water supply and sanitation services, at best.

152. In Australia, the Productivity Commission has suggested that more research is needed on water scarcity pricing, or on pricing strategies that reflect different levels of water security or quality of service. The latter approach echoes the point raised in OECD (2013e) that water users should be involved in the definition of the level of water security they are willing to pay for. The OECD guidelines on Stakeholder Engagement for Effective Water Governance provide some guidance on the organisation of such consultations.

153. As regards water services, economic theory shows that marginal cost pricing generates revenues that reflect actual costs of water services (OECD, 2010a). However, marginal cost pricing requires heavy data and reliable projections on water demand and the future costs of supply. In addition, marginal cost pricing can lead to high prices and expensive water bills, especially when demand is inelastic. OECD cities often settle for second best options. Recent developments are discussed below. Social sustainability of sophisticated water tariffs deserves particular attention.

Innovative tariff structures

154. An important innovation in the water industry is adapting tariffs to meet customers' aspirations and provide incentives to use water efficiently. The best known example is the suppression of tariff rebates for large customers (rebates were based on the idea of economies of scale) and the introduction of progressive tariffs, with either free initial allowances (like in Belgian Flanders), or lower first tiers (basic allowances included in the fixed part to be paid anyway). The objective is to send price signals to customers, while taking their specific situation into account. Similarly, seasonal tariffs use higher prices to cover higher costs during peak demand. Seasonal tariffs first request the introduction of sophisticated meters, so as to allow reporting consumption immediately after the tariff change.

155. Budget rates are tailored to the situation of individual customers. For instance, in Los Angeles, the tariff is progressive (two blocks), seasonal (higher in the 3 summer months, and also all year round in case the council decides it is a drought year), and adjusted to lot size (large properties are considered having larger 'essential' needs for their gardens and they have a larger first block). In Europe budget rates are not frequent, but some water companies in England propose variable tariffs, with either high fixed parts and low volumetric prices (for customers who have regular water uses) or low fix parts and high volumetric ones (for people who may have low consumption but some peaks).

Box 12. Innovative tariff structures: Water Budget Rate Structure in California

As California faces frequent and prolonged droughts, water utilities were concerned about the consequences of conservation efforts on their revenues and their ability to cover both fixed and variable costs of service provision. Simultaneously, customers complained about equity issues related to existing water tariffs, which did not account for households' features.

Water Budget Rate Structure have been experimented, to meet four objectives: (1) conservation of scarce water resources, (2) financial stability of the water utilities even during periods with very small water consumption, (3) equity and satisfaction of customers, and (4) funding of conservation and environmental programmes without raising taxes on customers.

The WBRS is comprised of fixed costs and variable cost components. The fixed cost part is priced at a reasonable level for the customers and the water utility. The variable costs comprised of several increasing tiers (between 4-6), depending on the water utility. The first and second tiers represent reasonable use of water by about 75% of the customers. The first tier in each WBRS refers to indoor water use and the second tier refers to outdoor water use. Both of these two tiers are anchored to legal and scientific parameters. They include indoor water use by the residency; the number of residents in the household; the indoor water use standard per capita; the number of days in the billing cycle; outdoor water use; the evapotranspiration value in inches per acre per day; the landscape factor; the lot size; a drought factor (fraction), representing the water reduction the retail agency faces; a monthly water allotment; days per month.

Rate structures adjust individual customer tiers on the basis of norms for efficient indoor and outdoor uses. Customers that exceed the first two tiers are considered inefficient and face significantly higher prices per unit of water consumed, compared to the second tier. Many water utilities compute the prices of the tiers following the second tier, by using the next alternative for water (the opportunity cost approach), such as imported water or water that is associated with much higher cost of provision. Customers are given the option of requesting to adjust the tiers (Variance) to their own parameters; parameters may include people in the household with special needs; irrigated area; livestock on premise; or business type.

The revenue collected from higher tier water use is reinvested in promoting long-term improvement programmes in water use efficiency, and support the water utility urban runoff programmes that reduce pollution of aquifers and wetlands.

Source: adapted from EPI Water (2011), Water Budget rate Structure: experience from urban utilities in California.

156. Providing incentives to use water efficiently can affect the financial sustainability of service providers. OECD cities and water utilities explore options to secure stable revenues even when water consumption declines. One option consists of decoupling revenues from the volume of water sold. In California, the Water Revenue Adjustment Mechanism (WRAM) and Modified Cost Balancing Accounts (MCBA) were first implemented in 2008 as part of a pilot programme to promote water conservation:

- the WRAM enables utilities to collect any revenue shortfalls that result from water conservation by calculating the difference between actual and adopted quantity charge revenues, and authorising customer surcharges;

- the MCBA allows utilities to recoup lost revenue from purchased power, purchased water, and pump taxes (Donnelly et al., 2013): water tariffs are adjusted to reflect the actual cost to operate the system.

157. These tariff structures serve multiple goals: i) sever the relationship between sales and revenue, and remove any disincentive to implement conservation rates and programmes; ii) ensure cost savings are passed on to ratepayers; and iii) reduce overall water consumption. The California Public Utilities Commission (CPUC) adopted the mechanisms as part of conservation rate design pilot programmes. There

are debates about the level of protection that utilities using such tariff structures enjoy. In March 2012, a Proposed Decision was issued that establishes a limit on WRAM/MCBA surcharges of 7.5% a year (see http://docs.cpuc.ca.gov/efile/PD/161942.pdf for more information).

158. An alternative approach is the Consumption-Based Fixed-Rate water rates (CBFR) experimented by the city of Davis, California. The tariff aims to recover all fixed and variable costs, no matter how much water is sold or saved. The rationale for CBFR water rates is that customers pay for the water they use, and for their share of the system that has been built to bring it to them (Loge, 2013). In this system, water customers have two fixed rates: one based on their meter size, and another based on their peak volumetric water use. Revenues generated by these two rates cover the utility's fixed costs. Loge argues that conservation is directly rewarded through lower bills, while rate increases due to lost revenue are diluted over the entire ratepayer base, based on the ratepayer's use of the water system. The new tariff structure will be implemented in 2015, using summer 2014 data as reference for peak use.

159. Innovative tariff structures have limitations. Some analysts claim they have paradoxical and 'disconcerting' effects (Beecher, 2012). Two limitations are particularly relevant in the context of this chapter. First, as noted above, water prices only drive water efficiency to a limited extent. Second, water pricing policies should pay particular attention to two distinct groups of water users. On the one hand, higher prices raise affordability issues; we turn to this in the next sub-section. On the other hand, the better-off users may be particularly unresponsive to price signals, while they may not be conscious of their water use; they may be less inclined to invest in water saving technologies and practices (although they can afford them). This group could be the target of conservation measures, although such a policy orientation may conflict with financial sustainability objectives.

Social sustainability of water pricing[16]

160. The financial sustainability of urban water management faces equity and distributional issues (see the discussion above about the water poor). The tension between financial sustainability and equity is well illustrated by debates about increasing block tariffs.

161. The first rationale for introducing volumetric payment of water, and additionally increasing block tariffs (IBTs), is efficiency in use and demand management. But there is another argument: equity. One can indeed argue that even if elasticity of consumption to price is small and IBTs have complex consequences, IBTs may still be justified in terms of utilities getting higher revenues from users who generate a costly peak demand; and, on moral grounds, most people support that water wasters should pay: metering and IBTs would be advocated in terms of consumer justice.

162. The trade-offs between efficiency and equity objectives in the provision of household water services typically occur while moving from an unmeasured to a metered charging structure, while rebalancing tariffs away from fixed charges towards volumetric charges, and while increasing fees and tariffs towards full cost pricing. There is considerable experience in OECD countries with policy measures to address water affordability for vulnerable groups, while attempting to make water pricing reveal the full economic and environmental costs of water services (OECD, 2003, p.12).

163. Supporting measures for the poorest families can be grouped in two broad categories: those supporting revenues of targeted households, and preferential tariffs. From a water resources management perspective, social tariffs fail to promote water-wise behaviour. The OECD EPIC survey (OECD, 2014e) establishes that low-income households more frequently engage in water-saving behaviour, but are less

[16] This section heavily relies on a paper drafted by Barraqué (OECD, 2013c).

likely to invest in water efficiency improvements. Therefore, social measures to address water affordability could include measures to facilitate access to water saving technologies and appliances.

164. The first group of measures includes social subsidies, vouchers, fractioned payments, and debt forgiveness. Many utilities argue that the social dimension of water services should be handled separately or, as AWWA wrote ‘think outside the bill’. In collective housing in particular, when water is paid in addition to the rents, it is much easier for tenants to pay a fixed charge for their water every month with the rent than a randomly sent variable bill. When they cannot pay, they may need a global support for the rent and general charges rather than for water alone.

165. One option to consider is to have water suppliers, as well as electricity or gas suppliers, give a small percentage of their turnover to a social housing fund, as is the case in France (OECD, 2013c). The fund operates at county level, since county councils are in charge of social and sanitation affairs. One of the problems is that this funding can only help people who are temporarily unable to pay. It is more difficult to support people who are in need but do not receive bills directly. Another option is to identify poor water users and offer them rebates or vouchers. This is the case in selected cities in France (e.g. the suburban SEDIF) or in Chile (OECD, 2013c).

166. The second group of measures to address affordability issues includes preferential tariffs, meant to keep water bills below a certain fraction of revenue (e.g. 3-5 %). They include keeping water charges under a threshold, and IBTs. Several cities are experimenting with the combination of increasing block tariffs (IBTs) with social rebates. In Dunkerque, the first block of 75 m^3/yr is supplied at 0.80 €/ m^3, and for families on benefits (CMUC in French) the price goes down to 0.30 €/m^3. The second block up to 200 m^3 costs 1.50 €/ m^3. Additional consumption above that threshold is billed 2 €/ m^3. There are no social rebates for upper blocks. Since it was considered illegal to use data on family sizes and to set the blocks per capita, these figures are multiplied by the number of apartments behind a meter, irrespective of the number of residents in each apartment. It remains to be seen how this social tariff will perform in terms of social redistribution.

167. Though the OECD (2003) acknowledged that some metering along with IBTs may have regressive effects on large poor families, it claimed that “the design of increasing block tariffs can be adjusted in several ways to make the sizes and prices of tariff blocks deliver the intended distributive effects” (ibid.). Some researchers challenge this claim, in particular in a developing country context (see Boland and Whittington, 2000; Komives et al., 2005; and a discussion by Baraqué in OECD, 2013c). In practice, where metering is collective, and indoor water use is both moderate and inelastic, IBTs may well end up as a useless complexity. More recently, Whittington *et al.* (2014) reviewed a variety of subsidised schemes in low and medium income countries and concluded that existing subsidies are very poorly targeted to poor households. They further noted that, with each tariff structure under review, “households in richer income quintiles receive a higher proportion of the subsidies than do households in the poorer quintiles” (p.21).

168. The point of experimenting with IBTs is that i) a general reflection on the distributive effects of tariffs levels and structures is required and ii) water utilities need to be directly involved in the social dimension of water charges. Now that the “water poor” notion is acknowledged, cities and utilities are urged to find alternative ways to address the situation.

Diversified revenue streams

169. The section explores new sources of revenues, which can contribute to financing water management in OECD cities. These include innovative business models for water utilities, land-value capture, or targeted taxes, e.g. on rainwater run-off.

Innovative business models for water utilities

170. Some water utilities are looking for additional sources of revenues to compensate for the decline in water consumption, for instance providing “beyond-the-meter” services to domestic and industrial customers. In doing so, water utilities may benefit from the experience of energy suppliers, which compensate lower unitary demand with additional services that add value to consumers (such as stable energy bills, consumption optimising, or green energy certificates). An increasing number of energy providers help customers to diagnose their consumption and control their expenses, which can be an additional source of revenue compensating the loss in direct energy sales. Electricity companies sometimes propose to customers to buy ‘clean’ or ‘eco-friendly’ energy at slightly higher prices to include pollution rights or off-set services.

171. Similarly, water utilities have large customers, like hospitals. It may be advisable to develop policies to help large customers to reduce their water footprint, even though the utility will eventually lose income in the short term. It is financially wise to anticipate the decrease of consumption rather than suffer from large customers altogether leaving the public service (e.g. sea-side resorts choosing private desalination).

172. A few water utilities set up specialised teams of water advisers, to induce water conservation practices, on top of checking leaky or wasting appliances. In Los Angeles for instance, a software using Geographical Information Systems (GIS) calculates the nominal water consumption of any single family house; when real consumption significantly departs from nominal value, a warning is sent with the water bill, with an invitation to let the utility’s water conservation team come visit and help find where water wastage or leaking takes place. In England and Wales, some water companies set up new plumbing departments to propose to customers’ additional ‘post-meter’ services. Such services can save costs for users, who may be charged for the service, thus generating additional revenues for the utility.

173. Contractual arrangements can reward the achievement of specific performance goals, thus generating additional revenues for effective utilities. In the UK, where water services are privatised, there is a concern that water companies would lose from supporting conservation measures. The Head of Water UK suggested that they be granted tariff bonuses to compensate their efforts (OECD, 2013c). Performance-based contracts can set targets related to, e.g. connection rates, reduction in non-revenue water, or water or energy conservation. Experience in the water sector is limited. Lessons could be learned from other sectors – energy, infrastructure – on the benefits and the ways to mainstream this type of contract. Recently, Lloyd Owen identified the emergence of service contracts, in particular performance-based contracts, as the most notable change in private sector participation for water supply and sanitation globally (Lloyd Owen, 2013)

174. Building on concrete illustrations, the OECD has developed guidelines for performance-based contracts for water utilities (2010b). The Guidelines address the key elements that need to be considered in connection with the preparation, implementation and periodic revision of a successful performance-based contracting mechanism. The major elements include: performance indicators, tariff related issues, contract monitoring, mechanisms for conflict resolution, conflict enforcement, risk mitigation.

Fiscal instruments targeted at specific externalities

175. Taxes can be an effective instrument to address negative externalities that affect water demand and availability, or the costs of water security. OECD cities have opportunities to consider new taxes to address externalities that have essentially remained unnoticed so far. The section covers two areas:

1. Land developments. New developments generate costs for urban water management, for instance when additional reservoirs are required to secure additional demands, or when properties are

developed in flood-prone areas. Land-value capture can incentivise water-wise land development and generate revenues to cover additional costs.

2. Rain water management. Chapter 1 indicated how the built environment can make rainwater more difficult and costly to manage. Fiscal instruments can recoup some of these costs and generate incentives for land owners to manage rainwater at source.

176. OECD cities would benefit from systematic monitoring of recent and future developments in these areas and from analysing the conditions that make them feasible. For instance, land-value capture requires a proper regime for land ownership and fiscal capacities.

Land-value capture as a means to finance municipal infrastructure

177. In a review of financing mechanisms for green urban infrastructures, Merk et al. (2012) note that real estate developers may pay for the infrastructure that is needed to connect their new development to existing infrastructure in the form of development charges (impact fees) and value capture (taxes that capture the value increases of real estate due to new infrastructure development nearby). Infrastructure needs related to new developments can be internalised in the financing of development projects. The costs of sprawl, for example, may be recovered from developers through development charges or other financial contributions, thus making sprawling more costly than infill development.

178. OECD cities gain experience with extracting value from land that benefits from improved services. This source of finance can take several forms such as selling land, taxing property or value added by public investment, financing infrastructures from gains generated by land development. Recently, land-value capture benefits from renewed attention: the rationale is to capture a proportion of increased value that accrues from new or improved infrastructure, which is further used to fund infrastructure. Successfully conceived and implemented, land-value capture shows interesting possibilities for integrated financial, land-use and infrastructure planning.

179. Experience accumulates in urban transport systems. In order to ensure profitability of sustainable transport infrastructure projects, governments and private operators often need to consider innovative financing instruments as alternatives to debt financing and user fares, given strains on debt financing markets and since user fares are often set at a level insufficient to cover operational expenses, due to social affordability concerns. Unlike user fares, which capture direct-use benefit from urban transit, land value capture tools capture the indirect and proximity benefits generated by transport infrastructure. They can be part of the capital financing mix as they can generate upfront revenues, thus reducing reliance on debt and fiscal risk (Peterson, 2012). Most experience has been for roads, metros and rail (see the illustration from the Copenhagen metro in Denmark, in Box 13), though nothing precludes such tools from being used for bus rapid transit systems (OECD, 2013g).

Box 13. Land value capture and new infrastructure: the Copenhagen metro, Denmark

The Copenhagen metro, completed in 2007, is one of Scandinavia's most ambitious transport infrastructure projects. The Ørestad Development Corporation (ODC) was established with the dual task to build the metro in Copenhagen and to develop the Ørestad area. 45% of the metro project is owned by the government and 55% by the municipality of Copenhagen. The area to be developed is about 600 metres wide and 5 kilometres long, and is situated about 2 kilometres from the city centre of Copenhagen. The project is characterised by a close interconnection of infrastructure, land use development and financing. Putting infrastructure in place facilitated the sale of land to private investors to help finance the metro system.

The ODC has carried out the following actions: took over the Ørestad land covering around 310 hectares from the owners, i.e. the municipality of Copenhagen and the Danish government; raised loans on commercial market terms, but with joint liability with the Danish government and the municipality of Copenhagen; designed, built and initiated the operation of the new Copenhagen metro. At the same time, the corporation continued the planning and construction of other infrastructure projects; sold/sells the land to developers and investors. The corporation used/uses the surplus from the proceeds of the sales to repay the loans.

The total cost of the project – building the metro and preparing the Ørestad area for development – is estimated at EUR 1.7 billion. It should be met by selling the land (50%), direct payments from the owners not contributing land themselves (10%), in lieu payments of real estate taxes (10%), and profit from the metro (30%).

Source: OECD (2007).

180. Land-value capture has its own limitations. In already densely populated and built-up areas, opportunities for land-value capture are limited. Relatively undeveloped areas benefiting from new infrastructure have considerably more potential. Peterson (2006) notes that, under specific conditions, exchanging landholding for infrastructures can contribute to infrastructure financing. Now, land leasing can only be a transitional infrastructure-financing strategy. At some point in time, the supply of land available for lease or sale will run out and cities will have to rely more on revenues from services provided by the infrastructures to recover capital costs. Moreover, such financing strategy generates risks, which are particularly acute where real estate prices are highly volatile.

181. Experience of land-value capture for urban water management is scarce. Peterson (2006) notes that, in a context where local property taxes are frozen, and local tax increases and municipal borrowing are restricted, California's localities turned to land assets as a way to finance infrastructure: new intergovernmental rules were adopted that allowed developers to issue land-based bonds to finance roads, sewer and water systems and other basic infrastructure that no longer could be financed by the public budget. Land became the collateral for a good deal of new infrastructure financing. USEPA has used a similar rationale to mandate property developers to invest in sewerage infrastructures (see Box 14). In a recent review of water management in the Netherlands, the OECD noted that property developers who locate outside the dykes generate future liabilities and should be accountable for future costs of protecting their assets (see OECD, 2014b, for a more detailed discussion).

Box 14. Property owners financing sewer renovation in the San Francisco Bay area

The US Environmental Protection Agency (EPA) has ordered municipalities and property owners in the east San Francisco Bay area to spend $1.5 billion upgrading sewerage infrastructure over the next 21 years.

The East Bay Utility District and seven San Francisco bay communities have been ordered by the EPA to spend the money to upgrade 1,500 miles (2,414 km) of sewer infrastructure. The municipalities will spend an estimated $900 million on municipal sewer upgrades, and property owners are expected to spend $600 million on private sewer lines through quality requirements applied when a property is sold.

The mandate is interesting on two fronts. First, it confirms that infrastructure upgrade is urgently needed. Second it points at property owners as a potential source of investment and indicates one way to induce private investment.

Source: adapted from Global Water Intelligence (http://www.globalwaterintel.com/news); published 31st July 2014.

A tax on impervious surfaces to finance urban drainage

182. In 2010, France introduced a tax on impervious surfaces to finance urban drainage. The objective is to manage rainwater at source, before it reaches sewerage networks, thus avoiding run-off and treatment downstream. Municipalities can set and design this new tax, on a voluntary basis. The Great Lyon metropolitan area has experienced this new mechanism. It proposes tax reductions when the owner of the land takes action to limit run-off (CERTU, 2012).

183. In practice, this mechanism is plagued with difficulties. Transaction costs are high, as a large number of bills have to be sent and managed. The main contributor to the tax is the city itself, as it is responsible for roads, the largest sealed surfaces in the metropolitan area. Additionally, this tax can be seen as a transfer from the general budget to water management. As there are a small number of large contributors, it may be more efficient to incentivise them, through targeted measures. While some adjustments in the design of the tool may be required, the rationale is sound and could be more systematically explored.

Box 15. Financing the Management of Urban Rainwater in France

The failure to properly manage rainwater affects the capacity of French local authorities to achieve the "good ecological status" mandated by the European Water Framework Directive. A dedicated fiscal instrument has been introduced, to promote rainwater management close to the source and limit run-off: since 2011, French local authorities have the capacity to set up a new public service dedicated to urban rainwater management. This new service can be financed, in full or in part, by earmarked revenues from a dedicated tax.

The tax is based on impervious surfaces, in urban areas or future development areas, whether or not the surfaces are connected to a drainage system. The tax is paid by the owner of the land or property, when the property is larger than a minimal area set by the local authority. The tax rate is set by the local government and cannot exceed 1€/m2/year. The tax rate can be reduced, in full or in part, where facilities are in place to reduce run-off: the reduction is meant to reflect the decrease in run-off. Several adjacent property owners can join, when they build and operate a common facility.

The main objective of this new tax is to create incentives to manage rainwater close to the source, by implementing mitigation measures that compensate the consequences of impervious surfaces. Another objective is also to raise revenues, earmarked for urban rainwater management. In the long term, the revenues generated by the tax are doomed to decrease, a trend that local authorities need to anticipate and factor in.

While engaging in feasibility studies, local authorities have the opportunity to reflect on their policy for urban rainwater management, the level of ambition and the policy packages they would like to implement (zoning, standards, information, tax, etc.). Stakeholder consultation is an important part of the process.

Source: CERTU (2012), *Taxe pour la gestion des eaux pluviales urbaines*, MEDDTL, Paris.

A role for private investors

184. This section reviews experience and considers options to make use of private sources of investment for urban water management. Here, private sources of funding include water service operators, financiers (who do not operate water services) and property developers. The capacity of private operators to generate efficiency gains, which translate into reduced financing needs, was acknowledged earlier in this chapter; it is not covered in this section.

Private Sector Participation in urban water management

185. Most OECD countries consider some form of Private Sector Participation (PSP) as an option to channel additional sources of finance to bridge upfront investment needs. With the aim to support governments and other stakeholders to assess and manage the implications of PSPs, OECD (2011), developed a *Checklist for Public Action*, providing governments with coherent set of policy directions and necessary steps to engineer a good partnership with the private sector. The *Checklist* highlights five key policy areas that can affect public-private co-operation: a) deciding on the nature and modalities of private sector participation; b) providing a sound institutional and regulatory environment for infrastructure investment; c) ensuing public and institutional support for the project and choice of financing; d) making the co-operation of public and private sectors work in public interest; e) encouraging responsible public conduct.

186. In an overview of water financing options for California, Ajami and Christian-Smith (2013) note that the challenge with PSPs is how utilities can leverage private capital to invest in projects such as efficiency and conservation projects, system operation and maintenance, systematic upgrades, and affordability. Individual projects may not be attractive for private financiers. One option is to aggregate projects in such a way that they will be assessed and financed as one single project. Project aggregation is an important emerging approach for facilitating investment in small-scale sustainable energy infrastructure.

For example, a US company (SolarCity) issued over USD 200 million securities (notes) backed by residential solar PV leases. Because many developers of sustainable energy projects lack the credit rating to themselves issue bonds, securitised bonds - where repayment depends on the quality of the assets rather than the creditworthiness of the issuer - have the potential to lower financing costs (Kaminker et al, 2015 forthcoming).

Opportunities to access equity finance

187. As an alternative to PSP, several utilities are exploring options to recycle some of the capital tied up in water infrastructures, to generate cash that can be used for new projects. Long-term investors such as pension funds might be interested to contribute and substitute for public money in the capital structure of the utilities, provided that the risk-return profile of the investment is attractive.

188. This recent development has far reaching consequences. First, as noted by Global Water Intelligence (GWI), "the emergence of a relatively liquid market for equity stakes in brownfield water infrastructure projects means that investors who are prepared to assume early risk – including construction risk – increasingly find that there is a natural exit opportunity once a project enters the operational phase." This is particularly the case in a context where the equity market is highly volatile and bond markets only ensure low yields: some water projects typically generate the stable revenues and limited risks that long term investors are longing for. Second, this option may be more palatable to public opinions than private investment. It is however limited to specific objects, readily isolated from urban water networks.

189. Typical deals which involve private equity firms cover desalination, wastewater treatment and reuse projects, for either municipal or industrial clients. Table 4 compiles recent large deals where private equity firms invest in water and essentially in urban water management. Such investments, however, are skewed towards specific asset classes: GWI notes that i) they are exclusively located in OECD countries, and ii) they have not exposed investors to single-asset risks.

Table 4. Selected large private equity investments in water

Selected large private equity investments in water

PE firm	Investment	Year invested	Deal value
Clayton, Dubilier & Rice	Ashland Water	2014 (a)	$1.8 billion
Kohlberg Kravis Roberts	South Staffs Water (b)	2013	Undisclosed
Kohlberg Kravis Roberts	Bayonne concession	2012	$150 million
Carlyle	Park Water (b)	2011	$102 million
Kohlberg Kravis Roberts	United Envirotech	2011 & 2013	$153.8 million (c)
JPM Asset Management	SouthWest Water (b)	2010	$427 million
American Securities, LLC	ADS (g)	2010	Undisclosed
Metalmark Capital	Ni America (b)	2007	$100 million (d)
Bain/Carlyle/CDR	HD Supply	2007 (e)	$10.3 billion
Apollo Global Management	Rexnord	2006 (e)	$1.825 billion
Blackstone/Apollo/GS	Nalco	2003 (f)	$4.13 billion

a) Deal pending b) Regulated utility c) Convertible bond + equity d) Growth equity commitment
e) Partially exited through IPO f) Exited in 2007 g) Filed for IPO in April 2014 Source: GWI

Source: Global Water Intelligence (GWI)

190. Several financial techniques can make urban water management more palatable to private investors:

- Maturity transformation consists in taking lots of short term trades and, using the portfolio effect, turning them into long term stable demand[17]. This helps to mitigate counter-party risk. Such groupings are particularly well-suited to decentralised water sectors, in which small and medium-sized service providers are struggling to access financing on their own merit. In the sector, maturity transformation has mostly been used as a basis for issuing bonds in countries with fairly mature financial markets. High transaction costs and limited knowledge, once again, can partly explain why this technique has remained somewhat limited beyond those markets (OECD, 2010c). Further diffusion may require establishing such grouped financing structures directly (e.g. revolving funds, bond banks, etc.) or fostering the adoption of legislation that make such structures more attractive (e.g. tax-exemptions on bonds issued by such structures, as practised in the US, or requirements that grouped financing vehicles be formed in order to access government financing).

- Raising equity can help strengthen the balance sheets of water companies which tend to often be under-capitalised. Interesting models have been developed in the water sector to mobilise equity via financial markets (such as the Hyflux Water Trust in Singapore), thereby diversifying away from mobilising funds from private water companies (whose ability to bring in equity capital is limited in any case) and using such equity injections to leverage other forms of finance for capital investments. Mobilising equity through capital markets can strengthen financial discipline and improve transparency, including for companies that are primarily government-owned (including a number of state water companies in Brazil, which are publicly listed) (OECD, 2010c).

- Credit ratings can help improve transparency and facilitate access to financial markets for borrowers. Significant progress has been made in awarding credit ratings to municipal governments and water companies, although the use of such ratings has remained limited, particularly in markets that are too small to develop a national rating scale and where the costs of maintaining credit ratings cannot be warranted. The financial crisis has significantly affected the credibility of rating agencies, however, and more generally the reliability of ratings has been questioned in the light of time gaps with regard to information and a potential lack of independence of rating agencies (principal-agency problem) (OECD, 2010c).

191. The high risk associated with newer technologies can also reduce financing options for innovative urban water management. As discussed in OECD (2013f), risk profiles vary according to the technology and its stage of development; the technology development stage determines which type of financing is most appropriate. For example, venture capital financing is generally suited for unproven and untested technologies, while project finance is used for mature technologies.

192. WaterTap Ontario is developing and promoting an "Invest to Save" fund for water infrastructure. This initiative is a response to many examples of innovative approaches that cost less than traditional capital projects; however these projects are typically not eligible for traditional infrastructure funding support. The "Invest to Save" fund aims to support projects for optimisation, efficiency and that use innovative technologies and approaches in the sector. These technologies and approaches will save money for both the Province and municipalities and create opportunities for companies to grow while continuing to meet essential levels of service (see http://www.watertapontario.com/news/blog/invest-to-save-fund-innovative-technologies/28#sthash.1gvVzrMK.dpuf for more information).

[17] This technique differs from aggregation, which takes lots of small units and turns them into a large scale parcel

Harnessing property developers to invest in water systems

193. Engineering firms are building water systems using private capital, and maintaining ongoing service contracts to finance this capital. Home and land owners are also investing their own capital (or servicing the debt on needed capital) in order to build decentralised systems for single-family or multi-family complexes (see Box 16, on Brisbane, Australia). In Mexico, the largest source of investment funding for water supply and sanitation, besides the Federal Government, is housing developers (22 percent). Property developers construct water and sewerage systems within their developments; they have increased their investments substantially as part of large subsidised housing programmes initiated in 2001 (World Bank, 2005).

Box 16. Innovation in a Greenfield Site: the Gap, Brisbane

The Payne Road residential subdivision in The Gap, Brisbane, is a Greenfield, 20-lot subdivision being undertaken by a property developer with an interest in achieving sustainable water management. This particular developer has other projects with similar planned features.

The developer has planned the site to have minimal water transfer in or out. This is achieved through rainwater tanks at each house connected to three large communal tanks. These communal tanks can be topped up from the town water supply in the rare event of insufficient rainfall. Only blackwater is discharged to the existing sewer network. Grey water is used for subsurface irrigation at each property.

The system architecture combines on-site systems and central infrastructure. This can be consequential for the operation of central wastewater systems. In Australia, water utilities report up to 40% reductions of wastewater collection flows due to, among other things, increasing on-site recycling; less water in the system can generate blockages and higher concentrations of contaminants (see the Water Services Association of Australia Report Card 2007-08).

In the Payne Road operation, the developer has kept local and state government stakeholders informed, and these parties maintain an ongoing interest in the project for monitoring purposes. Responsibility for ongoing management of the communal components of the system will be through a body corporate. This project, though small and insignificant in terms of Australia's overall urban water balance, is at the leading edge of decentralised approaches to sustainable urban water management. The water cycle is, to a great extent, localised and "closed loop", resembling much more closely the original natural water cycle than the intervention of conventional centralised systems.

A limitation on replication of this project is the large land areas required (each lot is 1,000 m2). There are also several unresolved questions such as how water will be supplied during power outages, potential health consequences and social acceptance and amenity over time. In addition, this project does not address the need to close nutrient cycles.

Source: quoted from Livingston et al. (2005).

194. Housing/property developers deserve particular attention as, in certain contexts, they have incentives to invest in water infrastructure (in particular in decentralised systems) to raise the value of their property. Australia is a case in point. Research by Australia's biggest property website (www.realestate.com.au) has revealed more vendors are seeing green credentials as selling points, and buyers are responding with one in ten people prepared to pay up to 20 per cent more for a 'green' home. As water supplies and sustainability move up the agenda, water-secure properties are becoming more popular; water tanks rank as the feature most likely to add value to a property. In France, rainwater harvesting is the second highest feature regarded by the public as a positive contribution to green building, after renewable energy and before renewable materials. However, this appreciation does not translate in the property value: owners of private houses in France have failed so far to recoup investment cost from the sale value of their property.

195. Innovative institutional arrangements may generate additional incentives for private investment in decentralised systems. In England, inset appointments generate opportunities to organise decentralised water systems in the context of a central infrastructure. There is reference to neither water reuse nor self-treatment of wastewater, but the stage might be set for further developments. Franceys (2007) signals some of the difficulties associated with inset appointments. We turn to them in the next chapter, as they are relevant for decentralised ways of providing water.

Box 17. Inset appointments in England

In England, “inset appointments” are an important means of introducing more competition to the water and sewerage industry: they allow some customers, particularly large ones, to choose who provides their water supply and sewerage services (for more information, see OFWAT). Inset appointments were initially allowed for large consumers, typically commercial users such as steel makers and breweries.

In 2007, Ofwat (The Water Service Regulation Authority, England) has granted Independent Water Networks Limited (IWNL) an inset appointment to supply a 950 home development in Corby, Northamptonshire. IWNL will serve its customers by buying water from Anglian Water and discharging sewerage to Anglian Water’s network. IWNL said its 2007-08 volumetric charge will be 5% lower than that of Anglian Water. Ofwat is considering other inset appointments.

Source: Franceys, 2007.

196. The capacity of decentralised water systems to attract (private) investment from parties which will benefit from the rent accrued by improved water services is particularly relevant in a context where public finance is scarce. As Rees et al. (2008) make clear, given limited government budgets and funds from donors, it is important that those functions and services which can raise capital or revenue from users or beneficiaries continue to do so. The opportunity costs involved in continuing to use public funds to provide private goods to those able to pay for them are high. To remedy this situation requires that the governance structure and finance strategies be mutually adjusted. From this perspective, water governance should provide the capacity to make the best use of available water and financial resources.

197. Similar reasoning applies to other technologies, such as sustainable urban drainage. Building on a case study in the UK, Swan (2010) shows how urban planning controls can incrementally improve storm water management and reduce run-offs. They would also “transfer some of the incurred costs away from the sewerage provider and onto local developers” (p.646). This echoes a point made earlier, that legitimises the exploration of new fiscal instruments to address externalities related to urban water management.

Appendix. Financing urban water management in Korea

198. While it has specificities, Korea illustrates some of the trends documented in this chapter.

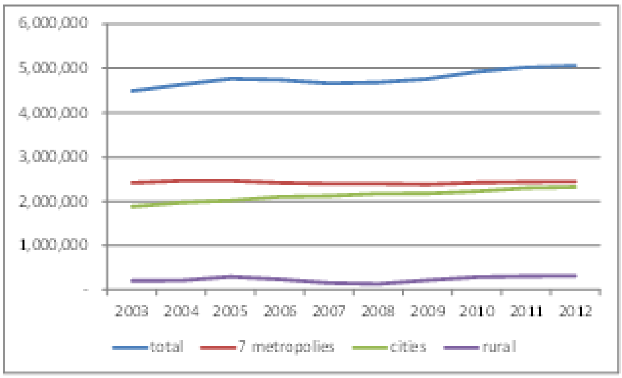
Water demand and expenditure in Korean cities

199. In Korea, water demand from households has increased slightly over the last decade. The aggregate figure masks disparities by type of settlements. Water demand has increased in mid-size cities[18], while it has been stable in metropolises and in rural areas (see Figure 13). In the capital city of Seoul, water demand per capita has declined over the last 6 years.

[18] Data on water use and expenditure are clustered around three geographical areas: metropolises, which include Seoul and 6 other large cities; cities; and rural areas, defined as Gun, i.e. administrative districts of less than 50,000 inhabitants, generally.

