Chapter 5

The governance of water infrastructure in Chile

This chapter identifies Chile's main water-related infrastructure and governance challenges in urban and rural areas, including rainwater infrastructure and desalination, as well as irrigation systems and dams. The chapter highlights the prominent water risks faced by Chile, as well as drivers that influence water demand and supply, including climate change, economic development, energy, urbanisation, demographic trends and territorial development. The chapter points to some infrastructure deficits both in quantity and type, and it makes some suggestions on how to move forward, including low-cost options such as green and natural infrastructure, demand management techniques and rainwater harvesting. The chapter includes a rudimentary assessment of Chile's institutional water framework against the OECD Principles for Water Governance and makes some recommendations on how water can drive sustainable growth.

* The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Water infrastructure and Plan Chile 30/30

The Plan Chile 30/30 was conceived with the objective of developing the level of infrastructure (transport, water, ports, etc.) that Chile needs to overcome the middle income trap and reach USD 30 000 GDP per capita in 2030. The objective of the Ministry of Public Works (MOP) is to quantify the infrastructure gap by benchmarking Chile against countries that face similar challenges to Chile's macro-zones,[1] and plan investments accordingly for the coming 15 years. It is worth noting though that while the Agenda 30/30 focused primarily on *economic growth* as an outcome, the Plan Chile 30/30 has started to change its paradigm towards a broader understanding of wellbeing and development, coming closer to the OECD's regional well-being framework, which encompasses both material conditions (income, jobs, and housing) and non-material conditions (health, education, environment, community, life satisfaction, civic engagement, safety, and access to services). In that context, the efforts to boost infrastructure should continue to be conceived as a systemic effort to contribute to the three pillars of sustainable development now and in the future, namely economic prosperity, social inclusion and environmental protection.

The Plan Chile 30/30 is a responsibility of the MOP, thus placing infrastructure under its area of competence. The MOP is the ministry with the broadest portfolio in Chile, which ranges from road and port infrastructure to certain areas of urban transportation and to water infrastructure. Other strategic areas fall under the competence of other ministries like the Energy Ministry, which plans and executes energy infrastructure, or the private sector, which offers water services in urban areas. The Plan Chile 30/30 does not consider all types of water-related infrastructure (e.g. hydropower infrastructure and urban water services are excluded), but primarily focuses on water services in rural areas (essentially drinking water supply, with plans to include wastewater treatment), irrigation, rainwater and flood protection infrastructure. These areas fall under the responsibility of the Directorate of Hydraulic Infrastructure (DOH), a department within MOP (Box 5.1).

Urban water services are a key area of infrastructure that falls outside the purview of the MOP, and is regulated by the Superintendence of Sanitation Services (SISS). Chile's urban water services, i.e. drinking water supply and wastewater treatment, operate using in a concessional regime to the private sector, which means different private utilities are responsible for providing water services and thus responsible for maintaining, renovating and building the distribution network.

The Agenda 3030, which was conceived as a support document for the discussions and development of the Plan Chile 30/30, calls for some investments that might help bridge some infrastructure gaps. For instance, the Agenda 3030 includes an investment programme in a series of big reservoirs that will increase water supply capacity and hence the country's irrigated surface area by 220 000 hectares at a cost of USD 3.2 billion over 15 years. There is also a plan to improve and increase small reservoirs, which the initial period of 2015–18 alone will invest USD 174 million (Ministry of Public Works, 2014). Moreover, it is projected to invest USD 58.6 million annually to improve rainwater infrastructure in 54 cities. All these investments represent efforts to provide solutions that will last for 20, 30, or 40 years, and they must therefore be carefully planned, since they come at an important cost and may have impacts on territorial development and land use.

Box 5.1. Who does what in Chile's water policies

Chile counts over 40 water-related institutions delivering 100+ functions, thus making it one of the most fragmented countries for water management in the OECD region (OECD, 2012). Chile is among the OECD countries that give the most dominant role to central government and limited prerogatives to the subnational level when it comes to water resources management. Key players in Chile's water institutional mapping include:

- **General Directorate of Water (Ministry of Public Works):** responsible for water resources planning; monitoring and information dissemination; issuing and regulating water rights under the Water Code; monitoring the execution of those rights; granting permission for major works; implementing policies and conducting surveillance of water in natural channels; supervising the operation of water user organizations; and developing the Public Water Registry.
- **Directorate of Hydraulic Works (Ministry of Public Works):** delivers water infrastructure to efficiently exploit water resources and protects populations against floods and other extreme events. In particular, the Directorate of Hydraulic Works is responsible for delivering irrigation dams and channels, rainwater and fluvial protection, and rural drinking supply systems. The Rural Potable Water Programme aims at supplying drinking water to rural areas.
- **Directorate for Planning (Ministry of Public Works):** responsible for short-, medium- and long-term planning of infrastructure, including water infrastructure.
- **Superintendence of Sanitation Services, established in 1990 as the main regulatory and enforcement body of water supply and sanitation services:** decides on tariffs for drinking water and sanitation services. For concessions, the Superintendent's Office works with private sector operators to ensure service quality and monitor industrial sites producing liquid waste.
- **Ministry of Health:** responsible for overseeing water quality standards and environmental regulations in the industrial sector.
- **National Hydraulic Institute (Ministry of Public Works):** research institute that investigates hydraulics matters and whose mission is to provide guidance to the national government by enriching knowledge on water resources. It is located within the Ministry of Public Works.
- **Ministry of Environment:** responsible for the design and implementation of environmental policies and programmes to protect and conserve ecosystems, as well as natural and water resources.
- **Superintendence of Environment:** oversees the compliance with all environmental and fiscal instruments included in the Law 19.300 (Law on Environmental Requirements). It also promotes and encourages stakeholders to comply with these instruments.
- **Service of Environmental Evaluation:** responsible for overseeing the System of Environmental Impact Assessment and ensuring that the environmental evaluations conducted in public and private projects are transparent, of good technical quality and efficient. It also promotes citizen participation in environmental evaluations.
- **National Irrigation Commission:** responsible for all irrigation issues, from policy design to infrastructure provision.
- **Chilean Commission of Copper:** develops, implements and supervises natural resource exploitation policies, including for water management in the mining sector.

Source: OECD (2012), *Water Governance in Latin America and the Caribbean: A Multi-level Approach*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264174542-en.

Water infrastructure investments need to be closely coordinated with other policy areas and sectoral plans to account for externalities in other sectors, as well as for the impact that other sectors in turn have on the water system. The development of rainwater infrastructure, water services or flood protection infrastructure has a direct impact, for example, on land use policies, and vice versa. The way in which the city and its hinterland will evolve is directly linked to the existence and the development of basic infrastructure that provides water safety and universal coverage. For instance, frequent floods in Chile, such as in March 2015, reveal that urban planning and rainwater harvesting have not been optimally co-ordinated in the past, and that cities have developed without taking water risks into account (UCHILE, 2016). In the particular case of urban water services, the coordination with private water utilities is also key to ensuring that urban development strategies and plans feature water-related constraints, especially in the peri-urban areas. Moreover, many decisions taken outside the area of water policy (land use, energy, agriculture, industry) have significant impacts on water, and vice-versa. For instance, it is not clear how water aspects feature in the energy agenda that has been outlined through 2050. The expansion of the agriculture frontier has been planned, but without evaluating related impacts and needs in terms of water resources. A thorough assessment of the distributional impacts of decisions taken on water-related policy areas is essential to identifying contradictory incentives and fostering policy complementarities, especially when it comes to exploring synergies in terms of future infrastructure. Also, in light of the multipurpose potential of the infrastructure that may be built in the future, it is essential to make the most of investments and foster policy complementarities across water-related domains, which requires effective inter-ministerial coordination. For instance, large dams can primarily serve to supply water for irrigation, but also as tourist attractions and to generate electricity or regulate floods.

Infrastructure should be considered a means to an end. The Plan Chile 30/30 cannot deliver its ultimate objective of developing the level of infrastructure that Chile needs to overcome the middle income trap, if it does not build concomitantly on the "3Is", namely infrastructure, institutions and information. While infrastructure can certainly play a role in Chile in securing sustainable access to water resources and services in the future, it alone cannot meet a challenge of the magnitude posed by all the country's water-related risks. Investments in physical infrastructure will need to be accompanied by robust governance frameworks, supported by strong institutions, and improved information systems in order to effectively guide decision making at all levels.

Key factors that affect water management in Chile

Water demand in Chile is projected to rise in the coming decades, unlike in other OECD countries where it is expected to decrease by 2050 (OECD, 2012a). Over the last few decades, water demand has increased in Chile, linked to the period of dynamic economic growth and the high specialisation of the economy in water-intensive sectors including mining, agriculture and forestry, and fish farming. COCHILCO (2009) reported that the mining sector alone is expected to increase its demand for water by 45% in 2020,[2] while forecasts indicate that agriculture will require an additional 4 km^3 over the next 40 years. These trends raise the issues of how to match supply with demand geographically, how to maintain water sustainability in the future, and how to minimise competition for water by transitioning further from water supply to water demand management approaches (OECD, 2016b), especially in the northern regions between mining and agriculture.

Chile faces water challenges that will require action to maintain current levels of supply and meet increasing demands. A new report *OECD Water Risk Hotspots for Agriculture* ranks Chile as the 10th country out of 142 (4th among OECD countries just after US, Mexico and Australia) subject to more severe water risks (OECD, forthcoming). The following long-term drivers in particular, affect the capacity of the system to manage too much, too little water or too polluted water, and to secure universal coverage in terms of water supply and sanitation services in the future:

- **Climate change** will continue to have noticeable effects over the next 50 years and will deplete the available resources, particularly in those areas of the country that suffer from the greatest shortages. The Directorate of Meteorology of Chile (DMC, 2015) estimates that in 2050 the minimum temperature in northern Chile will rise 2 °C on average, with an even greater increase in the stretch between Copiapó and Concepción, where the minimum temperature in the mountainous areas is expected to increase by 3°C. Meanwhile, total annual rainfall will decrease by between 200 mm and 500 mm in Central Chile. Geographic and climatologic variability will act as a compounding factor to these trends. While in the north, average rainfall is 87 mm/year and water availability barely reaches 510 m^3/person/year, the south of Chile has an average rainfall of 2 963 mm/year and water availability of 2 340 227 m^3/person/year (DGA, 2016).
- **Urbanisation and demographic growth** keep increasing at a fair rate. Currently, nearly 90% of the total population lives in cities, and this share will approach 95% by 2050 (OECD, 2013). Between 2002 and 2012, the mean annual national population growth was above the OECD average (1.04% vs. 0.67%) (OECD, 2016a).
- **Economic development** continues to be tightly linked to the performance of water-intensive sectors. In 2014, 92% of water resources were used for mining (11% of GDP), agriculture (3%) and manufacturing (11%). Governmental plans to expand the agricultural frontier and increase the importance of mining in central regions will further exacerbate the current tensions due to competing water demand.
- **Energy.** The *Energy 2050 Policy* (2015) calls for an increase in the use of renewable energies, where hydropower is meant to play an important role in the coming years. One of the goals of the energy policy is to boost the amount of electricity production from renewable energy sources to 60% of the electricity matrix by 2035, and to at least 70% by 2050 (currently, it is 30%) (Ministry of Energy, 2015).

Territorial specificities

Geographic and climate variability in Chile raise a number of challenges in terms of water resources management. The country extends longitudinally over 4 300 km, and its widest part is 445 km. The climate of the country varies from the driest region in the world, including the Atacama Desert extending over 180 000 km2 in the north, to numerous glaciers and humid weather in the south. The country has about 1 251 rivers that flow from the mountains to the sea, forming 101 small-scale hydrographic basins. The Andes, the Coastal Mountainous Chain and the intermediate depression create a special morphology that influences the rivers' paths, creating a complex water system to manage. These small-scale river basins are often at the same time the water source for users, which creates an interconnected system that is difficult to manage. The large number of rivers and the mountainous terrain provide a considerable potential for hydropower.

Chile is overall a water-rich country, where per capita availability of water resources largely exceeds the OECD average, but the water is unevenly distributed. Renewable resources in Chile, accounting for long-term averages, are approximately 55 640 m3/capita, which is close to double the OECD average (31 360 m^3/capita)

(Figure 5.1). Disparities between the north and centre (where most of the people live and work) and the south (where most of the water resources are located) are noteworthy. The four macro-zones used by the MOP to differentiate the infrastructure and development challenges that the country faces also apply when considering water and hydrological conditions (DGA, 2016):

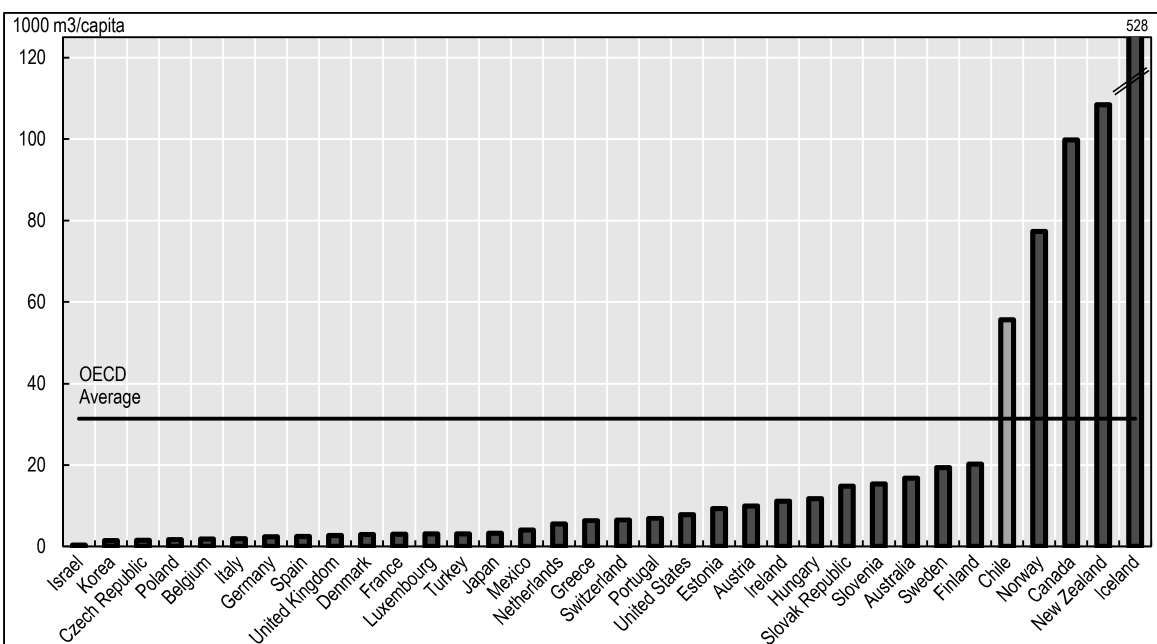
1. **North Macro-Zone**: characterised by an arid to semi-arid climate (more arid to the north) with an average rainfall of 87 mm/year, the lowest per capita availability among the four macro-zones (510 m^3/person/year), and includes the Atacama desert, one of the driest spots in the world.

2. **Centre Macro-Zone**: characterised by Mediterranean climate conditions, with an average rainfall of 943 mm/year, which is mainly concentrated in the winter season (3 to 4 months). Average water availability per capita is 3 169 m^3/person/year, with important disparities between Valparaíso area (around 1 000 m^3/person/year) and farther south in the region of Maule (7 000 m^3/person/year).

3. **South Macro-Zone**: characterised by a mild rainy and maritime rainy climate, with abundant rainfall (average 2 420 mm/year), which is higher to the south. Water availability is 56 799 m^3/capita/year.

4. **Austral Macro-Zone**: rich in water resources, rather sparsely populated and with low economic activity. The macro-zone has the highest average rainfall (2 963 mm/year) and water availability (2 340 227 m^3/capita/year).

Figure 5.1. Total renewable freshwater resources per capita, long-term annual average values



Source: OECD (2015), "Total renewable freshwater resources per capita, long-term annual average values", in *Environment at a Glance 2015*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264235199-graph23-en.

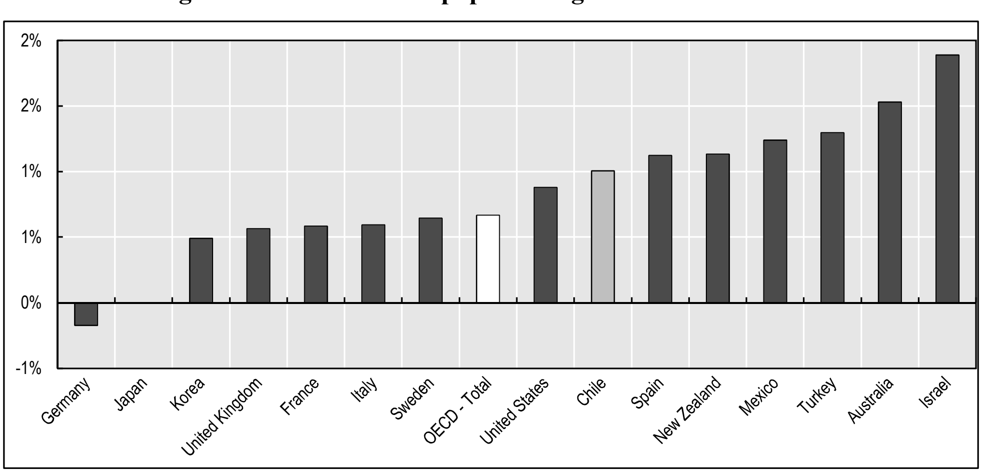
The diversity of geographic and climatological conditions in Chile requires place-based policy responses. The infrastructure needed in the north of Chile is different from that required in central Chile, or in the southern parts of the territory. Whereas the North Macro-zone suffers from severe water shortages, this is less true for the centre, and not an issue at all in the south. Thus, northern and central Chile need policies that target scarcity, through both increasing supply and reducing demand. The former can be costly, e.g. dams or desalination plants that require large investments, and have an impact on the environment. Water demand policies, such as more efficient irrigation techniques, awareness campaigns or reuse of wastewater, are usually more cost-efficient and less disruptive. Lastly, the south of Chile is less developed and has different needs, such as securing access to water supply and sanitation to rural population and improving rainwater infrastructure in less developed cities.

Demographic trends

Over the past 25 years, Chile has experienced a 50% increase in population and become highly urbanised. In 1950, 58% of the total Chilean population (3.5 million people) was living in urban areas. In 2010, approximately 15.2 million people lived in urban areas, representing around 89% of its population. Using the OECD definition of functional urban areas[3] (FUAs), approximately 77% of Chileans live in cities at present (OECD, 2013). Of the 26 functional urban areas, 15 can be classified as small urban areas[4], eight as medium-sized urban areas, two metropolitan areas (Valparaíso and Concepción), with only one large metropolitan area (Santiago de Chile). Small urban areas host 11% of the total national population, medium urban areas 15%, Valparaíso and Concepción are home to 11% of the national population, and Santiago is the biggest metropolitan area, accounting for 39% of the Chilean population (OECD, 2013).

Chile is above the OECD average in terms of population growth. National population grew at an average annual rate of 1.04% between 2002 and 2012, which is higher than the 0.67% registered on average for the OECD area (Figure 5.2). Demographic trends show an average growth rate (2002-12) of 1.2% in cities (OECD, 2013). The urban population continues to grow more rapidly than the total national population, and it is projected that 90% of Chileans will live in urban areas by 2025 (OECD, 2013).

Figure 5.2. Mean annual population growth rate 2002-12



Source: OECD (2016a), OECD Regional Statistics (database) Demography and Population, https://stats.oecd.org/ (accessed September 2016).

Drinking water supply and sanitation services represented 8% of consumptive water use in Chile in 2014. Approximately 44% of the water rights for drinking water are located in the Metropolitan Region of Santiago, and 12% in Valparaíso (Government of Chile, 2014). Domestic water consumption in 2014 accounted for 8% of water use (Figure 5.4), and water demand is expected to rise if population trends continue.

A water-intensive socioeconomic profile, geographically concentrated

The socioeconomic structure of the country puts pressure on available water resources. Mining, agriculture and manufacturing are the backbones of Chile's economic development and well-being, but they are water-intensive (Figure 5.3)[5]. Agriculture represents 82% of freshwater abstractions, human consumption accounts for 8%, industrial uses for 7% and mining for 3%. Agriculture and mining continue to develop in the north and centre of the country where the resource is scarce. Mining activities are geographically located close to the main copper reserves. The central region (IV, V, RM, VI), is home to 60% of the country's population, 16% of the world's copper reserves and 50% of the country's mining potential (CNID, 2014), and it represented almost 66% of national output in 2013 (Figure 5.5).

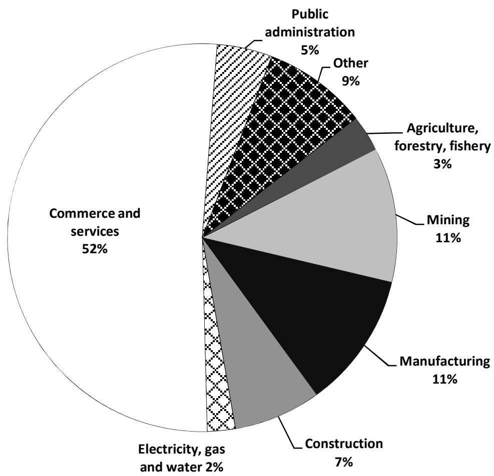
Water use varies significantly from north to south in Chile, according to the economic specialisation of the different regions. Economic activities in the North Macro-Zone are mainly dedicated to mining, though mining is less dominant in the north than agriculture is elsewhere (Figure 5.6). Agriculture has a predominant role in the Centre Macro-Zone and in the South Macro-Zone, while industrial and mining activities both play an important role in the Austral Macro-Zone (Figure 5.6). The North Macro-Zone accounts for 6.45% of total water use in Chile and 48.52% of the total water allocated to mining. The Central Macro-Zone concentrates 74.64% of Chile's total water use, 79.06% of the total water allocated to agriculture and 73.05% of drinking water, (mainly in the metropolitan areas of Santiago and Valparaíso) (Table 5.1). The South Macro-Zone represents 16.16% of total allocated water, and the most significant demand corresponds to the industrial sector (26.07% of total water allocated to industry). The Austral Macro-Zone has the lowest water demand (2.74% of total water), of which 19.27% and 21.66 are allocated to industry and mining, respectively.

Table 5.1. Water use as % of total allocated water to each use by Macro-Zone, 2011

	North Macro-Zone	Centre Macro-Zone	South Macro-Zone	Austral Macro-Zone	
			%		
Agriculture	4.61%	79.06%	15.79%	0.54%	100
Drinking water	7.66%	73.05%	15.54%	3.76%	100
Industry	7.96%	46.70%	26.07%	19.27%	100
Mining	48.52%	23.76%	6.05%	21.66%	100
Total	6.45%	74.64%	16.16%	2.74%	100

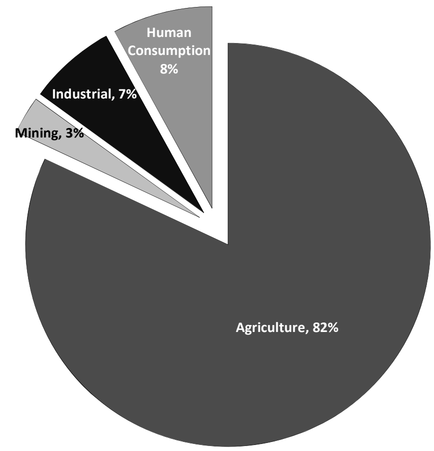
Source: DGA (2016), *Atlas del Agua: Chile 2016*, Dirección General de Aguas, www.dga.cl/atlasdelagua/Paginas/default.aspx.

Figure 5.3. Contribution to GDP by sector, 2014



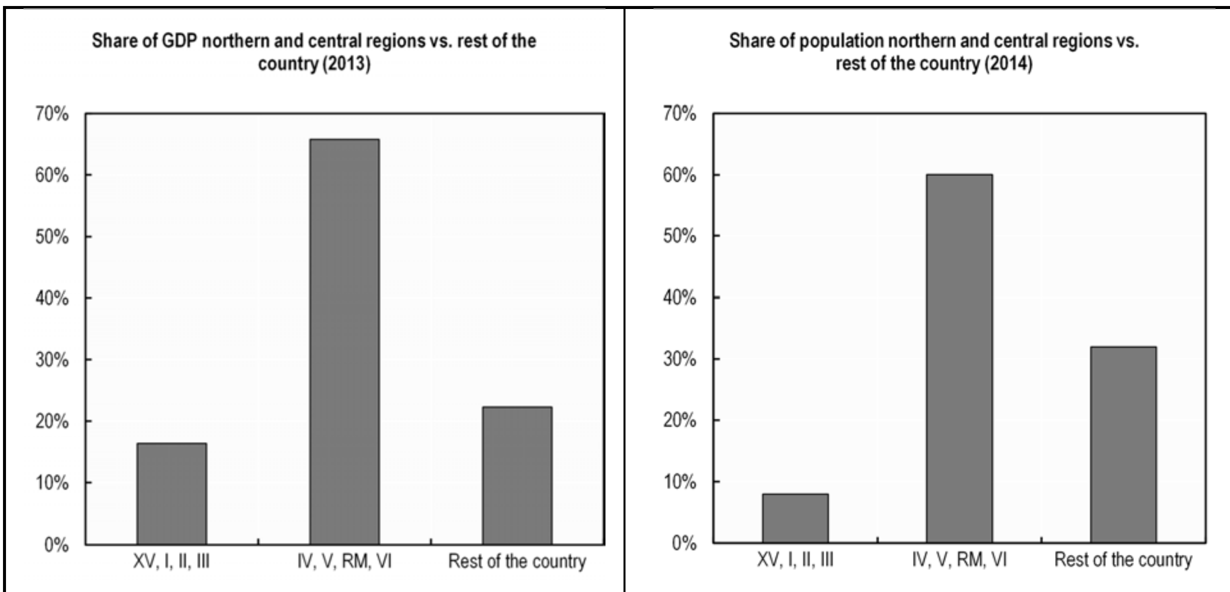
Source: OECD/ECLAC (2016), *OECD Environmental Performance Reviews: Chile 2016*, OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/9789264252615-en.

