The Future of Water: lessons and challenges for LAC

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The Future of Water: lessons and challenges for LAC

Juan Pablo Rud

1. Introduction

The water sector in Latin America and the Caribbean (LAC) looks like a calm and peaceful lake: abundant in freshwater, predictable and easy to navigate. A closer look shows a more difficult picture: water sometimes is not where it's most needed, and overall availability and quality are under threat. What could the region do differently to make the most of its water resources? Some of the problems are very conspicuous: current infrastructure is insufficient and inadequate; the sector's organization is cumbersome (e.g. a highly-fragmented structure of suppliers and regulators); regulation has failed (e.g. prices do not reflect water's economic cost, inducing excessive use); investment has been lacking in key services (e.g. most of the sewage remains untreated). In brief, the sector has been badly managed.

While the problems of the past remain the problems of the present, the future is not without challenges, as a warmer and less predictable climate, a transforming socio-demographic landscape (driven by urbanization and economic growth) and changes in land use near freshwater sources (such as modern agriculture) will most likely add extra pressure for governments to get things right. Although investing in infrastructure is both urgent and unavoidable, it may not be enough to deal with issues of scarcity or sustainability. Authorities will need to be open to the use of new or different regulatory instruments and to think outside the box. Countries will also need to embrace and stimulate innovation, and incentivize behavioral change in consumers to rationalize the use of water, for example to increase and improve water treatment and to encourage water re-use. Table 1 summarizes the key sector trends and the relevant instruments available to countries to accommodate to these changes.

Table 1. Trends and instruments in the water sector

Trends that affect the water sector	Effects	Instruments available
Climate change: a hotter, more variable environment.	Uncertainty over quantity and quality of water resources.	• Investment in infrastructure (e.g. national networks, storage) • Technology: desalination, identification of leaks, water re-use, eco-systems, wastewater treatment. • Regulation: water rights, price mechanism (e.g. separate charges to water use and effluent production), cost-recovery tariffs, institutional organization • Incentives and demand management: information campaigns and consumer behaviour, metering roll out, bonuses and fines • Water re-use.
Economic Growth and Urbanization	Increase in demand for access and quality from households, farmers, industries.	
Land use and agriculture: food security and productivity	Irrigation, deforestation.	
Social and environmental demands	Demand to meet water and sanitation needs in a sustainable way.	

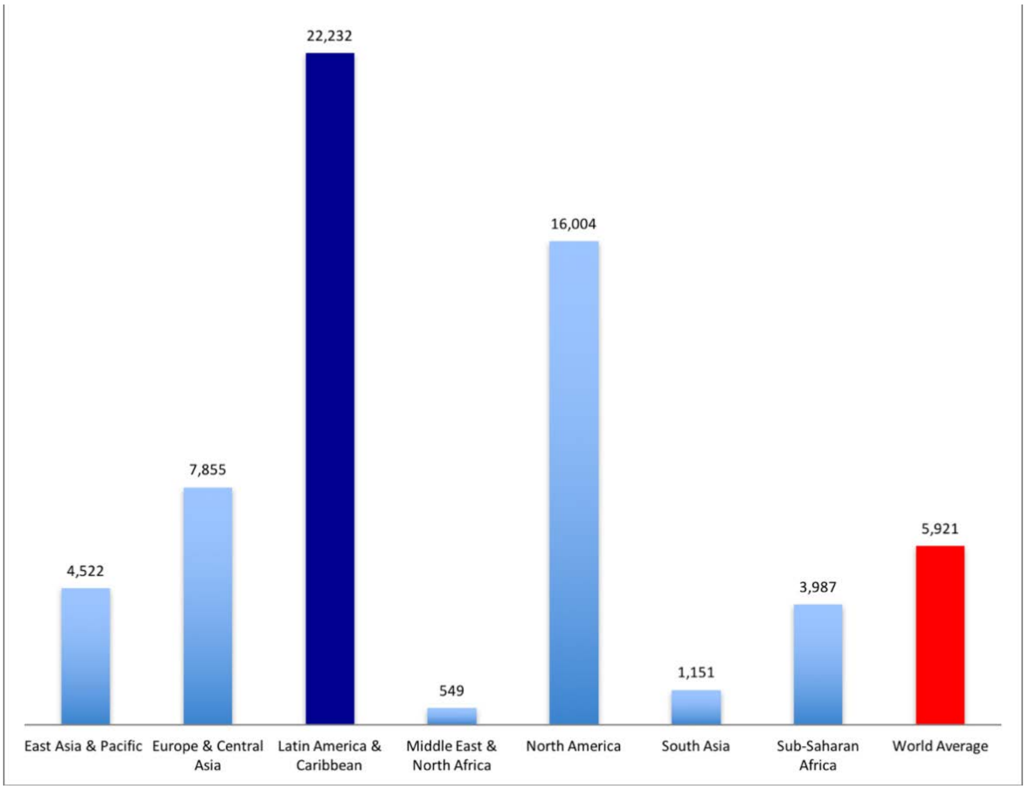
The obstacles ahead for governments, however, are plentiful. First, water is a sensitive and misunderstood good. Sensitive, because it is essential for all aspects of life, people and institutions (such as the United Nations) consider that access to clean water and to safe sanitation is a human right. But someone must pay for it, and sometimes users cannot or would not be willing to do it. Misunderstood, because most of the water that is abstracted from nature comes hidden in goods or services that people consume. A meaty diet, clothing, a clean car, a smartphone, or using an air conditioner are all directly or indirectly water-intensive processes. The links between food, water and energy cannot be seen in isolation.

Second, contrary to other sectors like energy, telecommunications or transport, technological change in water and sanitation is unlikely to be disruptive. Third, water bodies have not been well protected from contamination and from the conflict between their users (such as industries, farmers, and households). All this points to a simple conclusion: the old regulatory objectives, which have not been achieved so far, remain contemporary and become more urgent. Governments cannot avoid any more dealing with the political, cultural and economic processes that have been preventing the needed reforms to satisfy the population's water and sanitations needs while protecting the environment.

2. Water today

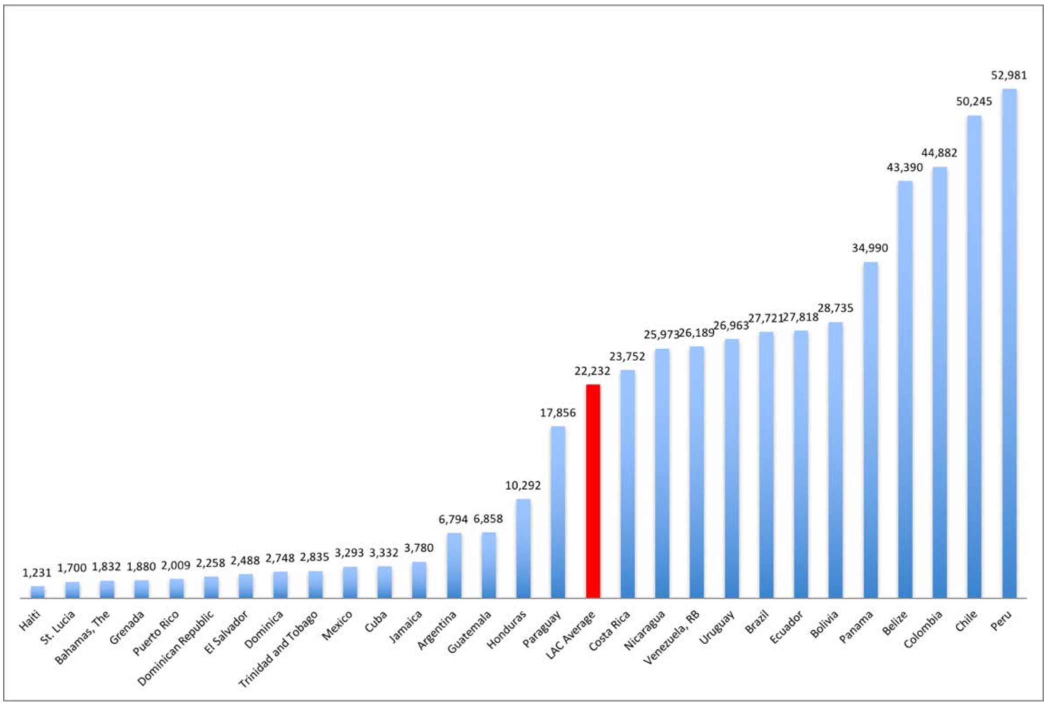
The region starts from an advantageous position, as it is the richest region in the world in terms of availability of freshwater resources. Figure 1 shows that LAC has almost four times renewable water resources per capita than the world average, and almost as much as North America, Europe and Central Asia combined. Most countries, on average, seem to be well above the United Nations thresholds for hydric stress (below 1,700 m^3 per person per year) or water scarcity (below 1,000 m^3 per person per year), as shown in Figure 2. Furthermore, the handful of countries that are at risk of falling below United Nations thresholds are Caribbean islands that may benefit from the development of desalination techniques that would increment the effective availability of water. Countries not only benefit from high levels of water resources but also have invested in population coverage of water and sanitation services. As shown in Figures 3 and 4, most of LAC's population has access to safe network water, and relatively high access to improved sanitation facilities.