Figure 13. Household water demand in Korea

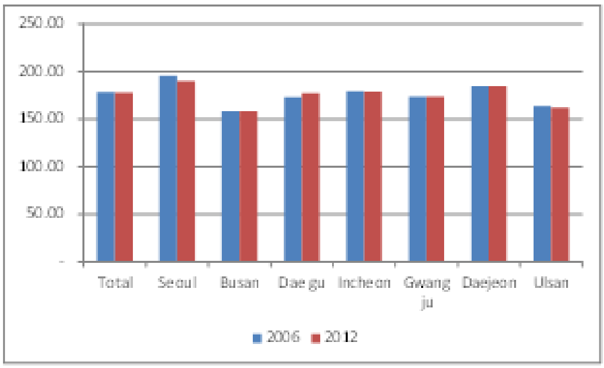
2003-2012



Source: based on statistics of waterworks(2003-2012).

Figure 14. Per capita water use in Korean metropolises

l/c/d, 2006-2012

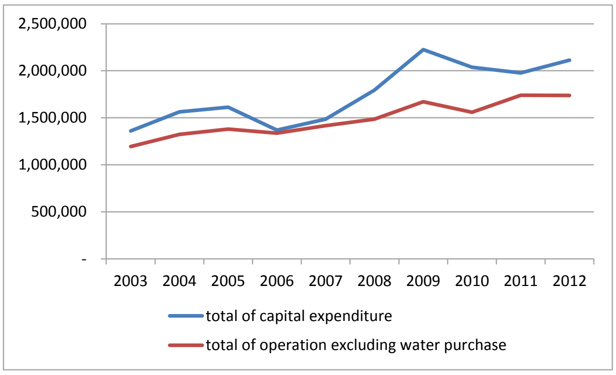


Source: based on statistics of waterworks(2003-2012).

200. Expenditure in water supply has risen steadily over the last decade, both capital investment, and operation and maintenance expenditure. The share of O&M is slightly higher in metropolises. Investment peaked in 2009, driven by a national effort to extend existing infrastructure, especially in cities and urban areas. In metropolises, improvement in water infrastructure accounts for the larger share of investment.

Figure 15. Expenditure for water supply

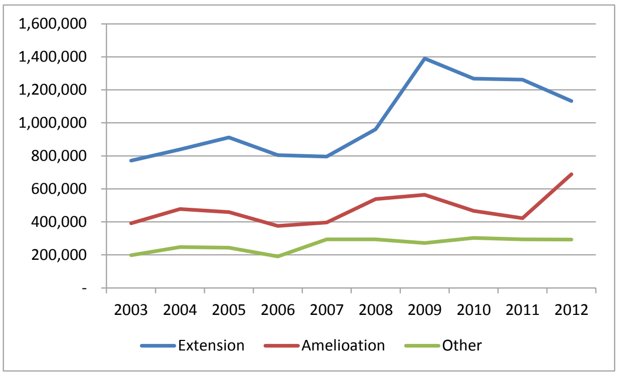
Breakdown between capital and O&M expenditures, 2004-12 (,000 wons)



Source: based on statistics of waterworks(2003-2012).

Figure 16. Breakdown of capital expenditure for water supply

2004-12 (,000 wons)

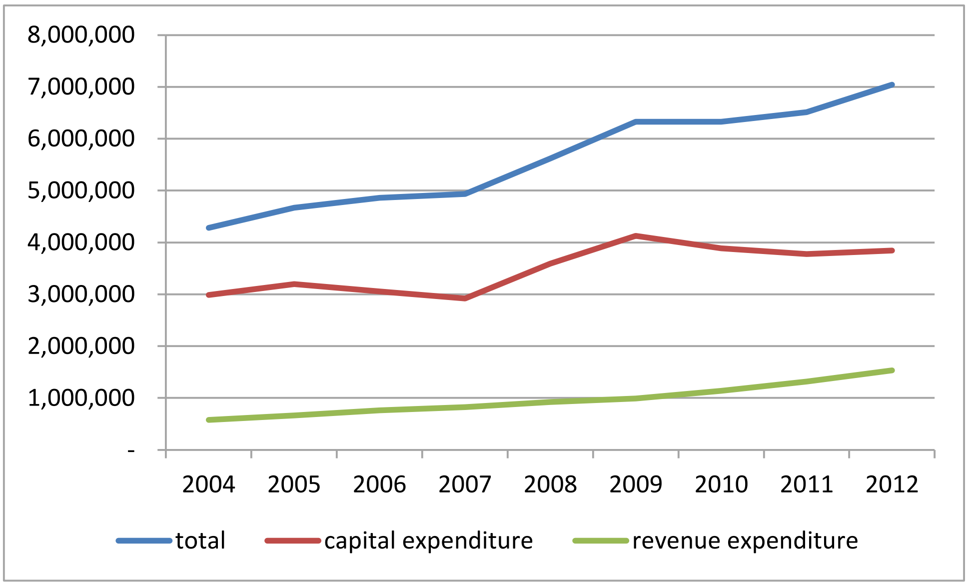


Source: based on statistics of waterworks(2003-2012).

201. Expenditures for wastewater collection and treatment have been rising over the last decade. Capital expenditure[19] represents more than 50% of the total amount, but its share is gradually declining. As cities are now equipped with better facilities, the cost of operation and maintenance rises. Capital spending plateaued in 2009. The trend is particularly acute in metropolises and cities; in rural areas, capital expenditure still represents more than 70% of total expenditures.

Figure 17. Expenditures for wastewater collection and treatment in Korea

Breakdown between capital and O&M expenditures, 2004-2012 (,000 wons)[20]



Source: based on statistics of waterworks(2003-2012).

Financing water supply and sanitation in Korean cities

202. According to the OECD survey on water pricing (OECD, 2010a), Korea stands out as the OECD country where water is cheapest (see Figure 11 above). The situation derives from an atypical combination of financing sources.

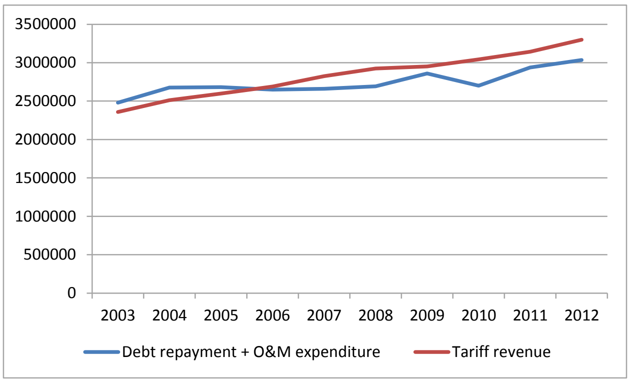
203. Revenues from water bills for water supply services amount to 50% of total revenues; they essentially cover O&M expenditure and debt repayment (see Figure 18). The share of tariffs in total revenues is higher for metropolises, where it reaches 2/3 on average, and lower in rural areas (about ¼).

[19] Capital expenditure includes extension and amelioration

[20] "Miscellaneous" do not show on the Figure

Figure 18. Revenues from tariffs for water supply services

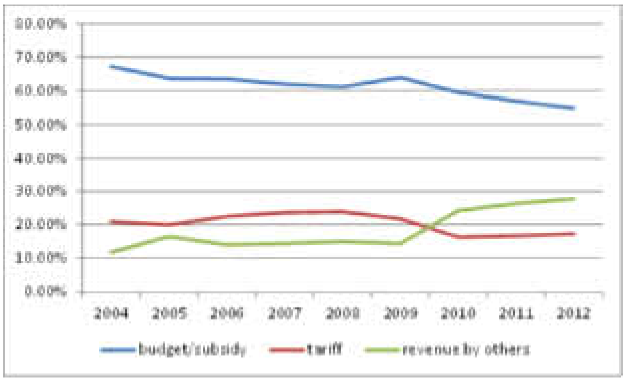
Compared with O&M and debt repayment, 2003-12 (,000 wons)



Source: based on statistics of waterworks(2003-2012).

Figure 19. Revenues for wastewater collection and treatment

Shares of different sources 2004-2012



Source: based on statistics of waterworks(2003-2012).

204. Revenues from tariffs for wastewater services only account for 20% of the total revenues; this share has remained stable over time. Transfers from public budgets represent more than 50% of the total revenues, down from 70% in 2004. The volume of budget transfers has plateaued since 2009. In Korea, an additional source of revenue has been rising over the last decade: revenues from "others", which include revenues raised from property owners or developers who cover (part of) the costs related to the extension of a network. The contribution of these "others" is particularly significant in mid-size cities, where it represents more than 1/3 of the total sources of finance in 2014 (compared to less than 10% in rural areas).

References

Ajami N., J. Christian-Smith (2013), *Beyond Water Pricing. An Overview of Water Financing Options in California*, Pacific Institute

Barraqué B. (2003), *The Three Ages of Engineering for the Water Industry*, Stanford-France STS conference, April 7-8, 2003

Beecher J. (2012), The ironic economics and equity of water budget rates, *AWWA Journal*, Accessible on http://editiondigital.net/display_article.php?id=964244

Boland, J.J., D. Whittington (2000), The political economy of water tariff design in developing countries: increasing block tariffs versus uniform price with rebate, in Ariel Dinar (ed.), *The Political Economy of Water Pricing Reforms*, Oxford University Press, pp. 215-235.

Cardno, C. (2013), *Group Seeks Sustainable, Integrated Water Projects*, The American Society of Civil Engineers

CERTU (2012), *Taxe pour la gestion des eaux pluviales urbaines*, MEDDTL, Paris

Donnelly K., J. Christian-Smith (2013), *An Overview of the "New Normal" and Water Rate Basics*, The Pacific Institute, Oakland, USA

Donnelly K., J. Christian-Smith, H. Cooley (2013), *Pricing Practices in the Electricity Sector to Promote Conservation and Efficiency: Lessons for the Water Sector*, The Pacific Institute, Oakland, USA

European Environment Agency (2013), *Assessment of Cost Recovery through Water Pricing*, Technical report n°16/2013, Luxembourg

Franceys R. (2007), *Innovative Business Models for Water Supply and Sanitation*, presentation at the OECD expert meeting on Sustainable Financing for Affordable Water Services, Paris, November 2007 (available at http://www.oecd.org/dataoecd/38/37/40015975.pdf)

Kaminker C., K. Eklin, O. Kawanishi, R. Youngman (2015 forthcoming), *Mobilising institutional investment for sustainable energy infrastructure: defining channels and approaches*, OECD Publishing Paris

Livingston D.J., N. Stenekes, H.K. Colebatch, N.J. Ashbolt, T.D. Waite (2004), *Water Recycling and Decentralized Management: the Policy and Organizational Challenges for Innovative Approaches* (available at WSUD)

Lloyd Owen D. (2011), *Infrastructure Needs for the Water Sector*, unpublished paper commissioned by the OECD in the preparation of the OECD report *Water Security for Better Lives*, OECD Publishing, Paris

Lloyd Owen D. (2013), One billion people can't be wrong, *Global Water Intelligence*, November

Loge F. (2013), Consumption-based fixed water rates: a novel conservation-oriented rate structure, *Policy Briefs*, University of California at Davis, Center for Water-Energy Efficiency

Marsden Jacob Associates (2006), Securing Australia's Urban Water Supplies: Opportunities and Impediments. A discussion paper prepared for the Department of the Prime Minister and Cabinet (available at http://www.environment.gov.au)

Merk, O., S. Saussier, C. Staropoli, E. Slack, J.H. Kim (2012), Financing Green Urban Infrastructure, *OECD Regional Development Working Papers* 2012/10, OECD Publishing; http://dc.doi.org/10.1787/5k92p0c6j6r0-en

OECD (2003), *Social Issues in the Provision and Pricing of Water Services*, OECD, Paris

OECD (2006), *Infrastructure to 2030. Telecom, Land Transport, Water and Electricity*, Paris

OECD (2007), *Infrastructure to 2030. Volume 2: Mapping Policy for Electricity, Water and Transport*, Paris

OECD (2009), *Alternative ways of providing water. Emerging options and their policy implications*, OECD, Paris

OECD (2010a), *Pricing Water Resources and Water and Sanitation Services*, OECD, Paris

OECD (2010b), *Guidelines for performance-based contracts between utilities and municipalities. Lessons learnt from Eastern Europe, Caucasus and Central Asia, Almaty, Kazakhstan*, OECD, Paris

OECD (2010c), *Innovative Financing Mechanisms for the Water Sector*, OECD, Paris

OECD (2010d), *Cities and Climate Change*, OECD, Paris

OECD (2011), *Better Policies to Support Eco-innovation*, Paris

OECD (2012), *OECD Environmental Outlook to 2050: The Consequences of Inaction*, OECD Publishing.

OECD (2013a), *Greening Household Behaviour. Overview from the 2011 Survey*, DOI: 10.1787/9789264181373-en

OECD (2013b), *Barriers to, and Incentives for, the Adoption of Green Water Infrastructure*, OECD, Paris

OECD (2013c), *New Modes of Water Supply and Sanitation Management and Emerging Business Models*, OECD, Paris

OECD (2013d), *Water and Climate Change Adaptation. Policies to Navigate Uncharted Waters*, OECD, Paris

OECD (2013e), *Water Security for Better Lives*, OECD, Paris

OECD (2013f), *Cities and Green Growth*, OECD, Paris

OECD (2013g), *Mobilising private investment in sustainable transport infrastructure*, OECD, Paris

OECD (2014a), *Water Resources Allocation. Sharing Water, Sharing Risks*, OECD, Paris

OECD (2014b), *Water Governance in the Netherlands. Fit for the future?*, Paris

OECD (2014e), *Greening Household Behaviour: Overview from the 2011 Survey, revised edition*, OECD Publishing, Paris

OECD, (2015 forthcoming), Water Governance in OECD Cities, OECD Publishing, Paris.

Olmstead S., R. Stavins (2009), "Comparing price and non-price approaches to urban water conservation". Water Resource Research doi:10.1029/2008WR007227

ONEMA (2012), *Observatoire des services publics d'eau et d'assainissement. Panorama des services et de leur performance*, Paris

Peterson G.E. (2006), *Land Leasing and Land Sale as an Infrastructure-Financing Option*, World Bank Policy research Working Paper 4043

Peterson, G.E. (2012), "Unlocking Land Values to Finance Urban Infrastructure", *Trends and Policy Options* n°7, The World Bank PPIAF

Poquet G., B. Maresca (2006), *La consommation d'eau baisse dans les grandes villes européennes*, Crédoc, 2006

PriceWaterhouseCoopers (2013), "Quels mécanismes de financement pour les gares urbaines?", study conducted for La Fabrique de La Cité, Paris

Rees J.A., J. Winpenny, A.W. Hall (2008), *Water Financing and Governance*, TEC Background papers, n°12, Global Water Partnership (available at http://www.gwpforum.org)

Swan A. (2010), How increased urbanisation has induced flooding problems in the UK/ a lesson for African cities?, *Physics and Chemistry of the Earth*, 35, pp.643-647

Thomas A. (2013), *Les politiques de gestion quantitative de l'eau*, presentation made at the workshop organised by the French Ministry of the Environment and the Toulouse School of Economy, 11 January

USEPA (2013a), *Blueprint for Integrating Technology Innovation into the National Water Program*, www.water.epa.gov/blueprint.cfm

Walton B. (2012), America's water infrastructure shows its age – the national debate about how to pay for repairs, *Circle of Blue*, 5 March

Water UK (2011), *Sustainability Indicators 2010-11*, London

Whittington D., C. Nauges, D. Fuente, X. Wu (2014), A diagnostic tool for estimating the incidence of subsidies delivered by water utilities in low- and medium-income countries, with illustrative calculations, *Environment for Development*, Discussion Paper Series, November

World Economic Forum (2014), *Strategic Infrastructure. Steps to Operate and Maintain Infrastructure Efficiently and Effectively*, Geneva, Switzerland

World Bank (2005), *The Mexico Infrastructure Public Expenditure Review*, Washington DC

CHAPTER 3. SUPPORTING THE DIFFUSION OF INNOVATIVE PATHWAYS

The chapter outlines the potential benefits of innovative approaches to urban water management, as well as barriers to their implementation. It covers both technical and non-technical innovation. It shows that innovation does not need to be high tech. Particular attention is paid to green infrastructures, smart water systems, distributed infrastructure and urban planning: innovation in these areas can contribute to urban water security, with appropriate business models, at least cost for the communities.

The chapter builds on selected case studies from OECD cities, which have embarked on innovative approaches to manage urban waters. The chapter also builds on previous work by the OECD on policies to support innovation in the environment and in water management in particular.

Key messages

205. Innovation in urban water management can be technical, such as the combination of information and communication technology and water infrastructure. It can be non-technical as well, such as water-sensitive urban planning. The distinction may be elusive, as innovative water management combines technological elements with innovative business models for service providers (be they public or private) and innovative governance (such as stakeholder engagement).

206. Innovation, both technical and non-technical, can lower the costs of enhanced water security in OECD cities. While it is burgeoning in OECD cities, its diffusion remains limited by a series of factors:

- Retrofitting is difficult, in particular in high-density areas.
- Lack of policy coherence hinders the competitiveness of innovative solutions; for instance when water prices fail to reflect opportunity costs of resource use, or when land use and urban development do not reflect the risks of building in flood plains.
- Regulations, funding mechanisms and lock-in failures favour grey infrastructures and incumbent urban water management practices over long-term sustainable practices. They often fail to recognise the capacity of users and the wider communbity to discuss about the pros and cons of alternative technologies;
- Lack of data (on river flows, or on track record of green infrastructures) weakens the case for innovative technologies.
- Innovative practices combine different scales in urban water management, from buildings to municipal and larger levels. Such combinations are hampered by institutional arrangements, which split incentives and responsibilities along the water cycle.

207. OECD cities that have overcome these barriers have usually combined several initiatives:

- A long term vision of water challenges and opportunities for urban development;
- Business models for water utilities and land development that factor in externalities related to water security;
- Governance structures that favour a whole-of-government approach to urban water management and reach beyong city limits; and
- Information campaigns to raise city dwellers' awareness of water-related risks and the costs of liabilities that result from short term visions.

208. Chapter 4 further explores innovative arrangements that support co-operation between OECD cities and their rural surroundings and contirbuet to enhanced water scurity at least cost for the community.

Introduction

209. Application of membrane technologies at decentralised scale in households, shopping centers, and universities etc. could completely change urban water systems and open up possibilities for large scale decentralised urban recycling (van der Steen, 2011). Similarly, the relationship between urban water management and energy consumption could change radically, as innovation on waste-to-energy technologies generate energy from wastewater, either directly using the heat of sewerage, or indirectly by using nutrient and sludge (the Dutch regional water authorities transform some of the wastewater treament plants they manage in Energy Factories; see http://energiefabriek.com/english for more information). In the near future, wastewater treatment plants will have the capacity to sell energy to the power grid.

210. These observations illustrate the potential of disruptive technologies to promote new approaches to the design and operation of urban water management systems. They also suggest a pragmatic approach for the deployment of innovation in urban water management, as opportunities arise through the constant renovation of OECD cities. This chapter reviews a selection of such innovations and discusses their potential benefits for future water management in OECD cities.

211. The chapter pays particular attention to the diffusion of innovation in urban water management: while technologies (hard and soft) are readily available, several barriers hinder their diffusion in OECD cities. The chapter analyses these barriers and explores options to overcome them. Selected innovations are used to illustrate the points made in the chapter: smart water systems; decentralised technologies and distributed systems; supplying water fit-for-purpose; green infrastructures; and urban planning.

Opportunities for disruptive technical innovations

212. This section explores selected disruptive innovations, based on recent developments in OECD cities. It focuses on smart water systems, which exploit recent developments in information and communication technologies; decentralised technologies; and distributed systems, which combine urban water management at different scales.

213. One point needs to be made: no technological option is universally superior, as each options generates trade-offs. Makropoulos and Butler (2010) discuss the potential benefit of exploring a portfolio of technological infrastructure options and assessing their benefits in specific contexts. They show that any technology and innovation generates "trade-offs between water use, energy use and land use, and these have an equilibrium point that is associated with the technological state-of-art. At a given technological state-of-art, further reductions in water savings signify increase either energy consumption (for high-tech solutions) or land use (for low-tech solutions). The strategies' evaluation indicates however, that until this equilibrium point is reached there can be significant gains in all three aspects [water supply, wastewater, and drainage]. After this equilibrium, improvements in one aspect inevitably signify costs in others. The choice of desired trade-off then depends on the specific constraints of the problem at hand" (Makropoulos, Butler, 2010, p.2795-6).

Smart water systems

214. The International Telecommunication Union (ITU) defines smart water management (SWM) in cities as the attempt to alleviate challenges in urban water management through the incorporation of information and communication technologies (ICTs) products, solutions and systems in areas of water management and sanitation (ITU, 2014). More specifically, Lloyd Owen defines smart water systems as "systems, components and software that allow the user to monitor, manage and act on data relating to the part of the water cycle that is pertinent to their interests. [They] can be characterised by features including: a high degree of automation, rapid response times or the capability to capture information in real-time; the

ability to transmit data between remote locations and the data processing facility; and for the data to be interpreted and presented to utilities and end users (see OECD, 2012b).

215. Smart water management is data intensive. In addition to data on water flows and water systems, SWM often uses complex mathematical modelling, to better understand river flows and improve the design of infrastructures (a point made by Green; see OECD, 2013b). The case study of Hamburg illustrates how a city can invest in data collection and modelling to respond to emerging challenges; it also illustrates other areas for innovative urban water management, which are developed in subsequent sections.

Box 18. Innovation in urban water management - the case of Hamburg

Hamburg Wasser (HW), a municipal company, is the main actor dealing with water supply and wastewater disposal in Hamburg, Germany. Drinking water supply is sourced from the local aquifer. 99% of the population in Hamburg is connected to wastewater disposal and adequate treatment.

HW will have to soon deal with a few challenges such as: a) increasing sealing rate in the future which can lead to overloaded sewers and watercourses; b) necessity to increase nutrient recovery from wastewater to face the future nutrient demand and comply with ecological standards; c) renovation of the aging infrastructure and adaption of the existing infrastructure; d) protection against salinisation of the groundwater wells; and e) new ways of energy supply and high rates of self-sufficiency for wastewater treatment processes.

Hamburg has two main objectives with regard to future water management, namely: a) to create a good database of rainfall events and to decentralise the retention of rainwater to avoid urban flooding; and b) to explore different uses of wastewater, e.g. as a source of energy, and recovery of nutrients from waste to be used in agriculture.

Hamburg has taken up concrete measures to respond to the challenges and fulfil its objectives.

SYNOPSE

Hamburg has launched a joint research project SYNOPSE (2013) to produce reliable planning instruments to measure rainfall and minimise costs in the future. SYNOPSE creates rainfall series to make realistic modelling and planning possible. It involves developing different precipitation models, and comparing the resultant digital series with real rainfall data.

RISA

The project RISA, Adaption of Rainwater Infrastructure, wants to promote sustainable rainwater management and to set up binding guidelines within a structural plan for rainwater management. It aims at managing rainwater so as to avoid flooding of basements, streets, or properties and to avoid water pollution from combined sewer overflow and urban or street runoff. The background to the project is the rapid expansion of impervious surfaces within Hamburg, which increases by one million m^2 (100 ha) every year.

HAMBURG WATER cycle in Jenfeld

The HAMBURG WATER cycle is an innovative wastewater concept based on source separation, i.e. separation of wastewater streams and energy recovery from the wastewater. As different wastewater streams (black water, grey water, and rain water) have different characteristics, the utilisation of wastewater is adapted to specific properties of the material flows.

Hamburg Wasser has taken up the responsibility to develop new business models and promote innovation in the water sector, though it requires time, effort, and strong and loyal partnerships.

Source : the case study was developed by Hamburg Wasser, for the OECD project

216. The potential benefits of SWM are multifaceted. Smart water management can enhance water quality and reliability, ensure proper management of green infrastructures, decrease water losses due to leakage, reduce operational costs, and improve customer control and choice (ITU, 2014). Particularly relevant from a water security perspective, smart technologies "can allow water, wastewater and storm water information to be abstracted and integrated with other data sources such as climate analysis and weather intelligence facilitating a holistic managerial approach to overcome the pressures and challenges within the system" (ITU, 2014, p.34). ITU further notes that these improvements contribute to both the efficiency and the financial sustainability of urban water management, as municipalities and water utilities are better able to recover costs from non-revenue water (e.g. leakages and illegal connections).

217. As an industry, the smart water market can be seen as booming and fragmented both in terms of the number of players and their market share, and in the lack of cross-sectoral applications. Companies to date have tended to concentrate on specific applications (OECD, 2012b). For this reason, market trends are difficult to document. Lloyd Owen estimates that global sales for smart water systems were in the range of USD 500-1,000 million in 2009-10 and they are forecast to rise to USD 5-16 billion by 2020. Smart water systems accounted for approximately 0.5-0.9% of the global water hardware market in 2010 and look set to account for 2.9-9.4% of the market by 2020 (OECD, 2012b).

Zooming in – how smart meters affect urban water management

218. Although it is only one of the typical applications of smart technologies for urban water management, smart meters attract a lot of attention. Smart meters, initially installed in American cities, are meters equipped with real-time information transfer to the utility. Smart meters are not mere technical devices: they partake in participatory water governance. They support a new, pro-active relationship with water users, allowing users to have a say in the definition of the service and a better control on the way they use water. In Boston, USA, meters registering unusual water consumption automatically warn the operator, who can in turn call up the customer to check whether this unusual consumption is due to a leak or to another reason. This is possible even though there is only one meter per building (note that Boston Water and Sewer Commission has access to the crucial information of the number of persons behind a collective meter). Smart meters facilitate the development of statistics about per capita water use and the analysis of water consumption. The case study of the city of Fukuoka, and their use of smart water management to improve operational efficiency, is presented in Box 19.

Box 19. Smart water management - the case of Fukuoka, Japan

Fukuoka city has population of 1.5 million in 2013. However, the city is not blessed with plentiful water resources. In order to meet the growing demand for water resulting from the development of the city and population growth, Fukuoka City has constructed an extensive water infrastructure network, comprising eight dams, five water purification plants, and approximately 4,000 kilometres of water distribution pipeline. However, many of the existing facilities are aging and need to be updated or renewed.

In 1978, Fukuoka City suffered a severe drought caused by abnormally low rainfall. Restrictions to water service lasted for 287 days. A total of 30,000 man x days and a massive amount of expenditures were devoted to adjust water distribution, typically by opening and closing valves. This operation caused various problems including a number of disruptions to water supply, and in some cases, insufficient water supply.

In 1981, Fukuoka City Waterworks Bureau developed a water distribution control system in an attempt to reduce water leakages and to promote water-efficient urban planning. The system has been modified repeatedly for improvements over the years to become what it is today.

The entire water service area is now divided into 21 blocks. A system was developed, capable of adjusting water pressure to the proper setting, based on the level of demand on a block-by-block basis. A number of water pressure gauges, flow meters, and electric valves installed on water distribution pipes are being monitored and remotely controlled by the Water Distribution Control Center.

The water distribution control system has improved operational efficiency in the following areas:

- Proper adjustment of water pressure within each block has lowered the overall water pressure in the entire water distribution system. This translates into a reduction in water loss from leakage by an estimated 4,000-5,000 cubic metres per day;

- In the event of any damage to the water mains,pipes or purification plants, water supply can be cut off immediately and changes to the water distribution areas can be made quickly, thereby minimising water loss from leakage.

Source: the case study was developed by Fukuoka City Waterworks Bureau for the OECD project (2014).

219. Data collected by smart water meters allow water managers and policy makers to fine-tune the relationship between water consumption and water prices or income. Innovative utilities can build on such data sets to develop refined demand forecasts. They can also factor in climate variations, irrigation needs, family sizes, existence of pools, etc. Smart meters can be coupled with ‘flow trace analysis’ software, which breaks down water consumption data by various types of indoor and outdoor uses. This can be very helpful for utilities willing to refine their foresight on water demands, but also to better target the customers and/or the appliances that should be replaced.

220. While the deployment of smart meters is growing rapidly, the analysis of the actual impact of smart meters on individual water use and customer behaviour is still at an early stage (Lloyd Owen; see OECD, 2012b). It is likely that the full potential of the technology has not been fully exploited yet.

Policies to support the diffusion of smart water management

221. In a paper commissioned by the OECD (see OECD, 2012b), Lloyd Owen has reviewed the experience of ten OECD countries to support smart water management. The analysis highlights how a combination of policies can contribute to the diffusion of innovation in water management. It also signals how innovation can diffuse as an unintended consequence of initiatives in other areas. Finally, Lloyd Owen

identifies some institutional barriers to be diffusion of smart water systems. These outcomes will be taken into account in the last section of the chapter.

222. Several countries have explicitly encouraged the development and deployment of smart water systems to improve water management. The focus in these countries tends to be on smart water metering and the collection and treatment of data in order to inform consumers on actual water use, to manage demand, and to detect leakages. The deployment of smart water meters can be coupled with a reform of tariff policies (to reflect scarcity), and a series of measures to encourage efficiency. For example, policies designed to lower water usage in California and Arizona have resulted in utilities adopting smart water meters to inform customers about their water usage. Incentives to reduce leakage in water supply and sanitation networks in France have spurred the diffusion of smart meters and investment in data monitoring, to detect and locate potential anomalies in real time. Malta is rolling out the world's first national smart water plan. Jersey is testing a similar approach. In Australia, government funding has supported a smart water meter trial covering an entire community (Wide Bay Water, Queensland).

223. Other governments (at national or state level) are promoting smart water systems as part of a policy to support green innovation, and information and water technologies. This is the case in Ontario, Canada and Israel, where new smart water companies have emerged. Korean national policy includes developing a comprehensive network of local and regional smart water grids.

224. Mixed signals in England and Wales have inhibited smart metering. Because of the regulatory structure, utilities engage in 5-year spending programmes only, and smart metering has too long a payback period for this model. In 2011, Ofwat noted the potential for smart metering but did not specifically consider it (except for leakage detection and non-revenue water monitoring, where pilot projects are underway). It has commissioned an evaluation of the costs and benefits of smart metering before setting prices for the period 2015-20.

225. Policies not initially targeted at deploying smart water systems can have unintended positive outcomes. For instance, competition for non-domestic customers in Scotland since 2008 triggered the diffusion of smart meters, as utilities strived to improve their performance and the service delivered to customers. Indeed, advanced metering, pressure management and pipe monitoring systems have reduced leakage with minimal physical intervention in England, Wales and Scotland.

226. Data privacy laws in the UK, Netherlands and in California, and concerns about possible health implications of data transmission (concerns about electromagnetic fields generated by meter radio transmitted), have prevented the installation of smart meters in some jurisdictions. Concerns regarding potential stranded assets can also inhibit the deployment of smart metering; for example, in Amsterdam, standard water meters were only recently installed, and the utility is reluctant to replace them with smart water meters.

Localised sanitation and drainage at source

227. Reflecting on future infrastructure needs, the OECD (2006) noted that the most developed countries now recognise that the large-scale centralised systems may no longer be viable, due to high maintenance costs and resource needs. This is true for water supply and wastewater infrastructure, rainwater collection and drainage. Recent developments in flood control in the Netherlands point in the same direction (see OECD, 2014b). this section reviews recent developments in localised sanitation and urban drainage at source.

Localised sanitation

228. Localised, on-site systems for wastewater management serve individual or small groups of properties. They can recover nutrients and energy, and can also be linked to local water supply and reuse technologies (Matsui *et al.*, 2001). They require less up-front investment than larger scale, centrally piped infrastructures and are more effective at coping with the need to expand services (USEPA, 2002). Various commentators suggest that they have a role to ply in urban water managvement, even in major developed cities (*e.g.* Tjandraatmadja *et al.*, 2005).

229. Localised wastewater and sanitation can be used to serve populations not connected to public systems. Rich countries with large metropolises but low population density, like Australia and the USA, still have significant populations served by private individual or community systems. In Europe, the situation is diverse: the proportion of households not connected to sewers is higher in low density or low revenue countries, or regions like Portugal and Spain, southern Italy and Greece, eastern European and Nordic countries, Ireland and even in some German *Länder*. In these areas, the connection of populations to public water systems is not fully achieved. Ireland has officially kept a large number of group water schemes, providing water to 8% of the population at small community scales (OECD, 2013c).

230. Localised sanitation systems are not merely a remedy to the limit of centrally piped systems. They are increasingly used in countries such as the United States, where on-site sanitation now comprises some 40% of all new developments (USEPA, 2002). Sustainable neighbourhoods in cities partly, or fully, replace traditional public systems by decentralised technologies. Paradoxically, these innovations take place in the richer and high density European member states (OECD, 2013c).

231. The performance of localised systems can compare with that of centrally piped infrastructure. For instance, an evaluation of localised systems in Ireland shows that, despite their difficulties to meet the standards now imposed at European level, such schemes operate sometimes better than public water systems, and the population they serve remains largely in favour of keeping them (Brady and Gray, 2013).

232. Innovation can contribute to improve the performance of localised systems. Research is on-going to serve communities that rely on individual and community systems with robust and simplified treatment, equipped with real-time information and communication technologies, to help set up community services operated from distant centres (e.g. work by Yoram Cohen, UCLA IoES).

233. These developments explain the renewed interest for localised, on-site sanitation. In the Australian context, the Australian Academy of Technological Sciences and Engineering (ATSE) recommends that Australian Governments encourage investment and uptake of such systems (ATSE, 2012).

Decentralised rainwater collection and drainage

234. Decentralised systems apply to storm water drainage. There is a growing use of “source control” technologies that handle storm water near the point of generation, *i.e.* locally. For instance, green roofs or pervious surfaces capture rainwater before it runs on polluted pavements and streets.

235. These solutions have several merits. They can:

- Alleviate peak flows, by capturing water at source and avoiding run-off on the streets or in sewer networks; as a consequence, the risks of urban floods or of sewer overflow in cases of heavy rain are mitigated.

- Minimise pollution, as rain water gets more heavily polluted when it flows over long distance on dry streets, pavements, or parking lots.
- Improve the quality of water returned to the environment; in particular, pervious surfaces allow rainwater to trickle through the ground and recharge aquifers.
- Avoid investment in additional hard infrastructure and treatment facilities; as decentralised drainage limits the flows conveyed through piped infrastructure, it can reduce the needs for extension of sewerage and treatment infrastructure; as such, it contributes to cost-effective adaptation to climate change.
- Harness private capital. Property and land developers can invest their own money to equip their property with localised drainage systems, in particular in the context of greenfield development; it may be more difficult and costly to retrofit existing infrastructures.
- Provide opportunities for direct use for, *e.g.*, toilet flushing. These opportunities derive from the fact that rainwater is collected and available locally and costs to transport water are avoided (see Chapter 2 for a discussion of the significance of such costs).

Box 20. Decentralised urban drainage - the case of Suwon, Korea

Suwon, Korea is a city with a population of over 1.1 million and an area of over 121 km^2. Because of the lack of water resources - the ratio of water self-sufficiency is as low as 11% - Suwon city procures the majority of the water it uses from K-water's multi-regional water supply system.

Suwon embarked on the "Rain City" project, designed to reduce water dependence on distant water sources and to secure enough water by using rainwater in preparation for future water shortage. Water quality was another driver for innovation: non-point sources of pollution continue to flow into streams, via rainwater run-off. In order to control water quality in the urban area, Suwon needed to reduce the volume of run-off from rainwater.

In order to promote Rain-city project, several actions have been taken:

- An ordinance was enacted, ("Municipal Ordinance on the Management of Water Circulation in Suwon") to establish the legal foundation for the promotion of rainwater storage facilities;
- A master plan for water management was set up from 2009 to 2011, which includes an analysis of the status of water resources, a plan to improve rainwater collection and use, and guidelines on the installation and operation of rainwater harvesting systems;
- Several facilities were installed, equipped to collect and reuse rainwater; for instance, multi-functional rainwater reservoirs on Suwon sports complex, rain boxes in private houses, artificial recharge systems;
- Support offered to 90% of the total installation cost of rainwater tanks, to encourage participation of citizens; and
- Education, to change the perception on rainwater collection and use; the programme helped understand how environmental resources circulate in the city.