Figure 5.4. Freshwater abstractions in Chile, 2013



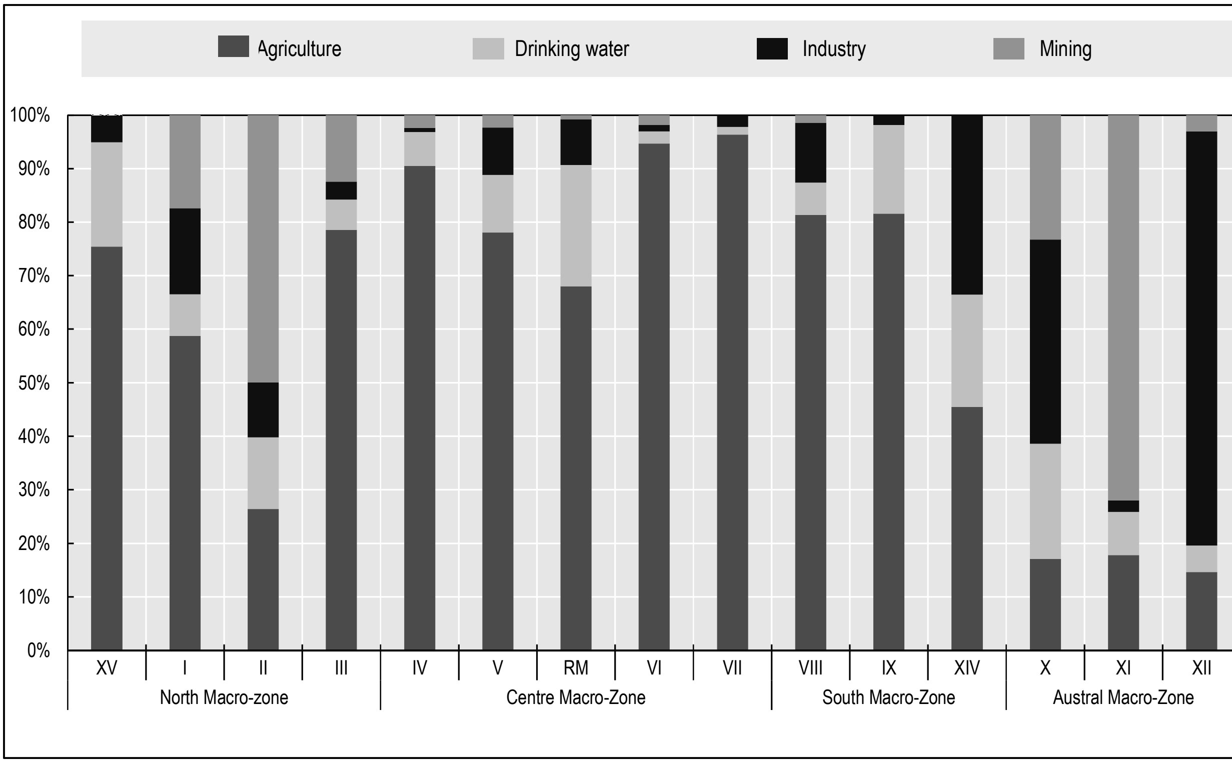
Source: OECD (2015b), "Water: Freshwater abstractions", *OECD Environment Statistics* (database). https://stats.oecd.org/Index.aspx?DataSetCode=WATER_RESOURCES ; OECD (2014a) *Historical population data and projections statistics* (database). http://stats.oecd.org/.

Figure 5.5. Regional contribution to national GDP (%) and population



Source: OECD (2016a), OECD Regional Statistics (database) Demography and Population, Regional Accounts, https://stats.oecd.org/ (accessed September 2016).

Figure 5.6. Water use per region, 2011

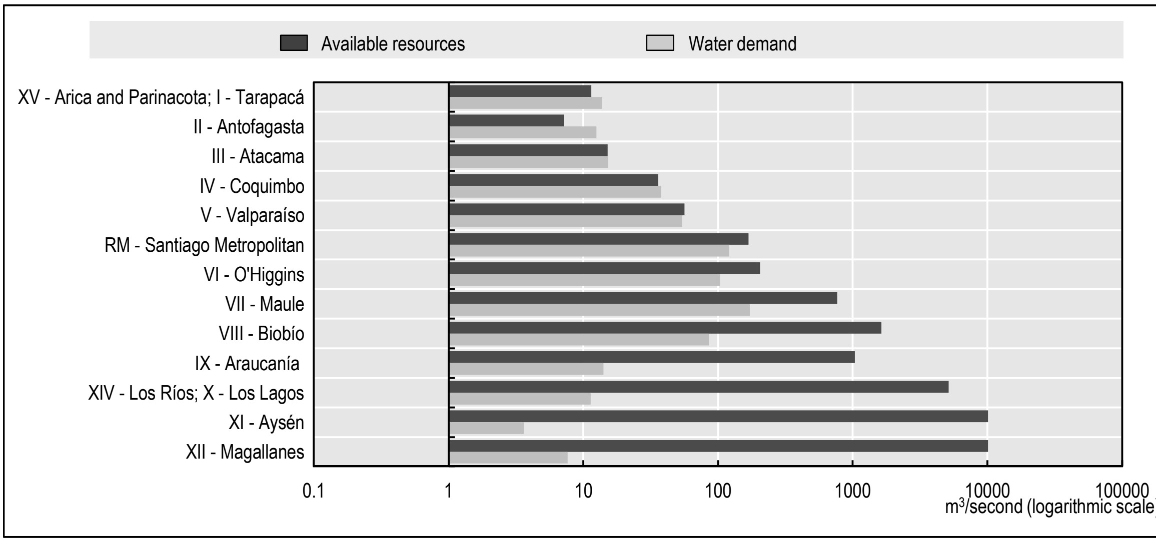


Source: DGA (2016), *Atlas del Agua: Chile 2016*, Dirección General de Aguas, www.dga.cl/atlasdelagua/Paginas/default.aspx.

The geographic concentration of activities in the north and centre has an impact on competition over water demand. Water demand exceeds water supply in northern and central regions such as Arica, Parinacota, Antofagasta, Tarapacá, Atacama, and Coquimbo. Particularly in Antofagasta (Region II), where the mining sector accounted for 66% of GDP in 2010 (OECD, 2011), the water deficit was the largest in Chile in 2016 (-5.3 m^3/s). The cities of Valparaíso and Santiago also suffer from water stress with values near from incurring deficit[6] (Figure 5.7). From region VI to X, south of the metropolitan region of Santiago, agriculture represents on average around 14% of GDP and 27% of total employment, while mining is below 1.32% of GDP. Although agriculture is a water-intensive activity, the higher availability of water resources in these regions reduces the pressure on the water system.

Chile's economic and social development depends heavily on the country's ability to meet water demands for its water-intensive economic sectors. The government plans to expand 10 000 ha of agriculture to increase Chile's national exports, and domestic water consumption together with urbanisation are expected to keep rising in the coming decade. Moreover, over time mining has gained traction in the north and is further developing in the central areas. Given the depletion of the northern reserves where mining activities were traditionally located, within the next 50 years mining is expected to shift further towards the central regions. There will be large investments taking place in the northern mining areas (USD 100 000 million) over the next 10-15 years to increase water supply (OECD, 2014) including investments in desalination plants.

Figure 5.7. Water deficit per region in Chile (2016)



Source: Based on data from DIRPLAN & INH (2016), "Análisis de Requerimiento de Largo Plazo en Infraestructura Hídrica", Dirección de Planeamiento del Ministerio de Obras Públicas (DIRPLAN) e Instituto Nacional de Hidráulica (INH).

In the face of these future trends, Chile needs robust and adaptive water policies to transition from supply to demand management, and from crisis to risk management. Whereas increasing supply through dedicated infrastructure might work in the short term, climate change and related uncertainties threaten the status quo in the medium and long term. A change of model towards a rebalancing of water supply and demand by using demand management approaches will be a more effective and efficient development strategy for the country, as explored later in this chapter.

Energy supply

In the face of rising energy prices and scarcity of energy resources, energy security is a crucial concern for Chile's current administration. Recent debates around environmental sustainability and climate change, as well as commitments to the reduction of CO2 emissions following the Paris Agreement, have raised further the profile of energy on the national political agenda. Chile imports 60% of its primary energy, which makes the country vulnerable to price instability, volatility of markets and supply constraints. Energy availability is considered by the Chilean government as a necessary condition for economic growth and development, as well as for a move toward better social inclusion.

The development of the Chilean energy sector is intrinsically linked to water resources management. Chile has historically generated a large share of its electricity from renewable sources. In the 1980s, no less than 80% of energy generation was hydroelectric. However, droughts caused frequent cuts in supply, which is why in the 1990s the national government decided to diversify the energy matrix by incorporating natural gas from Argentina as a new source of electricity. After Argentina restricted natural gas exports in 2004, Chile started relying on coal and thermal plants for its electricity production, thus resulting in a reduction in the share of hydroelectric generation in its electricity matrix. While over the past five years, the average share of hydroelectric generation was 32%, Energy Policy 2050 (Box 5.2) aims to raise the share of renewable energy to 60% of the electricity generation matrix by 2035, and at least 70% by 2050.

Box 5.2. Energy Policy 2050

The Ministry of Energy launched the "Energy 2050" initiative in July 2014, as a result of a participatory process, and the plan proposes a vision for Chile's energy sector in which the country will achieve a reliable, inclusive, competitive and sustainable energy system by 2050. The Energy Policy is built on four pillars: i) Quality and Security of Supply, ii) Energy as a Driver of Development, iii) Environmentally-friendly Energy, and iv) Energy Efficiency and Energy Education. Within Pillar 3, Environmentally-friendly Energy, one of the policy goals by 2050 is to achieve an energy matrix where renewable energy sources represent 70% of total electricity generation. The fundamental guidelines identified in the Energy Policy to reach this goal by 2050 are:

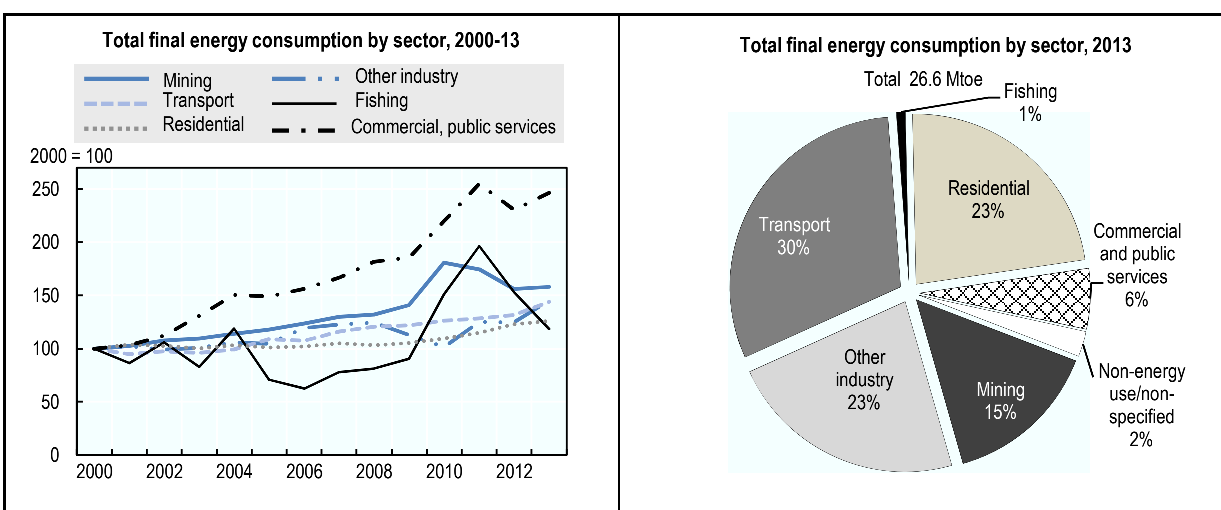
- promote a greater contribution from renewable energy sources (conventional and non-conventional) to the electricity matrix
- promote sustainable hydroelectricity development, to increase renewable energy's share of the electricity matrix
- promote the share in energy matrix of fuels with low GHG emissions and atmospheric pollutants.

Increasing hydroelectric power generation is therefore one of the central pillars in the Ministry's plan for the coming 35 years.

Source: Ministry of Energy (2016), "Energy 2050: Chile's Energy Policy", www.energia2050.cl/wp-content/uploads/2016/08/Energy-2050-Chile-s-Energy-Policy.pdf

Mining and industry account for the largest share of energy use (38%) (Figure 5.8). Energy demand in these sectors increased by 50% over the period from 2000-13, driven by the energy-intensive mining industry and paper and pulp production (OECD, 2016). Projections show that the mining industry's electricity consumption may increase by 81% by 2025 (COCHILCO, 2015). Other pressing energy demands are related to the development of alternative water sources (such as desalination and reuse) which consume large quantities of energy.

Figure 5.8. Energy consumption by sector in Chile



Source: OECD/ECLAC (2016), *OECD Environmental Performance Reviews: Chile 2016*, http://dx.doi.org/10.1787/9789264252615-en.

Better co-ordination and planning across water and energy policies are needed. As the Ministry of Energy targets 70% of electricity production through hydropower in the coming three decades, releasing water resources from dams in central and northern parts of the country where much of the hydropower potential is located will be unavoidable. The Agenda 3030, which was conceived as a support document for the discussions and development of the Plan Chile 30/30, aims at increasing water supply through dams to expand 300 000 ha of irrigated land by 2030, but Central and North Macro-Zone are already under water stress. Although hydroelectricity will use water from reservoirs when irrigators downstream do not need them, there is no explicit co-ordination between the Agenda 3030 (nor the development of the Plan Chile 30/30) and Energy Policy 2050. Both strategies were conceived in parallel, with rather limited inter-ministerial consultations, which could cause some implementation bottlenecks. Moreover, the mining industry keeps developing in the north and central parts of the country, and future plans include the development of desalination plants to deal with water scarcity. The latter initiatives will increase energy demands in already water-scarce and energy-scarce areas. This is why better co-ordinated policies in the water and energy domains would be desirable to make the most of policy complementarities. For instance, multi-purpose reservoirs that serve different policy areas (agriculture, energy, domestic supply, mining) when operated through consensus-based agreements, can increase efficiency in the use of the resource. Moreover, they help create economies of scale by pulling financial resources from different sources (private and public sectors) and sectors.

Climate change

Climate change forecast models project higher variability in water resource availability between the north and the south. The Directorate of Meteorology of Chile (DMC) estimates that in 2050, the minimum temperature in northern Chile will increase 2°C, with a 3°C rise in the stretch between Copiapó and Concepción. With respect to precipitation, it is expected that total annual rainfall will decrease between 200 mm and 500 mm in Central Chile and increase around 400mm in Southern Chile. The National Climate Change Adaptation Plan (2014) identifies a range of potential impacts on water and energy (Box 5.3). The plan states that the frequency of hot days will increase, and temperatures experienced once every 20 years will occur every two years in most regions of Chile by the end of the century. The majority of climate model simulations predict that floods and droughts (defined as two consecutive years of low precipitation) will become much more frequent (OECD, 2016). Floods will be particularly intense in the central region where most of the population lives, while droughts should increase in central and northern regions, thus generating more intense competition among domestic, agriculture and industrial water uses. Moreover, reduction of hydropower potential will put more pressure on Chile's energy system.

Box 5.3. Potential impacts from climate change in Chile

The National Climate Change Adaptation Plan (2014) identifies a range of potential impacts arising from reductions in water availability, rising temperatures and extreme weather events:

- Lack of water could constrain hydropower, with CEPAL (2012) estimating potential reductions in electricity generation in the range of 10% to 22%. Less available water for cooling could also affect thermal generation. Patterns of consumption will shift, as demand for cooling increases and that of heating decreases
- Increased soil erosion would negatively affect agricultural production. Pests are likely to be more prevalent, while some diseases could diminish. The zones of suitability for forestry, fruit and wine production will shift. Irrigated land could become more productive as temperatures rise, provided enough water is available.

Box 5.3. Potential impacts from climate change in Chile (*cont.*)

- Negative impacts on biodiversity could arise as the pace of climate change exceeds species' ability to adapt. It could take several centuries for ecosystems to find a new equilibrium following the disruption caused by climate change.
- Risk of flooding could increase. For example, CEPAL (2015) estimates that coastal floods that now occur in Valparaíso once every 50 years will occur every 11 years by 2070.

Monetary estimates show that overall, economic losses would amount to 1.1% of GDP under a higher-warming scenario (equivalent to a global temperature increase of 3.4 C) from now until 2100. These estimates pointed to economic benefits for agriculture and forestry, but net costs for fruit growing, livestock, hydropower and drinking water provision. A range of important impacts, however, were not considered. These include increased deaths in hot weather (either directly or as a result of interactions between temperatures and air quality), extreme weather, impacts on businesses and biodiversity. As such, these monetary estimates only capture a fraction of the potential costs of climate change in Chile.

Source: OECD/ECLAC (2016), *OECD Environmental Performance Reviews: Chile 2016*, http://dx.doi.org/10.1787/9789264252615-en.

Managing water risks

The previous sections revealed key trends that will altogether increase pressure in the existing water resources, and which will threaten water security in Chile. In the case of Chile as for many OECD countries, four types of water challenges need particular attention now and in the future to ensure sustainable and inclusive growth in the country.

- **Too much water:** Floods are becoming more frequent and also affect households supply and water quality. Floods affecting urban areas will have a bigger impact in Santiago and Valparaíso, which account for most of national output and 60% of total population. For instance, the heavy rains in central Chile in April 2016 have left an estimated 4 million people without drinking water. In Santiago, the national emergency response agency declared a red alert for the city of more than seven million people due to dirty water caused by the flooding. In May 2015 floods in northern Chile (Atacama region) caused 31 casualties and left 16 588 people homeless (ONEMI, 2015). The Chilean government estimated recovery costs of at least USD 1.5 billion (O'Brien and Esposito, 2015). According to the Chamber of Construction, in the last 30 years, eight of the ten biggest natural disasters measured by number of deaths were related to floods in urban areas or rivers beds.
- **Too little water:** The current drought, which began in 2007, is hampering the Chile's copper production, although it remains the world's top exporter. The drought is exacerbating forest fires, driving energy prices higher and having an impact on agriculture. This has economic implications, as Chile is among the countries with the largest difference in economic growth between drought years and non-drought years, with GDP varying by 1-2% (OECD/GWP, 2015).
- **Too polluted water**: Water quality levels vary across the country, and differences are noticeable from the south to the north. In the far south of Chile, where 80% of the 16 000 lakes and lagoons in the country are located, water quality is in general terms very good, mainly due to low population density and limited economic activities. In central Chile, large urban settlements like Santiago and Valparaíso have limited access to tertiary wastewater treatment, which together with large

agricultural runoff has caused eutrophication of coastal lakes, wetlands and estuaries. Also in central Chile, mining activity has elevated copper and salinity levels in some rivers, including in the Maipo River, which is the major source of irrigation and drinking water for the Santiago Metropolitan Region and Valparaíso. In the northern regions, surface waters often exceed permissible or recommended limit values of heavy metals and sulphates, mainly due to mining effluent (OECD/ECLAC, 2016).

- **Universal coverage of water services:** a key challenge in Chile is providing access to water supply and sanitation in rural settlements. According to the Joint Monitoring Programme, 7% of Chile's rural population currently lacks access to improved drinking sources and 9% to improved sanitation. Future trends in terms of urbanisation and population growth, together with infrastructure ageing in cities, will also increase the pressure on urban drinking water systems.

While infrastructure can help manage the above water risks, it cannot be the only response. Constructing more dams, upgrading channels to have less leakage, and installing efficient irrigation systems will certainly all contribute to increased water availability and reduce risks of too little water. Rainwater systems with larger capacity and higher coverage will help manage higher peak flows and therefore diminish the risk of floods in cities as well as reduce the impact on the environment, urban infrastructure such as water services infrastructure, and the society at large. Higher quality treatments in wastewater treatment plants will also diminish the risks of disrupting freshwater systems. However, investments in physical infrastructure will need to be integrated into wider governance frameworks, accompanied by sound water institutions and improved information systems. For instance, if rainwater systems are enlarged in Santiago but are not operated and maintained properly due to the fragmentation of competences across the state and municipalities, the system will not deliver on its intended goals. Dams that are not operated for multiple uses might supply water for one specific use, but they could miss out on generating benefits for other categories of users as well.

Due to Chile's particular water rights regime and water market, the space for public action in water management is somewhat limited. The National Water Code of 1981 created a unique system of water rights, known as one of the world's most pro-market systems. The National Water Code allowed for the development of a water market with the objective of achieving greater economic efficiency and water conservation. Whereas the former was achieved by allocating rights to productive activities, the latter is claimed to have failed due to monopolies and speculation. Water rights have been allocated by the national government to private users upon their request, free of cost. They were allocated for indefinite time periods, with the possibility of being passed down in inheritance from one individual to another. When there is more than one claim made on the same water source and not enough resources to satisfy them all, the right is allocated following a bidding/auction process. The right is tradable, with the goal of assigning the right of water access to those initiatives with the greatest market value. Once private parties are in possession of their water rights, they are responsible for the management and distribution of their water. In most Chilean rivers, these private parties are organised in Water Users Organisations (WUOs) (see Box 5.5) which are century-old institutions that have acquired the experience and social acceptance to manage water resources. However, WUOs focus on managing surface water resources for irrigation purposes in a specific river, and often do not have control over all rivers, tributaries, and groundwater resources that together form a basin. Thus, the government loses its power to establish integrated planning and a long-term vision, as it has no faculty over water allocation regimes and the prioritisation of uses. For instance, such an institutional framework limits the role of the state to manage trade-offs between upstream/downstream, current/future generations, water producers/water users, energy/agriculture /households /mining users. Given the current and future trends' impact on water demand and supply, these trade-offs need to be addressed as a shared responsibility across the public, private and non-profit sectors. The state's role in this context is to facilitate the effective and efficient functioning of the market through providing clear rules and standards to ensure that sufficient water is allocated for human consumption and the preservation of natural ecosystems, and facilitating access to sound information to guarantee that actors in the market can take the right decisions.

In 2005 and 2011, important efforts to reform the water code have been undertaken by Chilean administration. Since the 2005 reform, which established ecological flows, the state has been able to deny requests for water rights to preserve environmental minimum values. In addition, the reform included the possibility of creating water reserves under exceptional circumstances, the need for a justification in a water rights application, a fee in the case of non-use of water rights, and the obligation to report transactions on water rights. However, the 2005 reform did not change the basics of the allocation model and water trading as defined in the 1981 Code. This is why a new reform, which started in 2011, seeks to reinforce the role of water as a national public good and has the objective to facilitate public action in managing water risks in Chile. It was given legislative priority in 2014 and is now under discussion in the Senate's Special Commission for Water Resources, Desertification and Droughts, after having passed Congress on 22 November 2016The draft bill foresees a number of provisions, which are difficult to assess at the time of the drafting, but any attempt at strengthening the current institutional framework towards more sound public governance in Chile's water management is a significant step forward to set sound framework conditions to manage water risks.

The ongoing process to reform the Water Code also provides a good opportunity to engage stakeholders in the development of a country-wide strategy for water. The process should be used as a catalyst for developing a country-wide, national strategic vision on how water can contribute to sustainable and inclusive growth over the short, medium and long term. Raising the profile of water management on the national and local political agenda is essential to sustain Chile's productive matrix and to ensure the well-being of citizens.

An overview of water governance gaps in Chile

The following sections detail the most prominent gaps in Chile's water governance, measured against the *OECD Principles on Water Governance* (Box 5.4).

Box 5.4. OECD Principles on Water Governance

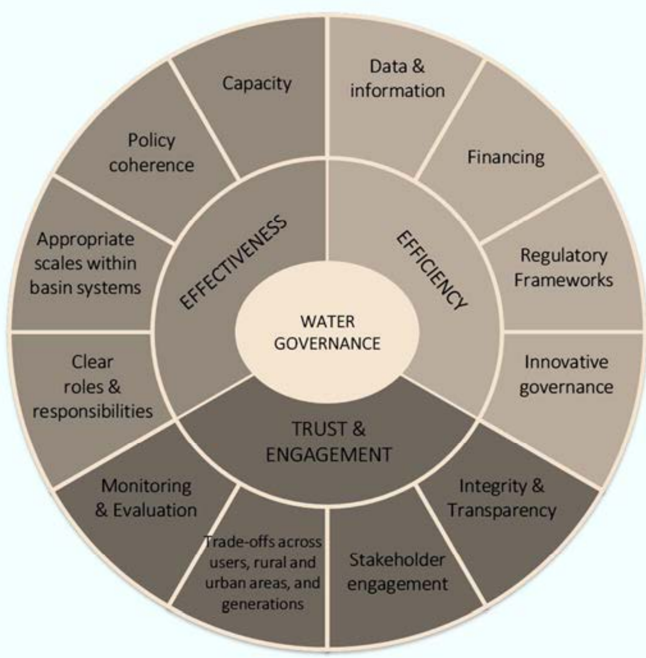
The 12 OECD Water Governance Principles aim to enhance water governance systems that help manage "too much", "too little" and "too polluted" water in a sustainable, integrated and inclusive way, at an acceptable cost, and in a reasonable time-frame. The Principles consider that governance is good if it can help to solve key water challenges, using a combination of bottom-up and top-down processes while fostering constructive state-society relations. It is bad if it generates undue transaction costs and does not respond to place-based needs.

Box 5.4. OECD Principles on Water Governance (*cont.*)

Coping with current and future challenges requires robust public policies, targeting measurable objectives in pre-determined time-schedules at the appropriate scale, relying on a clear assignment of duties across responsible authorities and subject to regular monitoring and evaluation. Water governance can greatly contribute to the design and implementation of such policies, in a shared responsibility across levels of government, civil society, business and the broader range of stakeholders who have an important role to play alongside policy-makers to reap the economic, social and environmental benefits of good water governance.

The OECD Principles on Water Governance intend to contribute to tangible and outcome-oriented public policies, based on three mutually reinforcing and complementary dimensions of water governance:

- **Effectiveness** relates to the contribution of governance to define clear sustainable water policy goals and targets at all levels of government, to implement those policy goals, and to meet expected targets.
- **Efficiency** relates to the contribution of governance to maximise the benefits of sustainable water management and welfare at the least cost to society.
- **Trust and Engagement** relate to the contribution of governance to building public confidence and ensuring inclusiveness of stakeholders through democratic legitimacy and fairness for society at large.



Enhancing the effectiveness of water governance

- Principle 1. Clearly allocate and distinguish roles and responsibilities for water policymaking, policy implementation, operational management and regulation, and foster co-ordination across these responsible authorities.
- Principle 2. Manage water at the appropriate scale(s) within integrated basin governance systems to reflect local conditions, and foster co-ordination between the different scales.
- Principle 3. Encourage policy coherence through effective cross-sectoral co-ordination, especially between policies for water and the environment, health, energy, agriculture, industry, spatial planning and land use.
- Principle 4. Adapt the level of capacity of responsible authorities to the complexity of water challenges to be met, and to the set of competencies required to carry out their duties.

Box 5.4. OECD Principles on Water Governance (*cont.*)

Enhancing the efficiency of water governance

- Principle 5. Produce, update and share timely, consistent, comparable and policy-relevant water and water-related data and information, and use it to guide, assess and improve water policy.
- Principle 6. Ensure that governance arrangements help mobilise water finance and allocate financial resources in an efficient, transparent and timely manner.
- Principle 7. Ensure that sound water management regulatory frameworks are effectively implemented and enforced in pursuit of the public interest. Principle 8. Promote the adoption and implementation of innovative water governance practices across responsible authorities, levels of government and relevant stakeholders.
- Principle 8. Promote the adoption and implementation of innovative water governance practices across responsible authorities, levels of government and relevant stakeholders.
- Principle 9. Mainstream integrity and transparency practices across water policies, water institutions and water governance frameworks for greater accountability and trust in decision making.