Figure 1. Total renewable water resources per capita by region (in m^3/person/year, 2014)



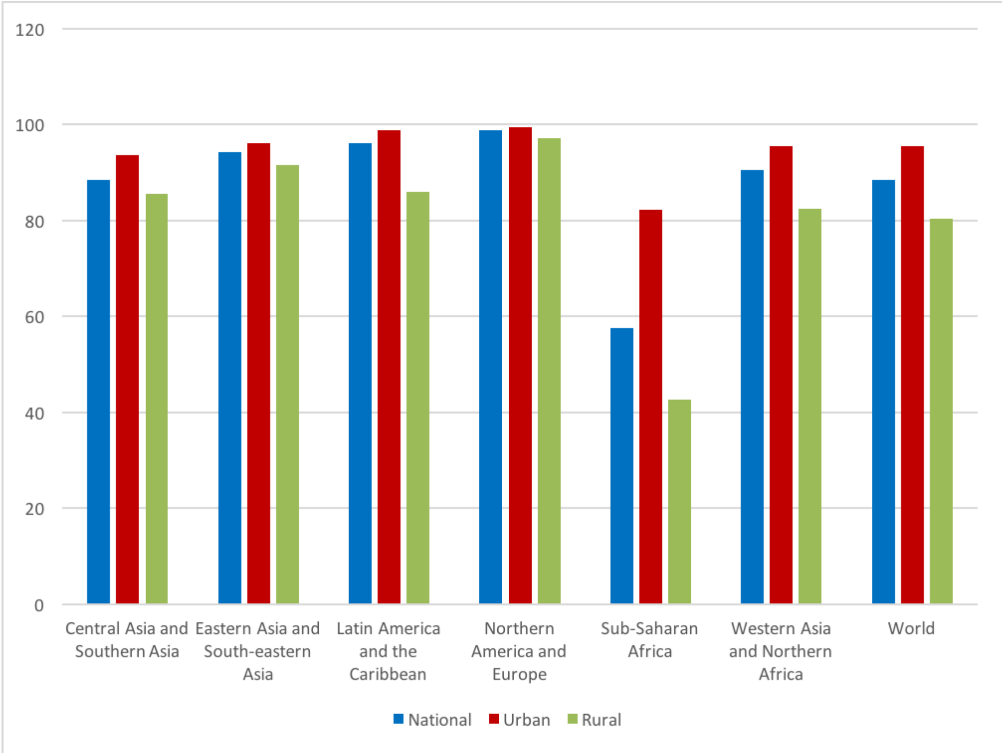
Source: Author's calculations using data from Aquastat-FAO and World Bank.

Figure 2. Total renewable water resources per capita in selected LAC countries (in m^3/person/year, 2014)



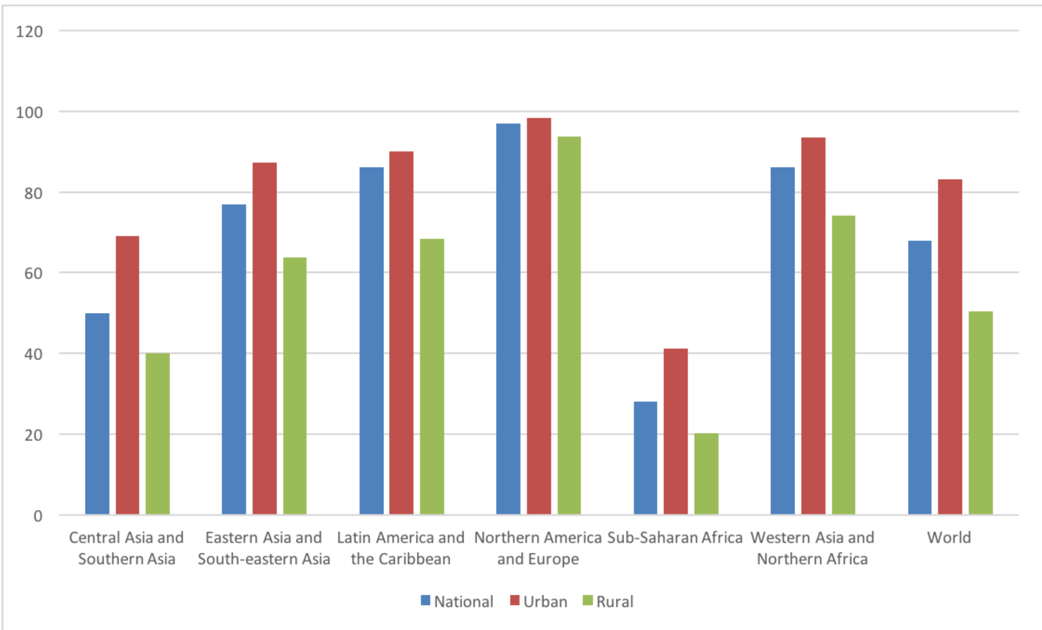
Source: Author's calculations using data from Aquastat-FAO and World Bank.

Fig 3. Access to improved drinking water by region in 2015 (%)



Source: WHO/UNICEF Joint Monitoring Programme - https://washdata.org/

Fig 4. Access to Improved Sanitation Facilities by Region in 2015 (%)

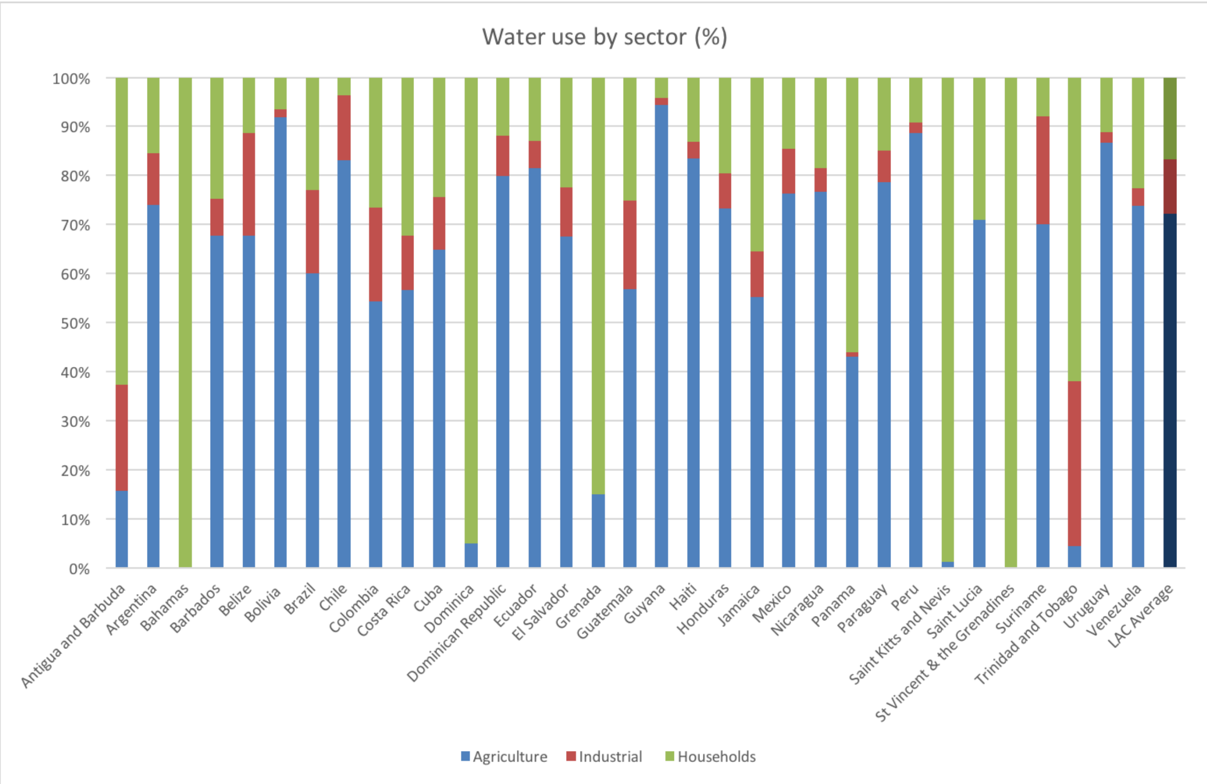


Source: WHO/UNICEF Joint Monitoring Programme - https://washdata.org/

However, even in a situation of relative abundance of water resources and good network coverage, the effective regulation and management of the water sector and the need for further investments in infrastructure remain paramount. First, water availability is not