Building on the initial success of the Project, the city devised a second plan for the Rain-City project, to be implemented during the 2015-2018 period with a city budget of 10 billion won. The second plan includes installing rain water recycling facilities of 10,000 m^3 capacity, and 150 small rainwater tanks.

Suwon's experience confirms that localised rainwater harvesting can be deployed in dense, built environments, where central, piped infrastructure is already in place. However, a comprehensive cost-benefit analysis is required in different climate regions to assess the economic viability of rainwater harvesting. The assessment should consider water quality, quantity and conservation, environmental impacts, energy saving, and the economy.

Source: drafted by Kunwook Kim, K-water, in the context of a secondment to the OECD.

236. OECD cities are gaining experience with decentralised rainwater collection and drainage (see the case of Suwon, Korea, in Box 20 above). In Australia, water management at, or near, the source of rainfall via direct roof runoff collection and storage is now part of the portfolio of how best to provide and maintain water supplies. Localised rainwater collection can be combined with grey water recycling, and even recycling of sewage water at source.

Policy implications

237. Experience accumulates with the implementation and exploitation of decentralised sanitation and urban drinange. Still some barriers have to be overcome. Some relate to the regulation and business model of water utilities. The case study of San Francisco, California, illustrates how decentralised water management best materialises when combined with a series of adjustments, including regulation, business models, and a new role for the water utility (see Box 21).

238. Another barrier to the deployment of decentralised water systems is the feeling of some communities being left out, when not connected to a central infrastructure. Lorrain (personal communication) notes that there is a risk that localised systems fragment the city into communities that would enjoy uneven service quality. Such a potential equity issue needs to be addressed. The concept of a public service operating non-networked systems is a promising avenue (a point made by Barraqué; see OECD, 2013c). For instance, in France, 5 million septic tanks are operating; they are now considered as technologies to be kept and upgraded. The implementation of the Urban Wastewater Directive led to a zoning of networked and non networked areas, the latter being served (or at least controlled) by SPANC (public services for decentralised sewerage). It is noteworthy that the collective management of decentralised technologies creates business opportunities for (public and private) utilities.

239. More generally, institutions in charge of urban water management would benefit from more systematically exploring the limit of centralised technologies in the periphery of cities and the potential benefits of decentralised systems. A fair assessment requires that urban water management be considered at different scales (the city and its surroundings; and at smaller scales, where localised systems can be operated) and that urban water governance be able to combine these different scales - a point that will be explored further in the next section.

Box 21. Decentralised water management - the case of San Francisco, California

The San Francisco Public Utilities Commission (SFPUC) is responsible for the provision of retail drinking water and wastewater services in San Francisco. Centralised water and wastewater infrastructure systems have been the key to provide high quality reliable water and sewer services in the city. As with many other US cities, San Francisco also faces dwindling water supplies, long lasting droughts and extreme weather events. Most of their options for new water supplies and control strategies tend to be controversial and expensive, urging them to evaluate new ways to collect, treat and reuse local water resources.

The SFPUC is embracing decentralised water treatment systems to provide supplemental water and wastewater services. Large scale buildings, both commercial and residential, produce alternate water sources such as rainwater, storm water, grey water, black water, that following treatment, can meet their own non-potable water needs. For example, the non-potable indoor water demand for toilet-flushing can be substantially met through capture, treatment and reuse of onsite alternate water sources.

However, high costs and lack of regulatory frameworks can create barriers for the implementation of distributed water system. In the United States, there are no overarching national water quality standards for onsite systems using alternate water sources, particularly regulations to address on-going operations and public health concerns.

The SFPUC launched a local program for regulating on-site water use called the *Non-potable Water Program*. The program creates a streamlined process for new developments to collect, treat and reuse alternate water sources for toilet flushing, irrigation and other non-potable uses. Additionally, the program establishes guidelines for developers interested in installing non-potable water systems in the buildings and local regulations to ensure appropriate water quality standards.

Subsequently, the SFPUC realigned governmental policies and created new regulatory framework by collaborating with the San Francisco's Departments of Building Inspection (SFDBI) and the San Francisco Department of Public Health (SFDPH) to develop a permitting, review and approval process for on-site system installation and operation. Moreover, SFPUC served as: a) program administration (providing outreach, technical and financial assistance); b) cross connection control (protecting the public water supply, including backflow prevention, testing, certification and tracking);p c) and developed a Water Use Calculator to help developers estimate the volume of the onsite non-potable supplies and demand available for their project.

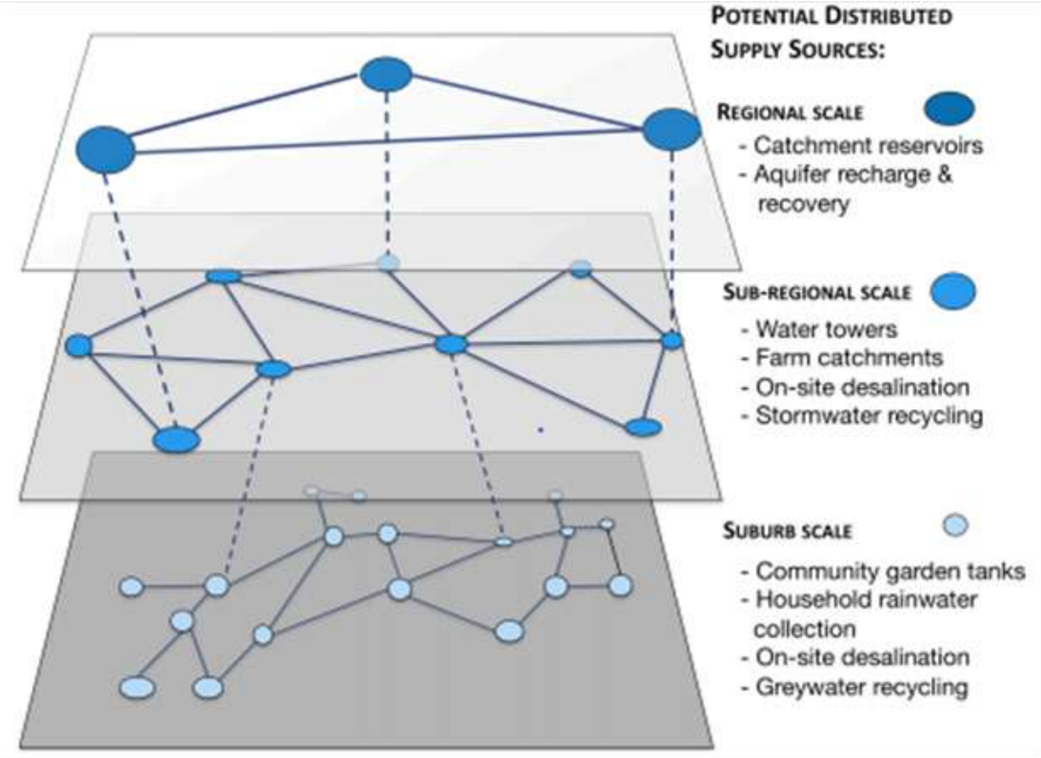
San Francisco's Non-potable Water Program allowed for micro-markets to emerge when two or more buildings share, buy or sell water without the public agency providing the service. The program shifts the burden of operation, maintenance and water quality compliance to the private sector while the public sector maintains oversight to ensure the protection of public health and the public water system. The move towards smaller onsite water systems holds great promise for reducing fresh water demands, aiming to building a more resilient and sustainable city.

Source: The case study was developed by Paula Kehoe, Sarah Rhodes, San Francisco Public Utilities Commission, for the OECD project

Distributed systems

240. Biggs et al. (2009) define distributed systems as a model where infrastructure and critical services are positioned close to points of demand and resource availability and linked within networks of exchange. Services traditionally provided by a single, linear system are instead delivered via a diverse set of smaller systems - tailored to location but able to transfer resources across wider areas. According to the authors, distributed systems represent a localised and highly networked approach to production and consumption, and blur the line between centralised and decentralised water models: the central infrastructure plays an arterial role at a regional level, while smaller, tailored systems operate and interact with users at the local level. Figure 20 depicts how distributed water systems combine different scales of operation, providing context-specific services, while transferring water within and across systems.

Figure 20. Distributed water systems



Source: Biggs C., C. Ryan, J. Wiseman, K. Larsen (2009), *Distributed Water Systems: A networked and localised approach for sustainable water services*, Business Intelligence and Policy Instruments, The University of Melbourne.

241. Distributed water supply systems have been advocated as part of the 'soft path' for water, characterised by Peter Gleick as an attempt to "improve the overall productivity of water use and deliver water services matched to the needs of end users, rather than seeking sources of new supply" (Gleick, 2002). In a systematic review of cases from Australia, Europe and the US, Biggs et al. (2009) show how distributed water systems can generate positive outcomes that enhance and supplement those provided by existing infrastructure models. Distributed systems can:

- Reduce costs and resource use, by adapting water management to context and making the most of available resources.
- Improve service security and reduce risk of failure, by building redundancies in the system.
- Adapt to shifting conditions and demands and respond to risk and uncertainty, by increasing the diversity and flexibility of water systems without locking utilities, customers and future governments into rigid pathways for delivering critical services.

242. At Piperton in the US, an arrangement of sub-surface, interconnected modular wastewater treatment units was used to service a growing suburban development. Treatment units were linked in a clustered network allowing any excess load at one unit to be diverted to others as required. Capacity (i.e. additional treatment units) could be added 'on-demand' to the network as population grew. This represented a significantly lower upfront cost compared to building or expanding capacity in a centralised treatment plant (Biggs et al., 2009, p.11).

243. In another context, Barraqué notes how distributed systems are adapted to the transition from oversized to more adequate infrastructure (see OECD, 2013c). In some German areas, demographic decline combines with the decrease of per capita consumption to induce such collapse in water demand that public systems end up being largely oversized. Some public operators admit that it will not be possible to sustain the present infrastructure; since it would need rebuilding anyway, one option is to redesign them with room for distributed technologies at single family, block or community level, in particular at the urban fringe.

244. Distributed water systems are not merely technical innovations. They require innovative governance. Porse (2013) discusses trends in storm water management in future cities. He argues for hybridised infrastructure, which combines conveyance and infiltration. He notes that such infrastructures require hybridised governance, which disperses management and financing responsibilities between central experts and private landowners. Porse notes that, as cities move towards infiltration-based options, they "will likely transfer more responsibility to landowners, such as building and maintaining swales, green roofs, or other treatments on private property" (2013, p.40). This transition in governance for urban water management is consistent with shrinking public budgets and with calls for public participation. It echoes developments in Chapters 2 and 5 of this report. However, such governance mode remains unexplored, and poorly aligned with the capabilities of centralised bureaucracies.

The benefits of non-technical innovations

245. This section reviews non-technical innovations, which can radically change the way water will be managed in OECD cities, potentially contributing to higher levels of security, at least cost for society. The emphasis is on the capacity to combine a variety of water sources, green infrastructures, and sustainable urban planning. Innovative business models for water utilities could feature here as well, but have been discussed in Chapter 2.

Combining a variety of water sources

246. The case for a holistic approach to urban water management, which combines water supply and sanitation with other functions, is gaining traction. It has been a distinctive feature of the global research programme SWITCH, which made a convincing case for a systemic approach to urban water management: "design and management of the urban water system based on an analysis and optimisation of the entire urban water system (infrastructure and human organisations, water supply, sanitation, storm water, etc.) will lead to more sustainable solutions than optimisation of separate elements of the system" (van der Steen, Howe, 2009; p.116). A holistic approach calls for systems engineering, whereby water bodies (rivers and groundwater) and infrastructures (networks for water supply and sanitation, and storm water) are designed and operated as one system. This requires moving away from silo approaches and governance.

247. The Australian Academy of Technological Sciences and Engineering (ATSE) argues that a holistic approach to urban water sources can be a cost-effective alternative to engineered additional sources of water (ATSE, 2012). A holistic approach can also be more adaptable to shifts in water availability and demand. In practice, it combines decentralised rainwater collection and treatment (as mentioned above), grey water recycling, and possibly recycling of sewage at source. The case of Tokyo, Japan (see Box 22) illustrates how different quality waters can be used in the city, for specific purposes.

Box 22. Promoting the use of non-potable water – the case of Tokyo, Japan

In the early 1960's, Tokyo experienced many episodes of droughts which encouraged the Tokyo Metropolitan Government to accelerate water resource development. Tokyo's water supply system was renovated and expanded several times to achieve 100% water service coverage. Since the early 80s, the government has been promoting non-potable water use to reduce the burden on sewerage systems and the demand on fresh water.

In 2003, it established the *Guideline on the Promotion of Efficient Water Usage* designed to provide guidance on the efficient use of water, including use of non-potable water and rainwater, applicable to large scale construction and development projects. Additionally, as an incentive, the *Business Standards Act* provides for easing the floor area ratio restrictions for those buildings installing non-potable water systems to such an extent as to offset the floor space used to accommodate such systems. Some municipalities provide subsidies for buildings installing rainwater harvesting systems as there is a high cost involved in the installation as well as maintenance and management of the non-potable water systems.

As a result of the efforts, the number of facilities installing the non-potable water system has steadily increased. As of 2012, in-building recycling systems were installed in 408 facilities, industrial water systems in 360 facilities and rainwater harvesting systems in 1335 facilities.

The Tokyo Dome, Japan's first all-weather multipurpose stadium is also equipped with underground storage tanks to collect rainwater from the roofs and a recycling-type non-potable water system whereby grey water from wash basins and kitchen sinks is recycled for non-potable use. These two systems combined provide roughly half of the total demand for water in the Tokyo Dome.

The increasing use of non-potable water is not only reducing reliance on surface water but also contributing to raising public awareness of the importance of saving water. The Tokyo Metropolitan Government continues to move towards comprehensive initiatives for efficient use of water and measures to prevent leakages, so as to ensure stable water supply and achieve greater water resource security.

Source: The case study was developed by Tokyo Metropolitan Government for the OECD project; based on data from the Ministry of Land, Infrastructure, Transport and Tourism (2013), *Heisei 25-nenban Nihon no Mizushigen* (Water Resources in Japan)

248. The holistic approach is supported by emerging concepts, such as urban metabolism, which maps all water flows in a city, thus facilitating a combined management (see Fernandez, 2014, for more information and application to OECD cities). Green (see OECD, 2013b) notes that most cities export more water than they import, as impervious surfaces convert a high fraction of precipitation into runoff. This runoff potentially is a resource, which can be used in the city, or downstream. However, in most cases, it is treated as a liability, collected in sewers and moved away to treatment plants, before it is released to the environment. As discussed above, this approach is costly, in terms of infrastructure, and generates risks of urban flooding and pollution when rainwater is conveyed into sewers and leads to overflow during heavy rains.

249. While the potential benefits of a holistic approach are better understood, so are the barriers that prevent its diffusion. The Australian Academy of Technological Sciences and Engineering (ATSE, 2012) notes that greater integration of water sources (natural, recycled or manufactured) in cities will require sophisticated risk management and water quality monitoring strategies to ensure the primacy of public health. Indeed, as a range of different quality and grades of water will be supplied to specific uses, it is crucial to ensure that the right quality water reaches the right final user. The OECD (2009) has argued that regulatory and institutional frameworks tend to pre-empt informed debates on these issues, and grant a priviledged position to mainstream, centrally piped management.

250. The ATSE also acknowledges that long-term participatory public awareness programmes should be undertaken to overcome negative community perceptions of recycled wastewater and treated storm

water, and to facilitate public acceptance of potable recycling. This orientation paves the way to public debate about the pros and cons of alternative techniques and management practices and about the level of security a community deems appropriate (OECD, 2013).

Green infrastructures

251. Green infrastructures are defined as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas" (European Commission, 2013). They are increasingly recognised as part of the answer to water challenges in OECD cities, especially when cities compete with other users (agriculture, thermal energy, for instance) to access the water they need, and when water management is considered in relation to land use and other policies.

252. UNEP (2014) lists green infrastructures for water resources management, some of which are useful in an urban context. Colin Green also adds demand management and local processing of black or grey water to this list (OECD, 2013b). Technologies related to recycling of sludge, energy generation from wastewater and energy efficiency in the water cycle could be considered as well (they are listed in Syracuse, an innovative tool for more efficient urban services developed by Suez Environnement; see http://www.safege.com/en/syracuse-2/). Energy efficiency translates the objective of water utilities to minimise costs into opportunities to generate additional revenues (see Chapter 2). Energy-related technologies have ancillary benefits in terms of energy and climate policies. Green infrastructures provide solutions to all four risks that determine urban water security: too little, too much, too polluted water, and the risk to the resilience of ecosystems.

Table 5. Green Infrastructure solutions for water resources management

Green infrastructure solution	Urban water management issue							
	WSS (including drought)	Water quality regulation			Moderation of extreme events (floods)			Protection of ecosystems
		water purification	biological control	water temperature control	reverine flood control	urban stormwater runoff	coastal flood (storm) control	
demand management	x							x
local processing of black or grey water	x	x	x					
wetlands restoration/conservation	x	x	x	x	x			x
constructing wetlands	x	x	x	x	x			x
water harvesting	x					x		
green spaces	x	x		x		x		x
permeable pavements	x	x				x		x
green roofs						x		x
protecting/restoring mangroves, coastal							x	x
Corresponding grey infrastructure (primary service level)								
dams, groundwater pumping	x			x				
dams, levees				x	x			
water distribution systems	x							
water treatment plant		x	x					
urban stormwater infrastructure						x		
sea walls							x	

Source: adapted from UNEP (2014), OECD (2013b).

253. Most of the technologies inventoried in Table 5 above are mature. Some have been in use for centuries. For instance, Venice has been relying on rainwater harvesting since its infancy; in the XIX century, Paris adopted a three-pipe system supplying non-potable water to uses that did not require potable water.

254. The benefits of green infrastructures are increasingly well documented. As noted in Chapter 1, the Nature Conservancy (2014) has computed that, if cities invested in the conservation of watersheds, 700 million people could receive better quality water and water utilities could save 890 million USD a year in water treatment costs. Watershed conservation may be particularlyly relevant to low-income cities that cannot offord the capital and O&M costs of built infrastructures.

255. The question then is: why are some cities early adopters, while others lag behind? We will look into barriers to the diffusion of green technologies in the last section of this chapter.Before we do this, it is worth reiterating a point made by UNEP (2014): green infrastructures work best in combination with existing grey ones, when appropriately sited and designed. The point is not to substitute grey by green, but

to combine grey and green, retrofitting green infrastructures to grey ones. This may be particularly challenging in OECD cities, already equipped by grey infrastructures and locked-in technical path dependency.

Water-sensitive urban design

256. The way the city is designed and built affects water demand and availability. It also affects a city's exposure to risks (in particular flood risks) and cities' resilience. Water-sensitive urban design factors water management in: it considers how to enhance water security and access to water services at minimal cost for the community, including financial, social and environmental costs.

257. Water-sensitive urban design starts by a thorough assessment of water-related risks, in an integrated manner: it considers water in connection with other domains, inlcuding infrastructure, mobility, energy, food, etc. In the Netherlands, new settlements and urban developments ought to pass a Water Assessment. The Water Assessment plays an important role in the co-ordination of water plans on the one hand, and municipal infrastructure and land-use plans on the other; it is a process instrument by means of which account is taken of water (quality, quantity, safety) management interests in the spatial planning process and decision making. The OECD review of water management in the Netherlands (OECD, 2014c) suggested that the Water Assessment could be made more effective (e.g. binding) in influencing the spatial planning process and decision making.

258. Water-sensitive urban design is gaining traction, as a concept that combines water infrastructure and urban development. As synthesised by van der Brugge and de Graaf (2010), it encompasses all aspects of urban water management, with additional urban design principles:

- Store or use water on site, rather than rapid conveyance of storm water;
- Capture and use storm water as an alternative source of water, thus demanding less potable water supplied by a utility;
- Use vegetation for filtering purposes;
- Use landscapes to protect water-related environmental, recreational and cultural values;
- Harvest water in decentralised systems for various uses; and
- Treat wastewater in decentralised systems.

259. Water-sensitive urban design obviously relates to several technical innovations dicussed above, including decentralised and distributed water systems and green infrastructures. Grant *et al.* (2012, p. 685) claim that "distributed water infrastructure can be introduced as part of comprehensive planning strategies that promote compact urban forms with mixed land uses and a focus on urban amenities, encourage alternative forms of transportation to permit narrower streets and reduce demand for parking, foster energy saving and waste recycling, promote water savings, and reduce liability for innovative developers".

260. OECD cities face distinctive challenges regarding water-sensitive urban design. While developing cities have the opportunity to build right from scratch, most OECD cities need to retrofit prevailing design and built environment. The case of Fukuoka, Japan (see Box 23), illustrates how water-sentitive urban design relates to various forms of innovation; it also shows how the diffusion of innovative practices can be slow in OECD cities.

Box 23. Water-sensitive urban design - the case of Fukuoka, Japan

In 2003, the Fukuoka City Ordinance on the Promotion of Water Conservation (hereinafter referred to as "Ordinance") was enacted in order to address changes in social conditions and in an effort to further promote water-efficient urban planning. The Ordinance covers three main areas: responsibilities of citizens and service providers; responsibilities of the city; and promotion of the installation and use of non-potable water systems.

Non-potable water systems are classified into the following three types:

- Area-wide systems: treated wastewater is supplied as recycled water on an area-wide basis for use in flushing toilets and watering trees. Such systems are operated by Fukuoka City since 1980 in the context of a programme for recycled water and sewage services;
- In-house systems: wastewater collected within a building is treated and reused as non-potable water in the building. Such systems are installed and operated by individual building owners; and
- Non-recycling-type systems.

Fukuoka City has been offering subsidies to promote the installation of non-potable water systems. In the case of in-house systems, construction costs for wastewater tanks, wastewater treatment facilities, and recycled water tanks are subject to subsidies in an amount equal to 4.2% of the cost of standard facilities. In 2012, a couple of such subsidies have been granted, for a total amount of 940,000 yen (7k€).

The enactment of the Ordinance was intended to build on and further promote water-saving efforts. However, as the use of non-potable water is very small in volume relative to that of potable water, the enactment of the Ordinance has had little impact on revenues from water tariff.

On the contrary, by promoting water-efficient urban planning, the city has been able to save on investments for the development of new water resources, such as the construction of new dams. It thus seems that the implementation of various water conservation measures, including the enactment of the Ordinance, has had a positive impact on investments in water-related facilities.

Source: the case study was developed by Fukuoka City Waterworks Bureau for the OECD project

261. In the Netherlands, the Delta programme brings together various authorities and organisations to protect the Netherlands against high water and to ensure enough availability of fresh water. One sub-programme, titled Delta programme New Construction and Restructuring, is focused on spatial adaptation. This sub-programme aims at making cities and other built-up areas less vulnerable to extreme weather conditions. Action will be taken in three steps, in collaboration with civil society organisations and companies: analyse how water-robust and climate-proof an area and its functions are; propose concrete objectives to improve water security and adaptation to climate change, and develop effective and efficient strategies; translate the objectives in policy plans, legislation and regulations, and in implementation programmes and maintenance procedures. Spatial Adaptation Guidelines have been developed to work through the steps, and can be used by authorities, private sector and civil society organisations (www.ruimtelijkeadaptatie.nl).

Barriers to the diffusion of innovation for urban water management

262. The diffusion of innovative solutions for water management in OECD cities faces several barriers. Some may be specific to particular innovative paths discussed above. Some are common to all.

Barriers common to disruptive technologies

263. OECD work on green technologies argues that market mechanisms alone will not provide an appropriate amount of eco-innovation at the right time (OECD, 2011). This is because innovators may not reap all of the benefits of their innovations and because environmental benefits may not be appropriately valued by markets. This certainly applies to innovation in urban water management. For example, when water is not properly priced, markets will not recognise the benefits of water conservation that derives from smart metering or sustainable urban planning; or when city dwellers are not aware of water-related risks, they may be reluctant to pay the costs of higher levels of security (see a discussion of the awareness gap regarding water risks in the Netherlands, in OECD, 2014). In such a context, governments are legitimate to take action, to remedy market failures.

264. Three barriers common to disruptive approaches to water management in OECD cities are listed below. First, fragmented institutions can limit incentives for the diffusion of water innovation. It is not always clear who is in charge, or who is accountable for one particular issue, especially when the issue cuts across such domains as urban planning, environment and economic development. For instance, how should permeable surfaces used for parking slots or streets be defined, in the context of urban drainage? Are they water-related equipments or transport infrastructures? Who is in charge of managing them? Who is responsible in cases of failure? (see questions raised by Chocat, 2013).

265. Second, disruptive innovations have long been perceived in opposition to existing assets and infrastructures. Indeed, the disordered development of decentralised solutions might undermine the sustainability of centralised systems. City managers now better understand that different pathways need to co-exist and be managed in a co-ordinated manner. Typically, distributed systems will not phase out centrally piped infrastructures: rather, both systems mually rely upon each other, to build redundancy and for security reasons.

266. Biggs et al. (2009) illustrate how new technologies can help identify sites for small-scale system intervention. The retail utility Yarra Valley Water (YVW) is using spatial information tools to map the energy intensity of providing water supply and treatment services to different suburbs. This helps identify sites where factors such as gradient, demand and distance from treatment stations mean that small-scale system interventions can save energy. Yarra Valley Water may then choose localised demand management or sewage treatment as a way to cut costs. This ability to track site-specific resource demand is opening up new areas for mutual cost cutting between developers and utilities.

267. Third, regulatory frameworks and funding mechanisms are better aligned with prevailing infrastructures, and sometimes favour or prescribe incumbent technologies (a point made by UNEP, 2014; and Green, see OECD, 2013b). Box 24 provides an illustration from the UK.

Box 24. Retrofitting sustainable drainage system - the case of Cromer catchment in the UK

Swan (2010) explores how the extension of a city affects the capacity of the drainage infrastructure to collect and treat rainwater. Alternative methods are compared to mitigate flood risks that result from the expansion of impervious surfaces in Cromer catchment, UK.:

- Conventional in-sewer storage. A typical conventional solution to flooding in Cromer would involve the installation of on-line storage within the sewer network (e.g. in the form of a concrete storage chamber or oversised sewer pipes) to store excess storm flows, releasing them back into the sewer later for subsequent conveyance down to treatment or disposal;

- Retrofit sustainable drainage systems (SuDS). The most straightforward retrofit SuDS option in this context would involve the disconnection of large individual properties from the storm sewer, using SuDS devices to deal with their storm drainage instead. Ground conditions at Cromer make it possible to consider both infiltration and storage-based SuDS devices; and

- Hybrid option. This approach would involve the combined use of the two preceding options to alleviate the catchments flooding problems.

Swan concludes that SuDS is feasible, appropriate, and allows tapping private capital: “the use of SuDS technologies within a ‘planning-based’ approach, involving the progressive imposition of ‘green-field’, or stricter, runoff restrictions to all new planning proposals (both new-build and brown-field redevelopment) submitted within a problem urban catchment may represent a more sustainable way to reduce the storm water runoff entering the system, and the associated problems, over the longer term. This approach would also transfer some of the cost away from the sewerage provider and onto local developers” (p.646).

Despite their relative merits, SuDS options are difficult to implement because, according to Swan’s analysis, the UK’s current regulatory and funding environment promotes ‘quick fix’ solutions to urban drainage problems.

Source: Swan, 2010

Specific barriers to the diffusion of distributed systems

268. Distributed systems face their own limitations and certainly are not appropriate in every context. For example, when facing water shortages, distributed storage forbids allocation of available resources where they are most needed. Similarly, in cases of floods, the piecemeal implementation of sustainable urban drainage can have adverse effects, if peak river flows cannot be managed at catchment level in a coordinated way.

269. Where they are appropriate, distributed systems face several barriers that limit their diffusion. First, they can weaken existing central systems, when the best-off consumers disengage from the central network, depriving the managing utility from revenues. This is an issue, as distributed systems work best in combination with centrally piped infrastructures. Utilities and city administrations may be reluctant to explore options that negatively affect the revenue base of the existing networks, unless alternative sources of revenues are identified (see the discussion in Chapter 2).

270. Second, distributed systems raise the issue of responsibility: who is responsible and accountable for the service provided at the level of a building or district? In France, for instance, the city mayor is accountable for the quality of the water supplied to city dwellers. It may be more difficult to take responsibility for a multitude of distributed systems, organised at different scales, and supplying water at different levels of quality for specific purposes. Accountability is an issue, as distributed systems require a capacity to monitor and control the quality of multiple water flows, at several levels.

271. Third, distributed systems illustrate how complex scale issues are for urban water management. Urban water management generates physical economies of scale: it is generally cheaper to operate a large treatment plant than several smaller ones. However, system economies can off-set physical economies of scale: on-site treatment and reuse technologies or sustainable urban drainage can save capital costs of extending central infrastructures; they can however require more energy, as economies of scale apply here as well. Japan was able to make extensive use of a variety of on-site recycling techniques, as large areas of the country were not connected to wastewater collection and treatment systems after World War II.

272. Biggs et al. (2009) report on research that illustrates the complexity of defining the right scale for wastewater treament. At an urban greenfield site, researchers compared four distributed wastewater treatment system designs against a centralised reference case. One design, which used four treatment plants and on-site greywater reuse, showed how splitting wastewater streams at their source could cut demand for sewerage treatment services by 65%. In another system design, 32-networked treatment plants treated all wastewater and then returned it via a third-pipe return system. This design reduced residential demand for potable water by one third and saved six percent on energy compared to the centralised option. The gain in energy efficiency was due to the lower energy needs of many smaller treatment plants and the use of recycled water (which reduced energy for pumping). A similar option using 315 smaller wastewater treament plants proved less energy efficient - suggesting that as the treatment system became increasingly localised (for this site), efficiency increased to a point, and then declined.

273. This analysis echoes the point made earlier, that any urban water management technique generates trade-offs between water, energy and land use. It follows that the optimal combination of centralised and distributed systems requires that externalities related to these three dimensions are properly reflected.

Barriers to the diffusion of green infrastructures

274. Green identifies specific barriers to the diffusion of green infrastructures for urban water management (see OECD, 2013b):

- The greatest problems exist in high density areas (central business districts), where green infrastructures are most difficult to implement because space is scarce to weave in water management. The existing stock of buildings adds to the complexity, as green infrastructures will require retrofitting. For example, Chapter 2 has argued that, in the UK, sustainable urban drainage accumulates in greenfield projects but has received less attention in existing urban areas (Swan, 2010). Still, Malmö (Sweden), Philadelphia or Portland (US), among other OECD cities, increase the level of permeable surfaces and limit run-off.

- As noted above, decision makers face trade-offs between water, energy and land issues; for instance when a flood plain is the only land available for urban expansion or economic development; or when water efficiency gains in appliances require additional energy.

275. These barriers illustrate lock-in failures, defined as "failures where cities are locked into complex infrastructure systems and where the associated skills, knowledge and capabilities are so dominant that shifts to more efficient alternative technologies are difficult to undertake" (Suzenet et al., 2002, p.145). Lock-in failures translate into difficulties in adopting new technologies outside of greenfield projects.

276. Several factors make green infrastructures particularly unappealing for policy makers:

- Data on water is scarce; capacities to measure, compute and model river flows are limited making it difficult to assess the benefits of green infrastructures and to design them;

- Uncertainty, and the costs of operation, maintenance and safety generate reluctance to adopt innovative approaches; and

- It is easy for policy makers and city dwellers to identify large physical interventions as immediate and visible responses to water risks, while green infrastructures do not provide the same signal.

- Green lands are not properly valued. In a report for UK Defra and Communities and Local Government (CLG), Forest Research (2010) notes that there is good evidence that green space can make positive impacts on local economic regeneration, especially for job creation, business start-up, increased land values and inward investment. However, the quality and quantity of this evidence is comparatively poor and would benefit from further case studies.

277. It follows that the economic case for green infrastructures may be weak. This may derive less from the intrinsic performance of these infrastructures than from the lack of historical data. The economic analysis of green infrastructures is complex and often lacks track records of past costs and benefits. Ancillary benefits can be numerous and difficult to assess and monetise; for instance, green infrastructures can mitigate climate change, as they capture carbon or reduce urban heat island effect. In addition, as UNEP (2014) notes, green infrastructures can appreciate in value and function over time, as soil and vegetation prosper. This makes the assessment of benefits even more difficult, putting green infrastructures in a disadvantaged position vis-à-vis grey ones.

Options to overcome the barriers to innovative urban water management

278. This section analyses strategies that contribute to the diffusion of innovative approaches to urban water management. It particularly emphasises: a) opportunities for innovative water management that derive from initiatives in other areas, hence the value of being opportunistic; b) the benefit of combining several policy instruments; c) the need to adjust urban water governance, re-emphasising the interplay between the four pillars identified in Chapter 1, at both central and local levels; and d) opportunities that derive from the current financial crisis.

Synergies with other policies

279. Cities can play a crucial role in encouraging innovative water management. The Syracuse project referred to above (http://www.safege.com/en/syracuse-2/) has reviewed strategies of selected cities to deploy innovative water management. The project notes that distributed systems derive either from citizens' initiatives to improve the quality of service where the central system fails, or from demonstration projects in cities which like to showcase local capacities or want to establish themselves as green. Stockholm and Vancouver are clear illustrations of the second case.

280. Drawing lessons from successful implementation of green infrastructures for urban water management, Green argues that green infrastructures often benefit from initiatives not directly aimed at urban water management (see OECD, 2013b):

- River restoration, or the reduction of permeable surfaces can be indirectly induced by regulations on adaptation to climate change (this was the case in London and New York City) or on water pollution from combined sewer overflows (in the US); and

- Incorporating water management into spatial planning and development control systems helps. In Germany, municipalities combine responsibilities for spatial planning and development control for the provision of water services, including surface water drainage.

281. This echoes a point made by Lloyd Owen (2006) in the review of countries experience with the diffusion of smart water systems (see the previous section): smart water systems may diffuse as an unintended consequence of non-related initiatives (such as opening markets for non-domestic water users in Scotland).

Combining policy instruments

282. Green notes that local initiatives that lead to the deployment of innovative urban water management combine several instruments (see OECD, 2013b): information campaigns on desired change; demonstration projects (symbols matter); and regulations; in Toronto, regulation was required to expedite downspout disconnections, an essential step to reduce run-off from rainfall and mitigate risks of sewerage overflow.

283. Economic instruments have a particular role to play. On the one hand, well-designed tariffs can signal scarcity of the reosurce and reflect some of the benefits of enhanced water security and improved water services. On the other hand, properly designed, targeted and time-bond subsidies to promote innovative water management can be less costly than the extension of traditional infrastructures. General Electric (2011) has reviewed local initiatives to promote water reuse, and highlighted the role of rebates and rate reductions. New York City's Comprehensive Water Reuse Programme provides a good example of strategic rate reduction in the context of a uniform volumetric tariff.

Box 25. New York City's Comprehensive Water Reuse Programme

The Comprehensive Water Reuse Programme in New York City offers a 25 percent rate reduction on water and sewer charges for buildings that maintain a Comprehensive Water Reuse System (CWRS). A CWRS building may capture, treat and recycle blackwater (i.e. sanitary wastewater), or greywater (i.e. wastewater from lavatories, showers, and clothes washers). The CWRS must achieve a 25 percent reduction in a building's baseline demand for potable water. Programme rules establish a baseline of 60 gallons per person per day for residential buildings and 10 gallons per employee per day for indoor use in an office building.

Since its inception in 2004, this programme has created an effective indirect subsidy for private water reuse systems. It has been estimated that for a large mixed residential and commercial water user, participation in the programme would reduce operating costs by more than USD1 million per year by 2012 and close to USD3 million per year by 2015.