Pillar 3: Enhancing trust and engagement in water governance

- Principle 10. Promote stakeholder engagement for informed and outcome-oriented contributions to water policy design and implementation.
- Principle 11. Encourage water governance frameworks that help manage trade-offs across water users, rural and urban areas, and generations.
- Principle 12. Promote regular monitoring and evaluation of water policy and governance where appropriate, share the results with the public and make adjustments when needed.

Source: OECD (2015c), OECD Water Governance Principles, available at: https://www.oecd.org/gov/regional-policy/OECD-Principles-on-Water-Governance-brochure.pdf.

Fragmentation of responsibilities in water-related competences

Chile has one of the highest levels of fragmentation of responsibilities when it comes to water-related competences. More than forty institutions are involved in delivering over 100 water-related functions. Both the 2012 OECD study *Water Governance in Latin America and the Caribbean* and other studies like one by the World Bank in 2013 highlighted this fragmentation and raised awareness among Chilean stakeholders. Within the MOP, several authorities have core competencies over water management, including DGA, DOH, and the Planning Directorate. In the past, the DGA and the DOH have seldom been involved in the planning of water infrastructure, but the Plan Chile 30/30 offers an opportunity to combine perspectives and identify needs for water-related infrastructure. It is critical for DGA to be able to control and monitor water rights, and DOH to execute infrastructure within the framework of an integrated vision. One way forward that Chile is currently considering to strengthen the institutional and coordination framework for water management is the establishment of an Under-Secretariat for Water Resources within the MOP. While such a figure might help solve the compartmentalisation within the MOP, there would still need to be effective coordination mechanisms with agencies and ministries outside the MOP. For the time being, such coordination is done informally through the Committee of Water Ministers established in 2014 as an operational body to bring together the ministries of agriculture, mining, energy, environment and public works. A step forward could be the formalisation of that Committee following a similar approach as the Under-Secretariat of Tourism, which relies on a formal inter-ministerial committee that ensures co-ordination with relevant sectors to tourism such as public works, environment, and transport.

Fragmentation, or the high number of responsible authorities, is not bad per se, if the right co-ordination mechanisms are in place and work properly (OECD, 2016). The traditional co-ordination mechanism for irrigation policies in Chile has been an inter-ministerial committee called the National Irrigation Commission (CNR) (Box 5.19), which operates under the umbrella of the Ministry of Agriculture. The Commission is in charge of designing irrigation policies and is led by a Council of Ministers. The Council is chaired by the representative of the Ministry of Agriculture, and gathers several ministries including the representatives of the Ministries of Economy, Finance, Public Works and Social Development. However, this mechanism has been claimed to be insufficient to effectively coordinate water policies across responsible authorities in Chile (OECD 2012, World Bank, 2013). In 2014, a Presidential Delegate for Water Resources was appointed to advise the President and Ministers on how to improve water resources management in Chile. At the time, it reflected a certain commitment to raising the profile of water in Chile, but the mandate of the Presidential Delegate ended in May 2016 before any National Water Resource Policy could be agreed upon by the different competent ministries and stakeholders. The views of the Presidential Delegate have however been captured in a document entitled "National Water Resources Policy", some guidelines of which are summarised below in Boxes 5.6 and 5.8. However, it is worth noting that, to date, this document has not been vetted by all competent authorities as a National Water Policy per se.

A lack of functional and hydrological scale in water management

A striking feature of the Chilean water management model is the absence of integrated basin governance systems that can provide for a functional and territorial approach to water risks. This can be very much explained by the specific geographical context (north/south asymmetry and very small-scale basins due to the mountain/sea specificity), but also by the high degree of centralisation in most of Chile's public policies, including water. In the absence of proper river basin governance, Water Users Organisations (WUOs) (Box 5.5) manage water in a rather fragmented way, and limited consideration is given to the need for conjunctive management of surface and groundwater. These century-old institutions have acquired the experience and social acceptance to manage effectively water resources. Though most of them have control over an entire river, they do not generally have control over all rivers and tributaries that together form a basin. These organisations focus on managing surface water resources for irrigation purposes, and they often do not coordinate with users withdrawing groundwater. As a result, the hydrological interconnection between the river and the aquifers is neglected. One of the reasons for the lack of coordination is the limited number of groundwater user organisations. OECD countries experience shows that effective groundwater management can provide a natural storage of water if properly managed, particularly in areas with unconfined sedimentary aquifers. There is therefore a need to seek alternatives to enhance basin governance in Chile, and the conjunctive management of groundwater and surface water within the current water rights context.

Box 5.5. Water Users' Organisations in Chile

Water Users Organisations (WUOs) have played a key role in water infrastructure development since the 19th century and operate and maintain a large share of it today. They manage a network of roughly 100 000 km channels without translating their operation and maintenance costs to the State. However, the development of this network was largely supported through different State subsidies (see Box 5.19).

The main types of Water Users' Organisations in Chile are:

- **Water Channels Associations** (*Asociaciones de Canalistas*): formed by water rights owners sharing the operation of a water infrastructure that takes water from a natural source and distributes water among the users
- **Surface Water Communities** (*Comunidad de Aguas superficiales*): formed by water rights owners that withdraw, channel and distribute water from the same water source
- **Groundwater Communities** (*Comunidad de Aguas Subterráneas*): formed by water rights owners that abstract water from the same groundwater source. These organisations control abstractions and manage information on wells and availability of water
- **Control Boards** (*Juntas de Vigilancia*): organisations with jurisdiction over a basin or part of a basin, which are formed by surface water communities, water channels associations and individuals that execute their water rights

Source: DGA (2016), *Atlas del Agua: Chile 2016*, Dirección General de Aguas, available at: www.dga.cl/atlasdelagua/Paginas/default.aspx.

Several policies, including the reflections captured by the Presidential Delegate for Water in the document entitled "National Water Resources Policy" (Box 5.6), have been aimed at promoting river basin management, but they have had little success. For instance, a series of Territorial Roundtables (*Mesas Territoriales*) were set up throughout 2014-15 to coordinate with the subnational authorities the implementation of national goals at local level and strengthen the role of WUOs. The roundtables included public and private actors, as well as universities and representatives of civil society, and were formed through an incremental approach. First, a broad-based meeting with public water authorities in the region was held to explain the role of the appointed subnational Delegate, the underlying goal of the roundtable and its methods of work. Second, relevant private sector actors, academics and civil society groups were invited to be part of the tables. Representatives were appointed in each region to set up the Territorial Roundtable, with the support of the Ministry of Interior, which appointed "subnational Presidential Delegates", and of the *intendentes* of the regions, who provided them with logistical support to carry out their functions (i.e. offices, vehicles, etc.). However, due to budget cuts in the Ministry of Interior in 2015, only a limited number of Territorial Roundtables remained, namely in Coquimbo, Valparaíso, Bio-Bio, La Auracania, Los Rios, and Los Lagos, because authorities in these regions decided to cover related operation costs.

There have also been attempts to develop integrated water resources management (IWRM) plans for individual basins. The Government of Chile and the World Bank worked towards an IWRM plan in Choapa, in the Region of Coquimbo, which was ultimately not implemented due to budgetary constraints. The project, which was revived by the DGA, foresees the participation of WUOs, civil society organisations and regional and local authorities together with the national government. The plan involves using hydrological models that include climate change scenarios, developing a platform that visually displays water resource information about the basin and proposing a coordination mechanism to help improve water governance in the basin in the long-term (Agua, 2016). Similar efforts are also being considered in the Copiapo River Basin.

Box 5.6. Provisions on river basin management in the Presidential Delegate's "National Policy for Water Resources" document

The latest policy statement of the Government of Chile on water management, issued by the Presidential Delegate, recognises river basins as a unit of territorial management and calls for:

- promoting integrated water resources management through place-based approaches in each basin, in order to account for the singularities of each basin in terms of future challenges, with the Territorial Roundtables to be implemented in each region as the first step forward
- studying the possibility of developing a normative framework for the implementation of integrated water resources management in Chile
- instruments for territorial management that consider basins as the unit for planning and management of water resources
- territorial development plans that consider the basin as the planning unit.

Source: Government of Chile (2015), "National Water Resources Policy 2015", www.interior.gob.cl/media/2015/04/recursos_hidricos.pdf

Policy incoherence across sectors

Chile's central government is characterised by a high degree of compartmentalisation. Sectoral ministries work in insulated silos, with limited mechanisms for ensuring alignment and integration across policy areas and investments. The lack of horizontal co-ordination is particularly challenging in water management, as many decisions taken in other policy domains (e.g. land use, energy, agriculture, industry) generate water risks and vice-versa. For instance, it is not clear how water management has been taken into account in the development of the energy infrastructure agenda spanning through 2050. It is also unclear how the National Commission for Irrigation has planned the expansion of the agriculture frontier and how relevant water stakeholders have been consulted and engaged (e.g. Ministry of Environment, Ministry of Energy, WUOs, etc.). A thorough assessment of the distributional impacts of decisions taken in water-related policy areas is essential to fostering policy complementarities, especially when it comes to exploring synergies in future infrastructure.

A Committee of Water Ministers was established to coordinate actions in policy areas with an impact on water. The Committee was promoted by the Ministry of Public Works, which is responsible for its Secretariat, and it was designed as an operational body to discuss trade-offs across the five water-related ministries: agriculture, mining, energy, environment, and public works. The National Presidential Delegate to Water Resources also sat on the Committee until the end of his mandate. To some extent, the Water Committee has supported policy coherence on a case-by-case basis rather than systematically. A notable case is the conflict among users regarding the Reservoir of Laja Lake, in the Bio-Bio Region. This 5 000 Mm^3 natural lake of environmental value (there is a waterfall that is a popular touristic attraction) is an important water source for the agricultural activity in the region, but the reservoir is managed by the National Energy Company ENDESA (*Empresa Nacional de Electricidad Sociedad Anónima*), as it holds the water rights. The conflict started when ENDESA was privatised in 1989 and used water rights to maximise its profits from the installed hydropower plant. This put additional pressure on the available water resources, and two main conflicts arose: first, agricultural users could not access the water resources the needed to keep up production, and second, the environmental sustainability of the waterfalls was threatened. In this context, the Council met and agreed upon an operational rule for the management of the lake's resources, which was first discussed by the ministries with a higher stake, i.e. Energy, Environment, and Agriculture, together with the users and stakeholders. Each ministry negotiated and liaised with their constituencies prior to holding discussions with their peers on the need to reconsider some of the water allocation entitlements.

The Water Committee is an informal mechanism rather than an institutionalised body. While this has allowed some flexibility and confidentiality when discussing sensitive issues, the absence of formalisation could call into question its accountability and sustainability over time. Relevant ministries argue that any formalisation would reduce its operability and delay implementation of measures. However, a more formal coordination body would also be better able to outlast political cycles and serve as a robust coordination mechanism, where trade-offs and conflicting interests could be managed effectively. In addition, a variety of complementary co-ordination mechanisms used by OECD countries can be considered in the case of Chile (Box 5.7).

Box.5.7. Menu of options for co-ordinating policies across ministries, public agencies and levels of government

In **France**, the Inter-ministerial Committee for Sustainable Development was created by decree in 2003. Presided over by the Prime Minister, it meets annually and is made up of the ministers responsible for interior affairs, social affairs, employment, foreign affairs, European affairs, defense, youth, education, research, economy, finances, industry, transport, housing, tourism, health, agriculture, culture, state reform, territorial development, cities and local communities, sports, and overseas territories. A representative of the President also takes part in the activities of the inter-ministerial committee. Its role is to define and monitor the implementation of governmental orientations to foster sustainable development, including regarding greenhouse gases and the prevention of major natural risks. It also ensures alignment the national strategy and action plans for sustainable development with the country's commitment in that field at European and international levels. The committee prepares an annual evaluation report on the implementation of the strategy and actions plans.

In **Australia**, the Council of Australian Governments (COAG) is the peak intergovernmental forum. The members of COAG are the Prime Minister, state and territory premiers and chief ministers and the President of the Australian Local Government Association (ALGA). The Prime Minister chairs the COAG. The role of the COAG is to promote policy reforms that are of national significance, or which need coordinated action by all Australian governments. The COAG is supported by inter-jurisdictional, inter-ministerial councils that facilitate consultation and co-operation between the Commonwealth and the states and territories in specific policy areas such as health, education, indigenous rights and the economy. Together, these councils constitute the COAG Council System. COAG councils pursue and monitor priority issues of national significance and take joint action to resolve issues that arise between governments. Councils also develop policy reforms for consideration by the COAG, and oversee the implementation of policy reforms agreed by the COAG. The COAG has been the co-ordinating and driving force behind the water reforms undertaken across Australian jurisdictions for more than 20 years.

In **Mexico**, there has been notable progress in addressing institutional fragmentation of water policy at the federal level. Some of these efforts were undertaken through the National Water Commission (CONAGUA)'s Technical Council. The council is an inter-ministerial body in charge of approving and evaluating the commission's programmes, projects, budget and operations, as well as co-ordinating water policies and defining common strategies across multiple ministries and agencies (SEMARNAT; SEDESOL; Secretary of Agriculture, Livestock, Rural Development, Fisheries and Food [SAGARPA.]; Treasury; Energy; CONAFOR; and IMTA).

Israel, the Water Authority Council created in 2007 is responsible for all decision making and policy setting by the Israeli Water Authority. It seeks to co-ordinate the actions of the ministries of Environmental Protection, Health, Finance, Foreign Affairs, and Infrastructure, which used to be collectively responsible for the decision-making process over matters concerning water and sewage. Under the previous arrangement, important decisions were often impossible to reach because of the diverging interests of each agency/ministry and a lack of incentives for compromise, which posed a risk of a lack a collective sense of responsibility for national decision making on water and wastewater management. The Water Authority Council was

Box.5.7. Menu of options for co-ordinating policies across ministries, public agencies and levels of government (*cont.*)

established to alleviate these frequent deadlocks.All policies and plans that the Israeli Water Authority or any other ministry proposes must be presented to the Water Authority Council Forum for approval before they can be passed. The efficiency of the Water Authority Council is founded upon two criteria – creating equal representation of all interested groups, and ensuring that effective and timely decision-making is their priority. This unifies the responsibility for decision making on national water and wastewater management and has substantially improved the efficiency and timing of decision making.

The National Water Council in **Spain** is a high-level consultative agency created in 2009 which includes autonomous communities, local entities, river-basin authorities, and professional and economic unions related to water. Horizontal co-ordination of water policies is ensured by the participation of the main directors-general of the Ministry of Environment, Rural and Maritime affairs (water, quality and environmental protection, sustainable development and rural affairs).

Source: OECD (2015d), *Water Resources Governance in Brazil*. OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264238121-en ; OECD (2011), *Water Governance in OECD Countries: A Multi-level Approach*, http://dx.doi.org/10.1787/9789264119284-en.

Data and information gaps

Chile has made important efforts to produce its Water Atlas, which provides an overall picture of the stock of water resources but, in general terms there are still data and information gaps on water resources management and planning that hinder decision making. Raw data is dispersed among a wide range of sources, which include the public sector, water operators, agricultural users and industry (i.e. mining and others). Often, the government has to provide estimates and, at the same time, misses basic indicators such as abstraction rate by use or the household drinking water consumption rate in rural areas. In particular, the Ministry of Agriculture reports that there is a need to improve measurement of water demands in the agricultural sector as currently volumetric abstraction is measured through water rights. Water rights in Chile are often not used entirely and there are also situations where users go over their assigned amount of water. The lack of enforcement and monitoring of water abstractions, both from surface and groundwater sources, hinders the exact measurement of water volumes for agriculture. In addition, there is little data online in workable format, and time series tend to be limited. A final concern is the inconsistencies, or the lack of convergence, between official sources of data and those produced by the private sector, in addition to the fact that the information produced with existing data does not always serve to guide decision making.

Chile is already taking action to address its information gap, but further progress is needed. These steps include the action guidelines produced by the Presidential Delegate in the document entitled "National Water Resources Policy", particularly those aimed at improving the country's water information system (Box 5.8). However, there has been no specific follow-up on the implementation of these action guidelines. More can be done to improve data production and the use of data to inform water resources planning and management processes. International standards and data quality measures implemented in OECD countries could serve as a compass to guide Chile.

Box 5.8. Provision on information systems in the Presidential Delegate's "National Policy for Water Resources" document

The National Policy acknowledges that access to clear and precise water-related information is critical for evidence-based decision making by both institutions and private water users. In particular, it calls for the following actions:

- establish an integrated National Public Water Resources Information System
- strengthen the role of the DGA in information systems, so that they are capable of implementing a complete public stock of water, with temporal reliable time series and updated data, and complete the water rights record, which is currently incomplete
- modernise and expand the programme of river gauges, rainwater meters, groundwater monitoring systems, reservoir level meters and quality measurements
- ensure private actors share water-related information by placing incentives through collaboration agreements
- develop a national research agreement between public and private actors, including universities, technological centres, WUOs and others, with the objective of enhancing water-related information and developing new information and technologies.

Source: Government of Chile (2015), "National Water Resources Policy 2015", www.interior.gob.cl/media/2015/04/recursos_hidricos.pdf.

An overview of water infrastructure gaps in Chile

The following sections capture the most prominent gaps in Chile's water infrastructure as measured against international standards. The types of water infrastructure analysed in this Chapter include: i) water supply and sanitation services, both in urban and rural areas; ii) infrastructure for non-conventional water sources; and, iii) irrigation and water resources infrastructure.

Water and sanitation services

Table 5.2. Access to water and sanitation services, 1990 and 2015

	Drinking water coverage					
	Urban (%)		Rural (%)		Total (%)	
	1990	2015	1990	2015	1990	2015
Piped onto premises	98	100	38	93	88	99
Other improved source	1	0	10	0	2	0
Other unimproved	1	0	25	7	5	1
Surface water	0	0	27		5	
	Sanitation coverage estimates					
	Urban (%)		Rural (%)		Total (%)	
	1990	2015	1990	2015	1990	2015
Improved+Shared facilities	91	100	53	91	85	99
Other unimproved	5	0	41	8	10	1
Open defecation	4	0	6	1	5	0

Source: WHO/UNICEF (2015), Join Monitoring Programme for Water Supply and Sanitation (database). https://www.wssinfo.org/documents/?tx_displaycontroller[type]=country_files.

As an OECD country, Chile is close to universal coverage of drinking water supply and sanitation, but has some important territorial disparities, in particular between rural and urban areas. The Joint Monitoring Programme (led by the World Health Organization and UNICEF) estimated that Chile reached 99% access to improved water sources and sanitation facilities in 2015 (Table 5.2). However, while in urban areas access to improved drinking water and sanitation services is 100%, in rural areas drinking water coverage in 2015 was 93%, with 91% for sanitation (Table 5.2).

Urban water supply and sanitation

Water services in urban areas are delivered by private concessions and regulated by the Superintendence of Sanitation Services (SISS) (Box 5.9). Chile's urban water services, i.e. drinking water supply and wastewater treatment, are in a concessional regime to the private sector, which means that different private utilities are responsible for providing water services under the regulation of the SISS. There are two types of concession regimes in Chile:

- **Concessions assigned for an indefinite time period.** Between 1998 and 2000, the State sold strategic participation of public companies to private water service providers. These private companies bought an important part of the public companies' stake and participated in capital increases. The main public companies where privatised using this scheme, including the service providers in Santiago de Chile and the regions of O´Higgins, Los Lagos and Biobío.

- **Concessions assigned for 30 years**. In 2001, the government decided to change the privatisation scheme by only transferring the private sector the right to exploit and manage water services concessions, and not the property. Rights for exploitation were assigned for 30 years under the agreement of undertaking the necessary investments, particularly in sanitation infrastructure. Under this scheme, between 2001 and 2004 the remaining eight public companies were concessioned to the private sector.

The delegation of urban water services to private providers worked for the expansion of urban sanitation services, which was the government's main goal. Chile restructured its water supply and sanitation services in the 1990s to make up for the backlog of public investment in sanitation infrastructure. Access to sewerage treatment increased from 20.85% to 73.30% between 2000 and 2005 and from 73.30% to 90.59% between 2005 and 2011 (Figure 5.9). In 2014, it is reported that 96.58% of households had access to sewage systems, with primary, secondary or tertiary treatment.

Box 5.9. Superintendence of Sanitation Services

The Superintendence of Sanitation Services (SISS) was established in 1990 as a public, decentralised, regulatory entity with command and control functions for water supply and sanitation services. Its responsibilities include oversight and auditing of service providers, enforcement of norms, control of industrial wastewater discharges and tariff setting. The regulator carries out the following activities:

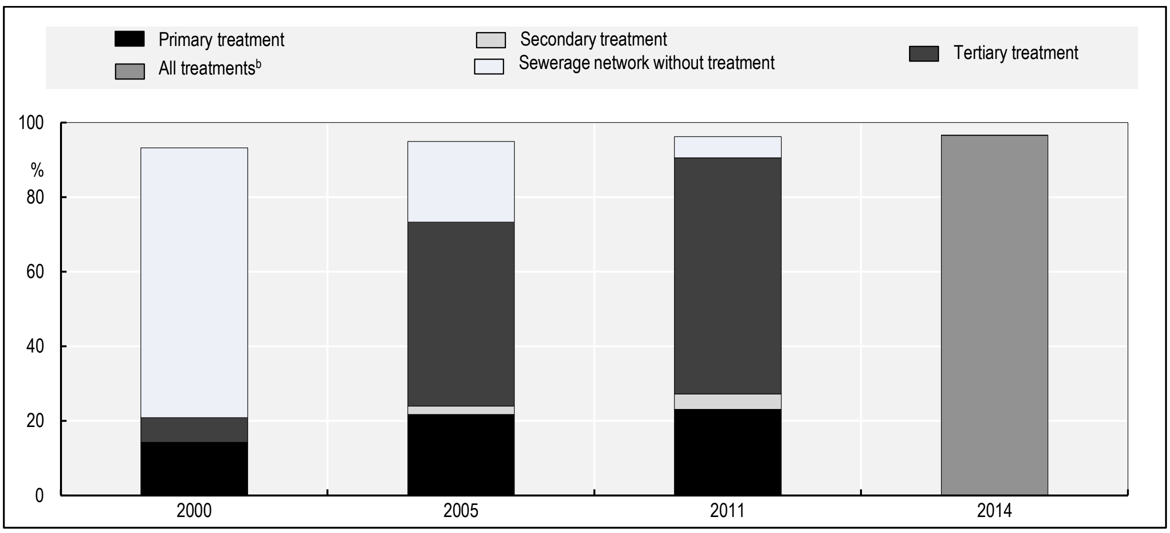
- revise, propose and monitor the implementation of technical norms related to design, construction and operation of WSS
- implement and enforce norms related to tariffs of services delivered by the concessioners, according to the legal tariff framework

Box 5.9. Superintendence of Sanitation Services (*cont.*)

- implement the concessions regime and ensure concessioners' compliance with SISS legal norms and resolutions, and take part in the initialisation, exploitation, transference and extinction phases of the concession regime
- Monitor industrial wastewater discharges, in particular enforcing quality standards
- enforce penalties and sanctions.

Source: SISS (2016), Historia del Sector Sanitario en Chile, www.siss.gob.cl/577/w3-article-3681.html.

Figure 5.9. Evolution of Chile's access to sewerage by percentage of population



Notes: Primary treatment: Physical and/or chemical process involving settlement of suspended solids, or other in which the BOD5 of the incoming wastewater is process reduced by at least 20% before discharge and the total suspended solids are reduced by at least 50%. Secondary treatment: process generally involving biological treatment with a secondary settlement or other process, with a BOD removal of at least 70% and a COD removal of at least 75%. Tertiary treatment: treatment of nitrogen and/or phosphorous and/or any other pollutant affecting the quality or a specific use of water (microbiological pollution, colour, etc.).

Source: OECD/ECLAC (2016), *OECD Environmental Performance Reviews: Chile 2016*, http://dx.doi.org/10.1787/9789264252615-en.

Chile's urban water supply and sanitation challenges are similar to those faced by other OECD countries and mainly relate to the infrastructure upgrade and the renewal needed to sustain current levels of service delivery and water safety. In OECD countries with relatively low GDP per capita, infrastructure development is ongoing and requires investment on the order of 1% of GDP (OECD, 2015a). An OECD survey of 48 metropolitan areas in 2015 showed that over 90% of cities reported ageing or lacking infrastructure as a prominent challenge. The latter can threaten universal coverage of drinking water and sanitation and diminish the capacity to protect citizens against water-related disasters. Similarly to other OECD countries and cities, Chile needs to modernise its facilities to deliver high-quality wastewater treatment. Currently, in Chile the norm that sets the quality of the service (SEGPRES N°90/2000) does not require treatment plants to have tertiary level treatment. Countries which have already raised levels of tertiary treatment include Austria, Germany, Luxembourg, the Netherlands, Spain, Switzerland and the United Kingdom (OECD, 2016). In European cities, this performance is high due to the EU Directive 91/271/EEC on urban wastewater treatment, which sets higher standards than the Chilean norm.

Selected benchmarks

Water infrastructure gaps are not easy to assess in general, as water systems are complex structures that depend not only on the "quantity" of infrastructure, but also on the type of infrastructure, its quality, its location, and how is it managed. Moreover, there is an overall lack of indicators for many types of infrastructure. For instance, there are no indicators for rainwater systems, green infrastructure, or natural infrastructure (i.e. ecosystem services). To assess the performance of this type of infrastructure there is a need to conduct individual cost-benefit analyses. For instance, a rainwater system is adequately designed and managed if it prevents flooding in a city and therefore saves losses to citizens and businesses. Ecosystem services can help improve water quality, protect from flooding and increase water availability by recharging aquifers.

Ageing water networks have negative impacts in terms of efficiency and generate failures to deliver the service. The indicator used to measure efficiency levels in urban water supply systems across OECD cities is water loss. Another indicator that has been used by the SISS to evaluate the quality of a network is the number of pipelines breaks every 100 km. Leaking pipes generate additional costs, both in environmental (more freshwater is used and lost, and some wastewater returns to the environment untreated) and financial terms (through the opportunity cost of leakage and the cost of treating water that leaks before it reaches the consumer, thereby increasing the unit treatment cost). In Chile, the future availability of water resources is predicted to decrease due to the effects of climate change, presumably driving up the future value of water, which could make further improvement of infrastructure efficiency more cost-effective (OECD, 2016).

In the following section, Chile's largest metropolitan areas are compared to equivalent cities in terms of water loss[7] and domestic consumption (Table 5.3). Chilean metropolitan areas are defined using the OECD definition of Functional Urban Areas (FUAs)[8], which are not bound by administrative boundaries of cities, but rather defined according to where people work and live (using commuting flows). According to this definition, Chile has 26 FUAs that altogether encompass 100 municipalities. In the case of Chile, FUAs included the large metropolitan area of Santiago de Chile (above 1.5 million), the metropolitan areas of Concepción and Valparaíso are (between 500 000 and 1.5 million), and the medium-sized urban areas of Coquimbo and Antofagasta (between 200 000 and 500 000)[9].