evenly distributed within countries. Take Peru, for example, the water-richest country in the region. Its main basin, The Atlantic or Amazonian basin, is in a sparsely populated area, while most of the population lives in the hotter and drier Pacific coast. This example highlights the importance of well-connected national networks. Second, most of the water resources are used by agriculture directly and usually excluded from regulatory frameworks. Figure 5 shows that, on average, more than 70% of freshwater resources of the region are used for agricultural purposes. In terms of total regional resources, this usage is explained by the largest, more populated and richest countries in the region. Finally, while access to improved sanitation facilities is high on average (more than 80% of the population, including 60% having access to the sewerage network), the region performs poorly in terms of treatment of wastewater (less than 30%). Despite similar levels of access to safe sanitation, sewage treatment remains lower than in most of Asia and Northern Africa, as seen in Figure 6.

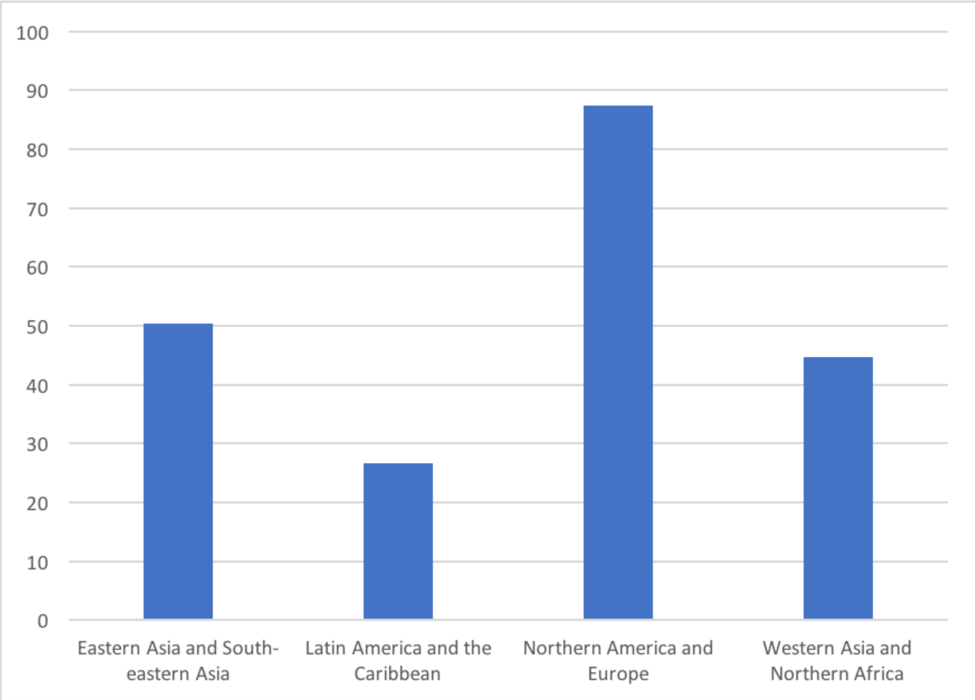
Figure 5. Water use by sector in LAC countries (2014)



Source: Authors' calculations using data from Aquastat-FAO.

The region needs to improve in other performance and efficiency indicators as well, such as the share of non-billed water, the extent that tariffs recover the full economic cost of water provision or measures of labor productivity of the sector (Lentini, 2015). To achieve the objectives of total permanent coverage in water and sanitation, high levels of wastewater treatment and water quality while being mindful of the environment and of the running costs of the service, regulatory agencies will have to finally embrace the economic underpinnings of water regulation and use the appropriate instruments to deal with the extremely important issues of access and equity.

Figure 6. Wastewater treated by region, 2015 (%)



Source: WHO/UNICEF Joint Monitoring Programme - https://washdata.org/

Similarly, in the face of new challenges and transformations in the water sector, regulatory frameworks need to adapt and to be flexible enough to deal with uncertainty and unexpected shocks. As of today, the gap with world's best practices is growing (Arias et al., 2019). For example, countries will need to implement complementary policies from both the supply and the demand sides to maintain high levels of improved water access and to improve wastewater treatment. While investing in infrastructure is both urgent and unavoidable, it may not be enough to deal with issues of scarcity or sustainability, and authorities will need to be open to the use of new or different regulatory instruments and to think outside the box. Countries will also need to embrace and stimulate innovation, and incentivize behavioral change in consumers. New technologies, such as desalination, digital identification of leakages or smart metering have the potential to mitigate some efficiency and supply problems while at the same time improving demand management. For these new possibilities to be materialized, regulatory frameworks need to adapt and be flexible enough, to enable and encourage innovation and the implementation of these new techniques.

3. Governance and regulation: still work in progress but some countries moved in the right direction

Most countries in the region have put in place regulatory frameworks that are inspired by international best practices. An ideal water sector would be efficient, equitable and both financially and environmentally sustainable. The guiding principle is that everyone should have access to clean water and safe sanitation that is affordable. Trade-offs are inevitable, as the sector requires large capital investments and the resource is sought by many competing users (such as agricultural producers, power plants or mines), that can abstract water directly.

Regulators around the world have developed tools to deal with issues related to the economic and social value of water, such as cost-reflective tariffs, water rights and appropriately designed and well-targeted subsidies (UNESCO World Water Assessment Programme, 2019).

However, most Latin Americas and Caribbean countries have struggled to implement good governance and economically sound principles in the water and sanitation sector. Arias et al. (2019) provide a summary of the performance of the sector in the region, relative to the benchmark case of England and Wales (see Table 2). Two issues stand out.

Table 2. Achievement of regulatory objectives in LAC and England and Wales

Regulatory objective	LAC	England and Wales
Coverage	Well below 100%, especially in wastewater	100%
Productive efficiency	Inefficient	Presumably efficient
Allocative efficiency	Inefficient, mostly due to the public subsidies aimed at maintaining low tariffs	Efficient, although with certain cross subsidies among rural and urban consumers
Social equity	Unequal, mostly due to ineffective social tariff systems and unfair access	Equal, but noting that the problem with poverty is much more acute in LAC than in E&W
Environmental sustainability	Unsustainable, in terms of the amount of wastewater discharged to the environment without treatment	Broadly sustainable
Economic sustainability	Unsustainable, given the dependence on public funds and the general lack of clarity in terms of technical mechanisms to set charges	Sustainable, noting that there is a general perception from the public that some companies are profiting at their expense from financial engineering
Resilience to tackle future challenges	Non-resilient	Presumably resilient

Source: Arias et al. (2019)

First, the ad-hoc design of the sector, with geographic and administrative decentralization at its heart, has not helped. In many countries, water and sanitation are provided by small isolated local suppliers, usually run by municipalities that lack the resources and capacity to deliver a good and reliable service. For example, service suppliers in the region have high levels of employment per number of connections, suggesting that productivity is low. This is even more problematic when water resources are somewhere else and coordination with national and regional agencies is generally difficult (see Table 3 for country details, taken from Ballestero et al., 2015).

Second, services have not been priced effectively. The tariff system should be designed such that revenues recover costs, and people have access to affordable services. But these

basic economic and social principles have often been sacrificed by inappropriate tariff structures. For example, access to very cheap water among the better off in urban areas simultaneously makes it more difficult for service providers to extend coverage and induces wasteful use.