Source: http://www.nyc.gov/html/dep/pdf/waterreuse.pdf

Adjusting urban water governance

284. Rolling out innovative water maangement at city scale requires adjustment of urban water governance. The argument derives from observations above. OECD cities will be in a position to more systematically explore innovative urban water management when fragmented insitutions are able to co-operate and envision the big picture (water, energy and land use), when cities can collaborate with their surroundings, and when stakeholders can voice their preferences.

285. This point is clearly illustrated by the city of Rotterdam. Van der Brugge and de Graaf (2010) argue that the transition towards water sensitive urban design in Rotterdam was made possible through a combination of policy and institutional innovations. However, city-wide implementation of planned infrastructure requires yet another set of institutional mechanisms, with regard to investments, operation and maintenance: it "either requires additional responsibilities for the existing authorities, or a new kind of

authority or cooperation mechanism which receives tasks for operation and maintenance of infrastructure developed by multiple stakeholders" (Brugge, Graaf, 2010, p.398).

Opportunities that derive from the current financial crisis

286. The current financial crisis creates opportunities for low-cost, alternative technologies (see Chapter 2 for a discussion). For instance, the US Army Corps of Engineers (USACE)[21] recently noted that "reductions in resources available for construction of federal flood control works present opportunities for expanded implementation of non-structural flood risk management options that are more efficient, less costly, and provide greater environmental benefits. Many of these strategies have been used successfully for years in many parts of the country. They have not always received full consideration, however, because of a historical emphasis on large engineered civil works for flood protection. Today's fiscal realities present the USACE opportunities to collaborate more closely with local communities in providing technical information and other types of support" (National Research Council, 2012, p.6).

287. The statement by USACE echoes several points made erlier, about the (implicit) bias towards incumbent technologies, the need to share information about the potential benefits of green infrastructures, and the requirement to co-ordinate local and national initiatives.

[21] The USACE is the institution charged with flood risk management, among other water infrastructures.

References

ATSE (2012), *Sustainable Water Management. Securing Australia's Future in a Green Economy*, Australian Research Council

Brady J., N.F. Gray (2013), Analysis of water pricing in Ireland and recommendations towards a more efficient water sector, *Water Policy*, IWA Publishing, 15, pp. 435-437

Biggs C., C. Ryan, J. Wiseman, K. Larsen (2009), Distributed Water Systems: A networked and localised approach for sustainable water services, Business Intelligence and Policy Instruments, The University of Melbourne

Brugge R. (van der), R. Graaf (de) (2010), Linking water policy innovation and urban renewal: the case of Rotterdam, The Netherlands, *Water Policy*, 12, pp.381-400

Chocat B. (2013), Une intelligence au cœur de la ville de demain, *Les Cahiers de l'Eau*, n°2, novembre, Suez Environnement

European Commission (2013), *Green Infrastructure (GI) — Enhancing Europe's Natural Capital*, COM/2013/0249 final

Fernandez J.E. (2014), *Urban Metabolism. City Typologies*, presentation at 2014 MIT Europe Conference, Brussels, May 21, 2014

Forest Research (2010), *Benefits of Green Infrastructure*, report by Forest Research. Forest Research, Farnham.

General Electric (2011), *Incentives for Water Reuse and Recycling*, General Electric Company

Gleick P. (2002), Water management: Soft water paths, *Nature*, n°418, 373 (25 July 2002), doi:10.1038/418373a

Grant S.B. et al. (2012), Taking the "Waste" Out of "Wastewater" for Human Water Security and Ecosystem Sustainability, *Science*, vol. 337, no. 6095, pp. 681-686

I2O (2012), "i2O Water helps Veolia water save 1.5 million litres of water a day". i2O, http://www.i2owater.com/page/6/?p=zpfeqwqq.

International Telecommunication Union (2014), Technical Report on Smart Water Management in Cities, ITU

Lloyd Owen D. (2011), *Infrastructure Needs for the Water Sector*, unpublished paper commissioned by the OECD in the preparation of the OECD report *Water Security for Better Lives*, OECD Publishing, Paris

Makropoulos C.K., D. Butler (2010), Distributed Water Infrastructure for Sustainable Communities, *Water Resources Management*, vol. 24, pp. 2795–2816

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

OECD (2006), *Infrastructure to 2030. Telecom, Land Transport, Water and Electricity*, Paris

OECD (2009), *Alternative ways of providing water. Emerging options and their policy implications*, OECD, Paris

OECD (2009b), *Private Sector Participation in Water Infrastructure. Checklist for Public Action*, OECD, Paris

OECD (2010b), *Guidelines for performance-based contracts between utilities and municipalities. Lessons learnt from Eastern Europe, Caucasus and Central Asia, Almaty, Kazakhstan*, OECD, Paris

OECD (2011), *Better Policies to Support Eco-innovation*, Paris

OECD (2012b), *Policies to Support Smart Water Systems. Lessons from Countries Experience*, unpublished paper by David Lloyd Owen commissioned by the OECD

OECD (2013b), *Barriers to, and Incentives for, the Adoption of Green Water Infrastructure*, OECD, Paris

OECD (2013c), *New Modes of Water Supply and Sanitation Management and Emerging Business Models*, OECD, Paris

OECD (2014a), *Water Resources Allocation. Sharing Water, Sharing Risks*, OECD, Paris

OECD (2014b), *Water Governance in the Netherlands. Fit for the future?*, Paris

Porse E.C. (2013), Stormwater Governance and Future Cities, *Water*, 5, pp.29-52

Steen P. (van der) (2011), *Application of Sustainability Indicators within the Framework of Strategic Planning for Integrated Urban Water Management*, SWITCH Deliverable 1.1.7

Steen P. (van der), C. Howe (2009), Managing water in the city of the future; strategic planning and science, *Reviews in Environmental Science and Bio/Technology*, vol. 8, pp.115–120

Swan A. (2010), How increased urbanisation has induced flooding problems in the UK/ a lesson for African cities?, *Physics and Chemistry of the Earth*, 35, pp.643-647

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

UNEP (2014), Green Infrastructure Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects,

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

USEPA (2010), *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*, EPA Office of Wetlands, Oceans and Watershed, Washington DC.

CHAPTER 4. REALISING THE POTENTIAL BENEFITS OF URBAN-RURAL CO-OPERATION

As most cities share water basins with rural areas, an efficient and environmentally sensible urban water management system needs to take into consideration the interplay between urban and rural uses of water.

This chapter identifies the main challenges at this interface, for which cities will increasingly have to coordinate with rural water users in their surrounding areas. It highlights the benefits of enhanced co-ordination and discusses some of the options cities can explore to realise such benefits.

Key messages

288. Many OECD cities share water constraints with surrounding rural areas. They will increasingly have to co-ordinate with rural water users to reach their water management objectives. Three specific water challenges, in particular, may benefit from rural-urban co-operation in the future: the increased competition for water resources (too little water), the management of floods (too much water), and freshwater quality conservation (too polluted water). Co-ordination benefits both urban and upstream communities.

289. Co-operation allows managing water at the relevant spatial scale. This is because both the drivers of the problems and the consequences of the chosen policies have significant effects across different areas, jurisdictions and economic sectors. It is also a means to allocate risks to parties best equipped to manage it. For instance, catchment protection programmes rely on the capacities of farmers to avoid pollution which would require costly treatments downstream.

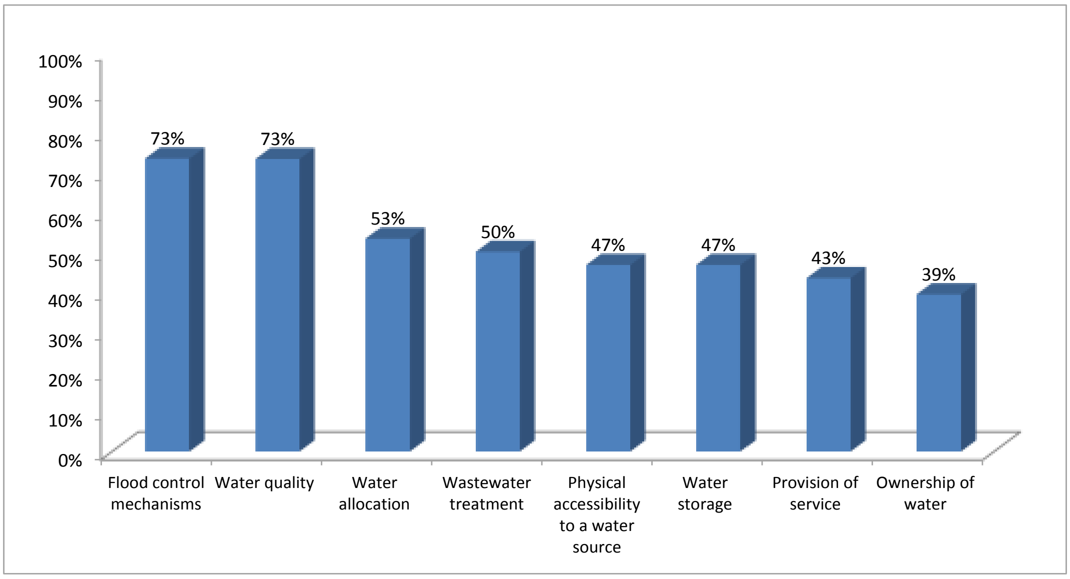
290. OECD cities use a diversity of approaches to co-ordinate with their rural surroundings for water management, many of which involve customised mechanisms to engage with parties and address well-defined objectives. Necessary conditions are required for cities to take action beyond existing regulatory frameworks. The role and degree of freedom of cities in the larger setting of water resource management play a critical role, together with the costs and benefits of engaging into action with rural areas. Transaction costs of more sophisticated co-operation arrangements may hinder their diffusion. Incentive mechanisms and key governance principles are essential factors for success for any approaches, as they contribute to building a trust relationship.

291. Whether cities should engage with their rural surroundings and how remain practical questions, which need to be assessed on a case-by-case basis. Approaches that are flexible, nimble, and that take account of the underlying drivers of the constraints they address (such as climate variation and population growth) are likely to be promising.

Introduction

292. An efficient and environmentally sensible urban water management system needs to take into consideration the interplay between urban and rural uses of water. Most cities share water basins with rural areas, with different population, stresses, infrastructure constraints and activities. Agriculture in particular is a major user of land and water – it accounted respectively for 36% and 44% of the total claims on national land and freshwater in OECD countries between 2008 and 2010 (OECD, 2013a) – and for this reason, can play a critical role in the sustainable management of water in cities.[22]

Figure 21. Issues generating interdependencies between cities and surrounding areas



Note: Results based on a sample of 30 respondents who indicated the issues being "very important" and "important".

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

293. Several issues generate water management interdependencies between cities and their rural surroundings. The OECD survey on urban water governance (OECD, 2015 forthcoming) identifies at least eight important issues calling for rural-urban cooperation (see Figure 21 above). They explicitly refer to three of the four water security challenges presented in Chapter 1:

- Too little water : the projected growth in competition for water resources, linked in particular to rising uncertainties about water supply due to climate change;
- Too much water: mitigation of flood risks, which are bound to increase in the future; and
- Too polluted water: the maintenance of adequate quality standards for water, as a source of drinking water and for the provision of ecosystem services.

294. There are very strong environmental and economic linkages between urban and rural users of water; these connections include flows of agricultural goods, manufactured goods, people, information, and ecosystem services between the two areas. Governments could therefore use this strong economic

[22] While agriculture will be the focus of this chapter, due to its primordial importance in water uses, it should be acknowledged that rural areas have mixed economies that can in some case be similar to those in urban areas.

regional interdependence as a platform to address the three water security challenges. Collaboration could be beneficial for all the parties involved. Cities can benefit from water savings and quality improvements upstream; and in turn, they can help farmers make the best use of water by incentivising or compensating those who contribute to water security. USEPA (2014) acknowledges that, when properly managed, "urban waters can yield positive impacts for populations in both urban and upstream communities: public spaces along rivers and lakes offer residents opportunities for community gatherings, recreation and environmental education […]; and increased access to waterways can spur the creation of new jobs and the growth of local businesses, whether cleaning up polluted or abandoned properties, opening businesses along the waterfront or working on water protection efforts like green infrastructure projects."

295. The urban-rural perspective also allows managing water at the relevant spatial scale, since both the drivers of the problems and the consequences of the chosen policies have significant effects across different areas, jurisdictions and economic sectors. Moreover, cities can target their policies in a way in which national or regional schemes may not be able to, thus allowing for less costly policy action. This is for example the case for flood mitigation activities, which are generally interdependent or generate risk externalities; for instance, the channelization of river upstream can increase flood risk downstream; hydraulic infrastructures and land cover composition can also affect flood risk for urban areas.

296. Co-operation can also help in water risk management, by spreading the three outlined water risks among actors, allocating the risks to actors best equipped to mitigate them, and possibly contributing to increasing flexibility and adaptability of responses to shocks. For instance, catchment protection programmes rely on the capacities of farmers to avoid pollution that would require costly treatments downstream. There are also significant uncertainties associated with the management of water resources, quantitatively and qualitatively, which are shared by both cities and their surroundings. Surface water interactions with groundwater, or the diffusion of pollutants at the regional level, in particular, are not always perfectly known.

297. In the next three subsections, three water challenges will be analysed and framed in economic terms: i) competition for scarce water (too little water); ii) flood management (too much water); and iii) water quality preservation (too polluted water). While risks to the resilience of ecosystems are not explicitly addressed, they are subsumed under the three previous ones; for instance, flood control and water storage can rely on flood plains, wetlands or groundwater recharge; water quality and wastewater treatment affect the resilience of freshwater systems. A fourth subsection will discuss partnerships as a mechanism to implement rural urban co-operation. The focus will be on implementation issues.

298. As a caveat, the analysis focuses on policies and initiatives used by cities and their surrounding areas to address one of the above-described key challenges. It will not delve into regional, national and international policies that already address these challenges at a higher scale. In practice, national or supranational water quality standards often play a critical role in water management for cities and their surroundings, both as enablers or barriers to local policy initiatives; however, if cities are not involved in their design, they will not be considered here. Measures described here are often built on national standards, complement them, and/or provide innovative approaches to address more specific constraints that are not covered by overseeing policies and standards.

299. A second limitation is that the analysis is conducted in a scale neutral fashion. The differences in scale of cities, context and characteristics are not explicitly addressed. This is done for simplification and to try and reach generalizable conclusions. But it is acknowledged that these differences will likely affect the feasibility and adaptability of proposed instruments if not their effectiveness, and would therefore warrant further analysis.

Managing competition to access water between urban and rural areas

300. Chapter 1 has documented competition between water users and future projections. Competition between cities and agriculture is less acute in OECD countries, where agriculture accounts for 44% of total freshwater withdrawal (compared to 70% globally; OECD, 2013a). Still, where water is in limited supply and, in particular, where times of water scarcity (droughts), the projected growth in domestic and industrial water demand will create tensions with the current agricultural water allocation. This increased competition may also have external effects, in particular on groundwater (OECD, 2014b). Over-drafting the resources can lead to stream depletion (affecting river-ways and lakes), salinity intrusion, and land subsidence that can affect both rural and urban communities. It may also result in depleting groundwater reserves with long term consequences such as the reduction of the resilience of agriculture and urban areas. This section discusses in more details how the competition between urban and rural areas to access water can be managed.

Policy objectives and responses

301. Competition creates a scarcity value for water, which will need to be allocated between the different regions and users. There are multiple ways in which this could be done (OECD, 2014c). All the possible policy choices are intended to yield the same end-result: a defined distribution of water abstraction entitlements to specific individual economic agents. Box 26 introduces in more detail the possible policy responses to the water allocation problem.

Box 26. Water allocation policies

Given an exogenous variation in water supplies, achieving an efficient allocation of water across users entails a redistribution of the current water stock. This could be achieved in many different ways, such as: administrative transfers, legislative settlements of conflicting claims, legal challenges to existing water allocation, public agency exercise of eminent domain or the re-design of large-scale water projects to favour different sets of users.

Possible water policies aimed at managing the competition for water resources differ mainly according to the degree of government intervention and to the economic dynamics being targeted. Given the choices faced by policy makers, this section will consider in more detail the following four possible measures aimed at turning the urban-rural competition for water resources into a mutually beneficial endeavour:

- Command-and-control instruments: technology standards and rationing policies;
- Water conservation measures in urban and agricultural areas;
- Economic instruments: water pricing and tradable water rights;
- Supply-side groundwater management tools.

Overall, the different policies addressing water competition should not be seen fixed and many sound policies combine and integrate the various different strategies. Moreover, as previously pointed out, one policy option is not always better than the other and the specific features of the context – i.e. the degree of market formalism in water interactions or the level of water scarcity – will affect significantly the successful execution of the chosen water policy.

Sources: Colby (1990); Olmstead (2010a); OECD (2014c).

302. The resulting water allocations should be assessed using the following three criteria: efficiency, equity and sustainability (OECD, 2014c). However, these standards do not always point towards the same

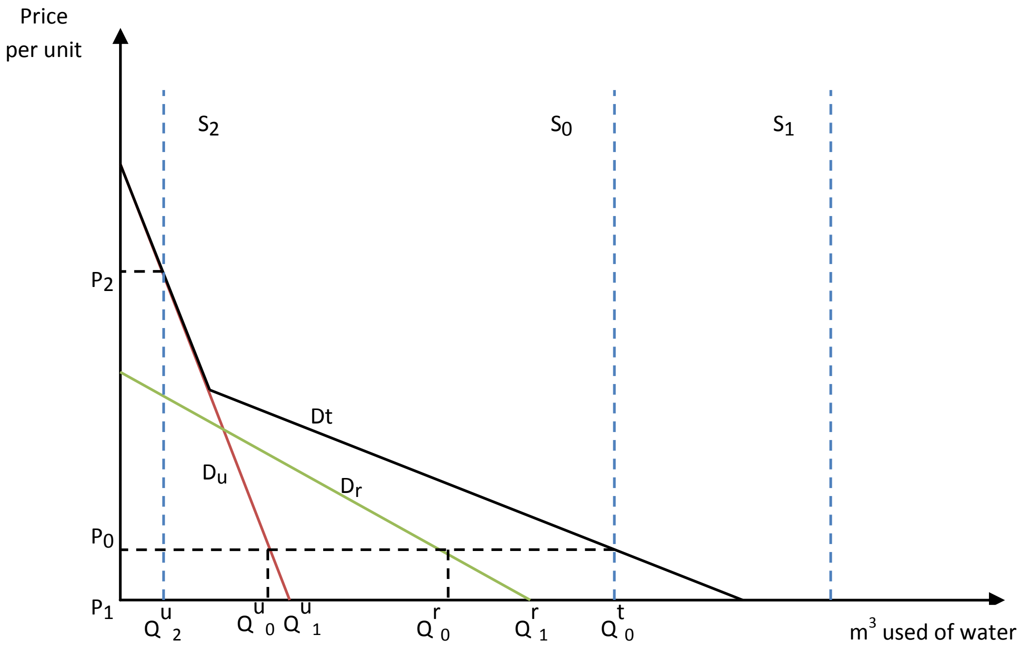
direction and this tension often leads to the emergence of an important political dimension of the problem. Policy makers will therefore need to strike a balance between these objectives when formulating their water management policies (OECD, 2014c).

303. An efficient allocation maximizes society's total benefits produced by water and requires the equalisation of marginal net benefits (MNB) across the allocated users. That is, the benefit from using an additional unit of water should be the same across urban and rural regions. If the available water resources are renewable (e.g., surface water), then current period's flow has to be optimally allocated among competing users. If, instead, the main source of accessible water is non-renewable (e.g., some groundwater dependent regions), then the allocation problem becomes a multi-period optimisation, for which the optimal solution requires the equalisation of the discounted marginal net benefits (PVMNB – Private Marginal Net Benefits) across time and users. Box 27 takes the first perspective and describes visually an efficient water allocation between urban and rural consumers in three idealised scenarios.

304. Equity considerations also have a role to play. Governments should strive to provide sufficient, safe, acceptable, physically accessible and affordable water to all households, regardless of their income or social status. Hence, policy makers might in some cases favour equity and fairness of the resulting allocation profiles over their economic efficiency. For example, in water-stressed regions low-income farmers may not receive enough water to sustain their livelihoods; an equitable allocation would therefore require shifting water resources to the more vulnerable groups in the society at the expense of economic efficiency. New Zealand provides an illustration that relates to the rights of indigenous people: iwi/Maori perspectives are considered in regional and district plans that include water management in both urban and rural areas.

305. A third objective of water resource allocation is to achieve a sustainable level of water consumption. This entails both the maintenance of a well-functioning hydrologic cycle and the preservation of the environmental services associated to water ecosystems. These uses represent only the residual claims on the available water stock; hence, in the absence of regulation, they will be satisfied only after the fulfilment of both urban and rural water demands. In a situation of increasing competition for water resources, these residual claims need to be protected by government's policies in order to avoid major environmental problems, such as irreversible damages to freshwater ecosystems or the creation of natural imbalances in water's natural cycle. One way policy makers can do this is by keeping the amount of water needed to meet the ecological needs and environmental flows of the system separate from the allocable water available to residential, industrial and agricultural users.

Box 27. Economics of rural-urban cooperation



The red (Du) and green (Dr) curves represent respectively water's marginal net benefits of urban and rural users; these can also be interpreted as their demand schedules. Agricultural demand for water is generally more elastic than the urban one. This is because agricultural producers have relatively more possible substitutes to water use than urban consumers, whose water demand is mainly driven by the fulfilment of basic human needs; for instance, farmers could switch to less water intensive crops or adopt water saving production technologies. The black curve (Dt) is the horizontal sum of the marginal net benefits and it represents the aggregate water demand of the urban and rural regions. The kink in the aggregate demand curve characterizes the different willingness to pay of urban and rural residents.

The graph depicts three different scenarios depending on the availability of the fixed water supplies: normal conditions (S0), water abundance (S1) and water scarcity (S2). Under normal conditions, the efficient allocation is achieved at price P0; total water supply (Q0t) is divided among urban and rural users (Q0u and Q0r) such that their marginal benefits of use are equalised. In case of water abundance, supply exceeds the total demanded quantity; there will be no competition for water resources and therefore the efficient price of water will be P1 (opportunity cost of water). Under severe water scarcity conditions (S2), such as in droughts, the optimal strategy to minimize total damages is to place a larger reduction of the water supply to the more price-elastic user, namely to agriculture. The efficient allocation will therefore entail allocating the entire supply of water to urban consumers, which will pay the higher price P2; rural regions will therefore not receive any water supplies. From a strict economic point of view, this allocation is optimal because the opportunity cost of diverting resources from urban users is higher than the corresponding figure for farmers.

In all three scenarios, the efficient allocation is reached through market interactions among the competing users of water. The market outcome is a set of water allocations and the corresponding price of the market transactions. This is however a highly stylised representation of the problem which does not take into account the complexities of the allocation process, the existence of transaction costs, the legal regulations of the market and the corresponding formal and informal institutional framework. It thus only provides theoretical guidance on how the urban-rural water interdependence should be managed. Its implementation will therefore be contingent on the actual economic, social and geographical characteristics of the specific water basin. It could therefore be optimal in some cases to dismiss this market model in favour of other types of regulations and policy objectives.

Source: Authors.

Command-and-control instruments: technology standards and rationing policies

306. A first policy option to deal with the projected growth in competition for water resources is the use of prescriptive or command-and-control (CAC) strategies. The two most common examples of these policies are: technology standards and water rationing policies (Olmstead, 2010). Technology standards are a way to force a reduction in the consumption of water by requiring the adoption of given types of infrastructure or production practices by industrial manufacturers, municipal water providers or farmers. These measures can also be targeted to very specific domestic uses of water, such as the mandatory adoption of low-flow appliances. The empirical evidence on the success of these programmes is mixed. In particular, technology standards may be subject to "rebound effects" – i.e. the introduction of the new water-saving technology may trigger users' behavioural responses that cancel the beneficial gains of technology adoption.

307. Rationing policies entail mandatory water use restrictions in certain areas, hydrological circumstances, or for given uses. Most national or regional authorities in OECD countries have developed priority allocation systems to apply in case of scarcity. OECD countries differ in their application and scope, but essentially consider drinking or domestic use as priority over agricultural (and other) uses (OECD, 2014c). For instance, in the Tisza-Koros Valley in Hungary, the highest priority is given to uses concerning drinking water, national security and domestic uses – which include medical waters and municipal services – followed by agricultural uses (animal husbandry and fish farming), environment (including nature's protection) and finally industrial and energy production (OECD, 2014c). Some other restrictions are quantitative targets or restriction to superfluous water uses such as lawn-watering or car-washing, but can be extended to (low-value) agriculture and domestic users in case of increased scarcity. Water restrictions may also force inter-sectoral water reallocations as shown in the example of Jingmen City, China, as presented in Box 28.

308. The main advantage of rationing policies is their simplicity, making them easier to implement. However, rationing policies may lack enough flexibility to allow for an efficient allocation of water among users and uses. They also require information, notably to define a baseline. For example, to reduce consumption during the 2014 drought, after blocking the use of the main canal to agriculture users, California's governor implemented a 20% reduction of water consumption for all users, with the implementation of fines. Such relative reduction is set compared to a baseline (past average use) that may differ largely among users and therefore not achieve an efficient allocation under the water constraints.

Box 28. Mandatory rural-urban reallocations in the Zhang He Irrigation System, China

The Zhang He Irrigation System (ZIS) in the Hubei Province (China) covers a total area of 5540 km^2 and it supplies water to the many rice paddy fields in the region and to the residents of Jingmen City along with several other industrial production activities. Due to the rapid urbanisation and industrialisation of the city in the 1990s, the amount of water devoted to residential and manufacturing activities overtook the share allocated to agricultural production. This inter-sectoral redistribution was not the result of free market interactions between the competing users, but rather a decision taken at a central level by the regional water operators. The use of water for agricultural production was therefore reduced unilaterally using a top-down restrictive approach.

The success of this water reallocation policy relies in the fact that the amount of agricultural production in the Zhang He basin did not decrease as a consequence of the reduction in allocated water; hence, the farmers did not suffer from a decrease in their livelihoods. This is because, the farmers adopted new water-saving production technologies such as the alternation between wet and dry irrigation methods or the construction of several small reservoirs that captured the generated runoff and the return flows from rice cultivation. In this case, a classical command-and-control policy was successful in driving a Pareto-enhancing transfer of water between urban and rural users. Moreover, this reallocation stimulus was simple and low in transaction costs.

In this case, the implementation of a water trading model would not have been feasible. In fact, it would have been almost impossible to manage an effective mechanism for monitoring the compliance of the many farmers in the Zhang He basin which own only a small fraction of the total cultivated land.

Source : Molden et al. (2010), Bin (2008).

Water conservation measures

309. Water conservation programmes are demand-side policies, whose final objective is to provide incentives for the reduction of the amount of water consumed by residential, industrial and agricultural users. One of the greatest advantages of these policies is that they reduce the dependence on direct abstraction of freshwater supplies; for this reason they are especially fit for those areas in which there are significant political, economic and environmental barriers to procuring new sources of water supplies (see Box 9 for an illustration in Southern California).

310. There are four types of incentives that these programmes may use as leverage for the abatement of water consumption: information incentives, access to conservation technologies, cash transfers and financing (California Urban Water Agencies 1994). Information incentives include the provision of free audits or training programmes aimed at making agricultural and residential water consumers aware of the potential monetary savings associated with the adoption of water-conservation practices. However, in many instances, the provision of information might not be enough to nudge the behaviour of water users or to trigger the acquisition of new water-saving technologies; this is especially true for financially constrained water users. The government might therefore facilitate the access to conservation technologies. Other options to overcome this barrier are to lower the total cost of the water-saving investment through direct cash transfers or other financing mechanisms, such as contracting. In the South of France (Hérault), for instance, a contract was signed between the different stakeholders to reduce the use of groundwater around an aquifer, in exchange of payments shared by local, regional and national authorities (Barraqué et al., 2010).

311. The operational decisions taken to implement the programme will have a paramount effect on the degree of achieved water saving. Moreover, since a distinctive feature of these programmes is voluntary participation, a correct marketing of the initiative becomes central. Finally, each initiative should be flexible enough to accommodate the changing geographical and economic landscape and adaptive management should be pursued as a value in the execution of the policy.

Box 29. Southern California's Water Savings Incentive Programme

Water conservation programmes are a fundamental part in the procurement of water supplies in many cities of Southern California. The area is in great water stress and is vulnerable to severe droughts. Water conservation has therefore been taken as a tool to curb the demand for water in order to hedge the demand-supply mismatch in the region. In 1998 the city of San Diego initiated an agreement with the Imperial Valley, compensating farmers for water conservation measures, that has then become the largest rural-urban water transfer in the United States. In 2011 alone, the water savings by farmers sent to the city was equivalent to nearly 100 million m^3 . This totalis projected to reach 237 million m^3, representing 37 % of San Diego's water supply sources by 2021.

Moreover, it has also been estimated that conservation programme activities and water savings initiatives in Southern California resulted in the supply of an extra 66,000 acre feet per year of water. One of the water demand-management policies that helped achieve these results is the Water Savings Incentive Program for businesses, agriculture and large landscapes (WSIP). The programme is managed by the Metropolitan Water District of Southern California, which is a consortium of 26 cities and water districts that provides drinking water to nearly 19 million people in parts of Los Angeles, Orange, San Diego, Riverside, San Bernardino and Ventura counties.

The programme provides financial incentives for customised water efficiency projects; the incentives are paid based on the amount of water saved as a result of the projects. In particular, the programme pays back up to 0.60 $ per thousand gallons saved per year over the project life, up to a maximum of 10 years, and covers maximum 50% of the incurred costs. Eligible projects include: comprehensive changes made to an industrial process that will improve water use efficiency by reducing water consumption per unit of output and improvements to existing irrigation systems and plant material changes that improve water use efficiency for agricultural operations and large landscapes (WSIP Application Package). These measures freed water resources from industrial and agricultural users that were instead diverted into satisfying residential needs, which are the predominant claim on water resources of the area.

Source: McDonald and Shemie (2014), Richter et al. (2013), USEPA (2002), WSIP Application Package, http://www.mwdh2o.com/, http://www.bewaterwise.com/.

Economic instruments: water pricing and tradable water rights

312. Economic instruments for the distribution of water between urban and rural areas require the emergence of clear price signals, which provide incentives for the efficient use of water by individual consumers. Water pricing is indeed at the core of the Water Framework Directive 2000/60/EC, which establishes an integrated approach to water management in the EU through the concepts of incentive pricing, full cost recovery and polluter-pays principle. Putting the right price tag on water can be done either through administrative water pricing by a central authority, or through water quota trading. Whatever the approach chosen, it is recognised that in most OECD countries, there is substantial under-pricing of water for the agriculture sector, as illustrated in Box 30 (OECD, 2010).

313. Water quotas' trading can potentially foster an efficient redistribution of water resources across the competing users; in fact, as previously explained, standard economic theory predicts that letting urban and rural consumers trade their rights to water in a competitive market setting would result in the welfare maximizing allocation[23]. In other words, water trading allows for the attainment of those gains from trade deriving from the redistribution of water entitlements from low-valued users to the high-valued ones. Moreover, several empirical studies have found that economic instruments such as water pricing or tradable water rights offer a more cost-effective water management strategy than command-and-control

[23] Standard economic theory assumes that environmental and social externalities are (or can be) fully internalised, an assumption that seldom materialises.

policies, due to the heterogeneity in the users' marginal benefits from water consumption (Olmstead and Stavins, 2009).

Box 30. Full supply cost recovery for surface water delivered on-farm across OECD countries, 2008

100% cost recovery of Operation and Maintenance and Capital Costs

Austria; Denmark; Finland; New Zealand; Sweden; United Kingdom

100% cost recovery of Operation and Maintenance Costs, but less than 100% recovery of Capital Costs

Australia; Canada; France; Japan; United States

Less than 100% cost recovery of Operation and Maintenance and Capital Costs

Greece; Hungary; Ireland; Italy; Mexico; Netherlands; Poland; Portugal; Spain; Switzerland; Turkey

Less than 100% cost recovery of Operation and Maintenance Costs, with Capital Costs supported

Korea

Recovery of other costs through water charges or water pricing: oportunity costs, economic and environmental externality costs

- Australia: some environmental costs already recovered, but planned to recover opportunity costs, economic and environmental costs by 2010;
- France is recovering a share of the environmental costs through water charges;
- United Kingdom: currently recovering share of environmental costs.

Source: OECD (2010)

314. However, efficiency gains linked to the use of economic instruments have also to be weighed against the possibility of achieving unfair allocations. Equity implications of economic instruments overall depend on their precise design: whether water pricing scheme is linear or block-rate (see Chapter 2for a more detailed discussion of equity in water tariffs); how the initial allocation of water rights is made; in water-stressed regions, water trading may refrain low-income farmers from receiving enough water to sustain their livelihoods, etc. Equity implications have thus to be considered to foster the acceptability of reforms and their stability over the long run.

315. Rural-urban water transfers have been the subjects of several economic studies that compute the potential gains from water trading. These calculations are usually carried out using computable general equilibrium models (CGE); these models take an ex-ante perspective and are thus able to assess the gains from water trading between the competing market participants in various contingent scenarios. Even though the studies vary both according to the specific water basin taken as unit of analysis and to the different optimisation techniques used to solve the model, they all arrive at the same conclusion: in frictionless market settings, unrestricted water right trading among all the competing users is the policy option that yields the highest possible welfare gains to the population.

316. For instance, in the case of the Bow river sub basin of Southern Alberta, Canada, Ali and Klein (2014) conclude that overall net benefits under unrestricted trading are higher compared to any other possible allocation policy – i.e. seniority rule or people first – as well as under any water shortage scenario. Another example is given by Dwyer et al. (2005), in which using a multi-region comparative static CGE, the authors study the effects of expanding water trade from the irrigation sector to households and other industries in South-East Australia; assuming a sudden reduction in available water, the authors show that the gross regional product would decline only by 0.03 % when full water trading is implemented, whereas it would fall by 0.11 % when inter-sectoral trade is not allowed. The same results are found in many other regions such as: Italy and Spain (Pujol et al., 2006), Egypt (Gohar and Ward, 2010), north-central Chile (Hearne and Easter, 1997), the Yellow river basin in China (Heaney et al., 2005) and south Texas (Chang and Griffin, 1992).

317. Beyond efficiency, water trading also provides the system with the necessary flexibility in adjusting the allocation inefficiencies that derive from droughts. Indeed, by allowing trades between urban and rural areas, water markets are able to give access to water resources to those users that might have been excluded from them in the event of a drought. In other words, the flexibility in allocations that is embedded in water markets allows responding effectively and rapidly to severe supply shocks, such as the ones in droughts (Chong and Sunding 2006). This welfare-enhancing reallocation is not always possible under a prior appropriation regime without trade or under a traditional queuing allocation system.

318. The flexibility in water trading systems can be further enhanced by introducing dry-year option contracts to secure access to water. These adaptive management arrangements allow temporary water transfers that are contingent on water supply availability; they are therefore potentially able to mitigate risks related to water scarcity or competition to access the water the cities need. Such contractual arrangements were used to secure water to the Metropolitan Water District of Southern California (MWD), which entered in an option contract with the Sacramento Valley irrigation districts in 2003, for 146,000 acre-feet of water; other major agreements involve MWD and Palo Verde Irrigation District, or the city of San Diego and Imperial Irrigation District.

319. From an urban perspective, water markets also allow water allocations to be responsive to the demand stimuli stemming from urban growth. That is, by allowing the emergence of a clear price signal which will rise in the event of urbanisation of rural areas, water markets allow the attainment of the maximum gains from trade in the transfers of water. Finally, from the point of view of farmers, flexible water prices create an incentive to adopt new agricultural technologies. For instance, higher water prices deriving from stronger competition for water resources may lead to the wide-spread adoption of water-saving irrigation technology. Hence, water prices can also be an effective tool to induce water conservation (Caswell and Zilberman, 1985). An example of water trading including urban and rural users is shown in Box 31, in Reus, Spain.