Table 5.3.Clustering of benchmarked cities by size

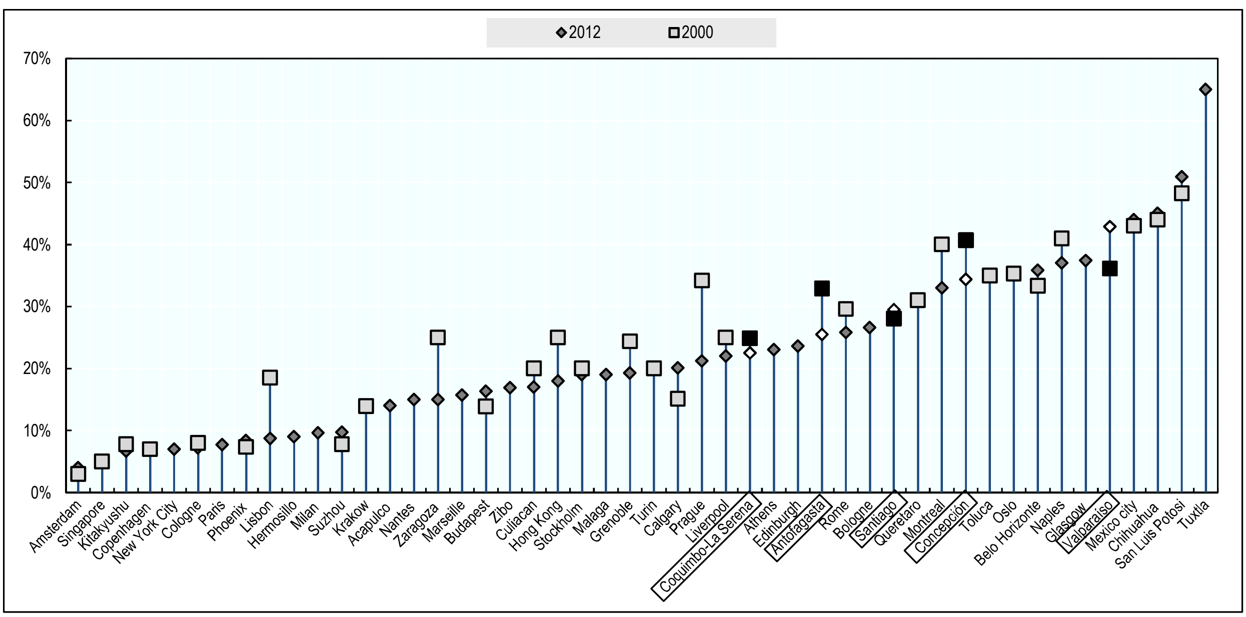
No. of inhabitants	Cities
More than 5 million	Mexico City, New York City, Paris, Hong Kong, Rio de Janeiro, Singapore, Santiago de Chile
Between 1.5 and 5 million	Amsterdam, Athens, Barcelona, Belo Horizonte, Budapest, Daegu, Lisbon, Marseille, Milan Montreal, Naples, Phoenix, Rome, Suzhou, Zibo.
Less than 1.5 million	Acapulco, Bologna, Calgary, Chihuahua, Cologne, Copenhagen, Culiacan, Edinburgh, Glasgow, Grenoble, Hermosillo, Kitakyushu, Krakow, Liverpool, Malaga, Nantes, Okayama, Oslo, Prague, Queretaro, San Luis Potosi, Stockholm, Turin, Toluca, Tuxla, Veracruz, Zaragoza, Valparaíso, Concepción, Antofagasta, Coquimbo-La Serena

Source: Based on Total Population of the urban core of the functional urban area (OECD, 2012b) and data provided by surveyed cities from non-OECD countries.

Water losses in Chile's major cities are higher than in most peer cities. Valparaíso (42.9%) performs slightly better than Mexican cities such as Tuxtla (65%) San Luis Potosi (50.9%), Chihuahua (45%) and Mexico City (44%), which feature at the bottom of the ranking. The city of Concepción also registers relatively high levels of water losses (34.4%), similar to Belo Horizonte (35.8%), Oslo (35.3%), Toluca (35%) and Montreal (33%). Santiago, with a share of 29.5%, has a higher rate than equivalent metropolitan areas such as Rome (25.8%), Hong Kong (18%), Milan (9.6%) and Paris (7.7%). It is worth noting that Antofagasta (25.5%) and Coquimbo-La Serena (22.5%) have the lowest rates out of the five Chilean metropolitan areas studied (Figure 5.10).

The evolution of water leakage differs across Chile's metropolitan areas. In Valparaíso, water losses increased from 36.2% to 42.9% between 2000 and 2012, and in Santiago from 28.1% to 29.5% in the same period. Valparaíso registered the largest increase in water losses among cities that provided data for years 2012 and 2000 (Figure 5.11). However, Coquimbo-La Serena, Concepción and Antofagasta have managed to reduce these losses in absolute terms: 2.3%, 6.3% and 7.4%, respectively.

Figure 5.10. Water losses in selected OECD and non-OECD cities



Notes:

1) from the surveyed cities: Budapest (data 2013); Liverpool (2012 figure is actual loss for Liverpool. 2000 and 1990 values are based on UU's regional data); Singapore (unaccounted-for-water: PUB monitors the UFW which comprises two components i.e. real losses [leakage] and apparent losses [metering]).

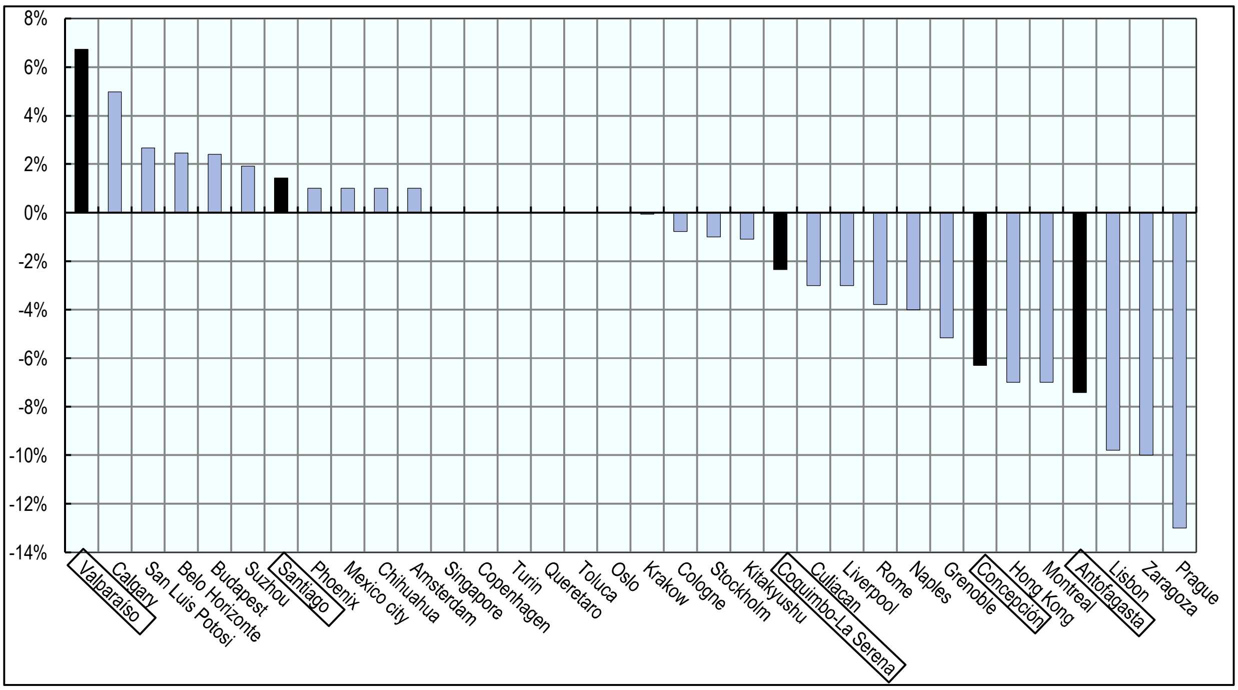
2) for Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for water losses. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central , Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango, San José de Maipo), Valparaíso (Viña del Mar, Valparaíso, Quilpué, Villa Alemana, Concón, Limachean), Concepción (Concepción, Talcahuano, Chiguayante, Coronel, San Pedro de la Paz, Tomé, Penco, Hualqui).

3) Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016); and OECD (2016), Water Governance in Cities. DOI: http://dx.doi.org/10.1787/9789264251090-en.

The economically optimal level of water losses in municipal networks is estimated to be on average between 10% and 20%, depending on the nature of individual systems (OECD, 2016a). The optimal level of leakage is reached at the point at which the cost of reducing it further is equal to the benefit gained (OECD, 2016). The value of water per unit is expected to rise in Chile due to the decrease of water availability in water-stressed areas. A more efficient network could thus contribute to saving water and increasing availability.

Figure 5.11. Evolution of water losses from 2000 to 2012



Notes:

1) from the surveyed cities: Budapest (data 2013); Liverpool (2012 figure is actual loss for Liverpool. 2000 and 1990 values are based on UU's regional data); Singapore (unaccounted-for-water: PUB monitors the UFW which comprises two components i.e. real losses [leakage] and apparent losses [metering]).

2) for Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for water losses. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central , Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango,San José de Maipo), Valparaíso (Viña del Mar, Valparaíso, Quilpué, Villa Alemana, Concón, Limachean), Concepción (Concepción, Talcahuano, Chiguayante, Coronel, San Pedro de la Paz, Tomé, Penco, Hualqui).

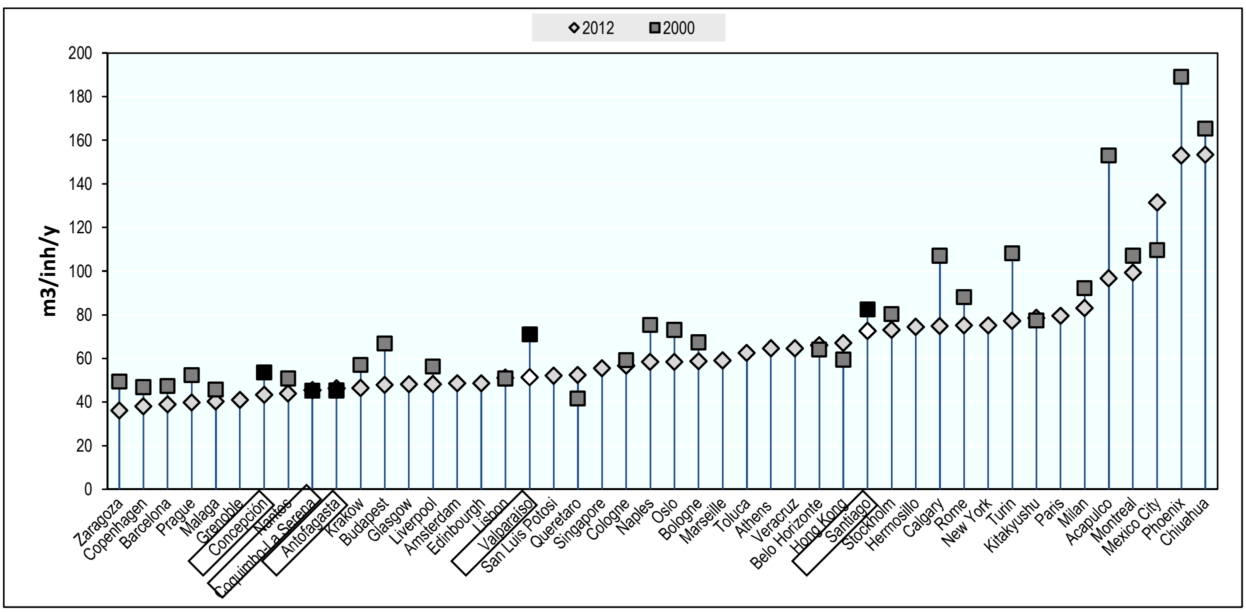
3) Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016); OECD (2016), Water Governance in Cities. DOI: http://dx.doi.org/10.1787/9789264251090-en

The average number of breaks of the Chilean urban water supply system was 20.9 (breaks) every 100 km in 2015 (SISS, 2015). The number of breaks differs greatly across water services providers in Chile recording a highest value of 34.6 breaks every 100 km and a lowest value of 0 breaks every 100 km (SISS, 2015). Based on international studies, SISS's Water Services Management Report (2014) argues that 40 breaks or more every 100 km indicates that the network is in a poor state, networks with 20 to 39 breaks have acceptable level of breaks, and networks below 20 breaks every 100 km have high standards.

Chilean cities are among the lowest domestic water consumers when compared with cities of similar size (Figure 5.12). Considering 2012 data, Concepción (43.21 m^3/inh/year), Coquimbo-La Serena (45.44 m^3/inh/year), and Antofagasta (46.25 m^3/inh/year) are among cities with the lowest domestic water consumption of the sample surveyed. Consumption levels in these three cities are similar to those in Malaga, Grenoble, Nantes and Krakow. Valparaíso (51.36 m^3/inh/year) also ranks among the cities with the lowest levels within its category. Santiago is a step higher in household water consumption (72.6 m^3/inh/year), equalling more or less other large metropolitan cities such as New York, Paris and Hong Kong.

Figure 5.12. Domestic water consumption per capita, 2012 and 2000



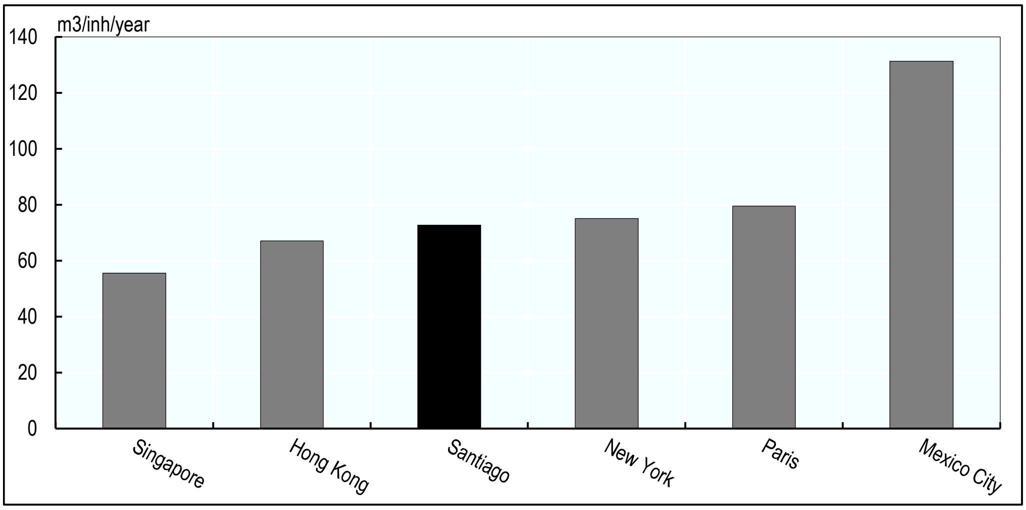
Notes:

1) for Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for domestic water consumption. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central, Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango,San José de Maipo), Valparaíso (Viña del Mar, Valparaíso, Quilpué, Villa Alemana, Concón, Limachean), Concepción (Concepción, Talcahuano, Chiguayante, Coronel, San Pedro de la Paz, Tomé, Penco, Hualqui)

2) Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016); OECD (2016), Water Governance in Cities,. DOI: http://dx.doi.org/10.1787/9789264251090-en.

Figure 5.13. Domestic water consumption in large metropolitan areas, 2012



Notes:

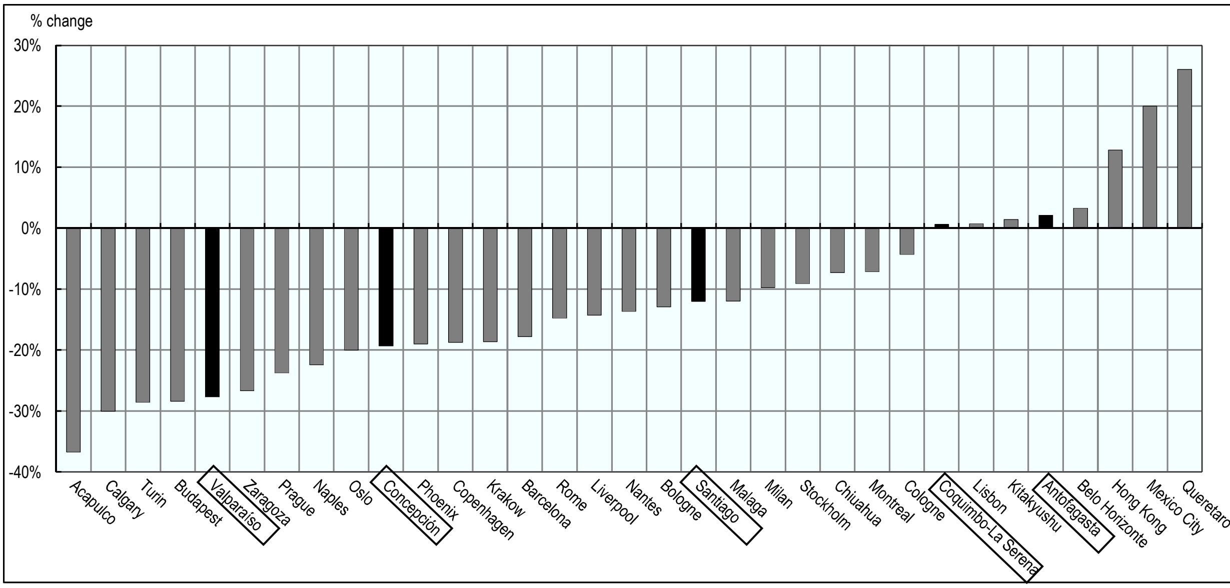
1) for Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for domestic water consumption. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central, Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango, San José de Maipo)

2) Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016); and OECD (2016), Water Governance in Cities. DOI: http://dx.doi.org/10.1787/9789264251090-en.

Trends in domestic water consumption differ across Chile's largest cities. Between 2000 and 2012, Santiago reduced domestic water consumption from 82.55 to 72.60 m^3/inh/year. During the same period, Concepción and Valparaíso also lowered consumption from 53.58 m^3/inh/year to 43.21 m^3/inh/year and from 71.04 to 51.36 m^3/inh/year, respectively. In terms of percentage change, Valparaíso registered the largest fall in consumption (-27.70%), followed by Concepción (-19.36%) and Santiago (-12.05%). In Coquimbo-La Serena and Antofagasta changes in domestic water consumption since 2000 have been minimum – with an increase of 0.64% and 2.10%, respectively.

Figure 5.14. Domestic water consumption per capita, percentage change 2000-12

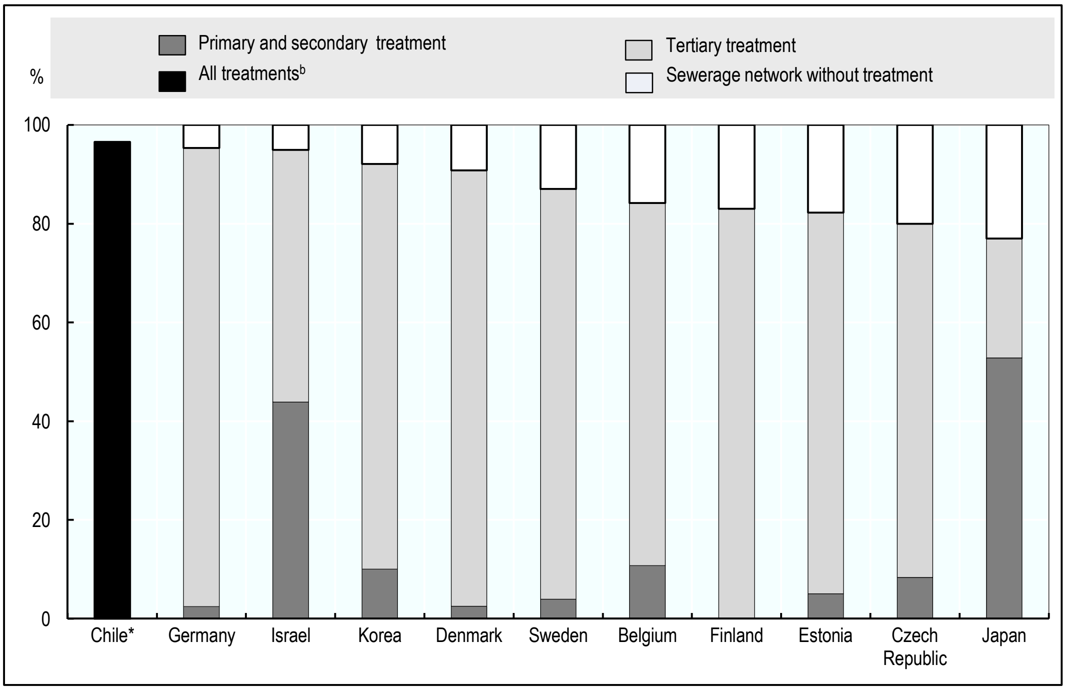


Notes: For Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for domestic water consumption. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central, Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango,San José de Maipo), Valparaíso (Viña del Mar, Valparaíso, Quilpué, Villa Alemana, Concón, Limachean), Concepción (Concepción, Talcahuano, Chiguayante, Coronel, San Pedro de la Paz, Tomé, Penco, Hualqui); Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016); and OECD (2016), *Water Governance in Cities*, http://dx.doi.org/10.1787/9789264251090-en.

Urban sanitation services are assessed in terms of the quality of wastewater treatment. The challenge OECD countries face, including Chile, is no longer related to access to sanitation services in urban areas, but rather the quality of the water resulting from the treatment process. The greater the quality of the treatment, the more opportunities arise to reuse the treated water. This reuse contributes to better efficiency of the water supply and can drive the tariff cost down. This recycling can be for alternative uses with less stringent water quality demands (e.g. watering gardens, cleaning streets, irrigation etc.). Chile ranks among the countries in the OECD with the highest access to sewerage systems with some level of treatment (96%) (Figure 5.15). However, the SISS 2015 Water Services Management Report indicates that a total of 37% of the country's wastewater treatment plants (109) are considered "vulnerable". This implies that these plants are at risk, as they are operating close to their design limit, if not beyond. These limitations encompass both hydraulic capacity and organic treatment capacity, with excess therefore putting companies at risk of non-compliance with quality standards, which can eventually result in negative externalities such as bad smells (SISS, 2015). Wastewater treatment in Chile is not as high in quality as in other high-level income OECD countries. While in the Netherlands, Germany, Denmark and Sweden the share of tertiary treatment was above 80% in 2011, in Chile it is lower (63% for the same year) (Figure 5.16).

Figure 5.15. Access to sewerage and type of treatment in selected countries, 2013 or latest available data

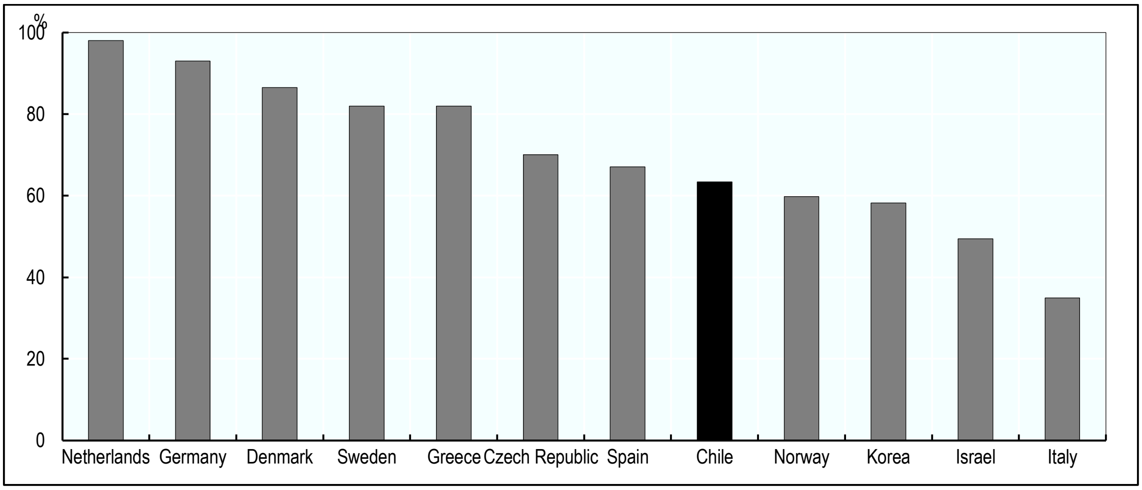


Note: Chile's data is for year 2014 and there is no disaggregation by treatment type. All percentages are calculated with respect to total country population.

Source: OECD (2015e), Access to sewerage and type of treatment, OECD Environment Statistics (database). http://stats.oecd.org/ OECD (2014a), Historical population data and projections statistics (database), http://stats.oecd.org/

Access to sewerage varies across Chile's largest cities, from 99.90% in Antofagasta, 98.74% in Coquimbo-La Serena and 98.59% in Santiago de Chile, to 93.91% in Concepción, where significant progress was achieved between 2000 and 2012 (Figure 5.17). The metropolitan area of Santiago de Chile registers the largest variability among its municipalities in terms of access to sewerage, especially in low income municipalities such as San José de Maipo (43.80%), Lampa (70.40%) and Calera de Tango (52.70%) (Figure 5.18).

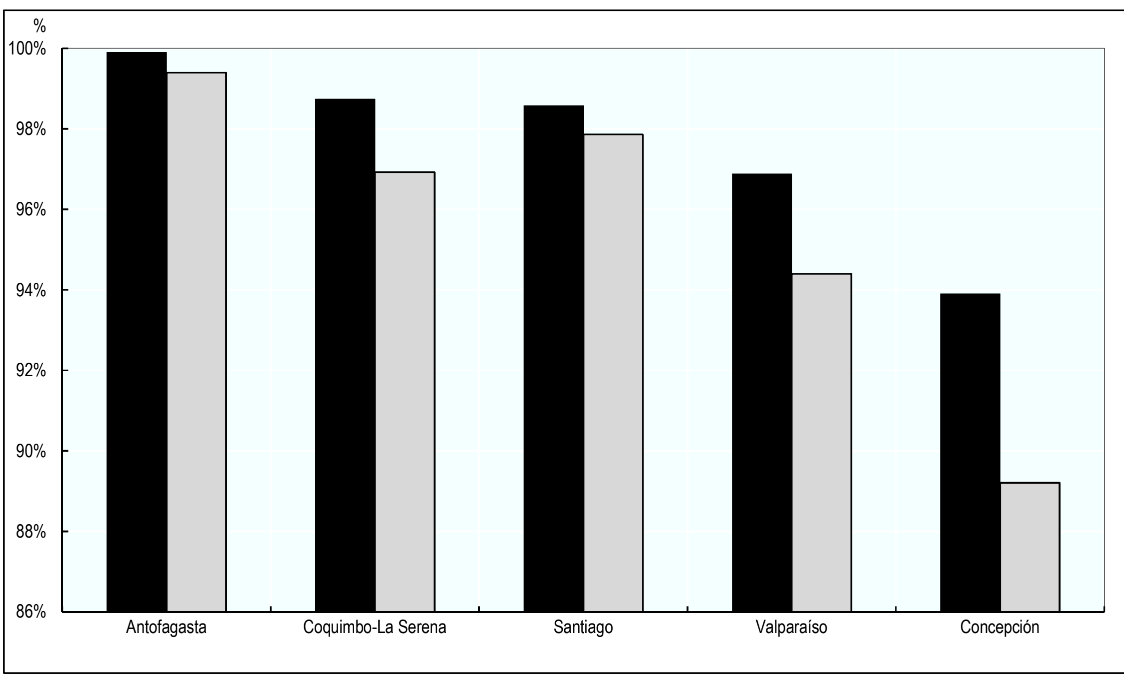
Figure 5.16. Tertiary Treatment in selected countries, 2011



Note: Data for Netherlands and Germany is for 2010 and for Spain and Italy for 2012. All percentages are calculated with respect to total country population.