Table 3. Separation of functions, by country

Country	Policy	Planning	Regulation & control	Provision
Argentina	Local governments	Local	Local	Municipal and local firms – Cooperatives
Belize	Central	Central	Central	National firms
Bolivia	Central	Central & local	Central	Local firms – Cooperatives
Brazil	Central	Central & local	Municipalities	Regional, state and municipal firms
Chile	Central	Central	Central	Regional and municipal firms
Colombia	Central & department	Central & department	Central	Municipal firms
Costa Rica	Central	Central	Central	National firm – Municipalities – Administrative committees
Dominican Rep.	Central	Central	Central	National and regional firms – Communal water boards
Ecuador	Central	Central	Guayaquil & Agencia de Regulación y Control del Agua	Municipal firms
El Salvador	Central	Central	Central	National firm – Municipalities – Rural cooperatives
Guatemala	Central	Central	--	Municipal firms – Rural communities
Honduras	Central	Central	Central & local	National firm – Municipalities – Private firm

Country	Policy	Planning	Regulation & control	Provision
Mexico	Central	Central & state	--	State and municipal firms – Water boards
Nicaragua	Central	--	Central	National firm – Municipalities – Communal organizations
Panama	Central	Central & local	National agency	National firm – Rural boards
Paraguay	Central	Central	National agency	National firm
Peru	Central & local	--	National agency	Municipal firms
Uruguay	Central	Central	National agency	National firm
Venezuela	Central	Central	Central	National firm

Source: Ballestero et al. (2015).

Some countries have been moving in the right direction to deal with these issues. For example, after the privatization of the water supply, Chile has set cost-reflective tariffs jointly with a system of direct subsidies for low income consumers, that addressed successfully issues of affordability. However, most operators are not financially sustainable and must rely on government transfers. Similarly, some countries have started to take seriously environmental and scarcity issues, that may result in depletion of water resources. For example, Peru has introduced a system of environmental fees to finance the conservation of water sources that is accrue to customers by municipal water providers. Chile, on the other hand, has introduced a market for rights to abstract raw water. This system separates water rights from land ownership, and declares that water rights are private and fully tradable. This allows the country to coordinate the different levels of water resources and infrastructure across regions. For example, while areas of relative scarcity, such as the north of the country, have experienced over-exploitation of water sources, in the water-rich south the lack of storage infrastructure has prevented a more efficient management of water resources across seasons.

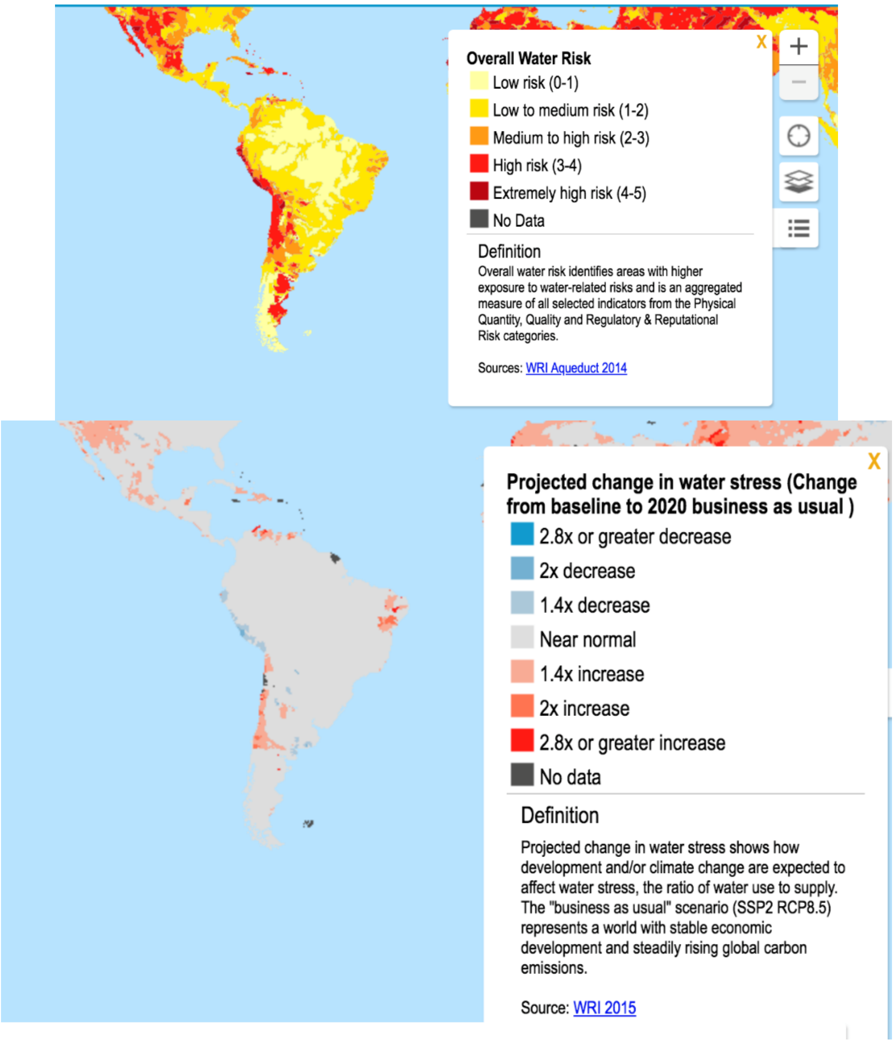
4. Challenges ahead for the water sector

LAC countries cannot escape the reality that the natural, social and economic environments are all simultaneously changing very quickly. These phenomena will all contribute to dramatic and sometimes unexpected changes in the water sector, both from the supply (e.g., seasonal freshwater availability, infrastructure requirements, and new technologies) and from the demand (e.g., quantity and quality of services required and environmental concerns) sides.

The region, just as the rest of the world, is getting hotter on average and is exposed to an increase in extreme weather events and more erratic precipitation patterns. According to estimates reported by the Intergovernmental Panel on Climate Change (Magrin et al., 2014) for different climate change scenarios, large parts of the region may expect up to 6 additional degrees by the end of the century. Even in the best-case scenario, average temperatures are expected to rise almost 2 degrees in most of the region. In this relatively optimistic scenario, Arias et al. (2019) report that the number of additional hot days per year (i.e. temperatures above 35 degrees) can increase by 30 in large parts of the region, including large and populous countries such as Brazil and Mexico.

Water resources, demand, and infrastructure are all potentially affected by this changing climate. First, the availability of surface water and groundwater (e.g. river, lakes and aquifer levels), depends on temperatures, precipitation and the process of replenishment of freshwater resources through the water cycle. There is evidence that areas already rich in water are more likely to get more water and drier areas are more likely to become even drier (Durack et al., 2012). For the latter, this implies a greater incidence of droughts, even in in areas usually rich in water, that will certainly increase episodes of hydric stress, as can be seen in Figure 7, that shows the current and future risk of water stress in different areas of the region (World Resource Institute, 2013).

Figure 7. Current and Future Risks of Water Stress

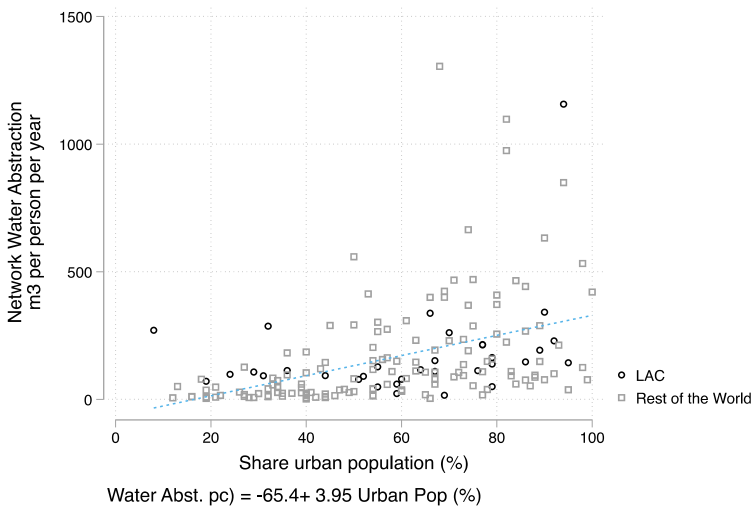


Source: AQUEDUCT, Water Risk Atlas, Water Resource Institute

Furthermore, freshwater availability, reliability and seasonal variation may also be affected by the reduction of natural reserves of water in solid state, such as glaciers or ice caps that store water in cold years and release it in warmer years. These changes in water availability may generate greater need for artificial storage of water, network connecting surplus and deficit areas, and a more appropriate use of pricing mechanisms to deal with scarcity. Second, climate change has also been linked to a permanent rise in sea levels or transitory ones (e.g., due to storm surges) that may introduce saltwater in freshwater sources at surface or groundwater levels. According to ECLAC (2015), every coastal point in the region shows a secular increase in sea levels, with areas such as the north of Brazil and the Caribbean increasing sea levels at a rate of 2.8 mm per year and is expected to increase to 3.6 mm per year between 2040 and 2070. By then, sea levels in some parts of the region could increase by up to 20 cm. In those circumstances, the cost-effectiveness of desalination techniques becomes crucial. Finally, there is the potential for more direct effects of extreme weather events on network facilities (e.g. floods may destroy or overload the wastewater network, extreme heat may crack pipes) or on water quality, as pollutant concentration may increase due to changes in the chemistry of water. These issues may require additional investments in infrastructure and in the treatment of drinking water.