Box 31. Water trading in Reus, Spain and the Siurana-Rudecanyes irrigation district

The Siurana-Riudecanyes irrigation district is located in the province of Tarragona (Cataluña) and it covers 4,000 ha of land. Since 1904, the stock of water resources in the basin has been allocated through a water market mechanism which is managed by the "Irrigation Subscribers Association of the Riudecanyes Reservoir" – an association that includes the city of Reus, the other municipalities and the small rural landowners of the region. The association is also responsible for the maintenance and repair operations on the water infrastructure as well as for the financing of new water procurement projects.

The market was instituted with the twofold purpose of securing enough water supplies for the city of Reus and for preserving the agricultural production activities of the rural areas. Water rights were distributed using fixed price public offerings only to the members of the Association, which had to own land in the basin. The collected revenues from these auctions were used to finance dams and other infrastructure. Moreover, the water rights were tradable among the members of the association through both temporal and permanent transfers and water prices were allowed to fluctuate according to supply conditions.

The market has always been very active with frequent trades between farmers and municipal water supply companies that provided water for domestic and industrial users. The market allocation mechanism was successful in accommodating both the changing urban supply water demands and the variations and diversity in the cultivated crops. Hence, the water allocation problem in the Siurana-Riudecanyes basin has been managed in a flexible and economic efficient way through a water trading mechanism.

Source: website of the association (http://www.pantaderiudecanyes.cat/); Tarrech et al. (1999) and Torregrosa (2009).

320. Despite their efficiency advantages, and beyond the presented examples, water trading regimes have not been widely implemented yet. In many OECD countries, water allocation between the competing users has remained a bargaining process often characterised by a strong political dimension. This is because, in some cases, second-best solutions might provide a more effective (albeit more costly) way to solve the water competition problem, while at the same time addressing the issues of fairness and food security.

321. Water trading mechanisms have also not been implemented widely due to the high cost of entry and institutional complexities involved in their establishment. In urban-rural water markets local rural communities should actively participate in the design of the rules and mechanisms regulating water trades. This will not only ensure a higher probability of participation in the programme (trades are always voluntary) but the design of the market will also benefit from the locals' knowledge of the geographical and social characteristics of the water basin.

Groundwater conservation policies

322. Groundwater represents a major source of domestic use of water, accounting for about 60% of all drinking water, and at the same time representing an increasing share of agriculture use, with 40% of total irrigation (OECD, 2014b). Due to its advantages, notably its relative insulation from climatic events, and accessibility by farmers, it has been intensively used in areas with limited or unstable surface water supplies, creating tensions with other users, and in some cases observable depleting reserves.

323. To respond to these concerns, affecting both urban and rural communities, a number of local management initiatives have been developed around cities, with the objective of finding ways to conserve groundwater supplies. Most of these did not involve demand side measures like restrictions, trading, or incentive measures, but rather integrating different sources of water and/or supporting practices with the goal of replenishing groundwater resources. They also revolve into the management of aquifers, and therefore may not always be connected directly with river basin managements (which do not generally

coincide spatially), or larger spatial units. Just as groundwater resource characteristics widely vary, approaches also differ based on the constraints, uses, and institutional constraints (OECD, 2014c).

324. First, in multiple cases, the use of treated wastewater has been offered by cities to irrigators in exchange for groundwater, with the purpose of conservation (or banking). This has been operated for instance, in Topeka, Kansas (Peck, 2007), where the city paid for groundwater rights in exchange of treated municipal wastewater. The conservation objective was fulfilled and the city reportedly did not use groundwater for seven years. The city of Wichita Kansas, facing the risk of groundwater depletion embarked into a large transfer of surface water into its section of the High Plains Aquifer. In Santa Clara, California, a conservation district was created and managed to stop land subsidence that damaged infrastructures. The district's management plan included monitoring of groundwater use among rural and urban users, importing surface water and artificially replenishing the aquifer with treated wastewater (Borchers et al., 2014). Another example is the Storage and Recovery approach (S&R) in groundwater conservation employed by the city of Tucson, Arizona, which serves the twofold purpose of storing water underground for future use while replenishing the already pumped groundwater (see Box 32). It also signals a remarkable capacity to adjust to demands from the community.

Box 32. Tucson's groundwater recharge – Storage and Recovery Approach

Tucson Water is a city department providing water to most residents in Tucson. Tucson Water's water resources planning and management must meet state groundwater regulations and national water quality standards for drinking water. Additionally, it has to comply with the *Groundwater Management Act* of 1980 (designed to curtail overdraft of aquifers that was occurring in the populated portions of the state, including Tucson) and accompanying regulations that require a demonstration that new residential growth in Tucson will be served by a 100-year Assured Water Supply (AWS).

Thus, besides relying on groundwater, Tucson lacked another source of water supply to comply with the AWS rules. The Central Arizona Project (CAP), a federally funded canal project that pumped the water from Colorado River from near sea level to a maximum elevation near Tucson, became significant to Tucson Water. Delivery of this renewable water supply provided Tucson Water with a much needed alternative to groundwater. The region's good quality groundwater did not require much treatment prior to delivery to customers but integration of this new water source required the construction of a large centralised treatment plant. With the aim to move away from groundwater overdraft, Tucson delivered treated CAP water, the first real infusion of surface water into the Tucson Water System.

However, this bold move was fraught with difficulties related to the introduction of water with a different chemistry from that of groundwater, and traveling in a different direction through old water mains. Issues with the quality of water and damages associated with burst pipes, coupled with utility hesitancy to acknowledge the problems, led to a lack of confidence and customer activism to restrict the manner in which this new water source could be used. These aspects effectively led to the prohibition of the use of the centralised water treatment plant.

As a consequence, Tucson Water decided to implement an indirect approach to utilizing CAP water. Instead of treating the water in a large storage facility before delivery, it deployed a Storage and Recovery Approach (S&R), which complied with the Arizona State regulations. This approach accomplished more than one goal: it a) avoided costs of centralised treatment plants; b) stored water underground for future use; c) replenished groundwater already pumped and d) addressed water management objectives. Thus, S&R approach allowed the utilisation of CAP water first by storing it underground, mostly through large, shallow spreading basins, where it mixes in the aquifer with groundwater and then by recovering it for delivery through the distribution system.

Tucson Water's commitment to meet long-term water demands from the community and its ability to be flexible and to adapt from direct delivery to S&R enabled it to utilise groundwater without large scale and expensive treatment systems, and to accommodate storage of water for future use. Additionally, Tucson's commitment to conservation recognises water banking as an important strategy for addressing long term needs for the region.

Source: The case study was developed by Sharon B. Megdal and endorsed by Tucson Water

325. Other cases have involved payments or financial transfers. Farmers have been paid by cities and industrial companies to encourage practices that help recover the aquifer, such as paddy rice flooding. The city of Ono in Fukui Prefecture, who received the Japan Water Grand Prize in 2012, was one of the early adopters of groundwater recharge via paddy fields storage in the late 1970s. A similar mechanism was introduced in Kumamoto, Japan, where the city acted in conjunction with Sony Corporation, and a local foundation to support farmers (Hashimoto, 2013a). The rice was then promoted as environmentally friendly. The city of Azumino set up a mechanism of pay for users to ensure conservation for the benefits of urban, industrial and agricultural users. Some other cities have used conservation easements, providing protection to land surrounding the city in exchange for aquifer recharge (in San Antonio, Texas, see Lee 2014).

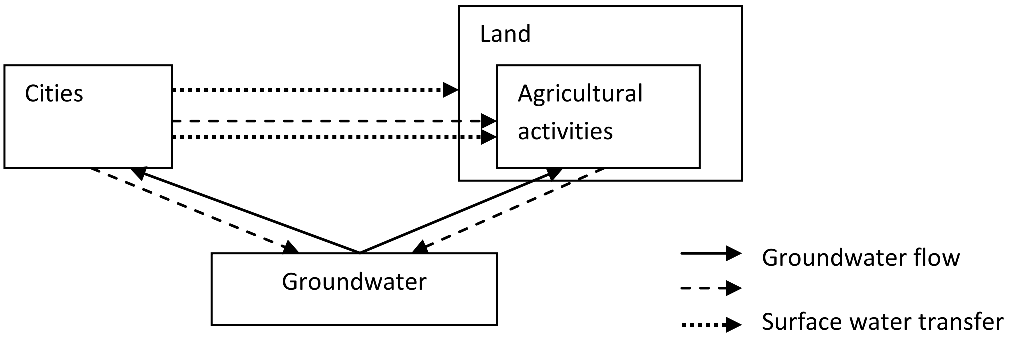
Box 33. Groundwater transfer arrangements: the case of Wichita and Azumino

The city of Wichita, Kansas, is located above the High Plains Aquifer; a large aquifer that is one of the most intensively used for agriculture in North America After decades of intensive pumping, especially for irrigation, starting in the 1940s, the water table declined by up to 13meters in some locations. In the 1990s it started an Aquifer storage and recovery programme with the goal of fighting against groundwater depletion affecting both the city and regionally located users. The project is based on the recharge of the aquifer by treated surface water from the Little Arkansas River during periods of above-normal flows via basin, trench or injection wells. The recharged volume is intended to a) be reused by the city for municipal use, b) benefit irrigators, and c) serve as a hydraulic barrier to prevent the intrusion of (natural) saltwater from underground oil-field brine plume. The project entered its second phase in 2009, with the goal of reaching a daily recharge of 378.5 million liters of water.

Japan has long been trying to conserve groundwater not only for its largely populated urban area, but also in part to fight with land subsidence and salt intrusion in coastal area. In the city of Azumino, Nagano Prefecture, the question of groundwater use became recently problematic due to competitive pressure from three sectors, agriculture, via the well-known wasabi production (requiring clean fresh water), industry, via the water bottle sector promising its water as pure water source coming from Japan's Northern Alps, and urban residents. A Groundwater Conservation Study Committee was initiated in 2011 to assess the problem and propose solutions. The conclusion of the study, published in August 2012, expressed the need for increasing recharge of the aquifer. The recharge is envisaged to be paid for by cooperative fund collected from groundwater users, with a fee depending on the contribution of the user to the recharge.

Source: Peck (2007), Sophocleous (2010 and 2012) and Hashimoto (2013a and 2013b).

Figure 22. Agriculture groundwater management and cities: water and financial transfers



Source: Authors.

326. As seen in these examples, and schematised in Figure 22, mechanisms that have been used typically involve water transfer, concessions, or payments by cities to rural activities in compensation for the service of ensuring sufficient quality groundwater supplies. In some cases, where externalities affect both cities and rural areas, contracts involve both types of users. But, like in other cases, agriculture is most often not at the origin of such arrangements.

327. A number of examples provided here come from a few countries and/or regions, in part because cities had the ability to operate on groundwater management, or were asked to do so due to external pressure. Just like in the case of surface water, some countries may have regional or federal schemes that do not leave degrees of freedom to cities. Moreover, groundwater use may also face limited oversight in many regions, due to a lack of investment in monitoring and less pressing concerns.

Mitigating flood risks in urban areas

328. Flood risk mitigation strategies include a set of activities from risk mapping to emergency plans, land use regulations, and hydraulic infrastructures such as dams. In the past decades, development of hydraulic infrastructures, improvement in flood risk management plans, better preparedness, among other efforts, allowed to reduce the vulnerability to flood risk in many OECD countries, in spite of increased exposure due to economic growth and urbanisation. However, recognition of the limitations of such traditional, engineer-based approach to flood control has led to the gradual emergence of a new paradigm during the last 10-15 years, based on a more integrated and landscape-based approach to flood risk management, and a stronger emphasis on ecosystem-friendly strategies.

329. It is notably the case of Integrated Flood Management (IFM), an approach promoted by both the World Meteorological Organization and Global Water Partnership since the early 2000s building on the pre-existing concepts of Integrated Water Resource Management (IWRM) (World Meteorological Organization and Associated Programme on Flood Management, 2009). The principle of IFM is to "integrate land and water resource development in a river basin, within the context of Integrated Water Resource Management, with a view to maximizing the efficient use of floodplains and to minimize loss of life and property" (WMO, 2009). In the European Union, the trend is towards moving priority from "grey" to "green" infrastructures, in close relationship with the concept of IFM, with a particular emphasis on the development of Natural Water Resource Retention Measures (NWRMs) (Linnerooth-Bayer et al., 2013) based on soil management practice. At national levels, typical examples include the Room for River initiative in Netherlands (see OECD, 2014d, for more information).

330. Rural-urban linkages are likely to be a major dimension of this reorientation of flood risk management, with agricultural land having the potential in certain areas to play a key role (OECD, 2010; Morris et al., 2010):

i) agricultural soils can contribute to water retention through the adoption of a set of appropriate farming practices; and

ii) agricultural land is also affected by flooding, but can also be used in an integrated landscape perspective for floodwater storage in order to reduce risk in urban or industrial areas, in view of minimizing the social cost of flooding.

331. Cities also affect flood risks in their environment: globally, urbanisation has expended sealed surfaces, exacerbating problems with run-offs in case of heavy storms (Swan, 2010). Storm water management is therefore a crucial issue in the mitigation of flood risks in urban areas; Box 34 analyses the problem and discusses the best practices that had been adopted by cities in Ontario, Canada, echoing similar experiences reviewed in Chapter 3. Finally, the rural environment can also benefit from more sustainable approaches to urban drainage, built into urban planning.

Box 34. Stimulating Innovative Storm Water Management in Ontario, Canada

The traditional approach to storm water management in Ontario is an efficient underground storm sewer network to convey urban runoff as quickly as possible to a nearby water body. Also, in older parts of some cities such as Toronto's downtown core, storm water is conveyed with raw sewage in a combined sewer network to a wastewater treatment plant.

The increase in impervious surfaces combined with traditional storm water management has significantly altered the movement of water in urban areas. The changes in terms of peak flow rate, the total volume of storm water, frequency and duration has had significant impacts such as bank erosion, as well as an increase in flooding potential.

Additionally, urban storm water becomes highly polluted as it travels along the urban environment picking up contaminants ranging from sediment, nutrients, hydrocarbons, heavy metals, road salt, pesticides and animal waste. This polluted water is mainly discharged into a water body untreated, and in the case of combined sewers, large storms can result in raw sewage and polluted storm water bypassing the wastewater treatment facility. Ultimately, the impacts of urbanisation include impaired fish habitat for spawning and rearing, a decrease in fish health, reproduction and diversity, and unsightly and potentially dangerous algae blooms.

Striving to address these issues, Ontario has undergone a series of transformations to evolve from its traditional storm water management approach focusing on flood control. Storm water management is now designed for runoff volume, peak flow, and quality, and factors such as temperature control, infiltration, water budget, and fish habitat. Some practices also address runoff duration and frequency, and are designed with Ontario's four seasons in mind, such as spring snowmelt.

The use of a treatment train approach is encouraged that incorporates source (e.g. disconnected downspouts, rain barrels, rain gardens), conveyance (e.g. swales, exfiltration systems) and end of pipe (ponds, engineered wetlands) control to manage storm water.

Under the Ministry of the Environment's Showcasing Water Innovation program (SWI), 16 storm water projects have been funded to stimulate innovative research, and ultimately help municipalities and the province manage storm water better.

Lake Simcoe Region Conservation Authority was awarded an SWI grant to retrofit existing storm water ponds to include quality control. Different retrofit methods and technologies were used at three pilot sites, and the conservation authority is assessing each to determine their effectiveness and applicability for future retrofits. Storm water ponds have been extensively used throughout Ontario so the lessons derived from this project will help inform municipalities on how to effectively upgrade their ponds.

Source: WaterTAP (2013); copied from http://www.watertapontario.com/news/blog/ontario-innovative-stormwater-management-oct2013-/32, last visited 14 April 2014.

332. Practical approaches involve specific sets of payments for ecosystem services, rewarding land owners for providing risk mitigation services via different practices and/or conservation. Box 35 illustrates such approaches in a few towns in the United Kingdom.

Box 35. Using agriculture fields for flood protection: examples in the United Kingdom

The role of agricultural land in flood risk management has been especially underlined in the United Kingdom. Several initiatives and pilot projects have been conducted that include agricultural lands as key players of flood management programmes, in the context of the programme Making Space for Water. One example is the recent pilot project Payment for Ecosystem Services (PES) on Flood Regulation in Hull. The objectives of this pilot were to characterize the current state of ecosystem services delivered to urban areas; to identify potential improvements of ES delivery; and to design potential payments for ecosystem services that could be applied. The pilot lead to propose two PES schemes, including a country Park scale PES would allow mitigating flood risk in the North West of the Hull by developing "swales, bunds, ponds, replacement of permeable road and car park surfaces and conversion of amenity grassland to semi natural grasslands and more varied woodlands". Another example is the Beckingham Marshes Washland Creation, which aims at creating 94 hectares of floodplain grassland in order to improve flood risk mitigation for the towns of Gainsborough and Beckingham on the River Trent. While agricultural land areas used to contribute to flood risk management in this area since the 1960's, this project also addresses restoration of natural habitats.

Source: UK Environmental Agency (2010); URSUS Consulting (2013).

333. Although promising, significant challenges remain to be overcome to allow for the development of such approaches. The first one is uncertainty about the linkages between land use, farm practices and flood risks, making it difficult to calibrate the appropriate level of intervention. Hopefully, integrated land-hydrological modelling could be helpful tools in this area. The second challenge is to find a set of policy tools able to incite farmers to contribute to flood mitigation in an efficient way. Information about the levels of risks is a major prerequisite, as underlined for example by the European Union in the Flood Directive requiring Member States to map flood risks. Land regulation such as zoning will certainly continue to play an important role in this area; however there is increasing interest for more decentralised and incentive-based policy instruments such as payments for ecosystem services.

Water quality standards and the provision of ecosystem services

334. Ensuring minimum standards in the quality of water available to urban and agricultural consumers is a highly regarded problem, especially among the citizens of OECD countries (OECD, 2013a). The demand for the provision of water quality is driven mainly by: (i) domestic consumers who use water for drinking and for the fulfilment of other basic water needs, (ii) water ecosystems and their related environmental, recreational and aesthetic uses (including in cities), and (iii) agricultural producers who need a certain quality of water for their irrigation activities. The needs are clearly very different and this creates a misalignment in incentives for water quality preservation. For this reason, managing the problem in an integrated manner through the use of the urban-rural interface might lead to more effective solutions. Water pollution entails significant costs for many OECD countries; for instance, it has been estimated that the costs of nitrate and phosphate damage in the Netherlands and in Spain are respectively 403-754 and 150 million euros (OECD 2012b).

335. The main drivers of the problem are: intensive agricultural and farming practices and the non-effective management of wastewater from domestic and industrial users. On the one hand excessive inputs of nutrients, phosphates and nitrogen fertilizers in agriculture together with greater nutrient concentration in animal manure are bound to worsen the water quality problem. On the other hand, the problem is compounded by lagging sewage treatment and the non-effective management of wastewater resources. On an aggregate level, there have been significant improvements in managing these drivers as shown by the reduction in average nitrogen balance volumes in OECD countries between 1990 and 2009 (OECD, 2013a).

336. The main policy objective is to foster sustainability and environmental protection of water systems without causing significant negative effects on regional economic growth and rural development. Hence, when dealing with water quality issues, policy makers will still need to reconcile the goals of equity and sustainability with the economic gains and job creation deriving from the polluting activities.

Policy responses

337. Possible policies include: environmental regulations, economic incentives, and information provision or a mix of them. In particular these are: a) stringent point source pollution standards (uniform command-and-control), b) payment for water quality services or performance-based conservation subsidies, and c) water quality trading. As noted above, standard setting is usually set up at a regional or federal level, and therefore rarely involves tailored arrangements between cities and rural areas. New Zealand is an exception, as regional councils are based on catchment areas, meaning that water related planning documents are at the appropriate scale to manage catchments regardless of whether they cross rural or urban areas. This section reviews experience with contractual arrangements that involve payments of farmers to improve water quality services, and rare schemes of water quality trading.

338. *Contractual arrangements and payments for water quality services* from municipal water organisations to nonpoint agricultural pollution sources are an alternative policy option to the deployment of expensive monitoring systems. These policies aim at creating mutually beneficial changes in land management uses and practices in order to achieve both environmental and economic gains. Typically, in the case of surface water, they are voluntary direct financial arrangements between large cities and rural areas, and they are based on the notion of payments for ecosystem services. The experience of the city of Munich, Germany, is presented in Box 36. Similar but smaller cases can be found in the Netherlands where water utilities run cooperative agreements with parties of 15 to 20 farmers, including training to reduce the use of inputs and the stimulation through the principle of ‘payments by results’ (i.e. proportional to the reduction of nitrates content in water pumped in the end). These arrangements often involve a small increase of water tariffs to cover the farmers’ compensations. Similar arrangements are controversial in France, where subsidising farmers beyond Common Agriculture Policy payments is considered as breaching the European rule limiting ‘Government subsidies’.

339. Some of the schemes were introduced explicitly to supplant existing regulations. For instance, the city of Rennes in France was confronted in the 1990s to excess Nitrate concentration related to drinking water. In order to complement the already existing tools, notably the European Union Nitrate Directive, the city developed a programme aiming at reducing Nitrate concentration in water supply by inciting farmers to modify their agricultural practices and by purchasing land for reforestation. The programme allowed reducing nitrate concentration below 50 mg/L since 2009, which is in line with the EU Nitrate Directive requirements. It is suggested that the programme was far more cost-efficient (about ten times) than building a water treatment station (Burik et al., 2011).

Box 36. Payments for water quality services: the cases of Munich

The Mangfall Valley in the Bavarian Alps supplies around 80% of Munich's drinking water to its 1.2 million inhabitants. The Valley is predominantly used by farmers and agricultural producers, whose activities were causing slow but significant increases in nitrates (15 mg/l) and pesticides concentrations (0.065 µg/l) in the city's water resources. To address the issue, the municipal water provider – Stadtwerke Munchen SWM – implemented in 1991 a voluntary payment scheme to encourage local farmers to adopt more sustainable organic farming practices.

After estimating the target area using hydro-geological models, SWM launched a public information campaign targeted to 120 farmers, which were mainly dairy producers. The payments were constructed in order to cover the expected lost income and the investments needed to switch to organic farming; more precisely, farmers received a payment of 280 €/ha/year for the first 6 years after the change and 250 €/ha/year for the following 12 years.

The programme successfully halved nitrates concentration to 7 mg/l; the price increase for final urban consumers due to the payment scheme (0.005 €/m^3) was lower than the avoided cost of water treatment facilities (0.23 €/m3). Moreover, more than 90% of the farmers adhered to the programme and the area of Munich is now considered to be the largest and more active market for organic farming products in Germany.

One of the key success factors of the programme was the city's strong involvement in purchasing and promoting the organic products from the Mangfall Valley. For instance, the city of Munich not only purchased the organic farming goods to supply its schools and municipal restaurants but also funded several marketing and advertising campaigns aimed at creating a brand identity for the agricultural goods of the targeted area. These measures helped building trust between urban and rural water consumers, which together with a clearly defined set of legal rules regulating organic farming practices in Germany, reduced contractual and transaction costs in the implementation of the payment scheme.

Source: Grolleau and McCann (2012).

340. Similar schemes have been implemented for groundwater quality conservation. Some involved land-related transactions. In Saint-Ivy, France, the commune bought the land formerly used by agriculture, to convert it to woods in order to protect the aquifer, in part because in France landowners cannot impose crop choices to tenants (Barraqué et al., 2010). In other cases, a performance contract was designed. For instance, in Santa Cruz County, California, a performance-based conservation initiative was piloted, between the Resource Conservation District and the strawberry company Driscoll's to monitor and improve groundwater quality, and better manage quantity (Levy and Christian-Smith, 2011). The plan includes targets, new monitoring mechanisms and conservation incentives payments for participating farmers (Levy and Christian-Smith, 2011).

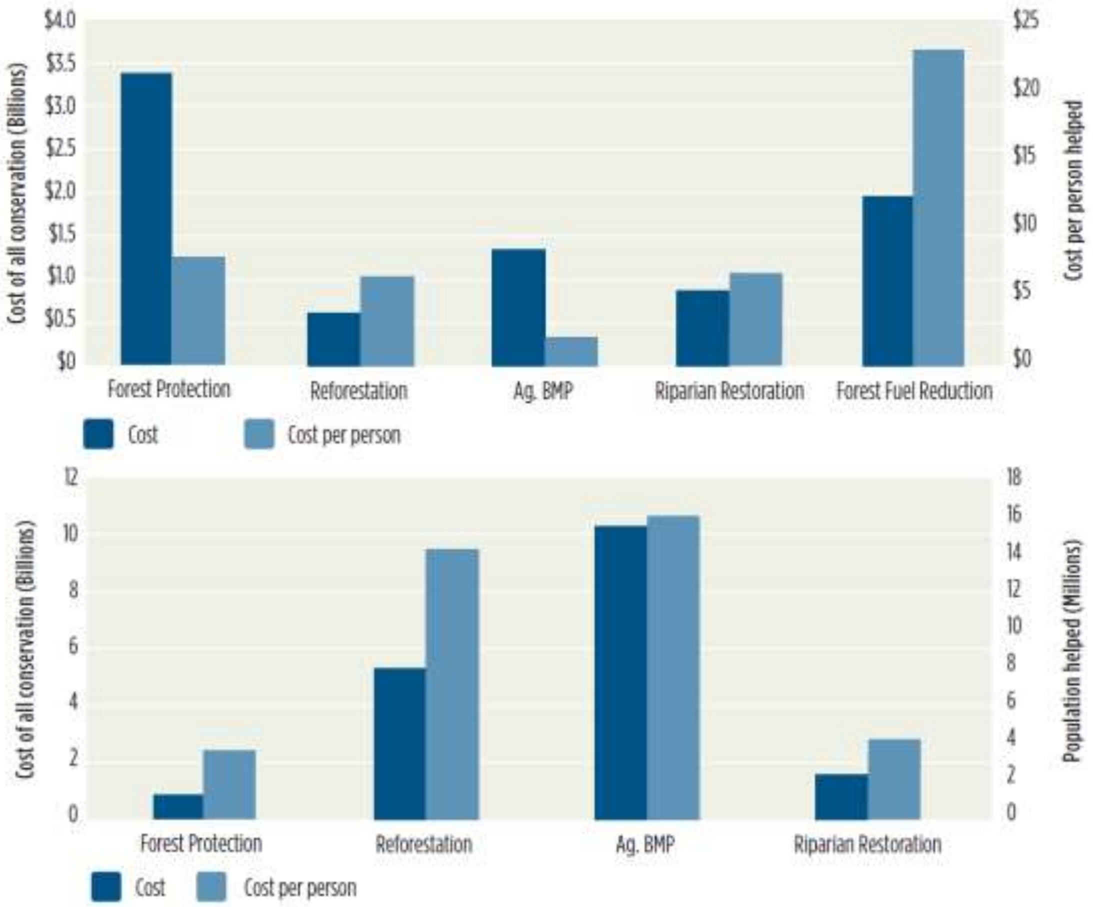
341. Other recent initiatives have aimed to facilitate dialogue and collaboration among various stakeholders under the leadership of third party regional authorities, including rural and urban interests. In New Zealand, the Waikato Regional Council and the Waikato and Waipa River iwi (indigenous peoples) have established a Collaborative Stakeholder Group, including representatives from the dairy and horticultural industries, sheep and beef farmers, the energy sector, local government, public water suppliers, and environmental NGOs. Their purpose is to develop changes to the existing regional water management plan to address the adverse effects of discharges to land and water in the Waikato and Waipa river catchments[24].

24 . See http://www.waikatoregion.govt.nz/healthyrivers for more information.

342. Widening the scope of these programs to entire watersheds upstream of cities if and where possible could further increase the benefits of contracting. McDonald and Shemie (2014) suggest that focusing on source watershed conservation strategies can be a cost-effective manner to reduce the challenges associated with water sedimentation and nutrient flows. They propose five strategies: forest protection, reforestation, agricultural best management practices, riparian restoration and forest fuel reduction, each of which would need to be adapted to local circumstances. They find in particular that increasing the adoption of best management practices on 0.2 percent of agricultural areas in watershed from which water is sourced in the 100 largest cities would result in a 10 percent sediment reduction in water supply (constituting the most cost-effective option as shown in Figure 23). The same option is less cost-effective than others for nutrient reduction (same Figure). These mechanisms would also reduce the cost for water treatment plant and operations (McDonald and Shemie, 2014).

Figure 23. Cost and effectiveness of water quality gains based on watershed conservation

10% sediment reduction (upper panel) - 10% nutrient reduction for the 100 largest cities (lower panel)



Source: McDonald and Shemie (2014).

343. *Water quality trading* is an application of cap-and-trade pollution control mechanisms, which prescribes a maximum level (cap) of total water polluting diversions allowed for all the subjects participating in the programme. The participants are then allowed to purchase and sell on the market the rights to pollute according to their own necessities, but always within the established cap.

344. The economics of cap and trade requires the fixing of a desired quantity of pollution and the consequent allocation of quotas to the emitters. A common price for water quality would thus emerge from the trading of these permits. The trading would result in the assignment of the majority of permits to those participants that can abate their emissions at the least cost. In this way, if implemented correctly the system would then curtail water pollution in the most cost effective way by ensuring the equalisation of the marginal costs of pollution reduction among the sources of water pollution. Furthermore, the system would produce a great amount of dynamic efficiency by penalizing highly polluting municipal, industrial and agricultural water users and by rewarding those who reduced their emissions. In other words, the cap and trade mechanism also creates a strong incentive to adopt water-saving and quality-enhancing technologies in order not to incur the higher costs of procurement caused by the resulting emissions' price. Box 37 provides an example of such scheme at a regional level that involved cities. But most of these schemes are set at a regional level or between rural water users, not with cities. Moreover, up to date, the outcomes of water quality trading programmes conducted in several countries of the world have been mixed (Shortle, 2012). Different barriers for their development have been identified (need for transparent and clear trading rules; significant differences in costs of abatement; need for dedicated institutions to manage the programmes), and implementation is especially difficult in the case of non-point source pollution.

Box 37. The Pennsylvania nutrient credit trading programme (PANCTP)

The Pennsylvania Nutrient Credit Trading Program targets the flow of nutrients from point to nonpoint sources from the state of Pennsylvania to the Chesapeake Bay. The bay's watershed, with its 165,534 km2, is the largest estuary in the United States and its ecosystems are severely impaired by nutrient pollution. In 2009, Pennsylvania accounted for 44% of the nitrates and 24 % of the phosphates that reached the Bay, which were mainly the product of agricultural runoffs.

The water quality trading programme was implemented in 2005 and it targets industrial, municipal and agricultural polluters of nitrogen and phosphorus. The programme is a partially capped emission reduction credit trading system that allows uncapped agricultural nonpoint sources to supply emission credits to capped industrial and municipal sources. Farmers produce emission credits by adopting best management practices that reduce nitrogen and phosphate's flows into the Bay. Market-based trading is facilitated by an online market trading platform and a trading clearing house, which are managed by a state agency that traditionally was in charge of financing water infrastructure development projects.

While the market started slowly, 259 trades were reported in 2013. The success of the programme has not been assessed yet.

Sources: (OECD, 2012b), online market platform: http://pa.nutrientnet.org/; Pennsylvania Department of Environmental Protection: http://www.depweb.state.pa.us/.

Implementation issues

345. The above review highlights a possible mismatch between proposed first-best solutions, at least from an efficiency perspective, and approaches in use. For instance, as noted above, water trading systems, despite their recognised economic efficiency, are mainly used intra-sector (OECD, 2010), and are rarely driven or used by cities. This discrepancy may originate from multiple factors, most of which relate to the ease of implementation. The cost of entry and institutional complexity of approaches may make them unfit for smaller scale, or difficult to establish among users. Another possible explanation is that in many instances policy makers decide to favour other objectives – i.e. equity or sustainability – over economic efficiency. Other global, national or local political objectives might also affect the implementation choice; for instance trade liberalisation, food or energy security, land grabbing, poverty alleviation or the interests of strong lobby groups might tilt the balance over one possible policy choice over another.

346. Two underlying questions best synthesise these issues in the context of rural-urban linkages: What is the appropriate scale for urban – rural co-operation over water management? What implementation challenges cities and rural actors face when considering optimal co-operation mechanisms?

***Scale of urban water policies and its implication on rural-urban co-operation*[25]**

347. As discussed in other parts of this chapter, it is worth asking in which cases cities and rural actors should be involved in water management actions beyond existing policies set up at a higher level. The answer clearly depends on the scope of the constraint they face regarding quality, scarcity or flooding risks. Cities that are centrally located in a water basin are bound to be more inclined to see the benefits of rural-urban linkages, even if implemented from a regional scale. Cities with limited surface water supply, depending on groundwater, or facing risks of salinisation and/or land subsidence, have a direct interest in linking with other users of underlying aquifers. In contrast, cities with no flood risks and high quality steady water allocation will have very limited incentives to act. The answer also depends on the adequacy and sufficient efficacy of prevailing policies. Cities' involvement will depend on the costs of instituting co-operation arrangements, which also depend on economies of scale. Rural-urban co-operation can entail excessive transaction costs and administrative burdens. The process of coordination across levels of government, in fact, requires time and resources, as well as capacities, which may not be in place at the start of the co-operation process.

348. At the same time, a city will only consider to undertake action if it has the liberty or authority to do so. Pre-existing conditions may confer authorities to manage water challenges at a specific level or following an established framework of operation in which there is limited degree of freedom for cities. For example, the Water Framework Directive requires all water stakeholders at the river basin level in the European Union to co-operate to reach specific objectives to fulfil their management plans. On the other hand other institutional contexts may confer or require cities to manage issues at their own level. And the regional or national authority may play an external role in ensuring that rural-urban cooperation linkages are balanced and functioning. The issue of decentralisation is therefore critical in understanding whether and how cities should link with rural areas in water management issues.

349. Moving past the question of intervention, the type of instruments also will depend on the scale of operation. First-best instruments may involve entry cost, or frictions that make them much less affordable than other more ad-hoc contractual solutions. Accounting for pre-existing regulatory frameworks that address the core constraints of water quantity and quality, the marginal benefit of action may be insufficient to cover the significant marginal costs it involves. In this setting, ad-hoc small scale contractual arrangements, which have the advantage of addressing the specific constraints of a particular city, and involving limited number of actors, may have much more appeal than well-defined but complex or challenging institutional responses.

Implementing rural-urban policies

350. The *second question*, related to the actual implementation of policies, revolves around the willingness of rural actors and cities to set up such linkages and the means to do so. As noted in a number of examples, cities are most generally the drivers of urban-rural linkages on water.

351. Rural-urban partnerships can help integrate water management between cities and their hinterlands. As defined in Box 38, they consist in cross-sectoral and holistic sets of initiatives (e.g. within a

[25] Chapter 5 addresses more generally the challenges associated with multi-level water governance in cities. This section only delves into issues related to the implementation of policy instruments to tackle the three water quantity and quality constraints.

wider package of environmental policy initiatives) or focus on single objectives/projects (i.e. management of water resources). For instance, a rural-urban partnership can aim at managing the production and the distribution of benefits associated with ecosystem services. In Forli-Cesena (Italy) for instance, the management of water resources is the result of a partnership among all urban and rural municipalities and chambers of commerce from three different provinces, which are also included in the co-operation process. Municipalities where water sources are located benefit from a share in the revenues from water provision, as well as from investments in natural and cultural heritage preservation and initiatives aimed at developing tourism in the area. At the same time, the other municipalities benefit from the availability of clean water and from the proximity to high-value landscape and amenities (OECD 2013b). Box 38 provides an example of rural urban partnership.