Source: OECD (2015e), Access to sewerage and type of treatment, OECD Environment Statistics (database), http://stats.oecd.org/

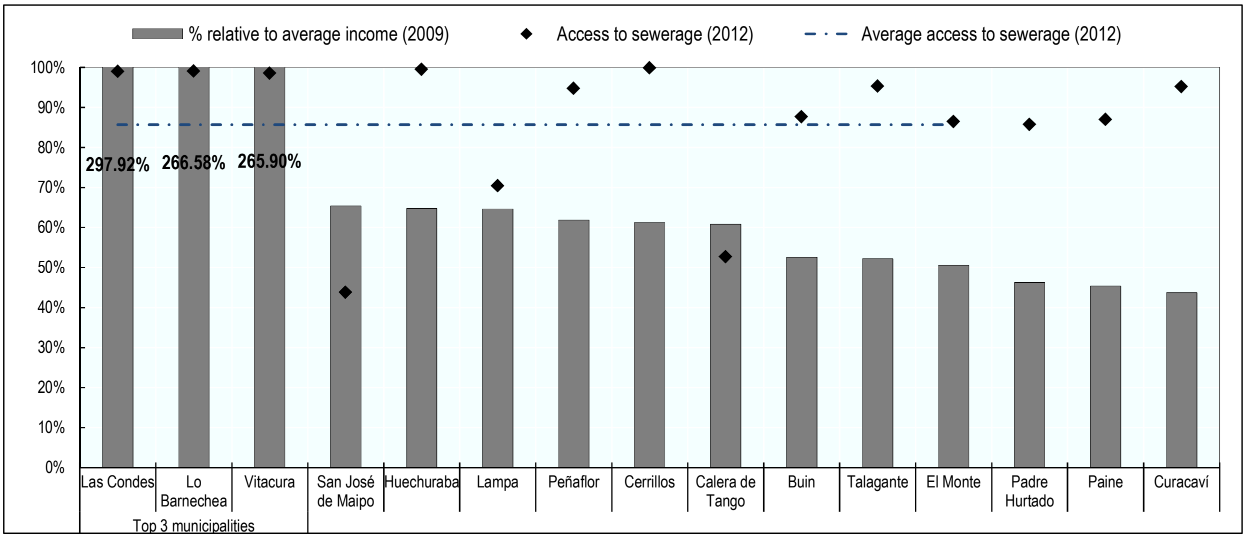
Figure 5.17. Selected FUAs' access to sewage systems in Chile



Note: for Chile's metropolitan areas data is aggregated for municipalities within the Functional Urban Areas and with available data for domestic water consumption. Santiago de Chile (Maipú, Gran Santiago, Las Condes, Estación Central, Colina, Lo Barnechea, Huechuraba, Vitacura, Peñaflor, Talagante, Buin, Cerrillos,Paine, Lampa, Padre Hurtado, Isla de Maipo, El Monte, Curacaví, Calera de Tango,San José de Maipo); Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016)

Figure 5.18. Income and access to sewerage, selected municipalities in Santiago FUA, (2012)



Note: Data corresponds to percentage of population served by urban water operators with respect to total population living within the area covered.

Source: Ministry of Public Works (2016c). Official statistics provided in the OECD Questionnaire for this report: Data Request on Water in Chile (2016)

Addressing Chile's urban water and sanitation infrastructure gaps

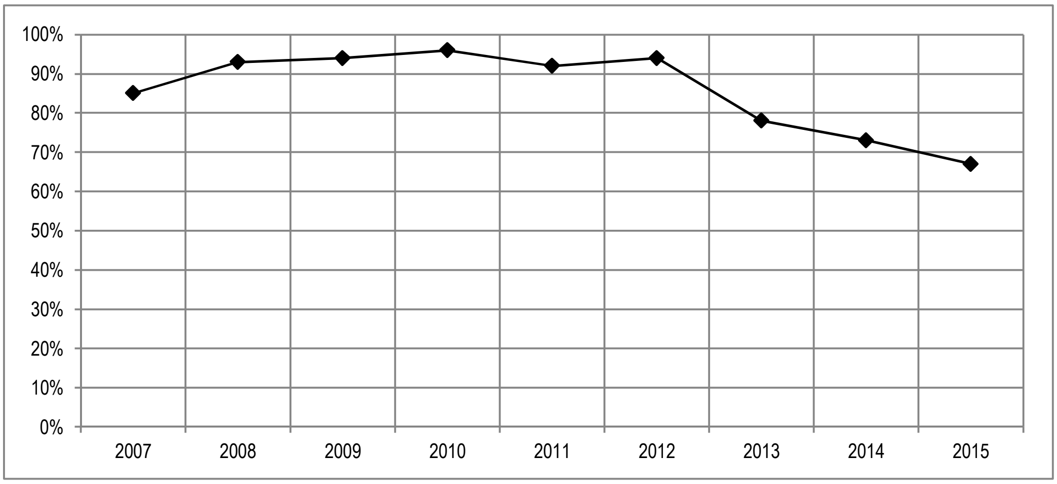
In its 2015 Water Services Management Report, the SISS also highlights the need for infrastructure renewal in certain areas of the water supply and sanitation networks. It is currently estimated that 40.4% of the water supply network in Chile was constructed of asbestos cement between 1950 and 2000 and has an estimated life span of 40 years, if maintenance activities are done regularly and effectively (SISS, 2015). This implies that a great part of the network must be closely looked at, and the same holds true for sewage systems constructed of pre-stressed concrete or cement. Moreover, some drinking water supply pipes that are over 60 years old and will require a specific diagnosis and, when needed, replacement (SISS, 2015). In 2015, the replacement rate was reported to be 0.32%, which implies that it would take 312 years to renew the entire network if such a rate remains constant (SISS, 2015). The current level of breakage rate (20.8 breaks per 100 km) could increase if the replacement rate remains constant. Thus, it is necessary to increase the monitoring ageing pipelines and pay closer attention to drinking water supply networks with higher breakage rate, which according to SISS 2015 data varies across concessions from 34.6 to 0.0 per 100 km of pipes.

It is not clear now how Chile will face renewing and modernising urban water services to ensure an efficient and effective system that is up to the standards of developed countries. The execution of investment plans to renew water supply infrastructure by private concessions in Chile has decreased during the last 3 years. Investment plans are agreed upon and negotiated between SISS and private concessions, and failure to comply with them can entail penalties. Between 2007 and 2010, private concessions carried out an average of over 90% of planned investments. This is reported to be due to the strong monitoring and enforcement of penalties and fines carried out by

SISS during that period (SISS, 2015). However, starting in 2012, the percentage of executed investments during the fiscal year (i.e. natural years)has been decreasing, and on average private concessions executed less than 70% of planned works each year (Figure 5.19). It is

worth noting however that there is currently no mechanism whereby delayed investments executed at a later stage of the plan period are reported in the following fiscal years

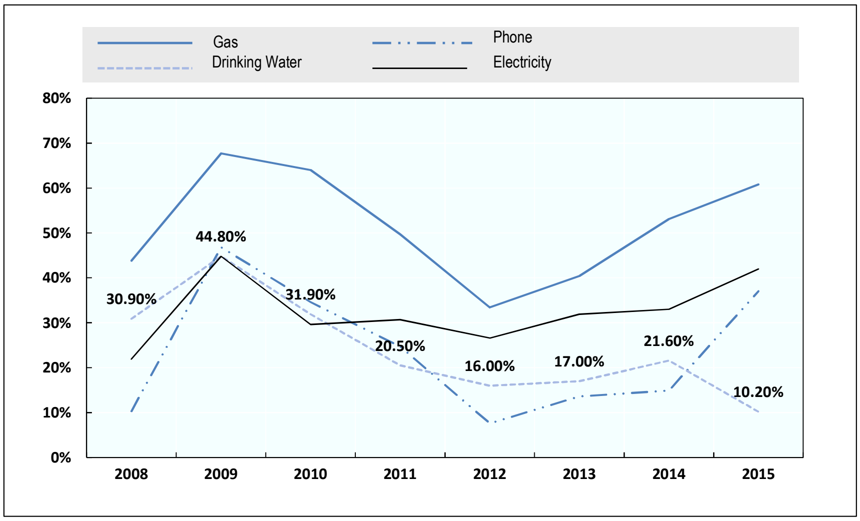
Figure 5.19. Execution of investment plans (%) by private concessioners in Chile, 2007-15



Source: SISS (2015), Informe de Gestión del Sector Sanitario 2015, www.siss.cl/577/articles-15784_inf_gest.pdf.

Perception surveys, which have been conducted by the SISS on a yearly basis since 2008, show that users are becoming less satisfied with water services. Since 2009, there has been a decline in the score given by users to drinking water services, which reached its lowest level in 2015 (10.2%) (Figure 5.20). According to the SISS survey, other basic services, such as gas, phone and electricity registered higher scores in 2015 (60.8%, 37.0% and 42.0%). This low level of users' satisfaction for drinking water supply in Chile is likely due to deficits in quality and quantity. Other studies, such as ProCalidad, show some differences with respect to the surveys conducted by SISS. For example, in the ProCalidad survey, which uses a different interviewing methodology (but the same scoring system: "net satisfaction"), electricity (38%) and internet (20%) services are not better ranked than water services (42%) (ProCalidad, 2017). Furthermore, the net satisfaction for phone services (43%) has only one point percentage difference with water services, versus 20 percentage points in the SISS Survey.

Figure 5.20. User Perception Surveys for Gas, Drinking Water, Phone and Electricity, 2008 - 2015



Note: The survey's sample consisted of 10 036 households in the 15 regions which are served by the 27 biggest concessioners in Chile. For each concessioner the sample used had a statistical confidence level of 95% and a sample error of 1%. User perception is measured as "Net satisfaction", which corresponds to the difference between the % of satisfied clients (clients that give grades of 6 or 7) and the % of unsatisfied clients (clients that give grades equal or below 4).

Source: SISS (2017), *User Perception Surveys*, www.siss.cl/577/w3-propertyvalue-3452.html (accessed 7 February 2017).

Investments in water infrastructure are capital intensive, and they can be recovered only over a period of time only. When investing in water infrastructure, seeking the highest value for money is therefore critical. Water loss can be distributed throughout the water supply system, which in big cities means hundreds of kilometres of pipelines, and real-time data is critical to identifying, locating and quantifying the leakage. OECD cities that have managed to improve their water information systems have been more effective at tackling leakages. Two good practices in the OECD area are New York City's plan to replace a portion of a critical aqueduct in the city's water supply system as well as Zaragoza's (Spain) policy to control and monitor leakages, which led to a 40% of reduction of water losses (Box 5.10).

Box 5.10. Fixing the institutions that can fix the pipes in OECD cities

Infrastructure renewal helps to slow the increase of environmental and operative treatment costs of treatment caused by leakages. Improving the information system, flow monitoring and the use of performance indicators related to water losses can also reduce inefficiencies and related environmental and financial costs. In **Zaragoza**, for example, consistent investments were made to reduce and control water loss, including rehabilitation of the pipeline network and pressure management controls. By 2008, losses from the system were reduced by over 40% compared to 1997, leading to yearly water savings of 20 million m^3 (Philip, 2011). Other cities have also significantly reduced water losses since the 1990s (Cologne, Grenoble, Kitakyushu, Lisbon, Liverpool, Montreal, Naples, Oslo, Prague, Rome and Stockholm).

Box 5.10. Fixing the institutions that can fix the pipes in OECD cities (*cont.*)

Since the 1990s, The Department of Environmental Protection (DEP) in **New York City** has been monitoring leaks in a portion of the aqueduct that connects the Rondout Reservoir in Ulster County to the West Branch Reservoir in Putnam County. There are two areas of significant leakage in the Rondout-West Branch Tunnel (RWBT) portion of the Delaware Aqueduct, the Wawarsing and Roseton crossings. Together, they leak approximately 35 million gallons of water per day. In response, the DEP plans to construct a bypass tunnel around the leaking areas in Roseton, which would consist of a new tunnel segment to bypass the leaking section and two shafts at each end. This work was started in 2013 and should be completed in 2023. Once the shafts and bypass tunnel are constructed, the aqueduct would be shut down and unwatered. At s: Chile 2016, OECD Publishing, Paris. DOI: ┴‼ HYPERLINK "http://dx.doi.org/10.1787/9789264252615-en" ¶ http://dx.doi.org/10.1787/9789264252615-en.

OECD/GWP (2015), Securing Water, Sustai

*Source: OECD (2016), Water Governance in Cities,*http://dx.doi.org/10.1787/9789264251090-en; UKRN (2015*), "Innovation in regulated infrastructure sectors",* available at: www.ukrn.org.uk/wp-content/uploads/2016/07/20150112InnovationInRegInfrSec.pdf*;* Philip R. (2011), "Reducing water demand and establishing a water saving culture in the City of Zaragoza"*, Case study:* Zaragoza, Spain, SWITCH Training Kit, www.switchtraining.eu/fileadmin/template/projects/switch_training/files/Case_studies/Zaragoza_Case_study_preview.pdf.

Upgrading Chile's urban water and sanitation infrastructure is a shared responsibility across public and private sectors. Chile has the peculiar challenge that all its urban water supply system is concessioned to private utilities, which has helped improve the efficiency of water and sanitation systems. Although Chile has been successful in mobilising investment for the development of infrastructure thus far, the current challenges that the country faces renewing and modernising infrastructure require new responses. The Chilean government must consider low-cost options, such as investing in information systems to identify and target with better knowledge leakages and problems in the network, and further resort to green and multipurpose infrastructure to make the most of policy complementarities between drinking water and other domains and minimise liabilities for future generations. For instance, the Development Plan for 2015-2029 of Aguas Andinas in Santiago (*Plan de Desarrollo 2015 – 2029 Sistema Gran Santiago*) includes a Plan of Hydraulic Efficiency that has the objective to tackle those segments of the Greater Santiago water supply network that register high unaccounted water losses, i.e. an average of 30%. The plan includes investments in information systems to better identify water losses and, once located in the system, installing equipment to reduce those losses. However, the latter does not imply that no large investments are needed, some systems are ageing and require more capital intensive solutions, but rather that these must be coupled with low-cost infrastructure solutions.

Low-cost alternatives: Natural infrastructure and demand management techniques

Investing in natural infrastructure can contribute to managing risks of too polluted water. There is a general misconception that ecosystem services are only relevant to water users such as the agricultural sector or rural communities. However, ecosystem services are also a valuable part of the stock of facilities, services and equipment needed to ensure water security in cities. For instance, in central Chile, where mining activity has raised copper and salinity levels in some rivers like the Maipo, ecosystem services could help increase water quality and reduce operation costs of water treatment plants. If water abstracted for the drinking water supply is of higher quality, then treatment requirements are lower and there is a lesser need to use chemical processes in treatment plants. This can also drive electricity savings, as treatment processes are shorter. Demand management techniques such as education, raising awareness or reuse of water are also lower cost alternatives than developing large infrastructure. However, they require improvements in resource monitoring and water use databases.

Showcasing the benefits of ecosystem services is important to raise awareness of stakeholders. The use of ecosystems economic valuations is increasing as tested tools for analysis. With ecosystem values in hand, decision makers can then weigh up the costs and benefits of alternate choices for water infrastructure (Emerton, L. and Bos, E., 2014). Moreover, if ecosystem valuations encourage relevant stakeholders to participate, i.e. water service providers, rural communities, agricultural users, better informed and consensus-based decisions can be made. A combination of natural and hard infrastructure can drive more sustainable and climate resilient projects (Emerton and Bos, 2014). Innovative experiments with payment for environmental services were carried out in the city of Quito, Ecuador for example (Box 5.11).

Box 5.11. Mobilise innovative financing for water resource management in Quito, Ecuador

The city of Quito, Ecuador, provides an example of how to make sustainable funding for water resource management. By 2025 the city's population is expected to reach nearly 4 million, increasing the demand for water by almost 50%. The municipal government and NGOs recognised the value of watershed services for the city and provided seed money to form the Water Protection Fund for Quito (FONAG). Water users (agricultural, energy, utilities, etc.) pay a fee to the fund that depends on their water consumption, where the largest share comes from the Quito Water Utility. By 2009 the fund held more than US$ 7 million. Using interest accrued, FONAG pays to protect and maintain ecosystem services. Short term benefits can already be counted, including the conservation of 730 000 hectares, improved water quality and supply for more than 13 million people, 52% of whom are poor, and economic benefits for 1 800 people associated with watershed management and conservation. Long-term (80 year) funding focuses on environmental education, research and watershed conservation.

Source: Smith, M. et al. (2006). *Pay – Establishing payments for watershed services*, http://mtnforum.org/sites/default/files/publication/files/5381.pdf.

Recycling rainwater and greywater are good options for water savings, but quality standards need to be set to avoid health-related issues (OECD, 2016) (Box 5.12). For the reuse of wastewater, a precondition is that urban and rural sewage and the treatment of effluent is of high enough standards to preserve the quality of water sources. The technical choices of treatment are defined according to the intended uses of such water, which could be direct outfall to rivers to maintain water levels, irrigating green spaces, cereal crops, tree planting, coolants for industry or aquifer replenishment (GWP, 2012). The development of wastewater reuse depends greatly on the pressure on resources and the costs (especially energy costs), and on how they compare with those of primary sources of water resources.

Box 5.12. Water reuse in Singapore

In 2003, the Public Utilities Board (PUB), Singapore's national water agency, introduced NEWater as one of Singapore's Four National Taps.[1] It is high-grade reclaimed water produced from treated used water that has undergone stringent purification and treatment process using advanced dual-membrane (microfiltration and reverse osmosis) and ultraviolet technologies. It has passed over 130 000 scientific tests and exceeds the drinking water standards set by the World Health Organisation and the US Environmental Protection Agency. NEWater is used primarily for non-potable industrial purposes at wafer fabrication parks, industrial estates and commercial buildings. During dry months, NEWater is used to top up the reservoirs and blended with raw water before undergoing treatment at the waterworks and then being used for the drinking water supply.

Box 5.12. Water reuse in Singapore (*cont.*)

Prior to the development of NEWater, Singapore had to rely heavily on local catchments and imported water from Johor in Malaysia as its key water sources. However, these two traditional sources are weather-dependent. While reclaiming used water is not a new concept, what is significant for Singapore is the wide-scale implementation and widespread public acceptance of NEWater for indirect potable use. This is part of an overall strategy to raise awareness among the population, stressing a new approach to water management by communicating to the public the need to look at water as a renewable resource that can be used over and over again. The price of NEWater is cheaper than that of potable water, and this has encouraged many industries to switch to NEWater. Strict enforcement of used water discharge also plays an important role in ensuring that water reclamation plants are able to function as designed and to supply part of the treated effluent to the NEWater plants. Water reclamation technology is relevant to other water-scarce regions. From an energy perspective, it uses about one quarter of what desalination would require. It is from this perspective that NEWater holds tremendous promise for developing cities.

1. The other three are local catchment water, imported water and desalinated water.

Source: OECD (2016), *Water Governance in Cities*, http://dx.doi.org/10.1787/9789264251090-en.

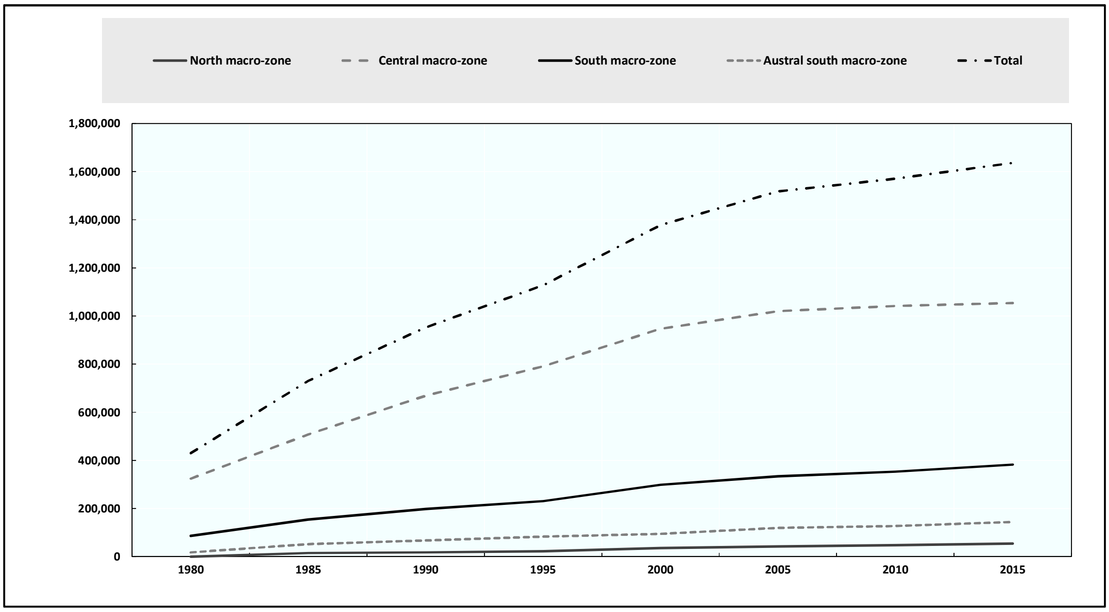
Rural water supply and sanitation services

Chile has engaged in significant efforts over the last few decades to foster access to water supply and sanitation in rural areas. Although sewage and wastewater treatment infrastructure partly exist in rural Chile[10], evaluating the percentage of the population covered in dispersed settlements is a daunting task. Official sources report that this is the most pressing challenge in Chile’s rural water programme. The Rural Drinking Water Programme (APR Programme) has been active since 1964, and it has been operated by the Under-Directorate of Rural Drinking Water within the DOH since 2011. The DOH delivers rural water services infrastructure, but citizens benefitting from the APR Programme are responsible for managing, operating and maintaining the systems through an APR Committee or co-operative. However, co-operatives and committees do not always have the necessary resources to cover the operation and maintenance costs of infrastructure, which is why DOH dedicates parts of its APR Programme budget to improving, renewing, expanding and maintaining the networks.

The results of the APR Programme in terms of access to drinking water supply have been noticeable. When the programme started back in 1964, coverage of drinking water supply in rural areas was marginal, around 6%, whereas currently over 93% of the rural population has access to improved water sources (Government of Chile, 2016). Since 1980, the total served population by this programme has increased from 400 000 people to over 1 600 000 (Figure 5.21). The two macro-zones with the most beneficiaries of the APR programme are the Central Macro-zone, with over one million people, and the South Macro-Zone, accounting for close to 400 000 people (Figure 5.21).

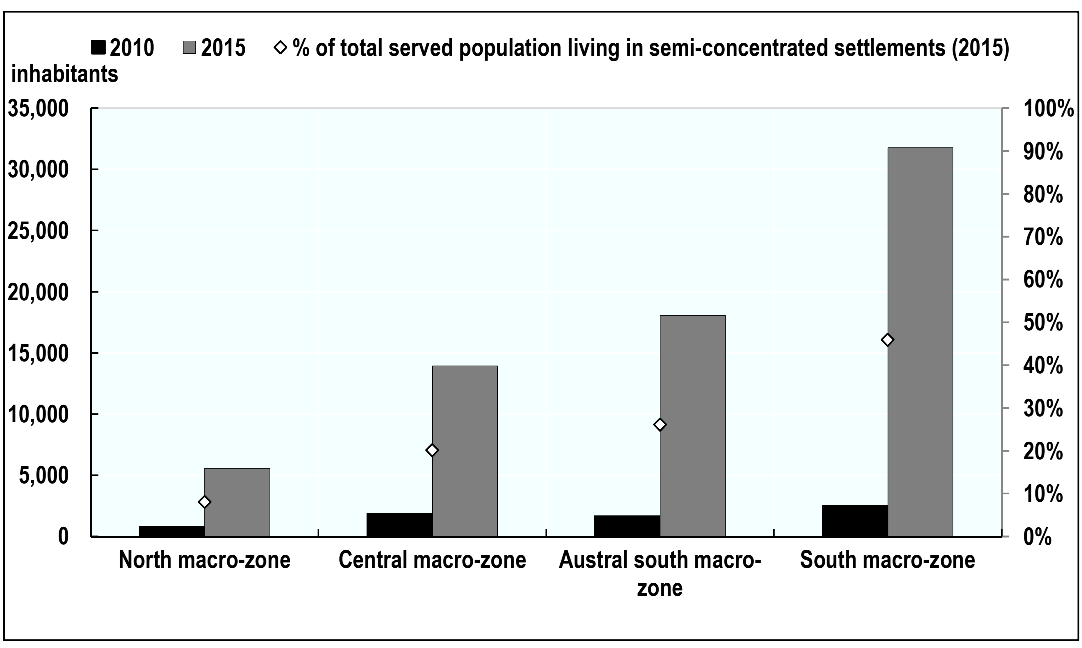
In 2015, the Chilean government reported that while concentrated rural communities have overall access to drinking water, sparsely populated areas still struggle to access basic water services. The APR Programme has been successful in securing access for the largest rural settlements, 100% of which are reported to have access to drinking water (Government of Chile, 2016), but there are still significant challenges in small or more disperse rural settlements (Figure 5.22).

Figure 5.21. Total rural population served in Chile, by macro-zone



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile".

Figure 5.22. People in sparsely populated areas served by APR



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile".

The renewed challenge to the APR programme is to secure access for the population living in semi-concentrated and disperse areas. Whereas in semi-concentrated areas traditional rural water systems might still be effective, in disperse agglomerations there will be a need to introduce innovative systems. The costs of these are presumably higher, and they serve fewer people than in semi-concentrated areas, which could make it challenging for projects to meet the criteria of the social evaluation methodology established by the Ministry of Social Development (DIPRES, 2015). The social evaluation methodology ensures that only projects that generate a minimum social return, i.e. in terms of economic or social outputs, receive funding from the Ministry of Economy, which means that it does not prioritise infrastructure in remote regions, given that the cost-benefit ratio of delivering rural water services in semi-concentrated and disperse settlements is smaller than in concentrated settlements. Therefore, such projects would not easily meet the criteria of the social evaluation methodology and qualify for funding. This could stand in the way of the APR's goal of providing rural water services to semi-concentrated and disperse settlements. Chapter 2 proposes ways forward for the revision of the social evaluation methodology that Chile could implement as it faces its renewed infrastructure challenges. These methods might consist of complementing cost-benefit analysis with a multi-criteria analysis framework that can be used to accommodate more long-term goals, strategic issues, and to improve alignment with broader policy priorities.