Another challenge for the sector comes from the increasing levels of urbanization. Even though around 80% of the population in LAC currently lives in urban areas, the urban population in LAC has been growing almost 40% faster than the total population, on average. This trend is expected to continue and deepen over the next few decades, with urbanization rates predicted to reach almost 84% by 2030, 87% by 2050 and 91.5% by 2100 (ECLAC, 2017). According to United Nations, around 45% of the population of LAC lives in 125 cities with more than 500,000 people and more than 15% in just 8 cities with 5 million people or more (UN, 2016). These cities (and smaller ones) are expected to keep growing: by 2030 the UN expects that more than 150 cities with 500,000 or more people will be home to almost 50% of the region's population. This will most likely generate an increasing demand for water and sanitation services, as more urbanized countries tend to show greater levels of water abstraction for domestic and industrial purposes, as can be seen in Figure 8.

Figure 8. Urban Population and water abstraction per capita in 2015



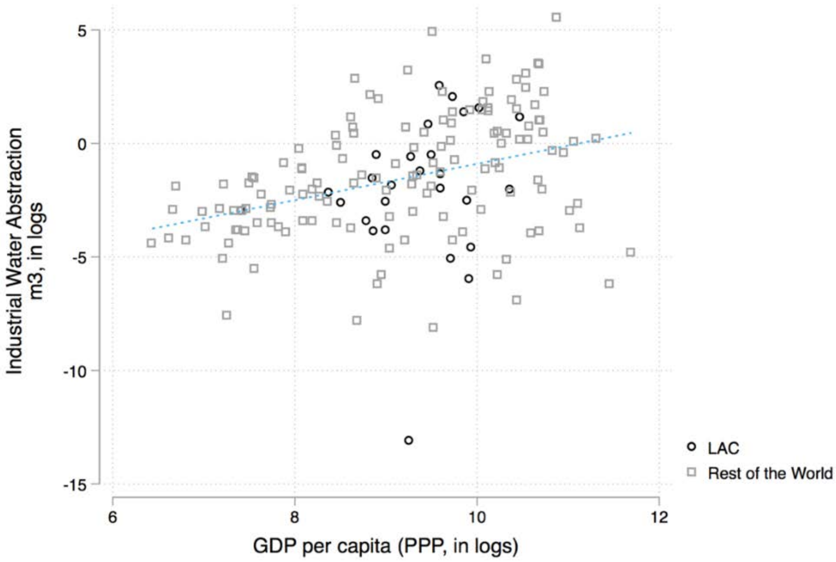
Source: Author's calculations using data from Aquastat-FAO and World Bank.

In any case, whether the urbanization process happens because population growth is concentrated in urban areas, because people move from rural areas to cities or because previously rural areas become urban, it will most likely result in greater use and demand for network water and sanitation. This projection is valid under the assumption that the region at least maintains its current level of access to safely managed drinking water in urban areas. Additionally, greater urbanization rates may also put even more pressure on the provision of safe sanitation, that currently relies on basic services and is well below the coverage of safe management of the excreta that can be found in other regions.

On the other hand, greater concentration in urban areas could be expected to reduce the unit cost of networks, simply because networks are broadly fixed investments and in more dense areas they are used by more people than in less dense areas. This means that it is unclear whether population growth and urbanization will generate social pressures that could materially change the economics of the sector. There is however one aspect of an increasing urban population growth that could potentially impact on the economics of the sector. This is related to the fact that the type of consumer that lives in cities may be more demanding in terms of quality of services than the type of consumer that lives in rural areas of LAC countries.

The aggregate abstraction of water per capita is also associated with greater levels of income per capita, even when controlling for the share of urban population. This cross-country relationship is slightly stronger when looking only at countries in LAC (the elasticity moves from 0.78 to 0.98), suggesting that as countries get richer the household demand for water also increases. While there are no long-term projections of economic growth, using current short-term IMF projections of 1.7 annual per capita growth (that is in line with the growth for the last 25 years), implies that water network abstraction in LAC should increase around 18% by 2030 (Arias et al., 2019).

Figure 9. Industrial water abstraction and GDP per capita in 2015



Source: Author's calculations using data from Aquastat-FAO and World Bank.

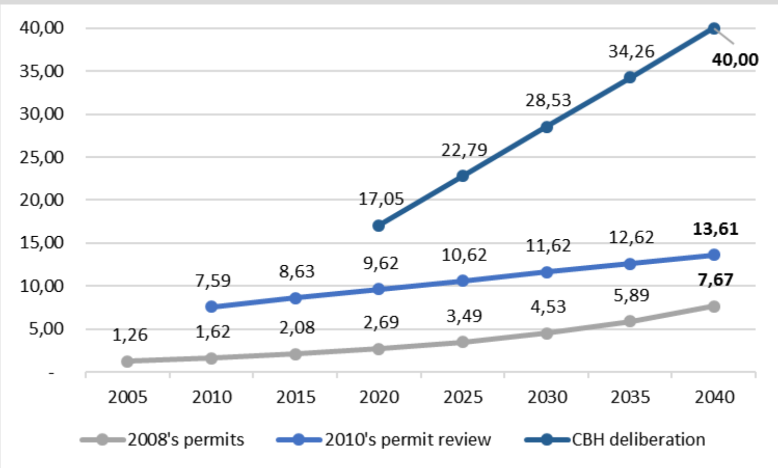
These additional demands for water and sanitation services due to economic growth and increasing urbanization happen in a context where around 70% of the freshwater resources are directly used by the agricultural sector. But economic development may

also generate new demands for water, that may compete against other uses, such as industrial use (e.g. mines) or power plants, as can be seen in Figure 9. So, while water abstraction for industrial and domestic uses may increase, water may also be key in increasing agricultural productivity, particularly among the rural poor. Many in the continent (particularly small-scale family farms) rely on rainfall, that is becoming increasingly erratic and unpredictable, and the availability of reliable sources of water for them may become a pressing issue. This has implications in terms of infrastructure provision (to move water across regions or to harvest rainwater), regulation that includes abstraction rights, conflict management and environmental concerns (e.g. pollution from industrial users such as mines and from fertilizers and pesticides, particularly from extensive agricultural users). The instances of conflict around water have been increasing over time. Since 2000, the Pacific Institute for Water Conflict Chronology (2018) has recorded 38 events with casualties, including protests over diversion of water resources, contamination, or attacks on water facilities, among others. Box 1 discusses an example of competition for water among different users in Brazil.

Box 1. Conflict over water use between agriculture and hydropower in Brazil (FGV-CERI, 2019 and OECD, 2015)

The São Marcos River is a federal river in the border of the states of Minas Gerais and Goiás in Brazil that serves both farmers and hydropower plants. One of the plants, Batalha HPP, had a concession that secured the supply and flow of water required to generate electricity by limiting the abstraction of water for other uses, upstream from the power plant, between 2010 and 2040. The cap in water abstraction established a maximum irrigated area of 63,500 ha. However, the total irrigated year has increased at a regular rate every year reaching almost 71,000 ha in 2013 and almost 83,000 ha today. This has generated conflicts between farmers, and particularly, between farmers and the hydropower plant and has prompted revisions to the abstraction rights set in the regulatory framework. Generally, the regulator (Comitê da Bacia Hidrográfica do Rio Paranaíba) increasingly prioritized the demands of water for irrigation purposes, declaring in 2016 the use of surface water in irrigation as a priority to permit granting. Figure B.1 below shows the evolution of abstraction rights for irrigation purposes according to the initial regulatory framework and subsequent revisions (in 2010 and 2016). More recently, in March 2018, the regulator increased again the water abstraction limits upstream of the hydropower.