Box 38. Rural Urban Partnership

Rural-urban partnership is defined as the mechanism of co-operation that manages linkages to reach common goals and enhance urban-rural relationships. Rural-urban partnerships are a possible response to gaps in existing levels of governance of urban-rural relationships and they can help deliver services and public goods, develop public goods and improve administration, focusing on spaces of functional territorial integration.

The concept of rural-urban partnership has distinct features, involving a collaboration with:

- an awareness of the interdependency of rural and urban areas in a given space (functional region);
- a membership mix that includes the relevant rural and urban representatives;
- a framework for action or objectives that represents mutual interests (urban and rural);
- initiatives aimed at yielding collective benefits to urban and rural partners;
- an organisational form that is fit for purpose to help realize the partnership's objectives.

Among the characteristics that distinguish rural-urban partnership from other types of territorial co-operation is the fact that both urban and rural areas must be directly involved in the process. This implies including urban and rural stakeholders, such as public authorities – e.g. urban and rural municipalities – and/or private agents (firms, civil society, etc.). Common to all rural-urban partnerships is a common set of objectives intended to be managed jointly, in a space where urban and rural dimensions are physically and/or functionally integrated.

Because they are driven by linkages between urban and rural areas, rural-urban partnerships reflect the existence of complementarities, which in turn allow territories to join efforts and resources to reach common objectives that cannot be achieved in isolation (or at least not as effectively).

Rural-urban partnerships can be **explicit** (if the rural-urban dimension is very clear, and the relations between the urban and rural stakeholders and their interests are taken into account in the partnership's membership mix, work and strategic objective) or **implicit** (if the partnership aims to improve co-operation through a common local development objective, strategy or project but still involves urban and rural authorities).

Three different designs can shape the form of co-operation:

- **Formal and institutionalised**: a formal commitment by the actors involved to reach out across their respective responsibilities and interests and to co-operate on certain issues; activities formerly carried out individually are integrated.
- **Formal but not institutionalised**: hybrid partnership with features of both formality and informality. It has all the characteristics of the first group except that it is not institutionalised and is less structured and looser. It has no independent structure, with staff or allocated resources
- **Informal**: members decide to join together in loose networks that permit mutual consultation and co-ordination. No particular body is laid down, rules for co-operation are not well developed, and competences are limited.

Source: OECD (2013b)

352. In most of examples involving agriculture, cities need to provide sufficient incentives for farmers to participate. Such incentives may result from external institutional constraints, such as regional or national requirements to act, or from external physical constraints (climatic events, saline water intrusion,

and rapid water stock depletion) that can be sufficient to trigger cooperative action for the sake of protecting a common interest. In the absence of shared constraints, however, cities will need to be proactive in defining the proposed mechanisms. Payments for water-related services, once again, appear as the most obvious mechanism to do so; such payments can focus on changing agriculture or water using practices. Trading mechanisms, which may involve other actors, also set a price that is bound to facilitate exchanges. Other reported mechanisms involve non-pecuniary benefits for farmers, including transfers of water, or groundwater conservation schemes that are mutually beneficial and that enhance water security for both parties.

Box 39. The New York city watershed programme : an example of rural-urban partnership

New York City has one of the few sources of natural, unfiltered water in the U.S. It is the largest water system in the country operating under an approved filtration avoidance waiver. Ninety percent of the City's water is from the 1,600 sq. mile area Catskill/Delaware Watershed which consists primarily in rural area of farms, forests and small towns with growing number of suburban developments and vacation homes.

A Memorandum of Understanding (MOU) was signed in 1997 by New York City, communities of Catskill/Delaware watershed, U.S. EPA, state of New York, and environmental organisations with the dual goals of protecting water quality for generations to come and preserving the economic vitality of watershed communities. The agreement established the institutional framework needed to implement the range of protection programmes identified as necessary by the City, the State, and EPA. In the past 15 years, the Department of Environmental Protection (DEP) and its partners have focused on several key watershed protection initiatives: the Watershed Agricultural Program (WAP), the acquisition of watershed lands, the enforcement of updated Watershed Rules and Regulations, and the initiation and expansion of environmental and economic partnership programmes that target specific sources of pollution in the watershed.

Watershed Agricultural Council (WAC) assisted agricultural and forestry communities with adopting management techniques to protect water quality and enhance economic viability. Conservation easements provided landowners with annual payments in exchange for maintaining the land in a natural state.

Over the last 20 years, DEP and its partners have implemented an aggressive and comprehensive watershed monitoring and protection programme that has not only maintained but enhanced the high quality of Catskill/Delaware water.

One of the most fundamental preconditions of the watershed agreement was the coupling of the recognition of Catskill residents that the City had a legitimate interest in seeking to protect the purity of its water, with the City's own acceptance that farmers in the Catskills just might be the best people to design an environmental protection programme that would be compatible with their needs as farmers. The innovative combination of watershed programmes and partnerships contributed to create and maintain the reputation of NYC's drinking water as one of the finest supplies in the United States.

Source: Extracted from http://www.nyc.gov/html/dep/pdf/watershed_protection/2011_long_term_plan.pdf; Appleton, A. (2002), "How New York City Used an Ecosystems Services Strategy Carried Out Through an Urban-Rural Partnership to Preserve the Pristine Quality of its Drinking Water and Save Billions of Dollars".

353. Beyond economic or tangible benefits to engage participants, lasting management schemes may need to rely on the capacities of cities to build trust with their rural area counterparts. Successful rural-urban partnerships require mutual trust and a clear understanding of the long-term benefit of the interaction. Differences between rural and urban areas in terms of capacity, economic and political power can complicate the relationship. They can stem from the lack of information, evidence, and data as well as the lack of capacity in rural areas. The institutional framework (regulatory and political barriers) can sometimes constrain rural-urban partnerships. The absence of proper mechanisms or incentives for co-operation can also undermine rural-urban co-operation even when there is interest on both sides. The involvement of higher level authorities, via national regulations or guiding principles, like the polluter-pay principle, may help overcome barriers to co-operation. So does co-operating on multiple issues (beyond water) involving rural and urban actors as a single undertaking.[26]

354. Several other general conditions need to be fulfilled. These include information sharing pre-during and post partnerships (as shown in Box 40). Stakeholder engagement and participation from an early stage are prerequisites for long-lasting trust building. The involvement of third parties as observers, participants or arbitrators, may also help. Transparency - via the setting of measurable objectives, monitoring efforts and the reporting of results- is also critical for trust building. More generally, good governance principles that apply at other levels in water management are required for rural-urban arrangements to thrive.

Box 40. Conditions for Success of Rural-Urban Partnerships

A successful rural urban partnership, including in the case of water, relies on 5 pillars, for which the role of local government is crucial:

- **Promote a better understanding of socio-economic conditions in urban and rural areas**. The local government can use the rural-urban governance framework to promote water quality, reduction in water consumption and flood protection.
- **Address territorial challenges with an approach based on *functional* linkages between urban and rural areas**. The local government can identify strengths and weaknesses of rural-urban areas in managing water and their interdependencies.
- **Encourage the integration of urban and rural policies by working towards a common agenda**. The local government can encourage the participation of different government levels in rural-urban partnerships, to achieve better policy integration, as well as aligning interests inside and outside the water box.
- **Promote an enabling environment for rural-urban partnerships**. The local government can develop trust and a shared vision of the territory by promoting pilot projects on easy “win-win” issues, education initiatives, dialogue facilitators and setting a balanced “rules of the game” (i.e. promoting a fair partitioning of voting rights within the partnership).
- **Clarify the partnership objectives and related measures to improve learning and facilitate the participation of key urban and rural actors.** The local government can facilitate the exchange of good practices and knowledge acquired though the rural-urban partnership, promoting evaluation of the initiatives and sharing information.

Source: Adapted from OECD (2013b), *Rural-Urban Partnership: An Integrated Approach to Economic Development*, OECD Publishing, Paris.

[26] Game theory has shown that enlarging the bundle of negotiated items can help players to find a solution.

References

Ali, M. K. and K.K. Klein (2014), “Implications of current and alternative water allocation policies in the Bow River Sub Basin of Southern Alberta”, Agricultural Water Management 133, 1-1.1

Appleton A. (2002), “How New York City used an ecosystem services strategy carried out through an urban-rural partnership to preserve the pristine quality of its drinking water and serve billions of dollars and what lessons it teaches about using ecosystem services”. Katoomba Conference, Tokyo.

Barraqué, B., et al. (2010), “Groundwater in the Southern Member States of the European Union : an assessment of current knowledge and future prospects. Country report for France”, European Academies of Sciences Advisory Council (EASAC), Brussels, Belgium.

Bin, D. (2008). Study on Environmental Implication of water saving irrigation in Zhanghe Irrigation system. Project report submitted to FAO Regional office for Asia and the Pacific

Borchers, J. W., Carpenter, M., Grabert, V. K., Carpenter, M., Dalgish, B., & Cannon, D. (2014). “Land Subsidence from Groundwater Use in California”.Summary Report, California Water Foundation and Ludhorf and Scalmarnini Consulting, Sacramento, CA.

Burik, B., Gault, J., and F. Bertoye (2011), "Payment for Environmental Services: First Global Inventory of Schemes Provisioning Water for Cities", UN Food and Agriculture Organization.

California Urban Water Agencies (1994), A Guide to: customer incentives for water conservation, U.S. Environmental Protection Agency, Office of Water

Caswell M., Zilberman D. (1985), “The choice of irrigation technologies in California”, American Journal of Agricultural Economics 67 (2) 224-34.

Chang C. and Griffin R. C. (1992), “Water marketing as a reallocative institution in Texas”, Water Resources Research, 28 (3), 879-890.

Chong H. and Sunding D. (2006). Water Markets and Trading. Annual Review of Environment and Resources, 31, 239-264.

Civita, M. V., Massarutto, A., and G. Seminara (2010), “Groundwater in the Southern Member States of the European Union : an assessment of current knowledge and future prospects. Country report for Italy”, European Academies of Sciences Advisory Council (EASAC), Brussels, Belgium.

Colby (1990) “Enhancing instream flow benefits in an era of water marketing”, Water Resources Research 26, 1113–20.

Dodds W. K., et al.(2009), “Eutrophication of U.S. freshwaters: analysis of potential economic damages”, Environmental Science Technology, 43 (1) 12-19

Dwyer, G., Loke, P., Appels, D., Stone, S., and D. Peterson (2005), “Integrating rural and urban water markets in south east Australia” (14-18 November).

Gohar A.A., and F. A. Ward (2010), “Gains from expanded irrigation water trading in Egypt: an integrated basin approach”, Ecological Economics 69(12), 2535-2548.

Grolleau G., McCann L. M.J. (2012), Designing watershed programs to pay farmers for water quality services: Case studies of Munich and New York City, Ecological Economics 76 (2012) 87-94

Groot, N. (2013) "Norm Groot: Projects address seawater intrusion", The Californian, December 16, 2013. Available at: http://www.thecalifornian.com/story/news/2013/12/16/norm-groot-projects-address-seawater-intrusion/4036377/

Hashimoto, J. (2013a), "Japanese Municipalities' Efforts to Conserve Groundwater", Japan for Sustainability Newsletter 133, September 2013. Available at http://www.japanfs.org/en/news/archives/news_id034270.html

Hashimoto, J (2013b), "Municipality's Efforts toward Sustainable Groundwater Use Awarded 15th JWGP Environment Minister's Grand Prize", Japan for Sustainability 8/8/2013. Available at: http://www.japanfs.org/en/news/archives/news_id032985.html

Heaney A., Hafi A., Beare S., and J. Wang J (2005), "Water reallocation in northern China: towards more formal markets for water", In Willett, I.R. and Zhanyi Gao, eds, Agricultural water management in China, Proceedings of a workshop held in Beijing, China, 14 September 2005, Canberra, ACIAR Proceedings No. 123.

Hearne R. R., and K.W. Easter (1997), "The economic and financial gains from water markets in Chile", Agricultural Economics, 15, 187-99.

Lee, L. (2014), "Rural conservation ensures cities' water supplies, benefits landowners", tx | H2O, Summer 2014, Texas Water Resources Institute, Texas A&M University, College Station, TX, USA. Available at: http://twri.tamu.edu/publications/txh2o/summer-2014/protect-our-land-protect-our-water/

Levy, M., and J. Christian-Smith (2011), "Groundwater Management in the Pajaro Valley", The Pacific Institute, Oakland, CA.

Linnerooth-Bayer J., Dubel A., Damurski J., Schroeter D., Sendzimir J. (2013), "Climate change mainstreaming in agriculture: Natural water retention measures for flood and drought risk management," Policy Update No. 7, FP7 RESPONSES Project - European Responses to Climate Change.

McDonald, R.I., and D. Shemie (2014), "Urban Water Bluepring : Mapping conservation solutions to the global water challenge", The Nature Conservancy, Washington DC. http://water.nature.org/waterblueprint/

Molden, D., et al. (2010), "Governing to Grow Enough Food without Enough Water—Second Best Solutions Show the Way", International Journal of Water Resources Development, 26(2), 249–263.

Morris, J., T. Hess and H. Posthumus (2010), "Agriculture's Role in Flood Adaptation and Mitigation: Policy Issues and Approaches", in OECD, Sustainable Management of Water Resources in Agriculture, OECD Publishing.

OECD (forthcoming 2015), *Water Governance in Cities*, OECD Publishing.

OECD(2014a), "Global irrigation water demand projection to 2050: An analysis of convergences and divergences", [ENV/EPOC/WPBWE(2012)2/FINAL], OECD, Paris, France.

OECD (2014b), “Groundwater Use in Agriculture in OECD countries: From Economic Challenges to Policy Solutions”, [COM/TAD/CA/ENV/EPOC(2014)42], OECD, Paris, France.

OECD (2014c), “Water resources allocation: Shared water, shared risks”, [ENV/EPOC/WPBWE(2014)1/REV1], Paris, France.

OECD (2014d), *Water Governance in the Netherlands: Fit for the Future?*, Paris, France

OECD (2013a), OECD Compendium of Agri-environmental Indicators, OECD Publishing, Paris, France.

OECD (2013b) Rural-Urban Partnership: An Integrated Approach to Economic Development, OECD Publishing, Paris

OECD (2012a), Environmental Outlook to 2050, OECD Publishing, Paris, France.

OECD (2012b), Water Quality in Agriculture, Meeting the Policy Challenge, OECD Publishing, Paris, France.

OECD (2010), Sustainable Management of Water Resources in Agriculture, OECD Publishing, Paris, France.

Olmstead, S. (2010), “The Economic of managing scarce water resources”, Review of Environmental Economics and Policy, 4 (3): 179-198.

Olmstead S., R. Stavins (2009), “Comparing price and non-price approaches to urban water conservation”. Water Resource Research doi:10.1029/2008WR007227

Peck, J.C. (2007), “Groundwater management in the High Plains Aquifer in the USA: Legal problems and innovations”, Chapter 14 in Giordano, M. and K.G. Villholth (eds) “The Agricultural Groundwater Revolution: Opportunities and Threats to Development”, CABI, Oxford, UK.

Pujol J., Raggi M., and D. Viaggi (2006), “The potential impacts of markets for irrigation water in Italy and Spain: a comparison of two study areas”, The Australian Journal of Agricultural and Resource economics, 50 , 361-380.

Richter et al. (2013) “Tapped out: how can cities secure their water future?”, Water Policy, 15, 335-36.

Shortle, J. (2012), “Water Quality Trading in Agriculture”, OECD, Paris.

Sophocleous, M. (2010), “Review: Groundwater management practices, challenges, and innovations in the High Plains Aquifer, USA- Lessons and recommended actions”, Hydrogeology Journal, 18: 559-75.

Sophocleous, M. (2012), “The evolution of groundwater management paradigms in Kansas and possible new steps towards water sustainability”, Journal of Hydrology, 414-415: 550–559.

Swan A. (2010), How increased urbanisation has induced flooding problems in the UK/ a lesson for African cities?, *Physics and Chemistry of the Earth*, 35, pp.643-647

Tarrech R., Marino M., and G. Zwicker (1999), “The Siurana-Riudecanyes irrigation subscribers association and water market system”, in Marino M and Kemper K.E., Institutional frameworks in successful water markets, World Bank Technical Paper no. 427

Torregrosa Martí, M. T. (2009), « La gestión del agaua en la Marina Baja (Alicante) », Temas de las cortes valencianas.

UK Environment Agency. (2010). Working with Natural Processes to Manage Flood and Coastal Erosion Risk.

URSUS consulting (2013), Payment for Ecosystem Services (PES) Pilot on Flood Regulation in Hull. Report for the DEFRA.

USEPA (United States Environmental Protection Agency) (2002), “Cases in water conservation: How efficiency programs help water utilities save water and avoid costs”, US EPA, Washington DC, USA.

USEPA (2014) “Urban waters”, webpage, www2.epa.gov/urbanwaters (accessed 24 September 2014), Washington, DC.

Water TAP (2013), “Lake Simcoe Project: Stimulating Innovative Stormwater Management”, www.watertapontario.com/news/blog/ontario-innovative-stormwater-management-oct2013-/32

WSIP Application Package, available at: http://www.bewaterwise.com/images/water-savings-incentive-program/Application-Pkg.pdf

World Meteorological Organization and Associated Programme on Flood Management (2009), “Integrated Flood Management Concept Paper”, WMO N° 1047.

CHAPTER 5. GOVERNANCE FOR URBAN WATER MANAGEMENT

This chapter explores governance arrangements to manage water in OECD cities. Building on previous OECD work on water governance and on two OECD Surveys carried out in 2013-2014, it identifies governance gaps to urban water management, trends in institutional organisation and policy tools to address them. In particular, this chapter explores three main governance arrangements responding to the challenges of a complex and fragmented sector: metropolitan governance, regulatory bodies for water supply and sanitation services, and stakeholder engagement.

Key messages

355. Cities face 7 major governance bottlenecks to effective water policy design and implementation:

- *Administrative gap*: water cuts across spatial scales in its ecological dimension, but institutional, functional and hydrological logics affect its governance in cities.

- *Information gap*: asymmetries of information and difficulty in collecting and sharing data can affect the decision-making process.

- *Policy gap*: several policy areas influence water governance in cities, and policy coherence is often overlooked.

- *Capacity gap*: limited scientific, technical, and financial capacities of local actors make it difficult to properly implement water policies and strategies.

- *Funding gap:* unstable or insufficient revenues undermine effective implementation of water responsibilities at sub-national level.

- *Objective gap*: conflicting objectives across water uses (agriculture, energy, etc.) and stakeholders can compromise long-term targets for integrated urban water policy.

- *Accountability gap:* difficulties in ensuring transparent practices across the different constituencies affect engagement, deliberation and decision making.

356. A range of governance arrangements can help cities and national governments overcome these obstacles. The chapter explores the modalities of three of them: metropolitan governance, dedicated regulatory bodies and stakeholder engagement.

357. Urban water management will increasingly combine multiple scales, from urban-rural co-operation to small scale water services. Metropolitan governance, as a mechanism to pool resources and capacity across municipalities within the metropolitan area (formal and informal ones) can help handle interdependencies across authorities and reduce fragmentation to manage water resources and water services efficiently. In a context of financial constraints, this governance arrangement gains traction. Central governments have a role to play to incentivise cities to explore it more systematically, among options that coordinate water management across scales.

358. The establishment of dedicated regulatory bodies for water and wastewater services is a consistent trend in a number of OECD countries. Where they have been established, they are seen as an institutional arrangement that can address several of the governance gaps identified above and promote transparency, policy coherence and coordination, continuity, predictability and credibility of decision-making, as well as accountability to users. The OECD survey on the governance of water regulators indicates that they are generally well equipped to achieve their objectives. Regulators benefit from their relatively recent establishment and from the experience of their peers in other utility sectors.

359. Stakeholder engagement is increasingly acknowledged as a means to secure the willingness to pay for water services, raise awareness on current and future water challenges, ensure the accountability of city managers and service providers to end users and citizens, manage conflicts on water allocation, ensure the political acceptability of different ownership models, and set convergent objectives across policy areas. The chapter proposes several tools and practices that can foster stakeholder engagement for water management in OECD cities.

Preamble

360. This chapter builds on the results and findings from two OECD Surveys carried out in 2013-2014 to document governance trends and arrangements for managing urban water:

- A Survey on Water Governance in cities across 100+ cities above 500,000 inhabitants, covering urban water governance drivers and challenges, and policy responses to fragmentation across *people*, *places* and *policies*. The following analyses are based on the responses provided by the first 30 respondents.

- A Survey to Water Regulators was carried out between September 2013 and September 2014. 34 bodies established to regulate the provision of urban drinking water and wastewater services completed the questionnaire (list provided in Appendix 2). The questions were designed based on the *OECD Best Practice Principles for the Good Governance of Regulators*. A dedicated report based on the survey describes the features of regulatory bodies, including their functions and powers, their institutional setting and internal organisation (see OECD, 2015 forthcoming a, *The Governance of Water Regulators*).

Governance challenges to urban water management

361. Water management cuts across multiple scales, levels of government and policy areas. To manage water within a whole-of-government approach, cities need to pay particular attention to 7 categories of governance gaps to effective water policy design and implementation (Figure 24).

Figure 24. OECD Multi-level governance framework: mind the gaps, bridge the gaps

Source: OECD (2011), Water Governance in OECD countries. A multi-level approach, OECD publishing, Paris.

362. Multilevel governance gaps should be considered in a systemic way as they are deeply interrelated and can exacerbate one another. For example, any city facing a sectoral fragmentation of water roles and responsibilities across public actors (policy gap) may also suffer from conflicting goals (objective gap). Because of silo approaches, policy makers may not willingly share information (information gap). This in turn undermines capacity-building at sub-national level (capacity gap) because local actors, users and private actors have to multiply their efforts to identify the right interlocutor in the central administration. Diagnosing the gaps is a primary step to overcoming obstacles and promoting more effective water policy and management.

The question of scale

363. An *administrative gap* occurs when there is a geographical mismatch between hydrological and administrative boundaries. This mismatch can have consequences in terms of the competition over water uses and the effectiveness of service delivery and investment. In administrative terms, *cities* are defined and established by legal actions that serve administrative and governmental functions. The administrative units are frequently those for which policy is implemented, but they are often arbitrary and reflect ancient patterns.[27] Cities can be part of *metropolitan areas*, encompassing different municipalities that are socio-economically closely connected to the central city (or cities), or included in *functional urban areas (FUAs)*, representing the integration between (large) cities and rural surroundings (see Chapter 1).

Figure 25. Scalar dimensions for water governance in cities

364. As functional geographies depend on the function in question, in the case of water resources management, appraising the metropolitan and hydrological logics is key to addressing linkages between urban areas (where most people live) and the surrounding environment (rural and watersheds) that sustain them. On the one hand, functional urban areas can be used to map centres of urban water demand (and appraise water-related investment needs beyond traditional city boundaries). On the other hand, catchments and basins are relevant to understand the hydrology (see Chapter 1).

365. Weak articulation between institutional, functional and hydrological logics affects urban water management. A majority of respondents to the OECD survey identified the lack of relevant scale for investment as the most critical administrative obstacle to effective urban water governance (57%). Chapter

[27] http://stats.oecd.org/glossary/detail.asp?ID=4497

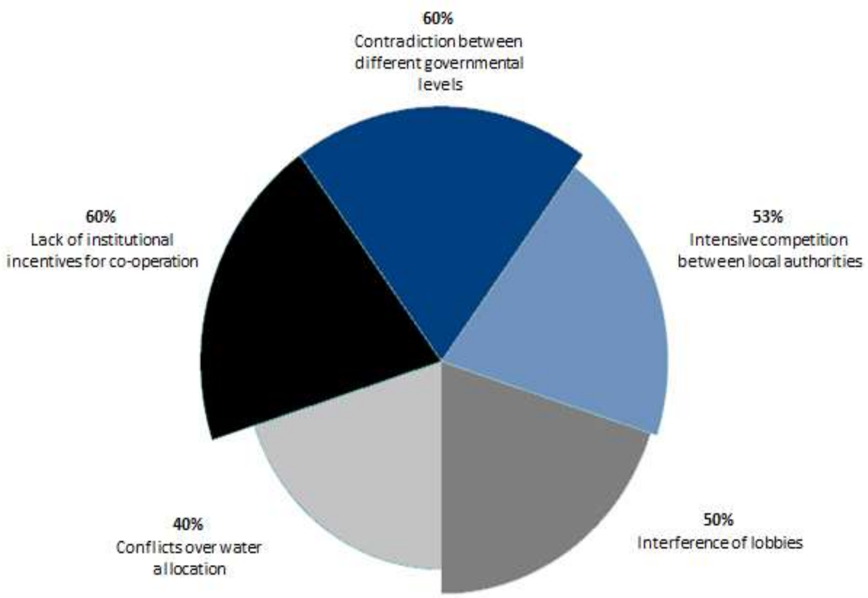
2 has noted attempts to find the right scale for urban water management, by amalgamating local authorities. Inter-municipal co-operation is also widely used across OECD countries to reach a critical mass for investment and service delivery. The basin scale links upstream and downstream communities.

Conflicting objectives compromising long-term management

366. An objective gap occurs when conflicting objectives compromise long-term targets for urban water policy. This can happen because of diverging interests between water-related fields, or of political discontinuity (e.g. in the case of short-term mandates of Mayors; as an illustrations, local mandates last 3 years in Mexico).

367. Water policy-making involves a diversity of actors at institutional, functional and hydrological scales, making the role of cities quite diverse within and across countries. Water conflicts between different municipalities in a given metropolitan area are increasingly common, and governance is key to align interests. Cities surveyed signalled a lack of institutional incentives for cooperation (60%), contradiction between levels of governments (60%), competition between authorities (53%) and the interference of lobbies (50%) as major challenges to long-term driven urban water management.

Figure 26. Perceived challenges to long term driven water management in cities



Note: results based on a sample of 30 respondents who indicated the options provided represent an obstacle (“major”, “important” and “somewhat an obstacle”).

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

Institutional and policy silos

368. Water management is fragmented and the responsible institutions at city, national or other levels tend to work in silos. As an example, several line Ministries and other governmental agencies are involved in the regulation of water services, including Ministries of Environment (for managing water pollution); Ministries of Health (for setting and monitoring water quality standards) and Ministries of Economics and

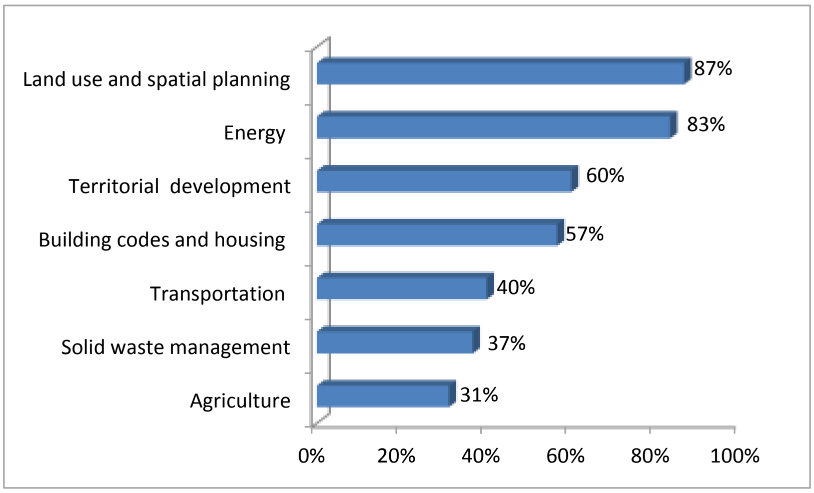
Finance (for tariff regulation) (OECD 2015 forthcoming a). At the vertical level, water services are characterised by multi-level governance from supra- to sub-national levels. The EU provides an illustration of supra-national regulatory powers in the water service sector, notably through the EU Water Directive. At sub-national level, municipalities are generally responsible for providing and managing water and wastewater service delivery.

369. Grey areas or duplications in the allocation of roles and responsibilities can contribute to poor water governance if coordination mechanisms are not in place to foster systemic approaches and trigger political commitment to cooperate at all levels. Cities surveyed reported the fragmentation of water-related tasks (50%), overlapping roles and responsibilities (47%) and the lack of coordinated legislation (40%) as prominent obstacles hindering policy coherence. The last case reflects situations for instance, whereby one piece of legislation, which may have negative consequences for water quality, can take precedence over other legal dispositions meant to prevent or remedy these potential negative consequences.

370. Cities reported several areas that directly influence water policy. They use a range of coordination mechanisms to ensure policy coherence (Box 41).

- Spatial planning (87%) influences the way water is managed within the city and can contribute to integrated water resources management and water security.
- Energy (83%) and water are closely connected: wastewater can generate energy, and energy is often required to tap alternative water sources; for instance, investment in desalination can enhance water security at the expense of energy security (e.g. in Barcelona). Policy coherence can reduce energy input and heat output of cities, while promoting efficient water uses.
- Building codes and housing (57%) are increasingly aiming at protecting citizens from rising sea levels and extreme weather, while being more water efficient.
- Solid waste can impair water quality and quantity (37%), when discharged into water bodies.
- Agriculture raises urban water governance challenges, especially in terms of controlling and avoiding the harmful consequences of the use of fertilizers and pesticides.

Figure 27. Policy areas influencing water governance in cities



Note: results based on 30 responses which indicated the influence from policy areas being “critical” and “important”.

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

Box 41. Coordinating water and related policies

Water & spatial planning: **Cologne** co-ordinates water and spatial planning for new building areas to prevent flood damages because of heavy rainfalls; **Melbourne** Water Sensitive Urban Design integrates water cycle management into urban planning and design. Mexico's *Desarrollos Urbanos Integrales Sustentables* integrates water and environmental aspects; **Glasgow**'s Metropolitan Strategic Drainage Partnership raises awareness of constraints in drainage infrastructure, and the resolution of these, and supports planning authorities' preparation of new local and strategic planning policies. There are different examples of urban flood prevention through land use planning. The integrated strategic planning in Paris provides for better integration of storm-water management in urban decision-making processes. **New York** and **London** also promote strategic plans aiming to maximise the use of green infrastructure and other urban facilities to avoid urban floods. Seoul has attempted a number of initiatives, such as building 77 more drainage facilities with the capacity to retain 554 054 square metres of water, but there is room to improve urban planning.

Water & energy: water and energy are inextricably linked to each other. Energy is required to extract, treat, and transport water and it takes water to produce energy, especially for cooling steam electric power plants. Municipalities spend between 25 and 60% of their budgets to supply energy for their city's water infrastructure. In **Budapes**t, legal requirements are used for coordination between water utility supply and energy sectors; Copenhagen has completed several water-saving campaigns like "Max 100" to raise awareness of citizens on daily water consumption.

Water & agriculture: the use of fertilizers and pesticides can have harmful consequences on water. There are local management initiatives and collective arrangements, including financial transfers for tacking the issue of water competition; experiences of decentralised urban-rural arrangements aims to reduce water pollution from agriculture, while agreements with farmers tries to reduce flood risk upstream.

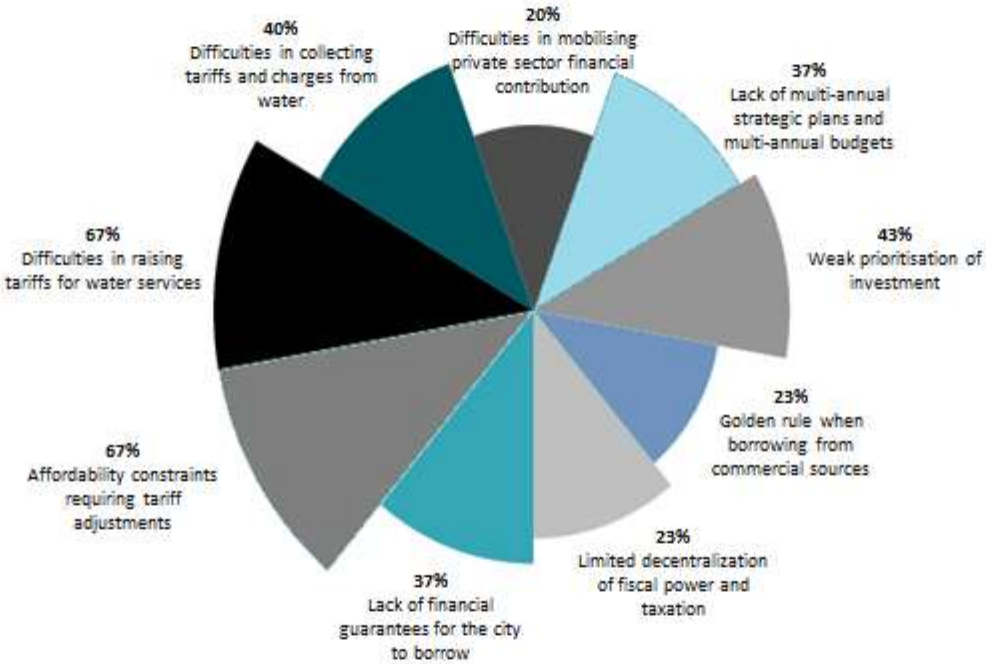
Water & Regional development: relevant policies for water management go beyond the water sector, and may concern other policies such as land use, transport planning, etc. On the one hand, water is essentially a local issue (pumped, treated, distributed and used locally). On the other hand, it has implications beyond the local scale as water drives or hinders economic development, competitiveness and assets of regions in a national framework. Given the importance of local actors and territorial specificities in the water sector, policymakers should find ways to maintain coherence while preserving diversity.

Water & environment: The Biodiversity Strategy for **London** published in 2002 recognises the importance of the Thames and other waterways for biodiversity, and promotes the restoration of degraded tributary rivers. **New York** Environmental Department is leading the Green Infrastructure Program to design, construct and maintain a variety of sustainable green infrastructure practices such as green roofs and rain gardens on City owned property such as streets, sidewalks, schools, and public housing. Green infrastructure promotes the natural movement of water by collecting and managing storm water runoff from streets, sidewalks, parking lots and rooftops and directing it to engineered systems that typically feature soils, stones, and vegetation.

Financial bottlenecks to effective governance

371. The funding gap consists in unstable or insufficient revenues undermining effective implementation of water responsibilities at sub-national level, cross- sectoral policies, and investments. The funding gap has different origins, some of which have already been discussed in Chapter 2. Cities surveyed reported difficulties in raising tariffs for water services (67%); affordability constraints requiring tariff adjustments (67%); and weak prioritisation of investments (43%) as major obstacles to their capacity to manage water effectively (Figure 28). Also, 37 % of cities surveyed lack multi-annual strategic plans and budgets; 37% also do not have financial guarantees to borrow money. In some cases (23% of respondents), a "golden rule" on public finance restricts cities' borrowing capacity. One out of five cities also reported difficulties to mobilise private sector (20%).