The Budget Directorate (Dirección de Presupuesto, DIPRES) evaluation report (2015) highlights noticeable damage and ageing of APR systems, creating obstacles to the reliability of the quality and quantity of water supply. Between 2011 and 2014, 22.1% of unexpected maintenance and operation costs arose due to the deterioration of APR systems. This is mainly due to the uneven distribution of technical, financial and managerial skills across different APR committees and co-operatives. Although all committees have the obligation to use planning instruments such as annual financial statements and activity plans, many do not have them in practice (DIPRES, 2015). As a result, over 5% of APR systems did not comply with the water quality standards, and more than 9% of APR systems failed to conduct bacteriological studies.

Insufficient data and information also hinder the efficiency of investments in the APR Programme. There is currently a lack of systematic and comprehensive monitoring of the results achieved by the APR. The DIPRES evaluation points to the difficulty of accessing reliable and complete data and information on the programme to enhance evidence-based decision making on rural investments. DIPRES recommends an expansion of the APR Programme database, incorporating a complete, regularly updated record of executed projects, including the following data in particular: typology of project (installation, enlargement, improvement, conservation and maintenance), start and end dates, costs and number of beneficiaries (population served). DIPRES also recommends promoting strategic planning of investments when targeting semi-concentrated and disperse rural settlements; building capacity, managerial skills and technical knowledge of cooperatives and committees responsible for operating, maintenance and financing of the APR system; and implementing monitoring and evaluation techniques by improving data and information production.

A future objective of the APR Program is to extend access to drinking water and improved rural sanitation services to 560 semi-concentrated settlements that represent 220 000 inhabitants. This should be enabled by the New Law on Rural Sanitation Services adopted in January 2017 with the following objectives:

- strengthen the management capacity of committees and co-operatives, while preserving their participatory component
- establish the rights and obligations of committees and co-operatives, based on the principles of solidarity and non-discrimination as to the rights to access rural water services
- establish and clarify the regulatory functions of the State in rural water services, including the methodology for calculating and revising tariffs for the services
- create an Underdirectorate for Rural Water Services (within the DOH) with the responsibility to develop a policy to support and promote committees and co-operatives' activities
- encourage the participation of the management staff of committees and co-operatives in the to-be-established National and Regional Councils
- incorporate the less densely populated rural areas in the scope of the Rural Water Programme, focusing first on areas with water stress
- incorporate improved rural sanitation services in the scope of the Rural Water Programme, and appoint a technical body to study the best solutions on a case-by-case basis, i.e. to decide between sanitation networks or localised systems.
- involve communities in the decision as to find the best solution.
- reduce fragmentation by having only one water operator per rural settlement for both drinking water and sanitation services.
- Bridging the rural water services gap.

The DOH should conduct regular monitoring of the APR Programme to anticipate supply cuts and the need for costly investments due to infrastructure replacements, and it should co-ordinate with Regional Councils to establish investment priorities. Financing of rural water services in Chile is done through the National Budgetary Law. The MOP provides regional governments with a list of projects and a certain amount of funds, and the Regional Councils (CORE) are in charge of prioritising them. The Rural Infrastructure Funds of the SUBDERE are channelled through the regional governments under DOH's responsibility to supervise the technical execution of the projects. Closer cooperation between the CORE and MOP would help identify dysfunctional or not properly operated or maintained rural water systems, as well as the most urgent investment needs in semi-concentrated and disperse settlements. The National Budgetary Law has provided flexibility for the APR Programme to make investments in small works and enabled CLP 2.5 billion Chilean pesos of investment per year between 2007 and 2011, with a peak of CLP 82 680 million in 2016 (over 400 rural drinking water supply systems registered maintenance works financed with this mechanism) (SAFI, 2017). This mechanism will therefore be key to preventing the collapse of rural water systems. In addition, the MOP could conduct a re-evaluation of the technical standards required for rural water systems to last longer, and it could identify network enlargement requirements in rural settlements with noticeable population growth.

The lessons gleaned from OECD countries' experiences can help in the choice of the right infrastructure to face the challenge of delivering water services to semi-concentrated and disperse settlements. While reflecting on future infrastructure needs, most countries now recognise that large-scale centralised systems may no longer be the optimal solution due to high maintenance costs and resource needs; this holds particular true for rural settlements where small distributed systems make more sense. The expansion of sanitation services within the framework of the Rural Drinking Water Programme is instead built around localised wastewater management systems serving individual or small groups of properties (Box 5.13). They require less upfront investment than larger-scale, centrally piped infrastructures and are more effective at coping with the need to expand services, as it is the current case of Chile.

Box 5.13. Localised sanitation services in OECD countries

Localised water supply and sanitation can be used to serve populations not connected to public systems. Rich countries with large metropolitan areas but low population density, e.g. Australia and the United States, still have significant populations served by private individual or community systems. The situation in Europe is more diverse: the proportion of households not connected to sewers is higher in low-density or low-revenue countries or regions – e.g. Portugal and Spain, southern Italy and Greece, eastern European and Nordic countries, Ireland and even some German *Länders*. In these areas, populations are not yet fully connected to public water systems. Ireland has officially kept a large number of grouped water schemes, providing water to 8% of the population at small community scales (OECD, 2013c).

Localised sanitation systems are not merely a remedy to the limited number 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 are partly – or fully – replacing traditional public systems with decentralised technologies. Paradoxically, these innovations are taking place in the richer and higher-density European States (OECD, 2013c). The performance of localised systems can compare with that of centrally piped infrastructures. For instance, an evaluation of localised systems in Ireland shows that despite difficulties in meeting the standards now imposed at the European level, such schemes sometimes operate better than public water systems, and the population they serve is largely committed to keeping them (Brady and Gray, 2013).

Innovation can contribute to improved performance of localised systems. Research is ongoing to provide communities reliant on individual and community systems with robust and simplified treatment systems, equipped with real-time ICTs, to help set up community services operated from distant centres (e.g. work by Yoram Cohen, UCLA Institute of the Environment and Sustainability). These developments explain the renewed interest for localised, on-site sanitation. The Australian Academy of Technological Sciences and Engineering (ATSE), for example, recommends that Australian governments encourage investment and uptake of such systems (ATSE, 2012).

Source: (OECD, 2013c), Brady and Gray (2013), and ATSE (2012) adapted from OECD (2015a), *Water and Cities: Ensuring Sustainable Futures*. DOI: http://dx.doi.org/10.1787/9789264230149-en.

Rainwater infrastructure

Under the current legal framework, rainwater infrastructure involves multiple players at the national level. According to Law 19.525, adopted in 1997, DOH (under MOP) is in charge of the primary network, while the Ministry of Housing is responsible for the secondary network. Moreover, each urban centre with more than 50 000 inhabitants must design its own master plan, defining the primary and secondary rainwater network of the city. A key fact is that rainwater infrastructure is not included in the concession regime to private utilities in urban areas.

While rainwater infrastructure exists in Chile's main cities, like Valparaíso, Concepción and Santiago, it is not does not function effectively against heavy rain episodes. Given trends in climate change and population growth in urban areas, efficient and effective rainwater collection systems are much needed in Chile. Flooding episodes cause material, human and economic losses. Flood risk from storm water is particularly high in areas where storm-water infrastructure has not been adapted to elevated runoff in creeks coming from mountains, as in Santiago. Urban expansion in the eastern part of

Santiago towards the Andean piedmont has also increased the amount of impermeable surfaces, contributing to increased risks from flood hazards (Romero and Mendoça, 2014). Medium-sized growing cities, such as Valparaíso or Antofagasta, must also consider further developing and maintaining this type of infrastructure in order to prepare for the future.

Urban flooding is a very local issue in water management, which could be under local responsibility considering the current process of decentralisation in Chile. Such a transfer of prerogatives to cities in Chile should go along with new availability of financial resources, either via national transfers from the central government or through the administrative capacity to raise revenues at the sub-national level. Chapter 3 depicts the necessary framework conditions and capacities of subnational administrations to ensure infrastructure investment at subnational level is effective and achieves pre-established objectives. OECD countries such as France have considered a range of options to raise revenue to account for rainwater infrastructure, including fiscal instruments (Box 5.14).

Low-cost alternatives also exist to reduce the impact of an insufficiently developed urban rainwater system, especially urban green infrastructure. As for the case of rural water services, decentralised systems also apply to rainwater drainage. In the OECD area, there is a growing use of "source control" technologies that handle rainwater near the point of generation (OECD, 2015a). For instance, green roofs or pervious surfaces capture rainwater before it runs onto polluted pavements and streets. These solutions have several benefits. First, they help alleviate peak flows: water is captured at the source so it does not run off into the streets and sewer networks, which mitigates the effects of urban floods, as it reduces the probability of experiencing an overflow in the sewer. Second, they help reduce pollution by stopping rainwater from getting polluted while flowing on the streets. Third, these methods can also help improve the quality of water returned to the environment: for instance, pervious surfaces allow rainwater to trickle through the ground and recharge aquifers. Lastly, they help adapt rainwater infrastructure to climate change, since decentralised drainage reduces urban flooding peak flows conveyed through the sewers, which helps alleviate the need for investing on the extension of sewage collection and wastewater treatment infrastructure (OECD, 2015a). Several OECD cities have developed full-fledged strategies to develop urban green infrastructure systems. One of them is San Francisco, which was among the pioneer cities ten years ago where a multilateral agreement was signed among the utilities' association, the city's building agency and the public health department to coalesce efforts in promoting decentralised systems (Box 5.15).

Box 5.14. Financing urban rainwater management 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. Thanks to a dedicated fiscal instrument introduced in 2011, French local authorities have the capacity to set up a new public service dedicated to urban rainwater management, which 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. It is paid by the owner of the land or property when the property is larger than a minimum area set by the local authority. The tax rate is set by the local government and cannot exceed EUR 1 square metre per year (EUR/ m^2/year). It can be reduced, in full or in part, where facilities are in place to reduce run-off. The reduction is meant to reflect the decreased run-off. Several adjacent property owners can join the mechanism if they build and operate a common facility.

Box 5.14. Financing urban rainwater management in France (*cont.*)

This new tax principally aims to create incentives for managing rainwater close to the source and limiting run-off by implementing measures that mitigate the consequences of impervious surfaces. It also aims to raise revenues earmarked for long-term urban rainwater management. In the long term, the revenues generated by the tax are bound to decrease as the objectives are met – a trend that local authorities need to anticipate and factor in. Local authorities have the opportunity when engaging in feasibility studies to reflect on the level of ambition of their urban rainwater management policy and the policy packages (zoning, standards, information, tax, etc.) they wish to implement. Stakeholder consultation should feature prominently in the process.

Source: OECD (2015a), *Water and Cities: Ensuring Sustainable Futures*, http://dx.doi.org/10.1787/9789264230149-en.

Given that floods are becoming more frequent in Chile, and affect households' supply and water quality with important economic impacts due to high recovery costs, a full-fledge strategy to deal with floods is much needed, beyond rainwater systems. Several OECD countries have an excellent track record at dealing with floods or the risk of submersion, such as the Netherlands. The Netherlands' flood protection policy is rooted in the 1950s when the first Delta Committee developed starting points and standards for flood safety, which were laid down in the Flood Defence Structures Act. Currently, the Delta Programme is the main policy instrument aimed at preventing floods (Box 5.16).

Box 5.15 San Francisco's rainwater harvesting

In 2008, San Francisco's Public Utilities Commission (SFPUC), Department of Building Inspection (DBI), and Department of Public Health (DPH) signed a Memorandum of Understanding (MOU) for the permitting requirements for rainwater harvesting systems located within the City and County of San Francisco. The MOU encouraged rainwater harvesting and its reuse for non-potable applications without requiring treatment to potable water standards. It also defined the roles of the participating agencies. Line of actions have included:

- The SFPUC has created and distributed guidance and material on rainwater harvesting. The material covers system design, system components, allowable uses, owner responsibilities, and permitting requirements. The SFPUC has encouraged all rainwater harvesters to notify the SFPUC with the design specifications of their systems for research purposes.
- DBI has issued permits for construction of properly designed rainwater harvesting systems for non-potable uses that meet the minimum criteria described in the MOU and in guidance materials prepared by the SFPUC. DBI has been responsible for the review of permit applications and inspection of rainwater harvesting systems that required permits.
- DPH has reviewed rainwater harvesting projects that propose any residential indoor uses of rainwater other than toilet flushing to assure the protection of public health.

System design, maintenance and use are the responsibility of the system owner. The MOU classified rain barrels and cisterns and defined the allowable uses of harvested rainwater. Water from rain barrels may be used for irrigation and vehicle washing; it is prohibited to connect rain barrels to indoor or outdoor plumbing. Water from cisterns connected to indoor plumbing may be used for irrigation, vehicle washing, heating and cooling, and toilet flushing. If a cistern is not connected to indoor plumbing, it cannot be used for toilet flushing. The MOU also included safety and maintenance requirements, required system components, labelling requirements, and DBI permit requirements.

Source: EPA (2008), Managing Wet Weather with Green Infrastructure, Municipal Handbook: Rainwater Harvesting Policies, available at: https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_harvesting.pdf.

Box 5.16. The Delta Programme

The Delta Programme is a national planning instrument that aims to achieve two priority goals for a country "safe now and in the future": protect the Netherlands against flooding and ensure freshwater supply. It is a joint endeavour between the central government, the provinces, municipal councils and regional water authorities, in close co-operation with social organisations and business. The Delta Programme is implemented through a Delta Act (legislation), a Delta Fund (financial resources) and a Delta Commissioner with ministerial ranking (leadership) The implementation of the Delta Programme consists in a series of short- and long-term flexible projects. The first Delta Programme was presented to the House of Representatives in 2010 and introduced a new flexible approach to water management, based on measurements and scenarios carried out by the Royal Netherlands Meteorological Institute in 2006. The second edition of the Delta Programme was presented in September 2011 with a new important element: the definition of five Delta Decisions, or priority areas for action in flood risk management and freshwater supplies. Building on multi-stakeholder dialogues, and technical calculations and assumptions, these decisions structure the Delta Programme and provide direction for the measures to be taken in the following areas:

- Water safety: updating safety standards and developing regionally oriented safety strategies
- Freshwater strategy: elaborating a strategy for the sustainable supply of freshwater
- Water level management in the IJsselmeer region: a decision regarding the long-term water level management of the IJsselmeer, focused on water safety and freshwater supply
- Rhine-Meuse delta: a strategy for the protection of the Rhine-Meuse delta and solutions for the freshwater supply
- Spatial adaptation: a national policy framework for the (re)development of built-up areas and recommendations regarding flooding and heat stress.

The Delta Act on Flood Risk Management and Freshwater Supplies that came into effect in January 2012 as an amendment to the Water Act is the backbone of the Delta Programme. It mandates a Delta Commissioner, appointed by the government, to lead the Delta Programme and submit a yearly proposal for action to the Cabinet, in consultation with the relevant authorities, social organisations and the business community. This annual report provides an overview of all measures, facilities, studies and ambitions related to flood risk management and freshwater supplies. The Delta Act also enshrines a Delta Fund, separated from the Infrastructure Fund, to finance the implementation of the Delta Programme and related projects and reduce the risk that too much or too little is invested in water safety and freshwater supply. The Delta Fund is split across five budget articles (Arts. 1-5) related to:

- investing in flood risk management
- investing in freshwater supplies
- management, maintenance and replacement
- experimenting
- network-related costs and other expenses.

The Minister of Infrastructure and the Environment bears final responsibility for the expenditures under the Delta Fund. The first official Delta Fund budget was sent to the Dutch House of Representatives together with the third Delta Programme report in 2013. In Budget Day 2016, the House of Representatives received the seventh edition of the Delta Programme, which presents the progress in implementation of the five Delta Decisions as well as other concrete measures for improving flood defence and securing freshwater supply.

Source: OECD (2014b), Water Governance in the Netherlands: Fit for the Future?, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264102637-en.

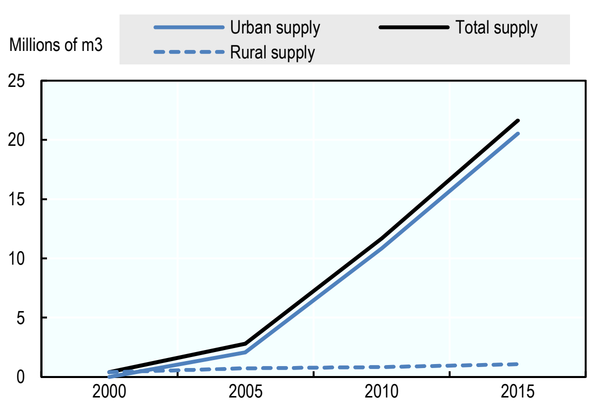
Infrastructure for non-conventional water sources

In Chile, desalination has expanded in the past two decades, mainly in the North macro-zone. Desalination for drinking water supply has developed in the five regions of the North Macro-Zone, where it increased by 2 500% in the last 15 years (Figure 5.23).

Newly available resources have been mainly used to satisfy urban water needs in the region of Antofagasta (Figure 5.24), where there has been a rapid development of volume supplied by this alternative source (from 2 Mm^3/year in 2005 to over 20 Mm^3 in 2015). Increases in rural drinking water supply by desalination have also been noticeable, particularly in Coquimbo, where it has increased from 0.1 Mm^3/year to over 0.4 Mm^3 (Figure 5.25).

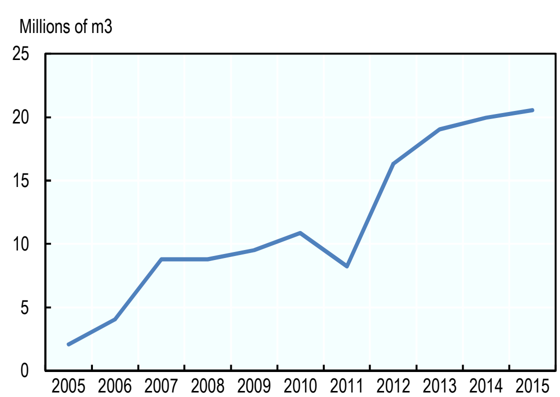
While desalination plants provide reliable, large supplies of quality drinking water, they are expensive and energy intensive. This type of water supply technique is independent of the hydrological cycle and does not reduce the amount of water available for other uses, as it uses brackish water or seawater. Its development has mainly been seen in countries with arid and semi-arid climates, such as Chile's North and Central Macro-zones. For instance, in the Mediterranean region, countries with severe water stress such as Spain, Algeria or Israel have explored the utilisation of this water source to increase the availability of water resources without depleting already over-exploited aquifers or surface waters (Box 5.16). However, investing in desalination to increase water supply is costly, and not all countries can afford it. GWP (2012) reports that the cost of water produced by large-scale desalination plants is between EUR 0.40 and 0.60/m^3 (and from EUR 0.20 to 0.30/m^3 if it is brackish water), without considering the high initial capital investment requirements. The cost is roughly twice that of conventional water sources, i.e. withdrawals from freshwater sources, and one and a half times that of reused water (wastewater that is used for other purposes after appropriate treatment).

Figure 5.23. Evolution of total drinking water supply from desalination



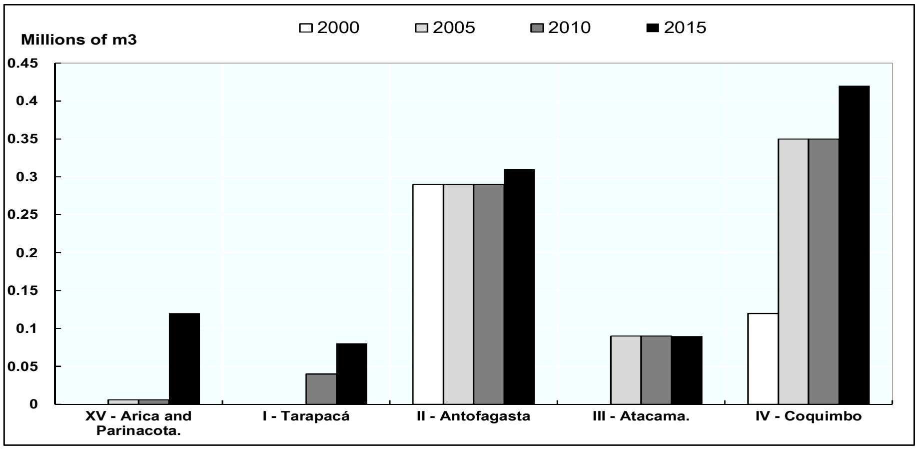
Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile".

Figure 5.24. Evolution of drinking water supply from desalination in region II - Antofagasta



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile".

Figure 5.25. Rural drinking water supply from desalination per region in Chile



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile".

There are plans to expand desalination in the north of Chile for mining activities. Increasing water demand in mining is being met in the North Macro-Zone with the construction of desalination plants. The Chilean Commission of Copper (COCHILCO, Comisión Chilena del Cobre) suggests that the water consumption of the mining industry will increase by 66% by 2020 over 2014 totals (Figure 5.26). In absolute terms, this will mean an increase of 10 Mm^3/year in the requirements of freshwater for mining activities. COCHILCO also expects that the majority of the increase will be covered by desalination plants constructed by major mining companies. In 2014, it is reported that 1.7 Mm^3 out of the 14.8 Mm^3 used by the mining industry was seawater (roughly 11%). However, in 2025 the percentage is expected to increase to 33%. In absolute terms, this will mean that of the 10 Mm^3 increase expected by 2025, 7.7 Mm^3 will be desalinated water. This will have an impact on the energy needed to operate these plants.

Box 5.17. Desalination in semi-arid countries in the Mediterranean region

Spain has a diverse climatological profile where the northern parts of the country are humid and have plenty of water and the east and south suffer from severe water stress. For example, e.g. the Jucar River Basin, located on the eastern Mediterranean coast, records 87% water stress. Spain ranks 4th worldwide in terms of desalination installed capacity (more than 1500 desalination plants and 2.5 Mm^3/day installed capacity). The country allocates a great proportion of these water resources from desalination to supply greenhouse agriculture production, which is mainly located in the region of Almeria (southeast coast).

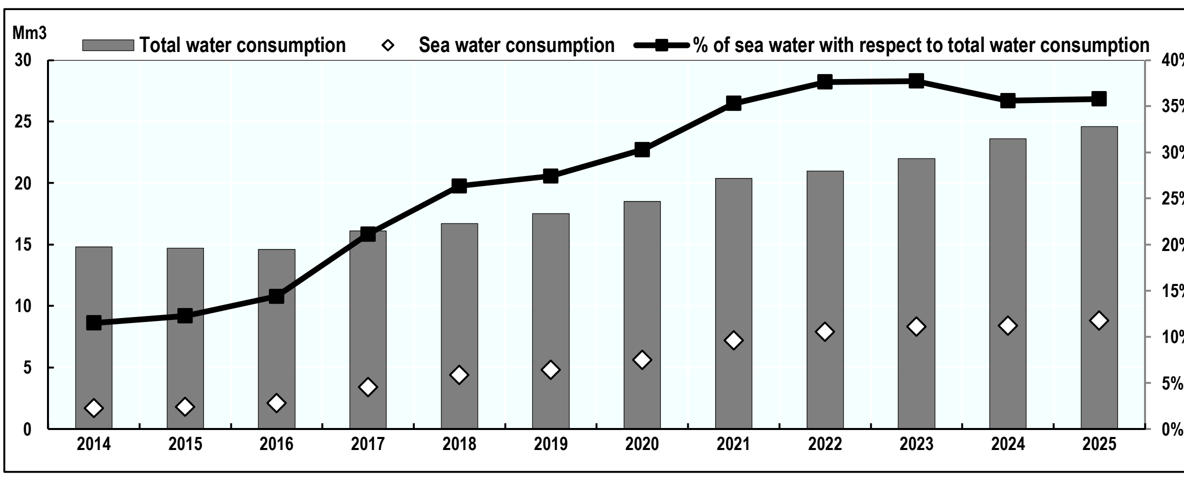
Israel is the country that has made the biggest commitment to desalination for its supply of water to meet current and future demands. Until 2004, Israel's water supply system was completely dependent on groundwater sources and rainwater, which was not enough to satisfy existing demands. It therefore started an ambitious desalination expansion programme with the construction of four plants that now represent 40% of the country's total water availability. In early 2015, Israel started operating the biggest desalination plant in the world, called Sorek. It cost USD 500 million and at full strength is capable of producing 627 000 m^3/day. The country plans to keep increasing production of desalinated water to 2 Mm^3/day in 2020 and 4.25 Mm^3/day in 2050, which should meet 70% and 100% of drinking water supply, respectively.

Algeria's desalination capacity is focused on urban water supply to the big urban centres of the country: Algiers, Oran and Skikda. Existing cheap energy in the country enables the economic viability of these projects, and the current total capacity installed in only these 3 cities is over 0.4 Mm^3/day.

Source: Adapted from GWP (2012), "Water Demand Management: The Mediterranean Experience", *Technical Focus Paper*, www.gwp.org/en/ToolBox/PUBLICATIONS/Technical-Focus-Papers/.

The coming developments of desalination infrastructure in Chile have had an impact on the forecasts as to the mining sector's energy consumption. COCHILCO's forecast for energy consumption considered three different scenarios: the maximum scenario, with all mining investment projects under consideration being executed; the expected scenario, based on uncertainties regarding some of the projects considered in the simulation; and the minimum scenario, in which only confirmed projects are carried out. For the maximum scenario, electricity consumption will increase 98.7% between 2014 and 2025, at an annual average rate of 6.4% (Figure 5.27). In the expected scenario, consumption would increase 80.6% at a rate of 5.5%. Thus, 16.5 TWh is the additional energy consumption that with high probability the mining sector would require to carry out its activities normally in 2025. COCHILCO reports that the increase is mainly explained by the new treatment processes of minerals in Chile and the increasing requirements of energy for desalination plants and pumping stations from the seaside to the mining pits (COCHILCO, 2015).

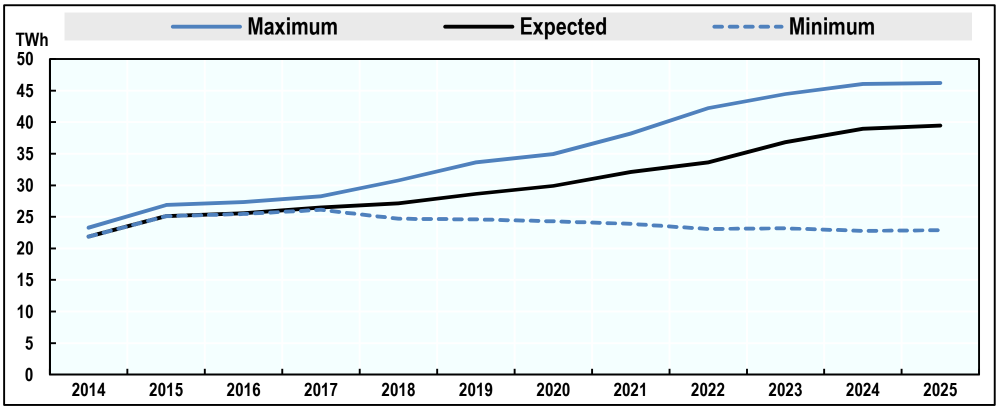
Figure 5.26. Projected water consumption by the mining industry in Chile, 2014-20



Source: COCHILCO (2015), *Factores clave para el desarrollo de la minería en Chile*, https://www.cochilco.cl/Recopilacin%20de%20Estudios/2015.pdf

Energy constraints have already had an impact on Chile's mining sector. In the region of Atacama, some important energy projects such as the Castilla project (estimated generation capacity of 2 100 MW) or the Punta Alcalde (740 MW) have been stalled due to uncertainty and lack of confidence among mining investors. In the absence of a sound water-energy coordination and strategic combination, if energy prices keep increasing due to rising demand, the competitiveness of Chile's mining sector might decline compared to others in Latin American such as Peru.