Figure B.1– Limits of consumptive uses upstream of Batalha HPP



Source: FGV-CERI (2109)

5. Preparing for the future: tackling supply and demand together.

A persistent challenge in LAC water and sanitation sector has been the need for more and better infrastructure. A drier future in a context of greater demand suggests that the capacity of the supply system needs to be increased and enhanced. In short, LAC will need more and better infrastructure to build a sector that is both resilient to shocks and efficient in using water resources. However, the focus should not be only on the supply side. A modern approach to the water and sanitation sector cannot ignore the role of demand management in reducing the use of treated water, and improving the sector's efficiency.

Many of the options that are available for countries to deal with their specific problems have been around for a long time. While challenges, and their appropriate solutions, are country-specific, these traditional instruments to improve the performance of the water sector would most likely be part of any country's strategy. That is, investment in the water and sanitation network and infrastructure remain paramount. Independently of how countries manage to do this, the objective is still to have more and better connected networks that allow water transfers from water surplus to deficit areas, or more plants for the treatment of wastewater. Similarly, countries or regions may want to invest in more storage (such as reservoirs) or try to tap unused freshwater resources. In cases where water access remains a challenge, cheaper alternatives, such as Rainwater Harvesting Systems may be available as a short-term solution to the problem of access to good quality water (see Box 2).

Box 2. Rainwater Harvesting System in El Salvador (FES, 2018)

The Rainwater Harvesting System (RHS) collects and stores rainwater for domestic consumption. RHS is a decentralized, domestic water source and thus are less vulnerable to threats of infrastructure breakdown, contamination of external reservoirs or fluctuations in the cost of operation. It is also an attractive option because it can provide better quality of water collected and offers the possibility of reducing demand on already stressed water grids. Capital costs of RHS are low when compared with expanding the water network, or developing local water systems from wells or boreholes. Also, operating costs are much lower than the cost of fetching water from sources at some distance from the household or than purchasing water from commercial providers. RHS has the potential to improve equity in access to water, since it can serve poorer and rural households that usually suffer from low access to the water network or low service quality.

FES, Fundacion para la Educacion Superior from El Salvador, analyzed the potential of this system to become a low-cost alternative source of water in communities without reliable water service from the water grid during the wet season. Some of the expected benefits include reducing the pressure on groundwater or surface water resources, improving the use of time (due to the time and effort of fetching water), avoiding polluted sources and improving sanitation (that is usually constrained by the lack of water). Some of the potential drawbacks include contamination from other pollutants, whether airborne or material accumulated in the rooftop or gutters (including bird droppings and organic material), vulnerability to dry spells and maintenance and repair costs.

Table B.1 Cost per cubic meter by alternative.

	San Salvador	Comalapa	San Miguel
Rainwater harvesting	$2.20	$2.15	$2.10
Purchased water	$5.00	$10.00	$7.50
Expansion of water grid	$10.48	$10.48	$10.48
Water fetched from a close source (less than 500 m.)	$15.62	$15.62	$15.62
Water fetched from a source at more than 500 m. from household (4 hr. for 200 l)		$31.25	$31.25
RHS plus purchased water (average per m3)	$3.60	$5.97	$4.67

FES developed a model to assess the potential of RHS in three localities in El Salvador where rural and/or urban households have not residential access to piped water and rely either on community taps or on groundwater resources. The results of a water balance model show that RHS can satisfy all water needs of a household during the rainy season, but is a very limited resource during the dry season. RHS is the most cost-efficient water source. With a very large tank (of at least 10 cubic meters), stored water could cover demand of the first 40-50 days of the dry season, at the cost of a significant investment. However, Table B.1 shows that RHS seems to be the cheapest water alternative, even when combined with purchased water (the current source of potable water for most of these households) to cover the rest of the dry season.

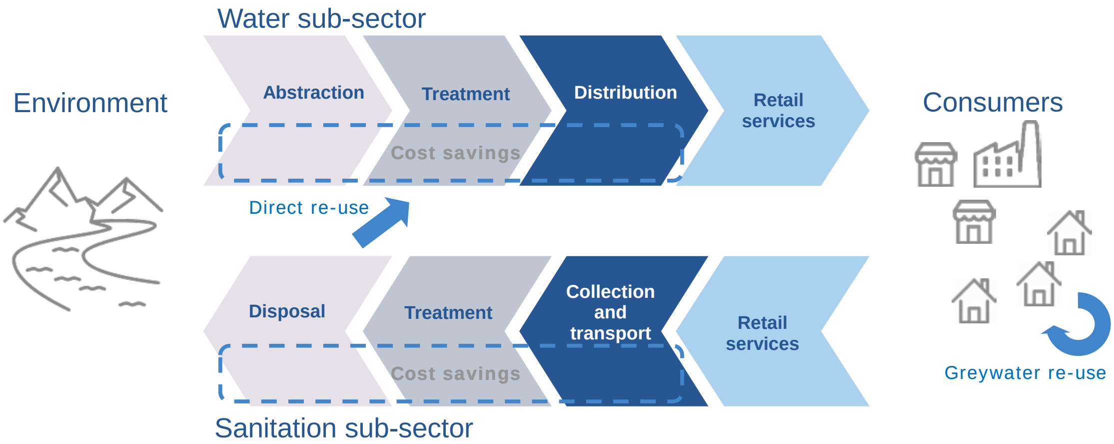
Countries can also implement newer strategies, by promoting the use of or investing in modern water-specific technologies. It must be noted that, as opposed of what happens in the energy, transport or communications sectors, these innovations are unlikely to structurally upset or induce a radical re-organization of the water and sanitation sector. However, they can be part of a mix of strategies that can substantially improve sector resilience and performance.

A good example is related to desalination techniques that can increase freshwater availability in coastal areas, many of which are very dry and have insufficient availability of fresh surface or ground water, such as the north of Chile or the Peruvian coast. While water supply could be increased with desalination infrastructure, that process is not without challenges, including potentially harmful implications for the environment. First, because these techniques require large amounts of energy. Second, because they generate a lot of waste in the form of brine (concentrated saltwater) containing several chemicals that are added to the desalination process, such as copper or chlorine.

Another set of technologies include new ways of re-using water, either by transforming dirty water into potable water before the water gets discharged into the wastewater network or by using it without treatment, for needs that do not required high standards of purity in the water. For example, with small investments on water filtering and home piping technologies, households could re-use "grey" water to flush their toilets. This could lead to material cost reductions across the whole sector. For example, 35% of the water consumption is used to flush toilets, which is currently done with drinkable water (Arias

et al., 2019). On a more ambitious scale, recycled wastewater can also be used for irrigation in agriculture or in industrial production. This would reduce considerably the demand for treated water and for network capacity. This shortening of the value chain is depicted in Figure 10 below.

Figure 10. The impact of water reuse in the water and sanitation value chain



Source: Arias et al. (2019)

The most important characteristics, key issues and lessons learned for alternative water reuse practices are summarized in Table 4, taken from Voutchkov (2018). The most common applications of non-potable reuse of recycled water include agricultural irrigation, landscape irrigation, industrial reuse and groundwater recharge.

Table 4. Wastewater Reuse Applications and Related Issues or Constraints

Category		Potential application	Issues/constraints	Lessons learned
Non-potable water reuse				
Agricultural irrigation	Unrestricted or restricted	Food crop eaten raw Food crop processed or cooked Pastures for milk production Orchards, vineyards with or without contact with edible fruits Fodder and industrial crops Ornamental plant nurseries	Water quality impacts on soils, crops, and groundwater Runoff and aerosol control Health concerns Farmers acceptance and marketing of crops Storage requirements	Good practices available to mitigate adverse health and agronomic impacts (salinity and sodicity) Storage design and irrigation technique are important elements Numerous reported benefits
Landscape irrigation	Unrestricted or restricted	Golf courses and landscape Public parks, school yards, playgrounds, private gardens Roadway medians, roadside plantings, greenbelts, cemeteries	Water quality impacts on ornamental plants Runoff and aerosol control Health concerns Public acceptance Water quality control in distribution systems	Successful long-term experience Good agronomic practices On-line water quality control can ensure health safety Numerous benefits
Urban uses		In-building recycling for toilet flushing Landscaping (see irrigation) Air conditioning, Fire protection Commercial car/trucks washing Sewer flushing Driveway and tennis court washdown Snow melting	Health concerns Control of water quality and biological growth in distribution systems Cross-connection control with potable water Cost of distribution systems	Dual distribution systems require efficient maintenance and cross-connection control No health problems reported even in the case of cross-connections (for tertiary disinfected reclaimed water)