Figure 28. Perceived challenges for the financial sustainability of water management in cities

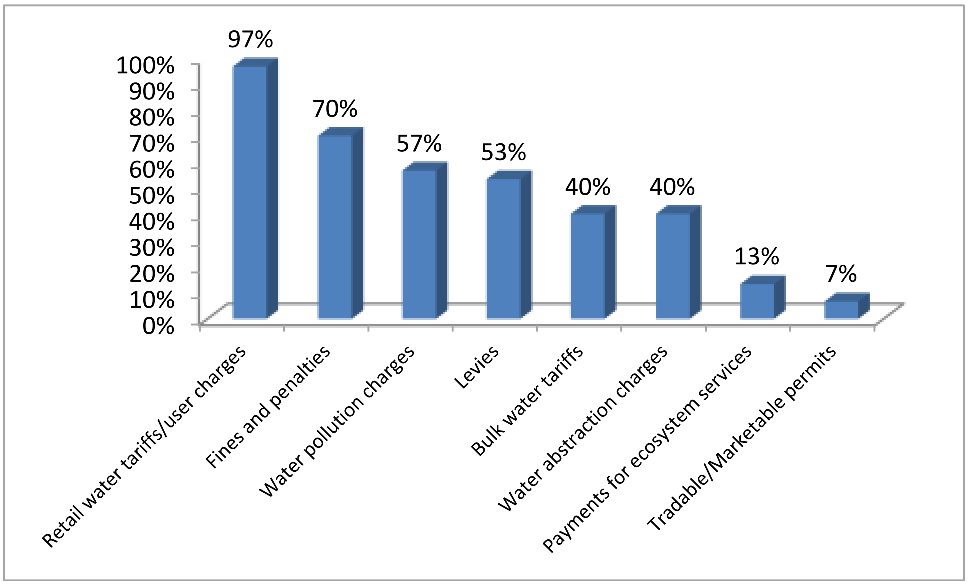


Note: results based on a sample of 30 respondents who indicated the options provided represent an obstacle ("major", "important" and "somewhat an obstacle").

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

372. Almost all cities surveyed have retail water tariffs or user charges in place. A majority use additional economic instruments for water management: fines, water pollution charges and levies are most common (Figure 29). 70% of cities surveyed have a role in tariff regulation. For example, the governing board of the City of Stockholm sets the principle for tariffs definition: tariffs have to be affordable, sustainable for financing the water management and encourage local treatment of storm water. Tariffs are used to produce drinking water, maintain the water and sewage network and treat the wastewater from buildings and storm water on the roads. City councils in Calgary and Montreal and French cities set the rates for tariffs. The ATO of Milan sets the tariff to be approved by the National Authority of Electricity and Gas (regulator). The HOFOR, a multi-supply company for metropolitan Copenhagen, which includes 8 municipalities, is responsible for setting the tariff subject to a national set price cap.

Figure 29. Use of economic instruments for urban water management in OECD cities



Note: Results based on a sample of 14 respondents who responded “yes” to the options provided.
Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris

373. The role of central governments in tariff setting reflects the degree of decentralisation in the country. In Mexico, tariff structures are set by each municipality, according to the laws that apply to each federal state. The federal level has limited powers to influence the process – only through the establishment of a voluntary norm and by providing financial incentives as part of federal programmes (OECD, 2013). In the Czech Republic, tariffs are set by individual utilities, but are subject to price controls by the Ministry of Finance. In some countries, the national level defines the basic principles for tariff structures and levels, including the number of blocks, while leaving some degree of flexibility so that local, technical and social conditions can be taken into consideration. This is the case in Portugal (see the section on dedicated regulatory bodies).

374. Many OECD cities have introduced measures to make water more affordable to the population at large and to selected groups. These usually target poor population (70% of cities surveyed), population living in slums (37%), ethnic minorities (30%) and disabled people (43%). Such measures include reducing the VAT or wastewater tax, using progressive social tariffs, avoiding water disconnection, setting up a national solidarity fund and abolishing annual fixed fees.

Capacity: the Achilles' heel of sub-national governments

375. The lack of scientific, technical, infrastructural capacity of local actors hinders the design and implementation of water policies or strategies within cities and beyond. The capacity gap has spill-over effects: it often triggers an information gap (quantity, quality, type), which in turn can generate an accountability gap. Many OECD cities face serious capacity challenges to manage water in the face of future challenges. This particularly the case when utilities are operating in the red; when more and more stringent environmental regulation cannot be enforced at lower level; when access to technological innovations is too costly; when the water sector does not attract sufficient professionals (e.g. the Netherlands foresees a shortage of 20,000 water professionals in the coming 2 decades); or when systems are not in place to produce, use and share policy-relevant data for decision-making and transparency.

Figure 30. Capacity challenges

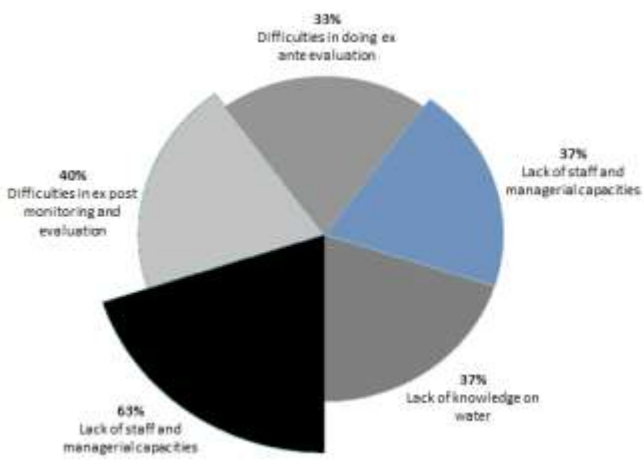
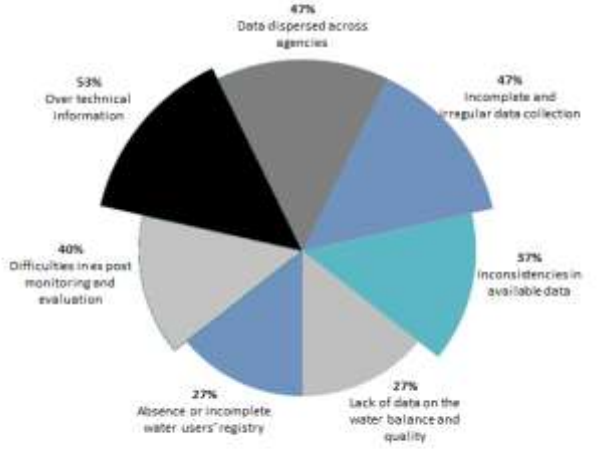


Figure 31. Information challenges



Note: results based on a sample of 30 respondents who indicated the options provided represent an obstacle ("major", "important" and "somewhat an obstacle").

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris

376. Cities surveyed reported the lack of staff and managerial competencies (63%) as the main source of capacity gap, followed by difficulty of ex-post monitoring and evaluation (40%) and poor planning (often not articulated with national legislation; 37% of cases) (Figure 30). In Mexico, funds allocated by federal programmes to sub-national governments cannot always be disbursed and sometimes have to be returned (with penalties), because of limited local capacity to develop and implement good projects. The professionalization of water staff is also a key challenge for capacity building at the sub-national level.

377. The capacity to produce, collect and share data of good quality varies from one city to another. Depending on the purpose, data might be collected by the local authority, the service provider, statistical offices or environmental agencies. Key issues concerning data include the *what* (available information is too technical, for 53% of respondents), the *when* (data collection is incomplete and irregular, for 40% of respondents) and the *how* (data is dispersed across agencies, making it difficult to track and compare; according to 40% of respondents) (Figure 31). Too technical data hinders the participation of lay people. For example, in London the complexity of the water planning system, including the highly technical modelling that feeds the figures in the plans, makes it very difficult for non-technical stakeholders to contribute; it hinders comparisons over time (GLA, 2011).

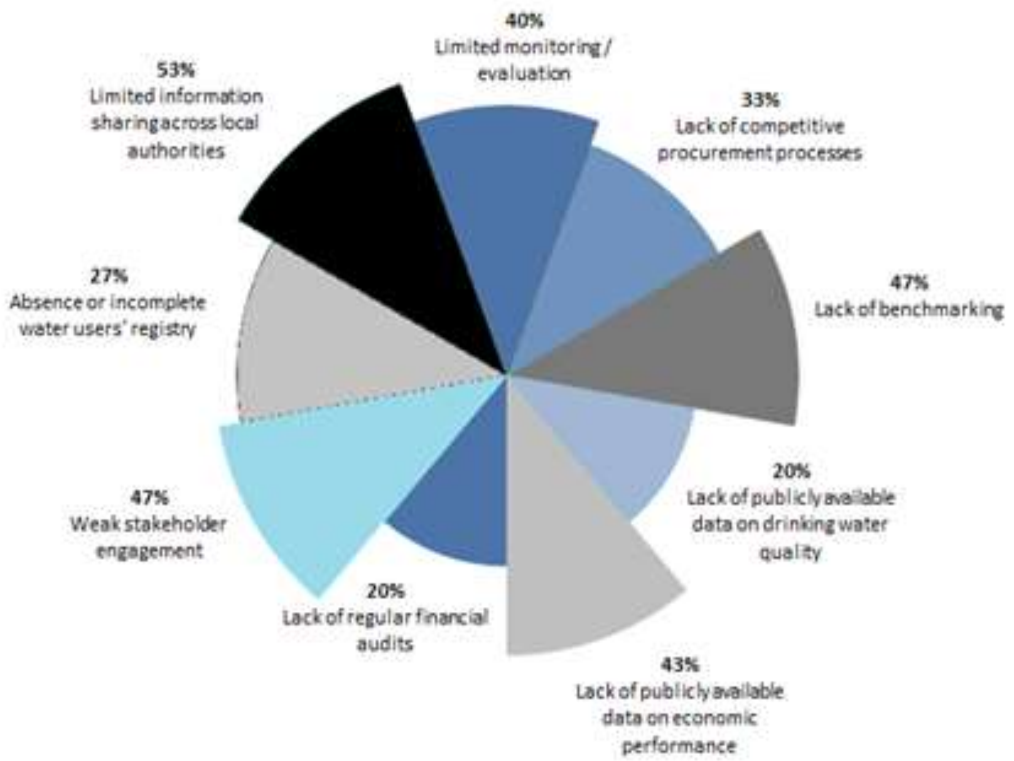
378. Also, the water sector displays important asymmetries of information. For instance, asymmetries of information on the status of water supply and sanitation assets may lead to suboptimal contractual arrangements between the authority and the service provider, market abuse and mistrust amongst consumers. Asymmetry of information was reported as the most important obstacle (53%) to accountability of water decision-makers (Figure 32). An easy and transparent access to data could address this type of challenge, which, in addition to monopolistic behaviours, also justifies the recourse to regulatory instruments to protect the public interest in tariff setting and investment decisions (see OECD, 2015a forthcoming).

Accountability

379. Cities surveyed reported a range of concerns that hinder the transparency and participatory nature or urban water management (Figure 32). These include in addition to limited information sharing across

local authorities (53%), the lack of benchmarking to evaluate water quality, quantity and service providers' performance (47%), as well as a limited monitoring to guide decision-making (40%). These gaps may also result from a lack of human and financial resources and expertise.

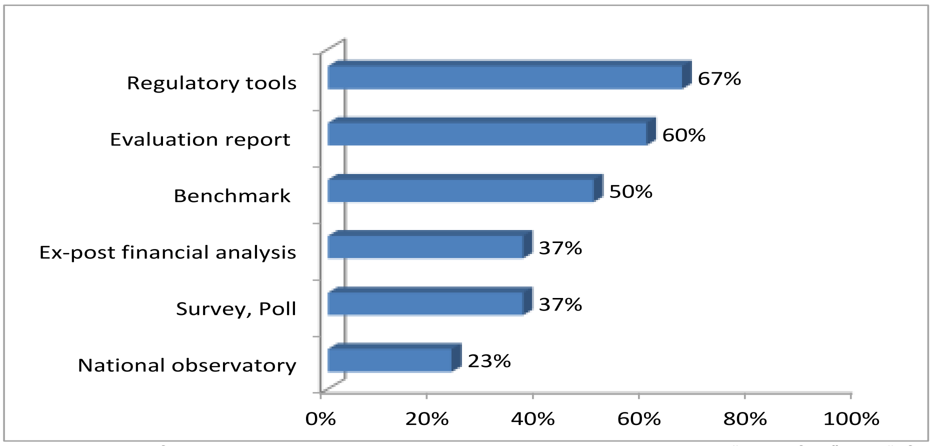
Figure 32. Perceived challenges to transparency and accountability for urban water management



Note: results based on a sample of 30 respondents who indicated the options provided represent an obstacle ("major", "important" and "somewhat an obstacle").

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

Figure 33. Mechanisms in place to assess the performance of urban water management in cities



Note: results based on a sample of 30 respondents who indicated the mechanisms being used "very often" and "often".

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

380. A range of mechanisms can be used to assess the performance of water management in cities, with a view to increasing transparency and accountability (Figure 33 above). Benchmarks and evaluation reports allow competition-by-comparison in the first case and provide useful information to citizens in the second, measuring the performance against indicators. Financial analyses help to get a clear picture of the financial needs of the local government. National observatories can monitor service delivery performance and improve transparency of information and accountability of the water service sector. The role of regulation is covered in the section below.

Governance arrangements for urban water management

381. Coping with multi-level governance gaps for urban water management requires an institutional setting and the use of tools that allow strengthening coordination across people, places and policies and addressing the market failures identified above. This section explores some of the governance arrangements (both the institutions and tools) that contribute to addressing the seven governance gaps mentioned above. The focus is on metropolitan governance, dedicated regulatory bodies for water utilities and stakeholder engagement.

Metropolitan governance

382. Rapid socio-economic trends are pushing towards a greater coordination across municipalities to jointly face investment choices and policy decisions. A recent OECD study (OECD, 2013) pointed out that the pressing need to build more effective metropolitan governance for stronger, more inclusive and sustainable growth is all the more salient in a context of recent crises and long-term pressure on public finances. This study categorizes governance arrangements in four groups. The bow below provides illustration in the water sector:

- **Informal/soft co-ordination**, lightly institutionalised platforms for information sharing and consultation;
- **Inter-municipal authorities**, sharing costs and responsibilities across member municipalities;
- **Supra municipal authorities**, as an additional layer above municipalities, introduced either by creating a directly elected metropolitan government, or with the upper governments setting down a non-elected metropolitan structure; and
- Special status of "**metropolitan cities**", a status for large cities, which puts them on the same footing as the next upper level of government and gives them broad competencies.

Box 42. Metropolitan arrangements in the water sector

Informal/soft co-ordination consists in lightly institutionalised platforms for information sharing and projects on water issues:

- The Metropolitan Glasgow Strategic Drainage Partnership (MGSDP) is a collaborative venture between local authorities (Glasgow City Council leading), the Scottish Environment Protection Agency (SEPA), Scottish Water, Scottish Enterprise, Clyde Gateway and Scottish Canals. It has been set to upgrade the Glasgow area's drainage and sewerage network, reduce flooding and support urban development requirements while improving water quality and the environment.

Supra-municipal cooperation: an additional layer above municipalities introduced either by creating a directly elected metropolitan government, or with the upper governments setting down a non-elected metropolitan structure. The co-operation across municipalities for water is based on established joint organisations such as companies or authorities, with coordination roles over water policy, planning and service provision:

- Conseil communautaire (France): elected body acting on behalf of the municipalities on specific water issues (i.e. water allocation; drinking water provision; research; operation/maintenance of infrastructures).
- Barcelona Metropolitan Area (BMA, Spain): the metropolitan authority has responsibilities throughout the water cycle from drinking water supply to wastewater treatment and reclaimed water production. It encompasses 9 utilities across 36 municipalities that compose the metropolitan area, 7 wastewater treatment plants and 3 reclaimed water plants. Managing urban waters at the metropolitan level has fostered a wider perspective, at the water cycle level, as well as shared infrastructure and expenses. The BMA encourages customer involvement to learn about the different needs and expectations across the territory. For the future, Barcelona is looking at alternative water resources and strengthened management at the water cycle level. To that aim, Aguas de Barcelona was created in 2013, jointly with a large metropolitan utility, to manage drinking, reclaimed and wastewater for all the metropolitan territory.
- Metro Vancouver: Under the name 'Metro Vancouver', the regional government provides services through four corporate entities, one of which is the Greater Vancouver Water District (GVWD). It has a role in Watershed management, water treatment, water transmission, wholesale distribution to municipalities, monitoring and reporting on Metro Vancouver water quality and planning for Metro Vancouver water system's sustainability.
- Authorities for Optimal Territorial Districts (Italy): autonomous entities made up of municipalities and responsible for water planning, water resource management and identification of service providers. They cover an area correspondent to the province or the river basin.

Inter-municipal single–purpose cooperation for water: contracts or ad hoc agency for water service provision across municipalities aiming at sharing costs and responsibilities (sometimes with the participation of other levels of government and sectoral organisations):

- Horizontal cooperation:
  - Association: Water Management Association of the West Bohemia Region in the Czech Republic, a voluntary union of 91 municipalities and two associations of municipalities from five districts (Karlovy Vary, Tachov, Sokolov, Chomutov and Rakovník). The association was established in 1993 to carry out the management, operation and development of water supply and wastewater treatment systems, which is a legal obligation of municipalities in the Czech Republic. The number of association members has more than doubled from its initial 40 municipalities from the Karlovy Vary region and now covers a population of about 186 000 inhabitants. It is a voluntary association to which member municipalities transfer their water assets upon joining and take them back when leaving. The governing body of the association is the General Meeting, where each municipality has one vote;
  - Syndicats intercommunaux (France): run by joint committees representing members of each local council and levying a compulsory contribution for water supply;
  - Mancomunidades (Spain): administrative form meant for purely inter-municipal cooperation in which municipalities appoint local politicians for the governing body of the mancomunidades, the number of which is proportional to the size of the population of the respective member municipalities. They help reaching economy of scale for water services.

- Vertical cooperation:
  - Consortia (Italy, Spain): standing organisations with a board and staff for drinking water supply cycle (from production to distribution) (i.e. Greater Bilbao Water Partnership, a Consortium of 43 municipalities, provincial government of Biscay, the Autonomous Basque Community and central government).

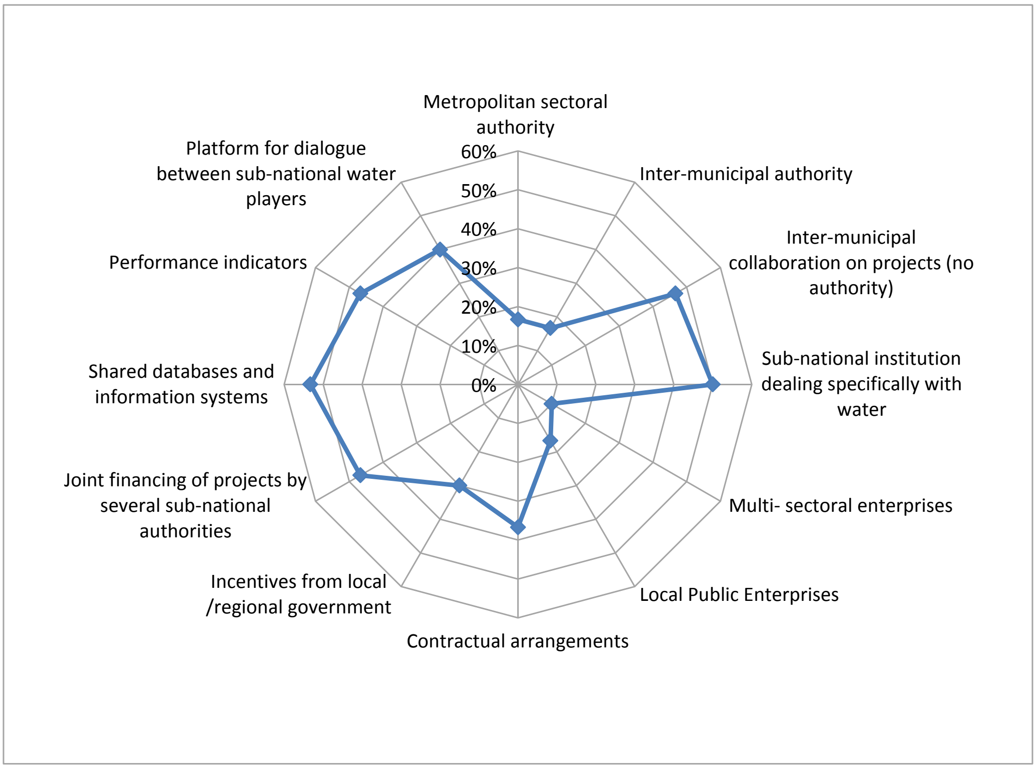
Metropolitan cities: cities that exceed a legally defined population threshold can be upgraded into a special status as "metropolitan cities", which puts them on the same footing as the next upper level of government. They have broader competencies in the water sector, such as planning, policy making, strategy setting and service provision.

- Seoul Metropolitan government: it sets policies aimed for water management and takes actions for improving water quality through an online water quality monitoring system;
- The Greater London Authority: it consists of the Mayor of London and the 25 member London Assembly, headquartered in City Hall, and has been responsible for strategic local government also in the water sector.

Source: OECD (2013), *What governance for metropolitan areas? Supporting growth and well-being across administrative boundaries*, OECD Working Paper; Vuokko O. Kurki, Tapio S. Katko and Pekka E. Pietilä, Bilateral Collaboration in Municipal Water and Wastewater Services in Finland, *Water 2010*, 2, 815-825; UNDP, Inter-municipal cooperation, http://www.municipal-cooperation.org/index.php?title=Czech_Republic
http://www.municipalcooperation.org/images/5/5e/Paper_Institutional_Shifts_in_IMC_Service_Delivery_Spain_2007.pdf
http://www.services.eaufrance.fr/docs/synthese/rapports/spea2009_201202_EN.pdf

383. These governance arrangements are likely to affect water management between the urban core and the surroundings, in terms of investment, information sharing, monitoring, stakeholder engagement, policy complementarities across different sectors (see Box 42 above). According to the OECD survey on urban water governance, a wide range of informal co-ordination tools are in place, beyond inter-municipal coordination (listed by 40% of respondents): shared databases/information systems (53%), performance indicators (47%), joint financing projects (47%), platforms for dialogue between sub-national players (40%).

Figure 34. Mechanisms for coordinating water policy across levels of government

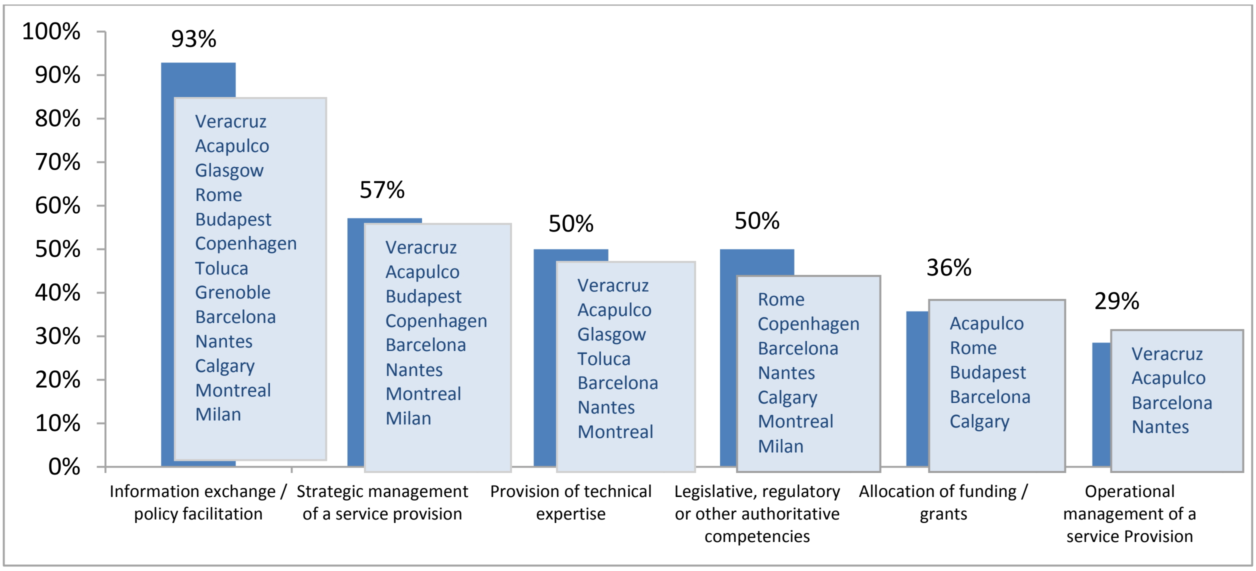


Note: Results based on a sample of 14 respondents who responded “yes” to the options provided.

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

384. Metropolitan authorities have gained increasing competencies on water management in the last decade. When they exist, they mainly operate as policy facilitator, favouring information exchange across the municipalities in the metropolitan area (Figure 35). A majority also has competences in strategic management of service provision (setting performance targets, hiring senior managers, organising calls for tenders, supervising sub-contractors) or legislative, financial or technical competences. Less than a third provide operational management for drinking water supply and sanitation services; in the OECD survey, Veracruz, Acapulco, Barcelona and Nantes are exceptions. In this report, the case studies of Auckland, Tokyo Metropolitan Government and Korean cities provide detailed illustrations of the organisation and operation of supra-municipal bodies for water management.

Figure 35. Competences on water of metropolitan bodies



Note: Results based on a sample of 14 respondents who responded "yes" to the options provided

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris

385. Strategies for water governance at metropolitan level may offer interesting models for application in the sector: increasing coordination across functional and hydrological logics for integrated urban water management; pooling resources for water resources management and service delivery; increasing policy coherence and creating synergies across sectors.

The establishment of dedicated regulatory bodies

386. In response to the governance gaps identified above, a large spectrum of regulatory functions needs to be performed in relation to urban / networked water services. These regulatory functions can be economic, environmental or embrace social issues, such as equity, affordability, universal coverage. They are summarised in a typology developed by the OECD (see Appendix 3).

387. Regulatory functions do not necessarily have to be in the hands of a single institution responsible for all of them. However, the recent evidence shows the consistent establishment of dedicated regulatory bodies in charge of overseeing networked water services (i.e. overseeing urban water services and centralised systems over a certain size) across a number of OECD countries.

388. This specific institutional mechanism is seen as responding to the governance gaps identified earlier in the Chapter and in particular the need to protect the public interest in a sector both complex and prone to market failures. This section analyses recent trends in this important domain that contributes to shaping urban water management building on the Survey on the Governance of Water Regulators (OECD, forthcoming).

The emergence of dedicated water regulators

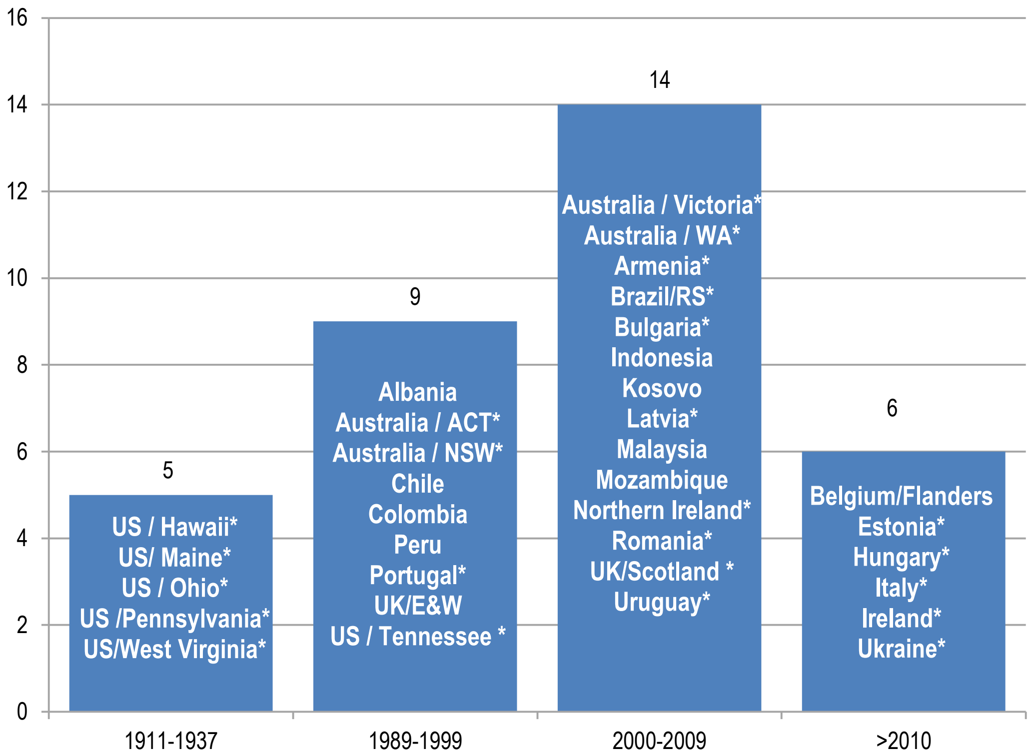
389. Countries have adopted different institutional organisations to ensure that the various regulatory functions in relation to water services are performed. A large literature reviews the different regulatory models for services. Among the various institutional organisations, the development of dedicated

regulatory bodies stands out across countries as a growing response to some of the pitfalls of regulatory frameworks for water services.

390. The OECD survey on the Governance of Water Regulators documents the consistent emergence of dedicated regulatory bodies for water services over the past two decades. While North-American water regulators were established before the Second World War, most of the other water regulators who responded to the survey came into force between 1990 and 2009. Over the past four years, six additional water regulators became operational, mainly in Europe (Belgium/Flanders, Estonia, Hungary, Italy), but also in Victoria, Australia. Today, several countries consider setting up a water regulator.

Figure 36. Year of operational establishment of water regulators

(Number of regulators/34)



Note: * Multi-sector regulators.

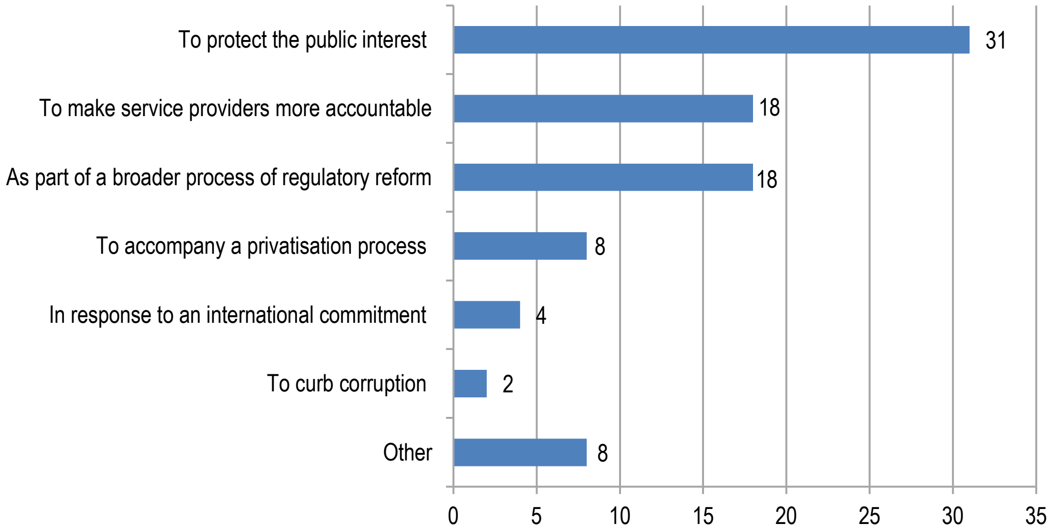
Source: OECD Survey on the Governance of Water Regulators (2014).

Why are they established?

391. The vast majority of regulators who answered the OECD survey justify their establishment on the basis of protecting the public interest (Figure 37). Making the service providers more accountable and being part of a broader process of regulatory reform are also prominent motivations for establishing a regulator. In addition, the establishment of a regulator is also justified in a number of cases by the need to make price-setting an independent process (i.e. at arm's length from government and protected from capture by private interest) or to catalyse regulatory expertise in the public sector.

Figure 37. Main reasons to justify the establishment of a water regulator

(Number of regulators/33)



Source: OECD Survey on the Governance of Water Regulators (2014).

392. Regulators for water services do not work in isolation. They are part of a broader regulatory framework at national and sub-national level that typically involves line ministries (environment or natural resources) and various public agencies. In particular, agencies in charge of environmental protection coordinate with water regulators to monitor the environmental sustainability of the WWS services. Local governments can be involved in WWS regulation. For instance, in Portugal, municipalities determine retail tariffs in collaboration with the water regulator as a shared competence.

What do water regulators do?

393. Regulators mainly oversee urban activities and centralised systems over a certain size. In several cases – Australian Capital Territory, Chile – the regulator does not have prerogative for rural water at all. The establishment of water regulators has usually accompanied deep reforms of the water industry in countries – in particular the corporatisation of water operators (the Australian Capital Territory) and the consolidation of water service provision around fewer but bigger providers (Ireland and Portugal).

394. Based on the survey, water regulators have a critical role in economic regulation, performance monitoring, regulatory enforcement and customer engagement. This positions water regulators as critical players in the reforms towards more transparency and a user-centric approach. Regulators also constitute a critical link in the regulatory governance cycle in support of the concrete implementation of government policies, by ensuring compliance and credibility of the regulatory framework.

- **Economic regulation (tariff setting and review of utilities' investment plans)**: All regulators surveyed except one have responsibility for tariff regulation. In a number of cases, this responsibility is mainly carried out in an advisory role (for instance in Belgium/Flanders, Hungary).

- **Data collection and performance monitoring related to water services**: All regulators surveyed but two have responsibility for monitoring service delivery performance, often in combination with a role in information and data gathering. In line with this, most regulators have the power to collect information from regulated entities through compulsory processes.

- **Enforcement of regulations and standards**: Regulators consistently have strong enforcement roles and powers. Most regulators can enforce compliance with regulation, investigate cases of breaches, and issue codes of conduct and guidelines either independently or together with other bodies. Most regulators have the power to impose fines and financial sanctions against regulatory infringements.

- **Customer engagement and protection**: More than two thirds of regulators report a function related to customer engagement and have a role in customer protection.

395. Based on the results from the OECD Survey on the Governance of Water Regulators, water regulators display a strong culture of consultation and routinely resort to cost-benefit analysis to ensure the quality of the regulatory process. Regulators regularly consult with regulated entities and more generally with the public at large. Two thirds face a legislative requirement to consult with regulated entities before making a regulatory determination and to conduct public consultation in advance of making a regulatory decision. When not required by law, consultation is carried out on a voluntary basis by water regulators.

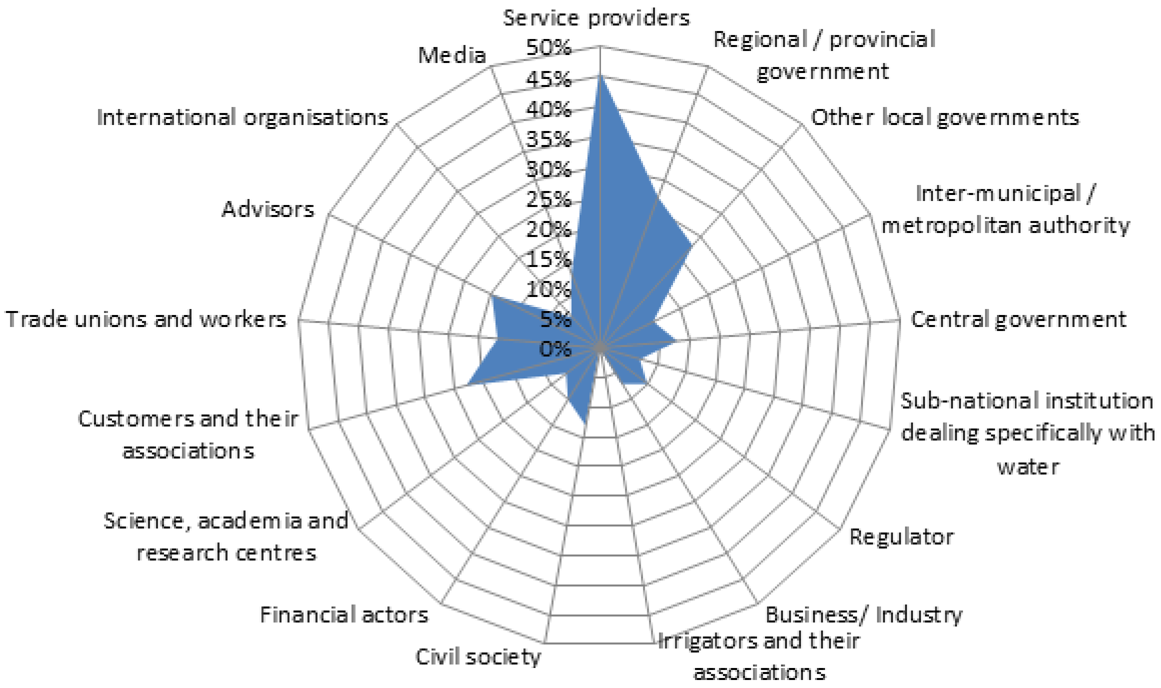
396. Regulators are subject to strong reporting requirements. Most are required to report to the Legislature on their performance, usually on an annual basis. All regulators but one face a legislative requirement to produce an annual report on their activities. Most regulators face a legal requirement to publish information related to various dimensions of the regulator's activity, in particular the costs of operating the regulator, the decisions, resolutions and agreements reached by the regulator, and the governance structure of the regulator.