Figure 5.27. Forecasted energy consumption in Chile's mining sector, 2014 - 2025



Source: COCHILCO (2015), "Factores clave para el desarrollo de la minería en Chile", https://www.cochilco.cl/Recopilacin%20de%20Estudios/2015.pdf.

Energy shortfalls and climate change require thinking of how energy will be delivered to desalination plants and how much this will cost. It is therefore crucial to minimise energy consumption and GHG emissions. An option for Chile could be exploring low CO2 emission options, i.e. reverse osmosis plants, and combining this infrastructure with energy recovery systems and higher performing membranes (which only need 3 to 4 kWh of electricity per m^3 of water produced). The use of renewables for desalination (wind, photovoltaic, solar and concentrated solar thermal) could be a way forward, particularly in the North Macro-Zone, where the potential for solar renewable energy is huge (Ministry of Energy, 2015). However, renewables are only an attractive option if used to supply small desalination plants at isolated sites. Worldwide, about 100 desalination plants, coupled to renewable energy sources, have been built in the past 20 years, several in the Mediterranean (Algeria, Egypt, Spain, Tunisia) (GWP, 2012). These low-capacity solar and wind-powered desalination plants are well designed and operated and supply sites cut off from quality water. The costs are immediately attractive. Desalination therefore appears to be an option to adapt to climate change, but it must not replace other sustainable possibilities, such as rational use of water. It should also primarily produce drinking water for human consumption.

When investing in costly infrastructure like desalination plants, future projections of costs and benefits become even more crucial. Desalination plants, besides requiring a high initial capital investment, are costly to maintain throughout their entire life-cycle. Desalination requires large amounts of energy and generates greenhouse gas emission when electricity does not come from renewable sources. As a result, it can be a costly option depending on energy prices, particularly in countries like Chile with energy supply shortfalls. Moreover, the variability of costs is high when the energy markets are volatile due to the dependence on external energy sources, as in Chile, and where the effects of climate change could potentially reduce the country's energy potential. Countries with uncertainties associated with variable costs might not be the ideal to places to develop large amounts of desalination water supply. These uncertainties hinder solid investment assessments in desalination, as future costs cannot be forecasted with a high enough level of confidence. Thus, long-term quality feasibility studies could entail great savings if they shed light on the opportunity for investment. Some OECD countries, such as Australia, have developed desalination projects that have not turned out to be profitable in either economic or social terms (Box 5.17).

Box 5.18. Investing in desalination in Sydney, Australia

In 2007, a contract for a desalination plant was signed in Sydney due to concerns over water shortages. However, the construction of the plant took several years, during which the end of the drought alleviated some of the water security concerns. Following the construction of the plant, water prices increased by 50% from 2007 to 2010 to cover the costs of investment. By contrast, if scarcity prices had been introduced in Sydney prior to building the desalination plant, the market would have sent signals about the optimal time to invest in desalination. By estimating the optimal time to invest in desalination based on efficient volumetric prices, Grafton and Ward (2010) found that the investment in desalination in Sydney was made prematurely, and led to welfare losses valued at hundreds of millions of US dollars per year. These losses arose from the costs associated with using mandatory water restrictions rather than dynamically efficient pricing and, ultimately high volumetric water prices needed to cover the high capital costs associated with the premature construction of the desalination plant.

Source: Grafton and Ward (2010) adapted from OECD (2013b), *Water Security for Better Lives*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264202405-en.

Innovation in cities' water cycles can also help mitigate energy shortages and make energy available for other purposes. Electricity is a heavy feature of the annual budget of water utilities, due to operations such as pumping from withdrawal and to treatment plants, which often occur outside of populated areas (OECD, 2016). To make up for these requirements, increasing efficiency of the water-energy cycle is becoming an important goal for water managers, and innovative practices have emerged to foster greater coherence among water and energy policies at the local level. For instance, in Budapest, legal requirements are used for coordination between water utility supply and the energy sectors. In Singapore England, and Chile (Box 5.19), important investments have been dedicated to innovative water-energy-waste projects. Further innovations can be encouraged through experimentation and pilot testing.

Box 5.19. Innovation in water-energy-waste projects

In Singapore, energy consumption is and will continue to be a challenge to water supply and used water operations. The PUB, Singapore's national water agency, seeks to mitigate the impact of energy on the processes through a long-term water supply strategy known as the "Four National Taps" – (i) Local catchment water from the reservoirs; (ii) Imported water from Malaysia; (iii) NEWater: ultra-clean, high-grade reclaimed water; (iv) Desalinated water.

Among the Four National Taps, desalination is the one with the highest energy consumption. With the aim of cutting current energy use at least by half, PUB has partnered with Evoqua Technologies (previously Siemens Water Technologies Corporation) to pilot electrically-driven processes to desalt seawater and move forward with other innovations. PUB is looking into building rooftop solar panels at waterworks and installing floating solar systems on the reservoir to explore alternative and sustainable energy sources. By 2025, the country plans to construct Tuas Water Reclamation Plant (TWRP), which will incorporate technologies to improve energy efficiency and manpower requirements. It will be located within the National Environment Agency's (NEA)'s Integrated Waste Management Facility to reap the potential synergies of the Water-Energy-Waste nexus. This co-location marks Singapore's first initiative to integrate used water and solid waste treatment processes to maximise both energy and resource recovery while minimising land footprint.

Box 5.19. Innovation in water-energy-waste projects (*cont*.)

England has also engaged in cross-sector technical innovation by generating energy from waste. In 2011, Thames Water opened a GBP 1.5 million sewage sludge dryer at its water treatment plant in Slough, Berkshire. Previous attempts to generate power from sludge at the company's Crossness sewage works in southeast London had been limited by the high water content of the sludge collected (75%). The main role of this process was therefore to reduce waste more efficiently. With the new dryer, the water content is reduced to 5% and the sludge is produced as flakes or granules. This enables it to be burnt like wood chip, and requires less gas to burn it and generate electricity. The electricity is used to power Thames Water's operations, generating GBP 300 000 a year of operational cost reductions and reducing carbon emissions by 500 tonnes a year.

Chile's second biggest wastewater treatment plant, Mapocho-Trebal, which treats an average flow of 6.6 m^3/s generates energy from waste. The treatment plant generates biogas that is then used as fuel for engines of electric energy co-generation, and the resulting electricity is mainly used for self-consumption. In the Mapocho-Trebal plant biogas generates thermal energy that is used in the wastewater treatment process. In 2013, the plant started a modernisation process to improve energy efficiency and resulted in the certification of the ISO 50.001 norm that specifies the requirements for establishing, implementing, maintaining and improving an energy management system. Chile has also included innovation in pipelines where the existing hydraulic energy within the system is used to generate hydropower. This is the case for instance of the regulator valve in San Antonio which is installed in the drinking water supply system linked to the drinking-water plant of San Enrique.

Source: OECD (2016), *Water Governance in Cities*. DOI: http://dx.doi.org/10.1787/9789264251090-en ; UKRN (2015), "Innovation in Regulated infrastructure sectors", available at: www.ukrn.org.uk/wp-content/uploads/2016/07/20150112InnovationInRegInfrSec.pdf ; Aguas Andinas (2015), "*Reporte de Sustentabilidad 2015*", available at: https://www.aguasandinas.cl/la-empresa/desarrollo-sustentable/reportes-de-sustentabilidad

It is crucial to monitor and evaluate closely the impact of desalination projects on the local environment to ensure sustainability in the medium and long-term. Desalination produces an effluent of salty water with around double the salt content of the average of oceans in the world, which when released into the ocean raises salinity and can affect the marine environment. Desalination projects located along the coastline discharge their effluent to the marine ecosystems, raising the salinity of the water. To ensure that this highly concentrated brine does not disrupt natural ecosystems there have been some recent developments to install diffuser systems that will control dilution of brine with sea water and reduce the impact area. Continuous monitoring of the membrane of desalination infrastructure and of fauna and flora in marine ecosystems are called for to avoid environmental catastrophes (GWP, 2012). A way forward would consist of strengthening the institutional, legal and regulatory framework that governs desalination infrastructure, in particular in three areas:

- **Environmental impact assessments and permits**: this area seems ideally suited to meeting the challenges of developing desalination in Chile. Desalination projects must undergo environmental impact assessments conducted by the Environmental Evaluation Service (Servicio de Evaluación Ambiental, SEA). Only after this body grants its approval can the desalination plants be executed. Given the plans to develop more desalination projects in Chile, there might be a need to expand the scope of the environmental impact assessments to also take into account the expected aggregated effects if several projects are undergoing the impact assessment at the same time. The Ministry of National Defense is in charge of monitoring, regulating and supervising the coastline and territorial sea of Chile. It is therefore the competence of this ministry to grant the necessary permits (duration of 50 years) to use any land within its jurisdiction.

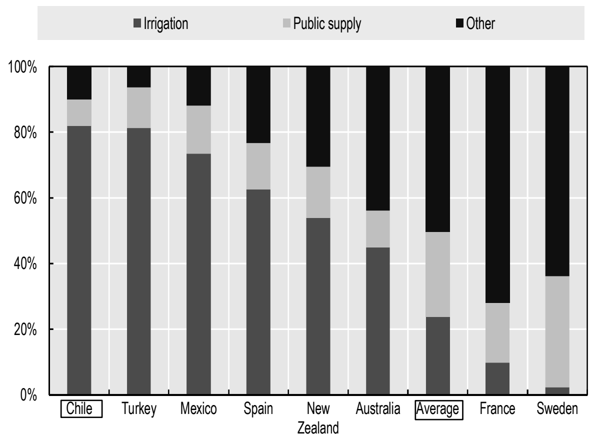
- **National policy and private investment**: the development of desalination projects has responded to the necessities of private users rather than to a co-ordinated strategy by the Chilean government. Thus, there is currently no coherent land use planning strategy for Chile's northern coastline to develop these projects. There is also no co-ordinated approach to managing trade-offs among water users in the north of Chile, with desalination as part of a response. A coherent national policy could set the guidelines in this area.
- **Legal status of desalinated water**: the Water Code only regulates land water resources, and not water resources resulting from seawater treatment. Although, seawater is considered a public good in Chile, there is neither a regulation nor a regulatory authority that oversees the management and use of the water resulting from desalination processes (iAgua, 2015). Thus, there is no clear framework that sets rules and holds investors and public authorities accountable. Key questions then arise on the nature and scope of the entitlements that mining companies or water service providers use to desalinate sea water, on whether desalinated water used to recharge aquifers or lakes can be considered as land water resources, and as to whether the desalinating plant or the public authorities will be held accountable if there is a breach (Rojas and Delpiano, 2015).

Irrigation and water storage infrastructure

Agriculture is the main water user in Chile, as most countries worldwide. In 2013, Chile withdrew 1159 m^3/capita of freshwater overall, which is second highest in the OECD, below only Estonia (Figure 5.29). Chile aims to be one of the leading countries in exports of agricultural products and is the OECD country with the highest share of water dedicated to agriculture (82%). Only Turkey (81%) and Mexico (73%) come close to this level (Figure 5.28). This fact is explained by Chile's economic structure and the importance of its water-intensive sectors, particularly agriculture, is reflected in the shares of water allocation by use. There are plans to expand the agricultural frontier by an additional 300 000 ha, which will raise a range of issues, posing significant challenges for water resources management prompting calls for irrigation efficiency.

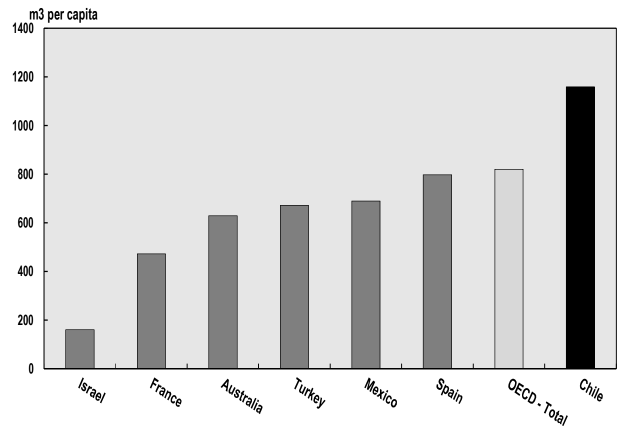
Chile's agricultural sector has been an integral part of the country's development in the last 25 years, and it is based on a subsidised irrigation infrastructure policy. Figure 5.31 shows that between 1990 and 2012, Chile's irrigated area increased by over 65%, with over a 20% increase just since the year 2000. Chile's irrigation infrastructure development has been based on subsidies for the private sector with a view to increasing the irrigated surface. In 1985, Law 18 450 on the Promotion of Private Investment in Drainage and Irrigation Works laid the groundwork for a new irrigation policy through subsidising the cost of new equipment to increase expand irrigation. In 1990, the law was modified to also include irrigation infrastructure in the subsidy scheme (up to 75% of the infrastructure cost was eligible to be subsidised). The three main guidelines of the modified law were the Large Irrigation Works Programme, the Medium-sized Irrigation Works Programme and the Small-scale Irrigation Works Programme. The first two focused on the promotion of dams and major channels, while the latter targeted the promotion of distribution systems. Almost all efforts between 1990 and 1999 were focused on increasing water security. They included improvements in water availability for an area of 12 000 ha thanks to the Santa Juana dam, and an increase in irrigated surface by 11 200 ha with the construction of the Pencahue channel (FAO, 2015).

Figure 5.28. Freshwater abstractions by major primary uses in selected OECD countries, 2013 or latest available data



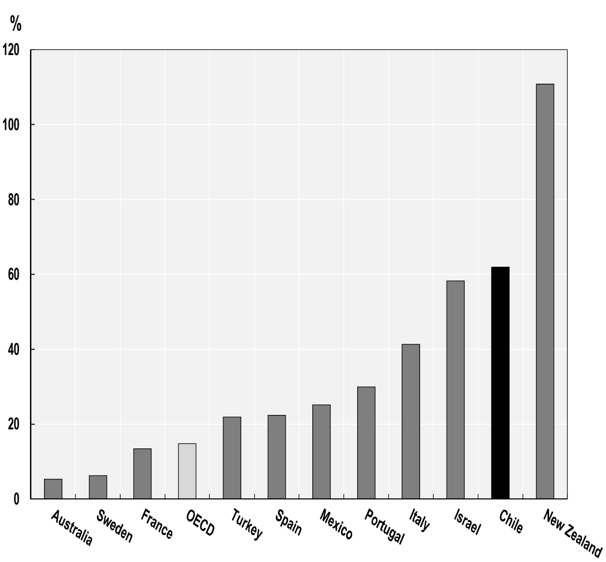
Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile"; OECD (2016), OECD Environment Statistics (database) Freshwater abstractions, https://stats.oecd.org/ (accessed September 2016).

Figure 5.29. Freshwater abstraction per capita in selected OECD countries, 2013 or latest available data



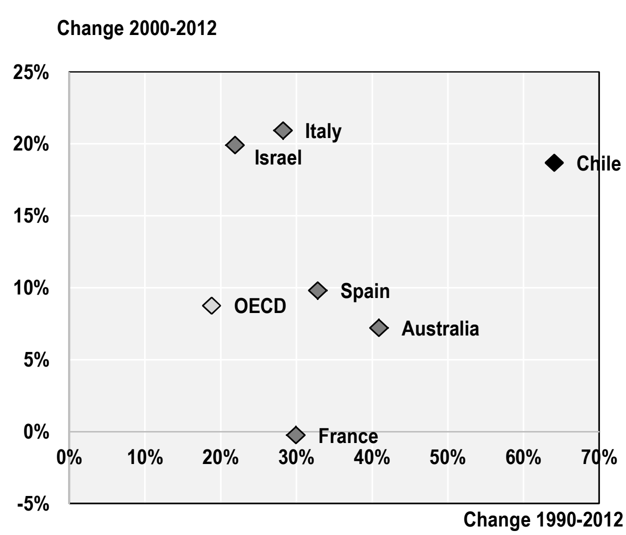
Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile"; OECD (2016), OECD Environment Statistics (database) Freshwater abstractions, https://stats.oecd.org/ (accessed September 2016).

Figure 5.30. Percentage of irrigated area as arable land in selected OECD countries, 2012



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile"; OECD (2017), Environmental Performance of Agriculture (Edition 2013), OECD Agriculture Statistics (database). http://dx.doi.org/10.1787/data-00660-en (accessed April 2017).

Figure 5.31. Change in irrigated area as a percentage of arable land in selected OECD countries



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile"; OECD (2017), Environmental Performance of Agriculture (Edition 2013), OECD Agriculture Statistics (database). http://dx.doi.org/10.1787/data-00660-en (accessed April 2017).

The Law on the Promotion of Private Investment in Drainage and Irrigation Works (passed in 1985) remains the instrument supporting private endeavours in Chile. The main objectives of the law are to: i) increase irrigated surface; ii) improve water supply in irrigated areas suffering water stress; iii) improve quality and efficiency in the use of water; iv) recover irrigated areas in bad conditions. The consensus around this strategy is clear, and it has been renewed until 2022, with an allocation of USD 85 million. One of the main impacts since 1997 has been the increase in the coverage of new irrigation techniques from 90 000 ha in that year to 300 000 ha in 2007 (FAO, 2015). The National Irrigation Commission (CNR) organises a public tender every year to assign subsidies to irrigation infrastructure projects (Box 5.19). The DOH, under MOP, is responsible for monitoring the execution of the works and ensuring that quality and technical requirements are met.

Box 5.20. National Irrigation Commission (CNR)

The National Commission of Irrigation was created in 1975 to increase and improve the country's irrigated area. The CNR is run by a council of ministers councils headed by the Minister of Agriculture, and rounded out by representatives of the ministries of Economy, Finance, Public Works and Social Development. The CNR's main functions include:

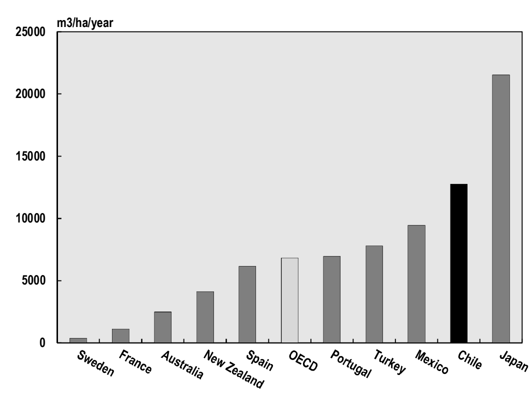
- contributing to the design of the national irrigation policy
- oversee and control the investment of funding included in the national budget items which are planned to be invested in irrigation works
- improving the efficiency of irrigation processes through development and productive transformation projects
- focusing on the development of remote areas of the country and producers in a disadvantaged position
- promoting private investment in irrigation infrastructure by optimising investments and allocating subsidies for irrigation and drainage
- evaluating the technical and economic feasibility of investments in irrigation infrastructure in the country's river basins
- administering the application of Law 18450 on the Promotion of Private Investment in Drainage and Irrigation Works, ever since the passage of the law in 1985.

Source: CNR (2016), "Historia: Comisión Nacional de Riego", www.cnr.gob.cl/Conozcanos/Paginas/Historia.aspx (accessed November 2016).

Chile's rate of freshwater abstraction per hectare of irrigated land is among the highest in the OECD (Figure 5.32). Chile abstracts 12 761 m^3/ha/year, which is well above OECD average (6 821 m^3/ha/year), and second only to Japan, with 21 450 m^3/ha/year. Other countries such as Mexico (9 450 m^3/ha/year), Turkey (7 790 m3/ha/year), Spain (6 150 m^3/ha/year), New Zealand (4 120 m^3/ha/year) or Australia (2 480 m^3/ha/year) withdraw less freshwater per hectare while also allocating large shares of their water resources to agriculture (Figure 5.32). These figures depend on the meteorological effect (i.e. irrigation water abstractions can be complementary to net precipitation in the country), the water resource effect (i.e. farmers can change their irrigation patterns depending on the seasonal availability of water resources), and the composition effect (i.e. relative shares of agricultural activities or crops grown), and the efficiency of water resources use (i.e. upgrade of irrigation systems or better weather information systems) (OECD, forthcoming 2017a). With regards to efficiency, Law 18450 contributed to the improvement of irrigation efficiency in Chile, but the country is still lagging behind other countries such as Italy, Brazil and France, which have managed to develop more modern irrigation systems in their agricultural sectors (Figure 5.33). Specifically, in contrast to modern techniques such as pressurised irrigation, traditional surface irrigation technique still dominates most of Chile's hectares (72.29%).

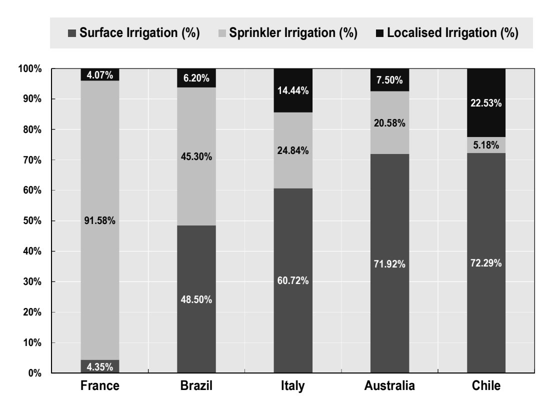
Improving the irrigation system's efficiency should be a priority, particularly in the Central Macro-Zone where most agricultural activities are concentrated. The share of irrigated land in the Central Macro-Zone plus region VIII (Biobio) adds up to over 89% of the total irrigated land in the country. A distinction should be made when analysing irrigation techniques in Chile, as the climatological conditions of the areas where the irrigated land is located vary significantly from north to south. For example, in region IV (Coquimbo) water availability is around 35.9 m^3/s, and in region VII (Biobio) this number is around 767 m^3/s (see Figure 5.7). Traditional irrigation techniques still dominate irrigation in this area. Figure 5.33 shows that only in region V (Valparaiso) is the share of hectares irrigated with new irrigation techniques larger than the share of traditional irrigation (58% vs. 42%), while in region IV (Coquimbo) the totals are about the same (51% versus 49%). It is likely that intense competition for water resources in regions IV (Coquimbo) and V (Valparaiso) has driven the agricultural sector to be more efficient. Nevertheless, there is still room to promote more efficient practices in regions with large shares of irrigated land, particularly in Santiago Metropolitan Region (RM) (34% hectares with new irrigation techniques and 12.5% of total irrigated land) and in the region of O'Higgins (VI) (28% of hectares with new irrigation techniques and 19.2% of total irrigated land). If subsidies are set to promote efficiency, these must be combined with soft measures (irrigation and watershed conservation plans) in order to prevent farmers to switch to water-intensive crops or expand irrigated areas that could lead to an increase in the overall consumption of water.

Figure 5.32. Abstractions per area of irrigated land in selected OECD countries, 2013 or latest data



Source: Ministry of Public Works (2016c), Official statistics provided in the OECD Questionnaire Data Request on Water in Chile for this report: "Review of the Gaps, Standards and Governance of Public Infrastructure in Chile"; OECD (2017), Environmental Performance of Agriculture (Edition 2013), OECD Agriculture Statistics (database). http://dx.doi.org/10.1787/data-00660-en (accessed April 2017).

Figure 5.33. Irrigation systems in selected OECD and non-OECD countries, 2007 or latest data



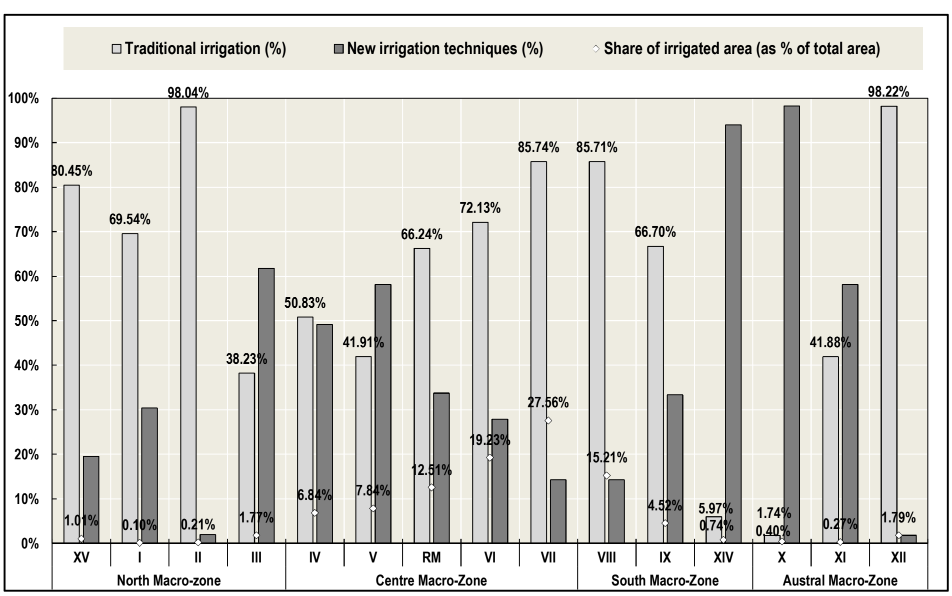
Note: Italy, Chile and France data dates back to 2007, Brazil and Australia to 2010

Source: FAO (2016), Aquastat: Irrigation and drainage database, www.fao.org/nr/water/aquastat/irrigationdrainage/index.stm.

Water resources infrastructure is complex to quantify and assess. While dams or groundwater pumping stations can be inventoried, such a stock-taking does not provide evidence that such infrastructure can meet water demands in the agricultural or mining sectors. Another way of quantifying irrigation infrastructure can be to count the current kilometres of channels. However, a country can have a large number of dams for water storage, which may not work if not designed adequately to fit the water availability and demand (e.g. oversized dams) or not managed and operated effectively. For instance, large empty dams suffer from cracks and fissures, as the structural design considers certain levels of water height calculated under specific hydrological scenarios. This can result in costly investments in maintenance and operation. On the contrary, if irrigation systems have canals with craks these can in fact be an important vector of groundwater recharge, so moving to better infrastructure can reduce recharge and contribute to further depletion of groundwater. Thus, each infrastructure assets needs to be carefully assessed against the territorial specificities of its location.

In the face of climate, economic and urban trends, some infrastructure could contribute to better water supply management for irrigation. Selected dams and aqueducts could contribute to keeping up the level of current water consumption and to an extent to meeting increasing demand. Investments under consideration include pumping infrastructure for groundwater sources, building and upgrading channels and improving irrigation systems, and developing in the medium-term small-scale desalination plants and dams to supply drinking water (*Plan de Embalses Pequeños*). The Plan Chile 30/30 should combine these investments with softer and less capital intensive measures, i.e. wastewater reuse from cities or better groundwater management. For instance, in the Southwest United States, under a similar agro-ecological and climatic conditions as in North and Central Chile, an OECD study that look in-depth on water risks for agriculture called for a combined set of measures: i) increasing efficiency in agriculture and urban water management; ii) more refined groundwater management; iii) investment in water banks and recycled wastewater systems; and, iv) well-defined water transfers (Cooley H. et al., 2016).