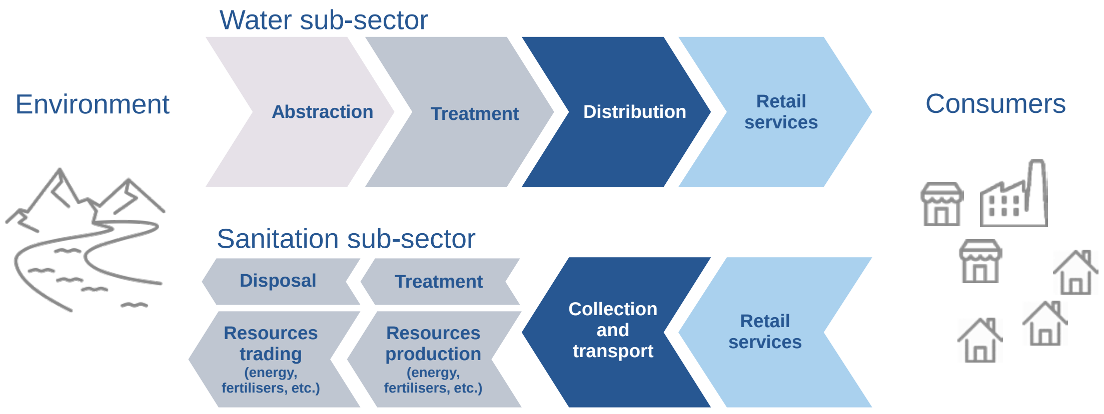
Environmental/ Recreation uses	Unrestricted or	Recreational impoundments Environmental enhancement (freshwater or seawater protection) Wetlands restoration Fisheries Artificial lakes and ponds Snowmaking	Health concerns Eutrophication (algae growth) due to nutrients Toxicity to aquatic life	Emerging application with numerous benefits for the cities of the future: improving living environment, human wellbeing, biodiversity, etc. On-line water quality control can ensure health safety
Industrial reuse		Cooling water Boiler feed water Process water Heavy construction (dust control, concrete curing, fill compaction, and clean-up)	Scaling, corrosion and fouling Biological growth Cooling tower aerosols Blowdown disposal	Water quality to be adapted to the specific requirements of each industry/process Request for high reliability of operation, cost and energy efficiency
Potable water reuse				
Indirect potable reuse with replenishment of:	Aquifers	Groundwater replenishment by means of infiltration basins or direct recharge by injection wells Barrier against brackish or seawater intrusion (direct recharge) Ground subsidence control	Health concerns Groundwater contamination Toxicological effects of organic chemicals Salt and mineral build-up Public acceptance	Successful practice since 1970s Multiple barrier treatment ensures safe potable water production Efficient control by means of advanced modelling tools
	Reservoir	Surface reservoir augmentation Blending in public water supply reservoirs before further water treatment	Health concerns Public acceptance Eutrophication (algae growth) due to nutrients	Successful practice since 1970s Multiple barrier treatment ensures safe potable water production Improvement of water quality
Direct potable reuse		Pipe-to-pipe blending of purified water and potable water Purified water is a source of drinking water supply blended with source water for further water treatment	Health concerns and issues of unknown chemicals Public acceptance Economically attractive in large scale reuse and chronic water scarcity Environmental buffers	Multiple barrier treatment ensures safe potable water production No health problems related to recycled water in Namibia since 1968 Cost efficient compared to indirect potable reuse

Source: Voutchkov (2018)

Similarly, resource recovery and the use of eco-systems are changing the way we think about wastewater and how it can be treated to purify water. In fact, water discharged is slowly changing its nature, going from waste to a resource-rich commodity. Valuable resources can be recovered from wastewater (including solids and urine) and used as fertilizers or as an input to produce animal feed. Also, wetland ecosystems are being used as an effective way to treat water (removing nutrients and toxic metals) and to provide water for other uses. For example, to generate habitat for animals, such as amphibians, or to irrigate green areas, such as forests (Science for Environment Policy, 2015).

The main change is that the wastewater treatment activity becomes a resource production activity. This change would transform the wastewater industry from a single product industry (where clean water is the only product) into a multiproduct industry (where clean water is just one of the many goods or services that are produced). Some of the resources produced may be used internally by the water and sanitation operator. For example, energy generated in treatment plants may be used in the same resource production activity. This has the potential to achieve substantive cost efficiencies. For example, energy recovery technology development is projected to be able to make treatment plants 100% energy self-sufficient by the year 2030 (Voutchkov, 2018). Other resources may be sold to other users, creating a whole new activity focused on trading resources. The new configuration of the water and waste water value chain resulting from changes in resource recovery is depicted in Figure 11.

Figure 11. The impact of resource recovery in the water and sanitation value chain



Source: Arias et al. (2019)

Finally, other technological innovations are helping with demand management and improvements in water supply. As in other sectors, smart and digital technologies, such as GIS, smart meters or satellites are used to generate information that can improve the performance of the network. Table 5 summarizes the potential uses and challenges associated with digital technologies in the water and sanitation sectors. The key take-away message is that new technologies can help utilities in maintaining the network, identifying leaks and preventing faults, and monitoring measures of water service quality. Through the collection of large amounts of data, it can also help both supply and demand in understanding better consumer use and promote sustainable practices, by measuring and keeping records of water use. Consumers' experience with water and sanitation use can also improve as digital services affect the relationship with the suppliers, empowering consumers. As in other industries, these changes are not without challenges: workforce and consumers need to acquire new skills not to be excluded from technological change, providers need to upgrade their own capacity to generate, process and analyze large amounts of data and systems need to be protected against cyber-attacks.

Table 5. Digital Water

Technology	Use	Challenges
Satellites and drones	Surface and groundwater evaluation and flood forecasting. Assessment of real-time conditions upstream (including water quality). Assessment and preventative maintenance of network assets and leak detection	• Water utility workforce to adapt and learn new skills • Cybersecurity to protect critical infrastructure • Water utilities need the capacity to process these data

Blockchain	Permanent and collective record-keeping of water use and transactions for a range of stakeholders	for more informed decision making • Digitally savvy consumers and digital inequality • Standardization between various data collection, storage and monitoring digital platforms
Smart meters, advanced metering infrastructure and other digital solutions	Real-time monitoring: real-time pressure, flow, and water quality Identify high-risk pipelines for replacement and leaks. Identify over-consumption and promote sustainable and efficient water use. Consumer access to utility data and information with ease, professional services. Adoption of off-grid solutions for water quantity and quality.	

Source: Sarni (2018), Voutchkov (2018)

Some of these changes are already transforming the water sector in LAC counties. For example, to identify and help reduce network leakages (see Box 3). Leakages are substantial even in advanced countries. For example, estimates suggest that around 20% of water in the network is lost through leakages in the UK (NIC, 2018).

Box 3. Using satellite technology to reduce leakages in Trinidad & Tobago

Water leakages reach up to 50% of produced water in Trinidad & Tobago. The Water and Sewerage Authority is implementing a strategy to identify sub-surface leaks in the municipal water distribution system using satellite remote sensing technology, provided by a private sector partner (Utilis). The satellite sends microwave signals that, after filtering out buildings, vegetation and other objects, can identify a signature typical of treated drinking water. As treated drinking water would only be in the area when the pipes are leaking, the satellite can pick up network leakages. This information is overlaid to digital maps that allow authorities to identify the exact location where repairs are needed. Authorities estimate that the timely and precise identification of leakages imply that costs are 90% cheaper than traditional methods.

6. Regulatory tools for a challenging future

We have seen that a warming and uncertain world, coupled with demographic and economic dynamics, imply that local and national governments in LAC may need to start thinking more systematically about how to deal with scarcity of water. The problem is not new and certainly not unique to the region, even though it will present itself in ways that are context-specific. That means that regional authorities do not necessarily need to

come up with radically new approaches. Their ability to cope with issues of scarcity can be based on experiences from countries in other regions that have used a variety of policy instruments to deal with it, including appropriate pricing strategies, incentive frameworks to rationalize the wasteful use of water and the promotion of creation and adoption of innovative solutions to problems. The implementation of a modern, comprehensive and flexible regulatory framework is thus key to send the right signals to both utilities and consumers in a context where hydric stress may become increasingly salient. Modern, because it needs to account for new developments that can contribute to a better regulation of the sectors, such as digital technologies and big data. Comprehensive because, as discussed in the previous section, historically distinct issues like water scarcity and wastewater treatment can be tackled simultaneously and because in times of scarcity regulation may need to account for the fact that freshwater is also used by different competing groups that extract water directly (such as farmers, power plants, industries, mining companies). And flexible because over-regulation may stifle new developments and the adoption of innovations to tackle local or general problems.