Stakeholder engagement

397. Stakeholder engagement is herein defined as the process through which individuals, groups, and organisations have the opportunity to take part in the decision-making that will affect them, or in which they have an interest. It is key for coordinating various actors and interests in cities. As a governance instrument, stakeholder engagement can help build trust and ownership, secure the willingness to pay for water services, raise awareness on current and future water challenges, ensure the accountability of city managers and service providers to end-users and citizens, manage conflicts on water allocation, ensure the political acceptability of different ownership models, and set convergent objectives across policy areas. Stakeholder engagement mechanisms can bring together urban planners, water service providers, regulators, advisors and civil society to develop dynamic integrated approaches.

398. City departments interact with various authorities when it comes to managing water. Their main counterparts are service providers (listed by 46% of respondents to the OECD survey on water governance in OECD cities), followed by regional governments (27%), local governments (23%) as well as customers and their associations (23%). The interaction with central governments is less frequent (it takes place "sometimes" for one third of respondents, and "never or rarely" for 17% of respondents). There is also a rather low interaction with irrigators and their associations (50% of cities surveyed point out that they *never* interact with this type of stakeholder), civil society ("somentimes"40%), and business/ industry ("sometimes"40%).

Figure 38. Frequent interactions between cities and stakeholders



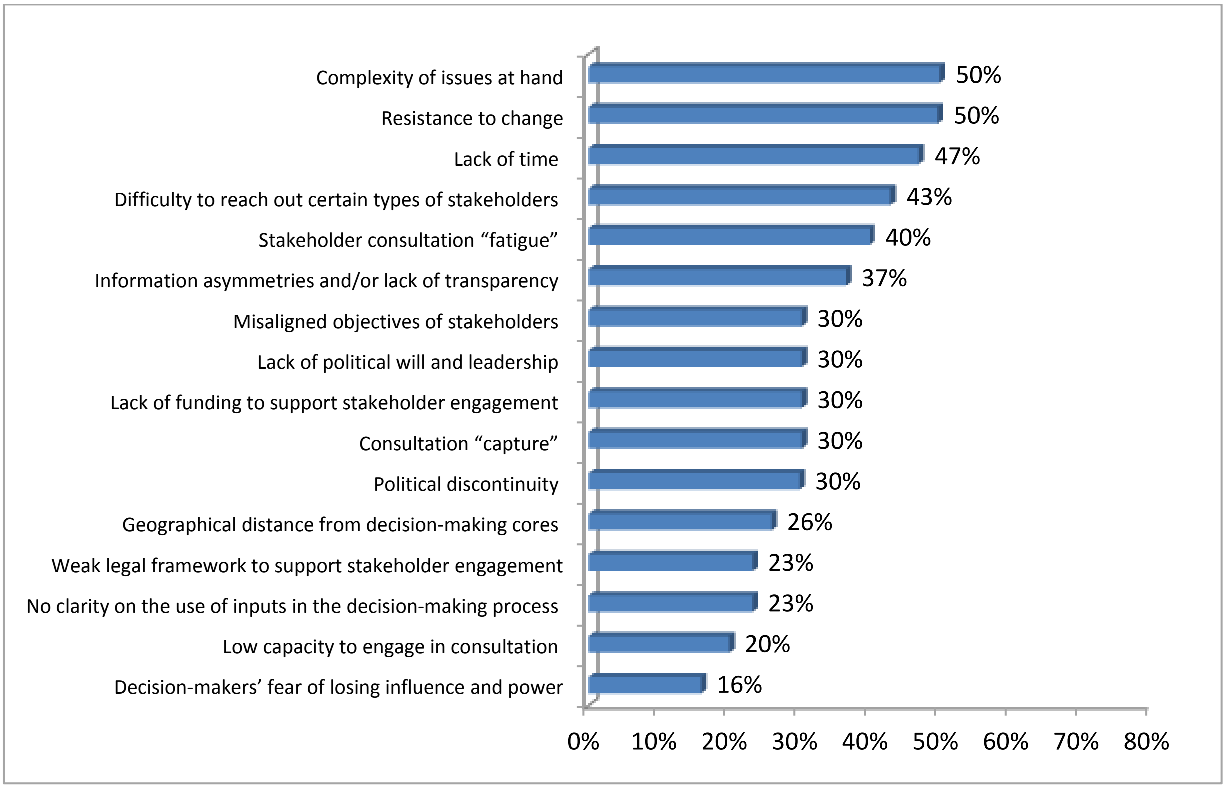
Note: Results based on a sample of 30 respondents who indicated the interactions to occur "always, very frequently".

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris.

399. Technology plays an important role in engaging stakeholders. 77% of respondents use web-based communication technologies (online platforms, e mail, social media, website and app) on a regular basis to engage with stakeholders; 67% use traditional media (newspapers, newsletters, TV, radio, etc.); and more than 60 % hold regular meetings to consult and engage in water-related decision-making.

400. Stakeholder engagement in water governance has been largely incentivised in the broader context of a bottom-up call for open government. However, in practice several obstacles are noteworthy (Figure 39). 50% of surveyed cities state that the major obstacle is the complexity of issues at hand and resistance to change. Other challenges relate to the lack of clarity and feedback on the expected use of stakeholders' inputs (leading to a *consultation fatigue*), as well as consultation capture from over-represented categories, the absence of political will and leadership, the lack of time, staff and funding, weak supportive legal frameworks, weak capacity, the lack of citizens' concern and awareness, information asymmetry and fragmented settings.

Figure 39. Obstacles to effective stakeholder engagement in urban water management



Note: Results based on a sample of 30 respondents who indicated the obstacles being “critical” and “important”

Source: OECD, 2015 forthcoming, Water Governance in OECD Cities, OECD Publishing, Paris

401. The principles deriving from the OECD’s work on stakeholder engagement for inclusive water governance (Box 43) provide some guidance cities may wish to consider to overcome obstacles to stakeholder engagement in water governance. Central governments have a role to play to promote the principles and facilitate their effective implementation.

Box 43. Principles for effective stakeholder engagement in water decision-making

- Inclusiveness and equity. Map all those who have a stake in or are likely to be affected by the outcome. List their responsibility, core motivations and interactions. A stakeholder analysis would help identify stakeholders, their interests and their potential role in supporting the decision making process in cities. Stakeholder analysis can help understand power relations. Stakeholder engagement increases the effectiveness of policies and their acceptability, showing the benefit of the shift from top-down management processes run exclusively by professionals and governmental authorities.

- Clarity, transparency and accountability. Define the ultimate line of decision-making, the objectives of stakeholder engagement and the expected use of inputs. Stakeholders need to be engaged in different phases of the decision making process, provided with the information needed for a successful interaction. Their involvement helps increasing the transparency of the process and help overcoming the short-termism and election interests of politicians.

- Capacity and information. Allocate proper financial and human resources and share needed information for result-oriented stakeholder engagement. Urban water management involves a plethora of complex issues. Dealing with them might be difficult and generate the stakeholder "fatigue". It is important to keep the motivation high, share visions, and communicate in an understandable language. Involving unheard voices in the process means to overcome the technical approach of hearing from experts in the field. This implies to invest in education and training to building awareness and promoting interactions.

- Efficiency and effectiveness: Regularly assess the process and outcomes of stakeholder engagement; learn, adjust and improve accordingly. The city needs to make sure that the inputs from the stakeholder engagement exercise are taken into account and that the outcomes are regularly assessed in order to improve the decision making process.

- Institutionalisation, structuring and integration: Embed engagement processes in clear legal and policy frameworks, organisational structures/principles and responsible authorities. Water issues at stake have consequences not only in the city itself, but in the surrounding area as well. When engaging stakeholders it is important to do it at the right scale, in order to scaling up from local level to city level and then to metropolitan level, when it needs be. The institutionalisation of the process it is crucial to strengthen the formal participation.

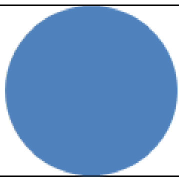
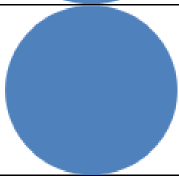
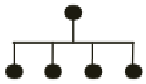
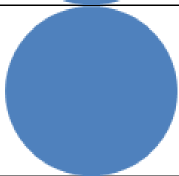
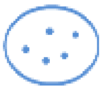
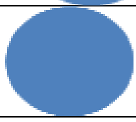
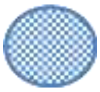
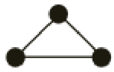
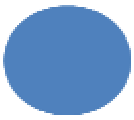
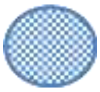
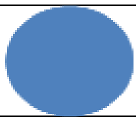
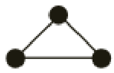
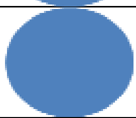
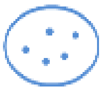
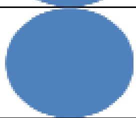
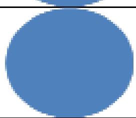
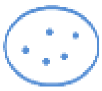
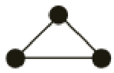
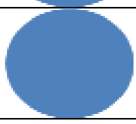
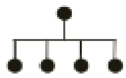
- Adaptiveness: Customise the type and level of engagement to needs and keep the process flexible to changing circumstances.Stakeholders and authorities in charge of water in cities need to be flexible and adapt to context. This implies overcoming the resistance to change and have a long term vision which allows for a shift in their perspectives on what is relevant not only for the present, but also for future generations.

Source: Adapted from OECD (2015 - forthcoming), Stakeholder engagement for inclusive water governance

Appendices

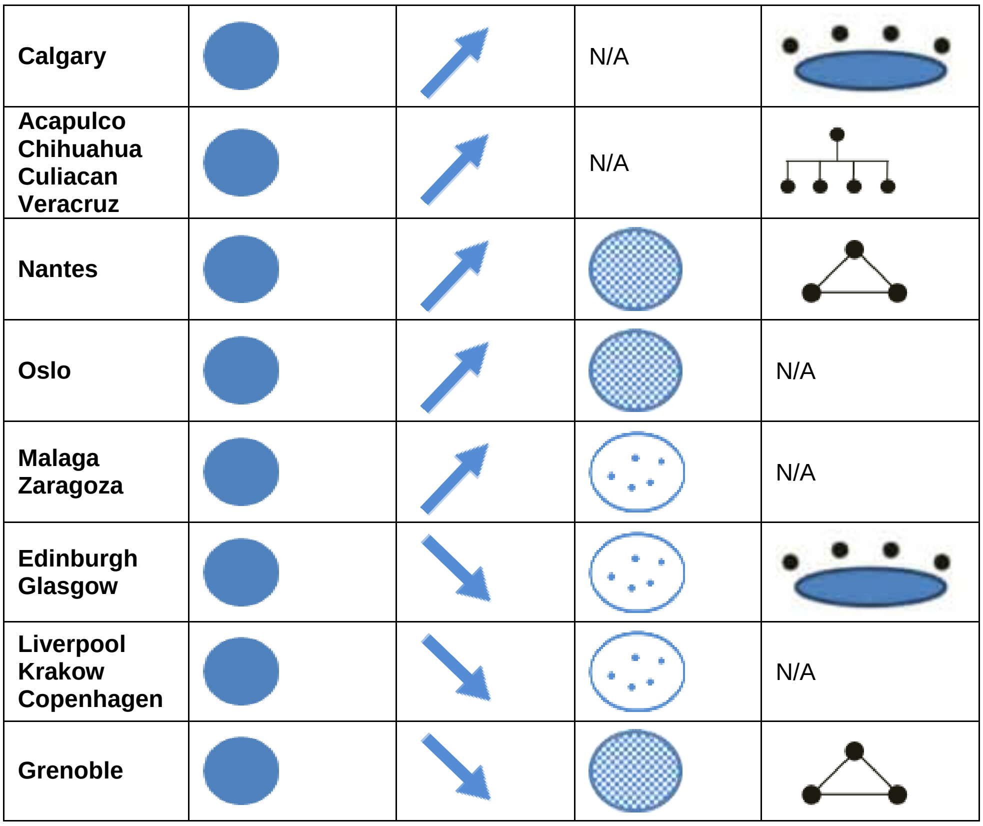
Appendix 1. List of respondents to the OECD survey on urban water governance

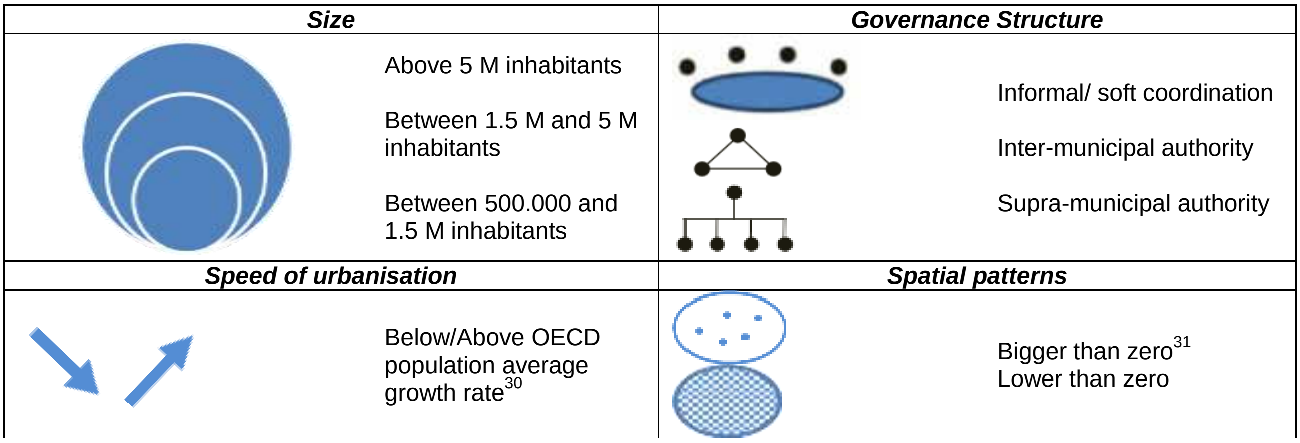
Table 6. Cities covered by the OECD survey on urban water governance

Cities	Size[28]	Speed of urbanisation	Spatial patterns	Governance arrangements[29]
Hong Kong **Singapore**			N/A	N/A
Mexico City			N/A	
New York				N/A
Barcelona				
Cologne **Milan** **Rome** **Stockholm**				N/A
Montreal			N/A	
Athens **Budapest** **Copenhagen**				N/A
Phoenix				
Amsterdam				
Toluca			N/A	

28 Total population metro area. Year 2012.

29 These governance arrangements are not specific to the water sector but reflect the approach to multi-level coordination of the city and its surrounding.





[30] OECD population average growth rate is 0.87, years 2000- 2012.

[31] Looking at land use, cities can be distinguished in terms of compactness and sprawling. The sprawl index allows classify cities according to the measure of the growth in built-up area adjusted for the growth in city population When the city population changes, the index measures the increase in the built-up area relative to a benchmark where the built-up area would have increased in line with population growth. The SI index is equal to zero when both population and built-up area are stable over time. It is bigger (lower) than zero when the growth of built-up area is greater (smaller) than the growth of population, i.e. the city density has decreased (increased). (OECD Metropolitan database). Data refer to the year 2006.

Appendix 2. Regulators that responded to the OECD survey on the Governance of Water Regulators

	Country/territory	Name of the regulator
1	Albania	Water Regulatory Authority of Albania
2	Armenia	Public Services Regulatory Commission of the Republic of Armenia (PSRC)
3	Australia/Capital Territory (ACT)	Independent Competition and Regulatory Commission (ICRC)
4	Australia/New South Wales (NSW)	Independent Pricing and Regulatory Tribunal (IPART)
5	Australia/Victoria	Essential Services Commission
6	Australia/Western Australia (WA)	Economic Regulation Authority (ERAWA)
7	Belgium/Flanders	Water Regulator - Flemish Environment Agency
8	Brazil/Rio Grande do Sul (RGS)	Agência Estadual de Regulação dos Serviços Públicos, Delegados do Rio Grande do Sul (AGERGS)
9	Bulgaria	State Energy and Water Regulatory Commission (SEWRC)
10	Chile	Superintendencia de Servicio Sanitarios (SISS)
11	Colombia	Regulatory Commission for Water and Sanitation (CRA)
12	Estonia	Competition Authority
13	Hungary	Hungarian Energy and Public Utility Regulatory Authority
14	Indonesia	Jakarta Water Supply Regulatory Body
15	Ireland	Commission for Energy Regulation (CER)
16	Italy	Regulatory Authority for Electricity, Gas and Water (AEEGSI)
17	Kosovo	Water and Wastewater Regulatory Office of Kosovo (WWRO)
18	Latvia	Public Utilities Commission of Latvia (PUC)
19	Malaysia	National Water Services Commission
20	Mozambique	Water and Sanitation Regulatory Council (CRA)
21	Peru	Superintendencia Nacional de Servicios de Saneamiento (SUNASS)
22	Portugal	The Water and Waste Services Regulation Authority (ERSAR)
23	Romania	National Regulatory Authority for Municipal Services (ANRSC)
24	UK/England & Wales	Water Services Regulation Authority (OFWAT)
25	UK/Northern Ireland	Northern Ireland Authority for Utility Regulator (NIAUR)
26	UK / Scotland	Water Industry Commission for Scotland (WISC)
27	Ukraine	National Commission of the State Public Utilities Regulation of Ukraine (SCWRM)
28	USA/Hawaii	Hawaii Public Utilities Commission
29	USA/Maine	Maine Public Utilities Commission
30	USA/Ohio	Public Utilities Commission of Ohio
31	USA/Pennsylvania	Pennsylvanian Public Utility Commission
32	USA/Tennessee	Tennessee Regulatory Authority
33	USA/West Virginia	Public Service Commission of West Virginia
34	Uruguay	Unidad Reguladora Servicios Energia y Agua (URSEA)

Source: OECD (forthcoming), The Governance of Water Regulators.

Appendix 3 – Typology of regulatory functions for WSS

Type of regulatory functions	Definition
Tariff regulation	Setting and updating prices, determining tariffs by consumer group, establishing caps on revenues or rate of return on investment
Quality standards for drinking water	Setting quality standards for drinking water and / or monitoring compliance
Quality standards for wastewater treatment	Setting quality standards for wastewater treatment and wastewater discharges and / or monitoring compliance
Defining public service obligations / social regulation	Setting public service obligations (including requirements on access to services) and performance requirements for operators.
Defining technical / industry and service standards	Developing the standards that underpin the technical modalities and level of service delivery
Setting incentives for efficient use of water resources	Establishing incentives or specific schemes to promote efficient water resource use
Setting incentives for efficient investment	Establishing incentives or specific schemes to promote efficient investment.
Promoting innovative technologies	Establishing incentives or specific schemes to promote innovative technologies
Promoting demand management	Establishing incentives or specific schemes to promote reduced water demands
Analysing water utilities' investment plans / business plans	In some cases, the regulator may be asked to approve the business plan or the investment plan of utilities.
Information and data gathering	Collecting data from operators, undertaking market research to identify trends and potential risks
Monitoring of service delivery performance	Monitoring of the performance of water services against a set of targets or of performance indicators. This can involve benchmarking water utilities.
Licensing of water operators	Granting or approving licences for the operation of water systems
Supervision of contracts with utilities / private actors	The obligations granted by the public authorities to a specific utility may be detailed in a specific contract (it is usually the case when a private actor is brought in). The regulator may be tasked with the supervision of the contract.
Supervising utilities' financing activities	Monitoring the financial schemes of water utilities (e.g. bond issuance, equity investments)
Carrying management audits on utilities	Auditing and /or approving the business plans of utilities
Customer engagement	Consulting with customers on regulatory issues; communicating regulatory decisions to the public
Consumer protection and dispute resolution	Handling consumer complaints about regulated entities
Advice and advocacy	Providing advice for policy-making and project implementation; identifying opportunities for reforms, encouraging improvements to the regulatory framework

Source: OECD (forthcoming), The Governance of Water Regulators.

References

Bicheron, P., et al. (2008), GLOBCOVER, Products, description, and validation report, Medias-France, Paris

De Albuquerque C. (2014), Realising the human rights to water and sanitation: A Handbook by the UN Special Rapporteur on the human right to safe drinking water and sanitation, http://www.righttowater.info/wp-content/uploads/BOOK-4-SERVICES-WEB-LR.pdf

Greater London Authority (GLA), (2011), London's strategy: securing London's water future. The mayor's water strategy, Greater London Authority City Hall, The Queen's Walk London

Lloyd Owen D. (2013), One billion people can't be wrong, *Global Water Intelligence*, November

Marques R. (2010), *Regulation of Water and Wastewater services – An international comparison*, IWA Publishing, London, UK.

OECD (2015 forthcoming), *The Governance of Water Regulators*, OECD Publishing, Paris

OECD (2015 forthcoming), Water Governance in OECD Cities, OECD Publishing, Paris

OECD (2015, forthcoming), Stakeholder engagement for effective water governance, OECD Publishing

OECD (2014a), *Water Governance in Jordan: Overcoming the Challenges to Private Sector Participation*, OECD Publishing.

OECD (2014b), Territorial Reviews: Netherlands 2014, OECD Publishing, Paris

OECD (2014c), Water Governance in the Netherlands. Fit for the future?, OECD Publishing, Paris

OECD (2014), *La gouvernance des services de l'eau en Tunisie : surmonter les défis de la participation du secteur privé*, OECD Studies on Water, OECD Publishing.

OECD (2014), *OECD Best Practice Principles for Regulatory Policy: The Governance of Regulators*, OECD Publishing.

OECD (2013), *Making Water Reform Happen in Mexico*, OECD Publishing, Paris.

OECD (2013a), Finland, fit for the future?, OECD Publishing, Paris

OECD (2013b) Rural-Urban Partnership: An Integrated Approach to Economic Development, OECD Publishing, Paris

OECD (2013c), Water and Climate Change Adaptation: Policies to Navigate Uncharted Waters, OECD Publishing, Paris

OECD (2013d), The Competitiveness of Global Port-Cities: Synthesis Report, OECD Publishing, Paris

OECD (2013e), *What governance for metropolitan areas? Supporting growth and well-being across administrative boundaries*, GOV/TDPC/RD(2013)2.

OECD (2012a), Compact City Policies: A Comparative Assessment, OECD Publishing, Paris

OECD (2012b), Environmental Outlook to 2050 The Consequences of Inaction Environmental outlook 2050, OECD Publishing, Paris

OECD (2012c), Demographic Change and Local Development: Shrinkage, Regeneration and Social Dynamics, I SSN 2079-4797, OECD Local Economic and Employment Development (LEED) Working Paper Series, OECD Publishing Paris

OECD (2012), *Recommendation of the Council on Regulatory Policy and Governance*.

CHAPTER 6. DRAWING THE THREADS TOGETHER

This chapter draws the threads together. On the one hand, it brings together some of the options discussed in the previous chapters to address future water challenges OECD cities face. Some are generic; others are more appropriate to address specific water risks. The chapter also highlights initiatives that other tiers of government can take to contribute to future urban water management.

Key messages

402. As they face growing and new water-related challenges, OECD cities will benefit from exploring responses that combine four dimensions: finance, innovation, co-operation with their rural surroundings and governance arrangements.

403. Some of these responses will be generic. For example, developing a long term vision that guides short term and piecemeal developments; stimulating initiatives from local entrepreneurs and a variety of stakeholders; and addressing equity issues that derive from water management.

404. Others are more appropriate to the specific issues that individual cities are facing. For instance, demand management is more appropriate in water scarce environment; distributed water systems are more competitive when existing networks have reached their full capacity, or when reclaimed water can be used locally.

405. This report proposes a typology based on urban characteristics that shape the appropriate response options for a given city in the face of different challenges. The three main dimensions of this typology are: the prevailing water resource (surface versus groundwater); urban features (e.g affluence, spatial patterns, or urban dynamics); and the institutional architecture (fiscal autonomy, and co-ordination mechanisms with surrounding cities and territories).

406. For instance, some cities have access to reliable local water sources, while others depend on extended networks; the latter have an incentive to co-operate with distant partners to secure the water they need and protect the quality of catchments. Cities in fast growing regions will compete with other users (energy suppliers, industry, farmers, or the environment) and may want to consider efficiency measures to alleviate competition. Additionally, such cities would also benefit from water allocation mechanisms that adjust to shifting circumstances and reflect the differential capability of cities, farmers and other users to mitigate water risks. Some cities manage water in an integrated way, while others co-operate with other institutions for specific services, for instance, in the Netherlands, regional water authorities, not cities, are responsible for wastewater treatment. Cities using integrated management may be better positioned to consider local reuse of reclaimed water, while others may be inclined to optimise steps in the water cycle separately.

407. OECD cities will not respond to future water challenges on their own. A number of initiatives taken by other tiers of governments will contribute to urban water management. They are clustered here around three categories: regulation (on land use, reclaimed water, or public procurement), the provision of resources (such as information and education) and incentives (financial, or else).

408. Future water management in OECD cities largely depends on the capacities of different tiers of government to work together and to engage with and make the best use of the initiatives of local entrepreneurs and stakeholders.

Introduction

409. The previous chapters have argued that OECD cities differ in their exposure to water risks, in the status of their water-related infrastructures, and in the way they are affected by institutional trends, such as territorial reforms and the allocation of responsibilities across levels of government.

410. OECD cities differ in their capacity to respond as well. The responses will depend on the nature of the prevailing water risks; distinctive urban features such as affluence, urban dynamics (growing versus shrinking cities) and spatial patterns; and the institutional architecture (fiscal autonomy and the way co-ordination across territories is organised) (see Chapter 1 in this report). Cities can use these criteria to situate themselves among similar others and tailor responses to future water challenges.

411. This chapter recapitulates some of the options discussed in the previous ones. Some are generic; others are more specific to particular water risks. The chapter also highlights the role other tiers of government can play in urban water management. It builds on OECD work on urban policies and on the experience of OECD countries in urban water management.

City-level responses to future water challenges in OECD countries

412. As argued in Chapters 2-5, responses to water challenges will combine four dimensions:

- Financing. OECD cities can minimise costs for urban water management via optimised maintenance and the exploitation of low-cost water sources; through water tariffs that secure stable revenues while serving water policy objectives and addressing equity issues; by ensuring that those who benefit from water security or increase its costs also contribute; and by accessing private equity.

- Innovation. A variety of innovations can enhance water security for OECD cities, at least cost for the community. The diffusion of innovative urban water management requires water prices that signals the scarcity of the resources and the externalities associated with water security; and institutional and regulatory frameworks that support sustainable urban water management practices that are fit for the future.

- Urban-rural co-operation. A number of co-operative agreements can minimise the costs and enhance the sustainability of urban water management. These include a) water allocation regimes that provide some flexibility to reallocate water between cities and other competing water users; b) arrangements for groundwater conservation; c) flood management that relies on land use; d) payments for ecosystem services, in particular for water quality conservation. Some of these agreements can translate into contracts across urban cores and rural hinterlands.

- Governance. OECD cities will be able to address emerging and future water services, when they combine different scales for water management (for instance, in the context of metropolitan governance), regulate water supply and sanitation services, and engage with stakeholders. A range of tools such as metropolitan governance, dedicated regulatory bodies and institutionalised or inclusive forms of stakeholder engagement can help bridge governance gaps and support more sustainable urban water governance.

413. Responses will also include a long-term vision for urban development, which guides the design and development of such projects as the construction of new facilities (hospital, or transport infrastructure) or the reconstruction of buildings and districts, at any given scale. Responses will stimulate initiatives from

a variety of local entrepreneurs and stakeholders. They will address equity issues, by analysing the distributional effects of water challenges and alternative options, and by targeted social measures.

414. Some of the options discussed in the previous chapters are targeted to specific water risks. They are clustered together in Table 7. The fourth water risk (risk to the resilience of water systems) does not feature in the table: as argued in Chapter 3, it is essentially addressed through green infrastructures, and any measure that promotes them will contribute to mitigating that risk.

415. Governance does not feature in the table because, as argued in previous OECD work on water security (OECD, 2014c) governance arrangements need to be adjusted to the severity of risks. This point was emphasised again in the context of national policy dialogues on water in the Netherlands (see OECD, 2014) and in Brazil (OECD, 2015 forthcoming).

Table 7. A menu of options tailored to specific water risks

Too much water	Too little water	Too polluted water
Storm water management – i.e. porous pavement, green roofing	Water conservation measures in urban and agricultural areas	Storm water management – i.e. porous pavement, green roofing.
Taxes on impervious surfaces	Groundwater conservation policies	Taxes on impervious surfaces
Payment for ecosystem services to restore natural grassland or wetlands for flood protection	Smart water systems and water distribution control	Payment for ecosystem services or contractual arrangements to improve water quality
Land use based flood protection	Distributed water systems, where they can facilitate water re-use in the city	Groundwater conservation policies
	Water prices that signal scarcity	Retrofit existing storm water ponds to include quality control
	Tariff structures that secure revenues when the volumes of water sold diminish	
	Beyond-the-meter services, such as alarms to warn customers of leaks	
	Command-and-control instruments: technology standards, rationing policies, priority allocation	

Beyond cities: a role for other tiers of government

416. While leaving wide latitude for local authorities to shape policies that fit local contexts, higher levels of governments can take a variety of initiatives that contribute to urban water management. Table 8 lists some of them, clustered around regulation, the provision of resources (such as information and education) and incentives.

Table 8. Initiatives from other tiers of government for urban water management

Type of action	Illustrations
Regulation	Codes for land use zoning (especially in hotspots), spatial planning (e.g. mandatory water tests as in the Netherlands), building and construction (e.g. technical standards for sustainable drainage systems developed in Scotland by the environmental regulator, for housing developments)
	Regulation on reclaimed water. Such regulation should clarify where reclaimed water is beneficial and how it should be factored in water management plans
	Public procurement rules that reflect long-term perspectives water-wise and value flexibility in water management
Provision of resources	Resources to provide, collect and share data and information across municipalities and different levels of governments (e.g. identifying, sharing and applying good practices; scaling-up successful experimentation; linking to sources of expertise)
	Facilitation of city-to-city peer learning (for instance by promoting networks such as *100 Resilient Cities*)
	A repository of information that can allow comparison of information across cities. In their area of expertise, water regulators can provide a platform to collect and disclose information related to regulation and the performance of water services, as well as contribute to develop common methodologies to compute performance indicators and other information
	Capacity development (including training and motivation)
Incentives	Use infrastructure finance, where available, to incentivise water-sensitive urban development or reward water-sensitive projects
	Awards for urban water management
	Water allocation mechanisms that adjust to shifting circumstances and reflect the distinctive capacity of cities, farmers and other users to mitigate water risks
	Encourage mechanisms at metropolitan level to pool resources and capacities across municipalities and to co-operate between urban and non-urban areas; a range of mechanisms apply, from informal coordination to metropolitan bodies
	Raise awareness and enhance engagement of those who have a stake in the outcome or who are likely to be affected

Box 44. Co-operation between cities and other tiers of government on water management

Israel

In Israel, 2/3rd of the territory is water scarce. Solutions for managing urban water are considered in combination with national water frameworks.

The national water authority of Israel has set a 2050 strategic plan for water and sanitation. In 2001, municipalities were asked to create professional water and sewage management agencies composed of representatives from local governments and with financial autonomy. These agencies have contributed to improve infrastructure with 30% of revenues from water and sewage collection invested back into repairs and maintenance. They have also managed to reduce water leakages.

Future urban water management will rely on innovative solutions. Among others initiatives, a project on “Water in Smart Cities” was launched by the Ministry of National Infrastructures, Energy and Water Resources. Smart city systems aim to address urban and rural water challenges (i.e. related to irrigation) and support the purification of industrial and domestic waters.

Israel has also adopted a National Strategic Plan to recycle and reuse water for agriculture irrigation (i.e. 50% of water used for agriculture is recycled) and in 2014, 50 water recycling centres were established.

Scotland

In Scotland, the governance framework for urban waters is largely centralised and water charges are geographically harmonised.

Cities in Scotland face challenges of aging infrastructures. This is the case of the wastewater system of Glasgow. A 10 year-long project was undertaken to renew this system and relied on the partnership of the central government with the city to better understand local realities, and extensive data gathering (e.g. water and wastewater flows modelling, etc.). Overall, the project cost around 600 million pounds and costs were brought down through knowledge creation and better alternatives. Synergies were also fostered with the city’s green infrastructure agenda and with strategies on flood protection and wastewater flow management.

Lessons learnt include the need to maximise co-benefits through partnerships between central and municipal authorities; engage with all stakeholders involved; and encourage complementarities with the city’s vision.

The United States

In the US, the Environmental Protection Agency has 10 regional offices that work at city level to support communities in improving infrastructure and drive innovation and technology through grant allocation. Municipalities also partner with the EPA to develop data on water quality and infrastructure. They are provided with economic incentives such as revolving funds on clean water and drinking water. The funds are allocated to the states and go into the development of municipal bonds for various infrastructure needs.

Urban water federal partnerships have also been launched with 13 Federal agencies and cities to connect and reconnect degraded urban catchments and rivers because of industrial activities. 2.1 million dollars were awarded in 2014 to 46 organisations in certain US cities, as well as in Porto Rico.

The United States has also developed “water clusters” for academia and corporations to simultaneously develop and support new technologies. Overall, 10 water clusters are ongoing, including one started with the National Laboratory in Cincinnati.

At Federal level, the government also provides certification on water related to green buildings regarding conservation, irrigation, and energy production through wastewater. In addition, Guidelines for water reuse were produced in 2012 to set minimum standards for different qualities and uses.

Source: contributions from OECD delegates at the 4th meeting of the OECD Water Governance Initiative.

References

Ahiablame, L. M., Engel, B. A. & Chaubey, I. 2012. Effectiveness of Low Impact Development Practices: Literature Review and Suggestions for Future Research. *Water Air Soil Pollution,* 223**,** 4253–4273.

Bazoglu, N. 2011. Measuring and coping with urban growth in developing countries. *Global Urbanization.*

Fernandez, J. E. 2014. Urban Metabolism: City Typologies. *Presentation at 2014 MIT Europe Conference.* Brussels, Belgium.

Kandulu, J. M., Connor, J. D. & MacDonald, D. H. 2014. Ecosystem services in urban water investment. *Journal of Environmental Management,* 145**,** 43-53.

Rouse, M. 2006. IWA Reference Paper: Sustainable Cost Recovery. Issue Date: August 2006. IWA Institutional Governance & Regulation Specialist Group and IWA Statistics & Economics Specialist Group.

Tortajada, C. 2006. Water management in Singapore. *International Journal of Water Resources Development,* 22**,** 227-240.

Annex 1. Glossary (in progress)

Black water

Brownfield development

City

Disruptive innovation

Greenfield development

Grey water

Membrane technologies

Performance-based contract

Urban area

Urban metabolism

Water security