Figure 5.34. Irrigation systems in Chilean regions



Source: INE (2007), "Censo Agropecuario 2007", Instituto Nacional de Estadísticas de Chile, www.ine.cl/canales/chile_estadistico/censos_agropecuarios/censo_agropecuario_07.php.

Strategic thinking about the type of infrastructure that would be the best fit for Chile's future is essential to making the most of policy complementarities. Multipurpose reservoirs are designed and/or operated to serve complementary purposes such as hydropower generation, flood control, water supply, ecosystem services, and irrigation. They are increasingly being used in OECD and non-OECD countries (Box 5.20). This type of infrastructure interconnects related sectors in a long-term and integrated way and strives to share costs and benefits across users efficiently. Successful stories of multipurpose dams bringing together energy and irrigation already exist in Chile (e.g. the Ancoa Reservoir). As Chile is looking to develop hydropower, multi-purpose reservoirs can have other uses besides irrigation.

Stakeholder engagement in infrastructure-related choices and decisions is critical to preventing social conflicts and building the needed social acceptance. In recent years, many large infrastructure projects, in Chile particularly hydroelectric ones, have faced severe conflicts and attracted a considerable amount of public resistance (e.g. HidroAysen, Barrancones). These deadlocks have contributed to a strategic shift towards increased investment in coal power plants, which are easier to realise given the lower rate of hydroelectricity as compared to the 1980s. Large infrastructure projects involve a wide range of private and non-profit actors. The corporate sector plays an important role in building, operating and maintaining these infrastructures, with several companies involved, such as ENDESA, AES Gener, Colbún S.A., Suez Energy Andino, E.E. Guacolda and Pacific Hydro. National and local NGOs act as watchdogs and have gained socio-political capital. However, some categories of stakeholders often get omitted and remain under-represented, such as urban and rural communities whose lives and activities are often the most affected by energy projects. Indigenous peoples are also seldom recognised in energy-related policy decisions at local and national levels, and they often lack the institutional structures and capacities to promote their interests outside their communities.

Box 5.21. Examples of multipurpose reservoirs in OECD and non-OECD countries

Multipurpose reservoirs and risks of too much and too little water

Wivenhoe Dam in Brisbane, Australia. Over the last 40 years, the city of Brisbane has experienced significant problems with both drought and flooding. After severe floods in 1974, the Wivenhoe dam was built to reduce the impacts of future floods and to store water during times of scarcity. The dam was designed to meet the region's drinking water supply with an additional 125% excess capacity to also cope with flood prevention. The design of the dam creates risk-risk trade-offs, i.e. the more water is stored the lesser chance of water scarcity, however, there is less capacity to capture flood water.

In 2008, during a drought period, the water level fell to around 17% and the dam operating rules focused on managing water scarcity. After several months of intense rains in 2010 the water level rose, which led to significant flooding throughout the city and surrounding area. While the dam reduced the impact of the floods, the operational rules resulted in water being stored when it could have been released earlier. Earlier release would have reduced the impact of the flooding and helped mitigate property damages worth about AUD 0.5 billion. The experience of Brisbane highlights the complex trade-offs that are present in flood management schemes.

Multipurpose reservoir: hydropower, irrigation, fisheries and recreation.

Arthurs Lake is a very good example of multipurpose water uses of reservoirs in **Tasmania, Australia**. The multiple purposes that Arthurs Lake can deliver are hydropower, recreation, a fishery and irrigation. Irrigation is a new purpose, after approval of the Midlands Water Scheme in August 2014. Farm Water Access Plans are in place and ensure the environmental sustainability of the scheme. Water price and supply in the irrigation district are underpinned by a water supply agreement between Tasmanian Irrigation and Hydro Tasmania. The agreement recognises that water taken from Arthurs Lake would have otherwise been used to generate electricity at Hydro Tasmania's Poatina and Trevallyn Power Stations, and considering

Box 5.21. Examples of multipurpose reservoirs in OECD and non-OECD countries (*cont.*)

the economic and financial benefits (and costs) was a key step to change the storage operating rules. With respect to accommodating irrigation needs, Hydro Tasmania evaluated the implications on electricity generation and associated revenues and developed a water pricing instrument to consider water sharing among users.

Lake Arenal Rica, Costa Rica. The wetland provides benefits related to several uses: hydropower generation, irrigation, tourism and fishing. Arenal Lake was declared a Ramsar site on 16 March 2000. The concerns about the lake, including the stability of its watershed, problems of deforestation and possible premature sedimentation, led the Government to create the Lake Arenal Watershed Management and Development Plan in 1996, and a was created Commission to implement the plan in 1997. The Commission offers a platform for dialogue involving all the interested parties and institutions. The environmental outcomes have been mixed, i.e. negative from disruptions caused by construction of the dam and irrigation project, and positive efforts to protect the forests and introduce a sustainable development approach to the management of the lake.

Source: OECD (2013b), *Water Security for Better Lives*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264202405-en; EDF/WWC (2014), Multipurpose Water Uses of Hydropower Reservoirs, "Sharing the water uses of multipurpose hydropower reservoirs: the SHARE concept", https://www.hydropower.org/sites/default/files/publications-docs/Multi-purpose%20water%20uses%20of%20hydropower%20reservoirs.pdf.

Early engagement of all those who have a stake in the outcome, may be directly or indirectly affected, and/or have the ability to influence the outcome positively or negatively is critical to these projects. The parties involved raise awareness, share information, identify hotspots and take collective action, including through compensation measures to mitigate unintended consequences. This is particularly relevant as a recent survey the Ministry of Energy, for instance, conducted as part of the development of its Energy Policy 2050 revealed that communities would not reject the construction of renewable energy technology, provided it complies with international environmental standards (Ministry of Energy, 2015). 97% of survey respondents indicated a willingness to support the construction of wind or solar power plants in their communities or in nearby communities, if they complied with the strict environmental and social requirements applied in developed countries and the offered concrete benefits. 90% of respondents concurred when asked about tidal power plants, 71% for geothermal power plants, and 57% and 56% for hydroelectric power plants using reservoirs and for run-of-river hydroelectric power plants, respectively (Ministry of Energy, 2015).

Conclusions and policy recommendations

Current and future climate, urban, population and economic trends are putting pressure on Chile's water resources, especially for the water-intensive sectors that are also sources of productivity, mining and agriculture. The energy policy aimed at increasing the share of renewable sources in Chile's energy matrix, particularly through the promotion of hydropower, is a compounding factor, especially as droughts become more frequent, with lower levels of reservoirs having a negative effect in hydroelectricity production.

Additional investments in hard, physical infrastructure will undoubtedly be needed to solve some of the country's water challenges. Urban water pipes are ageing and leaking and need to be upgraded, properly operated and maintained. Sparsely populated areas and settlements need to be equipped with rural water and sanitation infrastructure. Rainwater infrastructure is currently insufficient and results in costly damages when floods occur. The efficiency of irrigation systems needs to be improved. In some cases, multipurpose infrastructure can combine several of the above needs. A critical way forward is to consider policy complementarities to make the most of these large sunk costs, which can be recovered only over the long run and generate liabilities for future generations.

Coupling the development of grey infrastructure in cities (e.g. tertiary treatment in wastewater plants) with natural infrastructure (ecosystem services) can make investments more cost-efficient by reducing treatment requirements. In turn, this will offer benefits including contributing to a reduction in electricity consumption and the use of chemicals. Promoting green infrastructure in cities through rainwater harvesting systems will also contribute to limiting the need for grey infrastructure. Localised rainwater systems reduce peak flows in times of urban flooding and contribute to better water quality because rainwater is quickly disposed of from street pavements. As such, this makes rainwater systems more resilient and cities have to resort less to wastewater treatment.

In addition to investment in hard infrastructure, Chile will need to strengthen its institutional framework for water management to overcome fragmentation, scale and policy coherence challenges. While important steps have been taken with the ongoing reform of the Water Code (pending discussion and approval in the Senate), the recent attempts to foster coordination across water-related policies and raise the profile of water on the national agenda through the Presidential Delegate for Water Resources and the Committee of Water Ministers have proven insufficient to meet their intended goals. In addition, the lack of a sound basin governance system allowing for a functional approach to water management, and the inconsistencies across agriculture, land use, energy, mining and water policies, are both important challenges Chile must address for to ready itself for the future. The country must put in place a territorial approach to water planning and management. Further action needs to be taken to better coordinate actions across public, private and non-profit sectors, to engage all levels of government in water-related decisions, to manage trade-offs across users, to regulate grey areas such as desalination expansion, and to engage stakeholders for greater acceptance of infrastructure and policy choices.

What follows is a set of recommendations for water to drive Chile's future economic development and well-being. This will require a focus on a combination of policy responses, addressing water infrastructure gaps, not only in quantity, but also, and most importantly, in type. It will also mean improving water governance practices for infrastructure to deliver the intended outcomes.

A) Raise the profile of water management on Chile's national political agenda for water to contribute to sustainable growth and development.

1. **Design and implement a consensus-based national water resources policy that involves sound consultation across water-related ministries and public agencies, between levels of government, and with the private sector and society at large.** Chile's specific institutional framework based on water markets and the resulting atomisation of water rights should not stand in the way of the design and implementation of a solid national framework for water resources management, with clear guidelines, priorities and strategies for water to drive economic, social and environmental outcomes. Previous attempts at doing so, including the document "National Water Resources Policy" developed by the Presidential Delegate under the Ministry of Interior, can provide food for thought and a baseline. Such a national policy would help foster co-ordination of

otherwise fragmented actors and provide a framework for aligning objectives across sectors.

2. **Use the ongoing process to reform the Water Code as a good opportunity to engage stakeholders in the development of a country-wide strategy for water.** Building on the 2005 water code reform, which established requirements for ecological flows, the reform that started in 2011 has the potential to open a wider debate on how to place water as a key factor for national development and facilitate public action in managing water risks in Chile.

3. **Consider incentives to foster effective basin governance to reconcile administrative and hydrological boundaries.** Chile has a number of specificities in terms of climate variability (combining deserts and numerous glaciers), small-scale hydrographic basins formed by the 1 251 rivers flowing from the mountains to coast, and the special morphology that influences the river paths, creating a water system that is complex to manage. In this context, water users' organisations are critical players in the management of water resources, as long as these associations operate at the appropriate scale and are endowed with the needed prerogatives and resources to play fully their role. Chile could push forward a basin governance framework tailored to the territorial specificities of each basin. Raising awareness on the benefits of managing water resources at the basin level could be done through promoting the value of ecosystem services, for instance.

4. **Strengthen water information systems and use them to guide planning and decision making.** Improved information access, quality and disclosure across levels of government is a prerequisite for better water policy decision making, monitoring and evaluation. A common frame of reference should be set across institutions to foster data gathering on social, economic and environmental trends, in line with international standards and OECD best practice. Chile should also strengthen data collection on basic indicators such as abstraction rate by use and household consumption rate for rural drinking water. There is also little data online in a workable format, and time series tend to be limited. Another way forward is to address inconsistencies between official sources of data and those produced by the private sector and ensure that water-related data and information effectively guide decision making.

B) Invest in the right infrastructure mix, both in quantity and type, while favouring a tailored approach according to water management functions, and place-based needs and opportunities.

Urban Water Supply and Sanitation Services

1. **Develop a strategy and catalyse needed finance to upgrade, renew and maintain drinking water supply and sanitation infrastructure.** Engagement with utilities and end users will be needed to clarify who pays for what over the short, medium and long-term.

2. **Enhance efforts to transition from water supply to water demand management, especially in cities, to better manage risks.** This can rely on a combination of hard and soft measures, such as exploring possibilities to reuse rainwater and greywater, with the precondition that quality standards are put in

place to avoid health-related issues; enhancing public education on water conservation through awareness campaigns; and promoting the use of water saving devices (e.g. use of seawater for toilet flushing).

Rural Water Supply and Sanitation Services

1. **Consider further alternatives to large-scale centralised systems in semi-concentrated and disperse agglomerations**. OECD countries' experience in rural access to water and sanitation services indicate that localised systems can perform as well as centrally piped infrastructures. This applies both to drinking water supply systems and sanitation services.
2. **Strengthen the implementation of the APR programme to meet the challenges of delivering services to semi-concentrated and disperse populations,** building on three sets of actions:

- o Improve strategic planning and tailor investments in the APR Programme to take into account specific type of infrastructure needs of the new target population living in semi-concentrated and disperse agglomerations.
- o Revise the social evaluation methodology for Chile to face the renewed challenges of the APR Programme. For instance, complementing the cost-benefit analysis with a multi-criteria analysis framework that can be used to accommodate more long-term goals, strategic issues, and improve alignment with broader policy priorities.
- o Enhance technical, managerial and financial skills and capacities in APR committees and cooperatives, both to ensure that existing systems do not age at a faster pace than initially planned and to improve the efficiency of new systems.

3. **The DOH should conduct regular monitoring of the APR Programme to anticipate supply cuts and costly future investments due to infrastructure replacements, and it should coordinate with Regional Councils (CORE) to establish investment priorities.** Closer cooperation between MOP (DOH) and CORE will then be instrumental in identifying dysfunctional rural water systems and prioritising investments according to the most pressing needs.

Rainwater infrastructure

1. **Promote lower cost alternatives such as urban green infrastructure,** for example by employing "source control" technologies that handle rainwater near the point of generation, green roofs or pervious surfaces that capture rainwater before it runs onto polluted pavements and streets.
2. **Develop local or metropolitan strategies in Chile's large urban centres (Santiago, Valparaíso, Concepción) to foster resilience and adaptive capacity of water systems in the face of climate, economic and urban trends.**

- o This can be achieved through engagement with relevant stakeholders and working to boost rainwater harvesting, set incentives to better co-ordinate water and land use policies and raise awareness of the current levels of water risks and the shared responsibility to manage them.

Desalination

While desalination can generate a large amount of available resources, its impacts on the environment can be high, and its operation costs are driven by high energy consumption. In that sense, desalination should not preclude the country from making the most of water demand management instruments and the low-cost options explored in the chapter. Should Chile pursue the desalination avenue, several actions should be considered:

1. **Strengthen the institutional, legal and regulatory framework for desalination to contribute to a coherent strategy that respects the environment.**

- Develop a national policy on desalination that sets planning guidelines to ensure private investment is done right. Due to the cross-sectoral nature of desalination projects, such a strategy should not only be developed in conjunction with mining companies and water utilities, but also include the energy and agricultural sector, as well as environmental NGOs.
- As the environmental threats of desalination are well-documented, it is important to put in place clear, transparent and proportionate enforcement rules, procedures, incentives and tools (including rewards and penalties) to promote compliance.

2. **Future investments in desalination need to be carefully evaluated through sound feasibility studies that take into account initial capital investments as well as uncertainties in operating costs (related to energy prices) throughout the life cycle of the project.** Chile's energy shortfall and the effects of climate change require a process of reflection as to how energy will be delivered to desalination plants and what it will cost. Two concrete actions will help deal with energy constraints:

- Encourage the use of renewable energy sources (wind, photovoltaic, solar and concentrated solar thermal energy) for small desalination plants at isolated sites, particularly in the North Macro-Zone, where the potential for solar renewable energy is high.
- Drive innovation in cities that can help mitigate energy shortages, and make this energy available for other purposes. Electricity is a heavy feature of the annual budget of water utilities, due to operations such as pumping from withdrawal and to treatment plants, which are often outside populated areas.

3. **Closely monitor and evaluate the impacts of desalination projects on the local environment to ensure sustainability in the medium and long term.** Ensure that the highly concentrated brine does not disrupt natural ecosystems by installing cutting-edge technologies and reducing impact area. Continuous monitoring of fauna and flora in marine ecosystems is also needed to avoid environmental catastrophes.

Irrigation and water storage infrastructure

Selected dams and aqueducts could contribute to maintaining the level of current water consumption and to an extent to dealing with increasing demand.

1. Irrigation systems could be upgraded in Central Chile, where most of the water allocated to agriculture is used, but demand management should also be boosted in parallel to make the most of available resources and foster water use efficiency. International benchmarks show that Chile is below OECD countries in terms of irrigation efficiency (it is the country with the 2nd highest water abstraction per irrigated area, and above 70% of irrigation infrastructure still relies on traditional techniques). However, this upgrade should be done on a case-by-case basis, as efficiency in irrigation is also associated with lower recharge of aquifers.

2. Engage stakeholders in infrastructure-related choice and decisions, and strive to share costs and benefits across users in an efficient way. In a context, as Chile is looking to further develop hydroelectricity generation and expand its irrigation frontier, multi-purpose reservoirs offer opportunities to combine other benefits with irrigation. The Chilean government has an important role to play in establishing an institutional environment that encourages exchange and more bottom-up decision making to build social and political acceptance, mitigate conflicts, and empower communities and subnational governments in order for all parts of Chilean society to benefit from infrastructure projects.

Table 5.4. Water Governance and Infrastructure gaps and responses

Place water governance high in Chile's agenda for long-term sustainable development		
Theme	Gaps	Recommendations
Water governance	• Chile's central government is characterised by high degree of compartmentalisation. Sectoral ministries work in insulated silos, with limited mechanisms for ensuring alignment and integration across policy areas and investments. The lack of horizontal co-ordination is particularly challenging in water management as where many decisions taken in other policy domains (e.g. land use, energy, agriculture, industry) generate water risks and vice-versa. • A striking feature of the Chilean water management model is the absence of integrated basin governance systems that can provide the baseline for a functional and territorial approach to water risks. • Chile has made important efforts to produce the Water Atlas, which provides an overall picture of the stock of water resources but, overall, data and information gaps on water resources management and planning hinder decision-making.	• Establish a consensus-based National Water Resources Policy that involves sound consultation across water-related ministries and public agencies, between levels of government, and with the private sector and society at large. • Use the ongoing process to reform the Water Code as an opportunity to engage stakeholders in the development of a country-wide strategy for water resources management. • Consider incentives to foster effective basin governance that can help reconcile administrative and hydrological boundaries. There is room for building on the experience of the Territorial Roundtables and strong water users organisations already in place as well as lessons learned from past attempts. • Strengthen water information systems and use them to guide planning and decision-making. Improved access, quality and disclosure of information across levels of government is a prerequisite for better decision making, monitoring and evaluation in water policy.

Table 5.4. Water Governance and Infrastructure gaps and responses (*cont.*)

Choosing the right water infrastructure, both in quantity and type. Water infrastructure is heterogeneous and requires different approaches		
Theme	Gaps	Recommendations
Urban Water Supply and Sanitation Services	• Chile's challenges in urban water supply and sanitation relate to infrastructure upgrade and renewal needed to sustain current levels of service delivery and water safety. Water losses in Chilean major cities are higher than in most peer cities, and wastewater treatment is not as high-quality as in other high-level income OECD countries.	• Develop a strategy and catalyse needed finance to upgrade, renew and maintain drinking water supply and sanitation infrastructure. Engagement with utilities and end-users will be needed to clarify who pays for what over the short, medium and long-term. • Enhance efforts to transition from water supply to water demand management, especially in cities, to better manage risks now and in the future.
Rural Water Supply and Sanitation Services	• The renewed challenge in the APR programme is to secure access for population living in semi-concentrated and disperse area. In 2015, the Chilean government reported that while concentrated rural communities have overall access to drinking water, sparsely populated areas still struggle to access basic water services. • Insufficient data and information hinders the efficiency of investments in the APR Programme. There is currently a lack of systematic and comprehensive monitoring of the results achieved by the APR	• Consider further alternatives to large-scale centralised systems in semi-concentrated and disperse agglomerations. OECD countries' experience in rural access to water and sanitation services indicate that localised systems can perform as centrally piped infrastructures • Strengthen the implementation of the APR programme by: i) improving strategic planning; ii) revising the social evaluation methodology; iii) enhance technical, managerial and financial skills and capacities in committees and cooperatives. • Conduct regular monitoring of the APR Programme to anticipate supply cuts, and costly investments due to infrastructure replacements, and coordinate with Regional Councils (CORE) to establish investment priorities
Rainwater infrastructure operation and maintenance and expanding the network	• Rainwater infrastructure exists in Chile's main cities, such as Valparaíso, Concepción or Santiago, but it is not effectively functioning against heavy rain episodes • Medium-size growing cities must consider further developing and maintaining rainwater infrastructure to be fit for the future	• Promote lower cost alternatives such as urban green infrastructure resorting for instance to "source control" technologies green roofs or pervious surfaces. • Develop local or metropolitan strategies in Chile's large urban centres (Santiago, Valparaíso, Concepción) to foster resilience and adaptive capacity of water systems in the face of climate, economic, and urban trends.
Desalination projects	• There is no current land use planning strategy of the Chile's northern coastline to coherently develop desalination projects. • There is no co-ordinated approach to manage trade-offs across water users in the north of Chile, with desalination as part of a response • There is no clear legal framework that sets rules and holds investors and public authorities accountable. The Water Code only regulates land water resources and not water resources resulting from sea water treatment. There is neither a regulation nor a regulatory authority that oversees the management and use of the resulting water from desalination processes. • Energy shortfalls in Chile and climate change require thinking of how and at which cost energy will be delivered for desalination plants. Desalination requires large amounts of energy and as a result, it can be a costly option depending on energy prices.	• Strengthen the institutional, legal and regulatory framework for desalination to contribute to a coherent strategy that respects the environment. Actions include: i) developing a national policy on desalination that sets planning guidelines to ensure private investment is done right; and, ii) setting clear, transparent and proportionate enforcement rules, procedures, incentives and tools (including rewards and penalties) to promote compliance • Future investments in desalination need to be carefully evaluated through long-term sound feasibility studies, which take into account initial capital investments as well as uncertainties related to energy prices in operating costs during the life-cycle of the project • Closely monitor and evaluate the impact of desalination projects on the local environment to ensure sustainability in the medium and long term. Ensure that the highly concentrated brine does not disrupt natural ecosystems by installing cutting-edge technologies and reducing impact area. Continuously monitor fauna and flora in marine ecosystems to avoid environmental catastrophes.

Table 5.4. Water Governance and Infrastructure gaps and responses (*cont.*)

Choosing the right water infrastructure, both in quantity and type. Water infrastructure is heterogeneous and requires different approaches		
Theme	Gaps	Recommendations
Irrigation and water resources infrastructure	• Chile's rate of freshwater abstraction per hectare of irrigated land is among the highest in the OECD region. Although the Law 18450 contributed to the improvement of irrigation efficiency in Chile, it is still lagging behind other countries such as Italy, Brazil, or France. • In the face of climate, economic and urban trends, some infrastructure could contribute to better water supply management for irrigation. Selected dams and aqueducts could contribute to keep up the level of current water consumption and deal, to some extent, with increasing demand.	• Irrigation systems could be upgraded in Central Chile, where most of the water allocated to agriculture is used, but demand management should also be boosted in parallel to make the most of available resources and foster water use efficiency. This upgrade should be done on a case-by-case basis, as efficiency in irrigation is also associated to lower recharge of aquifers • Engage stakeholders in multipurpose infrastructure choice and decisions to and strive to share costs and benefits across users in an efficient way. The Chilean government has an important role to play in establishing an institutional environment that encourages exchange and more bottom-up decision-making.

Notes

1. The MOP has grouped Chile's 15 regions into four macro-zones according to their similarities in terms of territorial specificities, such as productive structure, climate conditions and demographic development. They are: i) North (XV, I, II, III); ii) Central (IV, V, RM, VI, VII), iii) South (VIII, IX, XIV); and, iv) Austral (X, XI, XII).

2 The study COCHILCO (2009) "Proyección consumo de agua en la minería del cobre 2009-2020" is the most updated source for future mining water demand. The MOP reports that the data could be outdated due to changes in copper prices, but the Ministry has no other available information or data source.

3. For details, see OECD (2012) "Redefining "urban": A new way to measure metropolitan areas," OECD Publishing, Paris.

4. Small urban areas are those with a population of less than 200 000 people; medium-sized urban areas are those with a population of between 200 000 and 500 000; metropolitan areas are those with a population of between 500 000 and 1.5 million; and large metropolitan areas are those with a population of over 1.5 million.

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5. It is worth mentioning that during the interviews with stakeholders as part of this policy dialogue, the Ministry of Agriculture emphasised the need to improve the quality of the measurements for volumes used in agricultural activities in Chile to foster water use efficiency.

6 In OECD/ECLAC (2016), the same graph with 2011 data registered water deficits for both Valparaíso (-15 m3/s) and Santiago Metropolitan Region (-13 m3/s)

7. Proportion of water loss as a percentage of net water production (delivered to the distribution system) reported by the surveyed cities.

8. The definition of Functional Urban Area (FUA) can be found at: www.oecd.org/gov/regional-policy/Definition-of-Functional-Urban-Areas-for-the-OECD-metropolitan-database.pdf, and the complete list of FUAs by country at www.oecd.org/gov/regional-policy/all.pdf.

9 Antofagasta (Antofagasta), Coquimbo-La Serena (Coquimbo, La Serena, Andacollo), Valparaíso (Viña del Mar, Valparaíso, Quilpué, Villa Alemana, Concón, Limache), Santiago (Maipú, Puente Alto, La Florida, San Bernardo, Las Condes, Pudahuel, Peñalolén, La Pintana, Quilicura, Santiago, El Bosque, Ñuñoa, Cerro Navia, Recoleta, Renca, La Granja, Providencia, Estación Central, Conchalí, Lo Espejo, Macul, Pedro Aguirre Cerda, Colina, Lo Prado, La Reina, Lo Barnechea, Quinta Normal, San Ramón, San Joaquín, Huechuraba, Vitacura, Peñaflor, La Cisterna, San Miguel, Talagante, Buin, Cerrillos, Paine, Independencia, Lampa, Padre Hurtado, Isla de Maipo, El Monte,

Curacaví, Calera de Tango, Pirque, San José de Maipo), Concepción (Concepción, Talcahuano, Chiguayante, Coronel, San Pedro de la Paz, Tomé, Hualpén, Penco, Hualqui).

10. The definition is constructed by the National Statistical Institute (INE) and classifies localities as either urban or rural. Urban localities are considered to be places with over 2 000 persons, or between 1 001 and 2 000 persons when 50% or more of the economically active population is engaged in secondary or tertiary activities. As a special case, tourism and recreation centres which have at least 250 clustered dwellings, but fail to meet the required population standard may also be classified as urban. The APR program has established its own definition for rural areas: i) Concentrated areas: population between 100/150 and 3 000 inhabitants with a minimum concentration of 15 households per km of drinking water supply pipe: ii) Semi-concentrated areas: disperse areas: minimum of 80 inhabitants and a minimum concentration of 8 households per future km of drinking water supply pipe.

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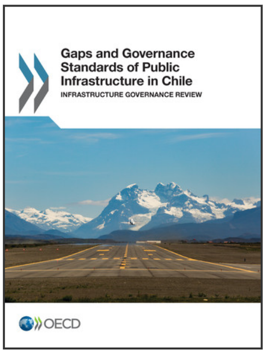

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