There are several tools that a modern, comprehensive and flexible approach to water and sanitation can use to improve efficiency in the water sector. First, despite structural, technological and societal changes to the water and sanitation sectors, the price mechanism remains probably the most important policy instrument that regulators need to update and get right. This has not been easy because trade-offs abound: e.g. access to water is rightly regarded as a human right but, at the same time, inadequate pricing induces wasteful use. The challenge for regulators is to design tariffs that allow for cost recovery and induce an efficient use of water resources but at the same time takes care of equity and affordability considerations (United Nations World Water Development Report, 2019).

Second, there are other regulatory tools that can help to generate gains in efficiency from the producer or the consumer side. As in other regulated sectors, introducing competition in the areas where is feasible is an important instrument to improve efficiency, increase coverage and spur innovation. Another market-based solution is the creation of a market for water abstraction, that can be used to create a comprehensive water regulation framework that can balance the needs of different types of users, many of which are excluded from current regulatory regimes, such as agriculture (which, as discussed above, constitutes around 70% of abstraction of freshwater resources in LAC), hydro-power plants or industrial users.

More direct interventions are also needed. For example, the detection of leakages can be assisted the rolling out of (smart) meters, or through other incentives to utilities (that can choose which technology is best suited for them, as discussed in the previous section). As in other matters of public interest, regulators can generate change through information campaigns, bonuses and fines, etc. Table 6, taken from Arias et al. (2019), provides a summary of regulatory policies that are considered key in the future of water and sanitation regulation.

Table 6. Examples of future water and sanitation sector regulatory policies

Regulatory policy	Rationale
Business-as-usual (aimed at achieving coverage in an efficient, equal and sustainable manner)	
Establish economic regulators that operate at arm's length from the government	Ensure economic sustainability
Implement regulatory systems that ensure tariffs are cost reflective (including external costs) while protecting vulnerable users	Achieve allocative efficiency while maintain equity Achieve environmental sustainability
Implement regulatory rules (that can work in the context of both private and public ownership of utilities) that incentivize companies to save costs	Achieve productive efficiency
Capacity building at both ministerial and regulatory agency level	Ensure that human capacity to implement the regulations in practice is available
Beyond-business-as-usual (aimed at tackling the new challenges posed by future changes facing the sector)	
Develop water abstraction rights trading markets	Create a method to improve the allocation of raw water resources in a future context in which there will be increased uncertainty on raw water availability generated by climate change
Implement additional incentives (such as the abstraction incentive mechanism in E&W) to deal with over-abstraction	Ensure environmental sustainability in the context of increased uncertainty on raw water availability generated by climate change
Implement upstream competition	Ensure that the regulatory system enables the development of innovations in areas such as resource recovery
Implement retail competition	Ensure that the regulatory system is able to respond to future more demanding and empowered customers Retail and water upstream competition could leverage the impact of abstraction rights markets further improving the allocation of scarce raw water resources
Develop a customer engagement framework	Ensure that the regulatory system is able to respond to future more demanding and empowered customers
Introduce a degree of discretion embedded in the regulatory regime so that both regulators and utilities can endogenously determine the outcomes to be pursued and the incentive schemes needed to encourage companies to achieve those outcomes	Provide resilience to tackle future challenges that are currently unknown

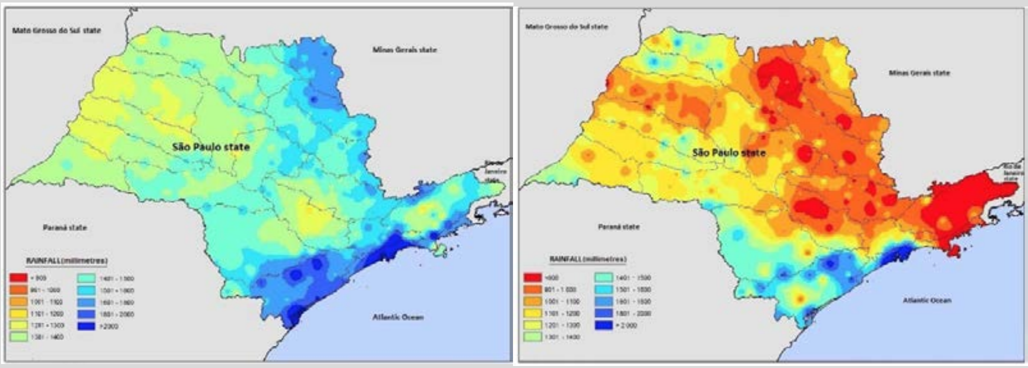
Source: Arias et al. (2019)

To illustrate the set of policy options available in the presence of a hydric crisis, Box 4 discusses how authorities in São Paulo, Brazil dealt with a very severe drought that affected the region between 2014 and 2015.

Box 4. Policy responses to a drought in metropolitan São Paulo, Brazil (Braga and Kelman, 2016)

During 2014–2015, the State of São Paulo in Brazil experienced its most severe water crisis in at least 125 years. Figures below compare the average annual precipitation in the State of São Paulo between 1979 and 2013 (left) and the average precipitation in 2014 (right). The severity of the drought was reflected in the reduction of around 50% in water resources the neighboring systems that serve water to the São Paulo metropolitan area.

Figure B.2 Annual precipitation in Sao Paulo (1979-2013 and 2014)



Source: Braga and Kelman (2016)

To cope with the crisis, the State Government and SABESP (Water and Sanitation Company of the State of São Paulo), implemented a set of structural measures (i.e. building emergency infrastructure) and a strategy of demand management via economic instruments and raising public awareness. The former included construction work to increase operational flexibility through inter-basin transfers and interconnection of production systems. The latter included an effort to reduce water losses by locating and repairing leaks, detecting illegal connections, rolling out new water meters and a public awareness campaign. An interesting policy innovation was the granting of bonuses to those who reduce water consumption and penalties for water wasting. The authors report that more than 80% of the consumers reduced consumption.

These measures eased the stress on the main water system that was affected by the drought, by reducing its potable water production in around 60%. While most of the relief came from infrastructure measures, an estimated 19% of the reductions were achieved thanks to economic incentives on consumers.

Even if there was agreement on the best possible policy reforms and required investments, these will not happen without some resistance and obstacles whether coming from politics, lobbying, public perception, or capacity and capability constraints. Table 7, taken from the United Nations World Water Development Report (2019), summarizes a set of causes associated with policy implementation gaps at various levels or for various processes. Policy implementation can fail if politics and special interests

prevent necessary changes to happen or push for unnecessary changes. It can also fail if objectives are extremely ambitious or unfeasible given the financial, time and capacity constraints that policy makers face.

Table 7. Types of gaps in policy implementation, and typical causes

Policy implementation gaps	Causes
Gaps in policy formulation process	Lack of transparency, oversight and influence over policy formulation External pressure to adopt blueprint policies not adapted to the context Lack of high-level political commitment Lack of participation in policy formulation Policy capture by elites or influential groups
Gaps in operationalization of the policy	Mismatch between the responsibilities and resources Time needed to build capacity not adequately considered Lack of legitimacy of institutions that implement policy Misalignment between water policies and informal water institutions Lack of capacity to monitor and enforce agreed norms Ineffective channels for users to signal demands or express dissatisfaction
Gaps related to characteristics and behavior of stakeholders	Monopolistic position of providers 'Third-party opportunism' Quality of the representation of stakeholders Policy processes 'captured' by specific interest groups Corruption, inefficiency and inertia
Gaps related to the overarching country governance situation	Political instability, protracted crisis and insecurity Governments' lack of capacity to carry out basic functions Lack of accountability in the public sector Poor (self-)discipline and leadership in government Lack of 'democracy': insufficient debate, lack of consultation and participation

Source: United Nations World Water Development Report (2019)

7. Conclusions

The future of the water and sanitation sectors cannot escape from the challenges that at national and local levels will inflict a combination climate, economic and demographic

changes. While the exact nature of the problems may be unknown, the type of actions and improvements that countries in the region will have to use to prepare themselves do not seem to be technically, financially or technologically implausible. The main constraint may come from the ability of policy-makers and regulators to manage the political and economic trade-offs that the water and sanitation sectors present. These are the problems that have already induced large gaps in availability, affordability and efficiency in the region and most likely will deepen in the future. The message is simple: invest more, manage better, be flexible and be open to new policy instruments and technologies. Despite all the uncertainty, in LAC countries the future of water and sanitation can only look good if countries succeed to solve the problems of the past.

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