KONRAD ADENAUER STIFTUNG

WATER SECURITY CHALLENGES IN LATIN AMERICA

A focus on the water-energy nexus

Fernando Anaya

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Water security challenges in Latin America: A focus on the water-energy nexus

Fernando Anaya

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Water and energy services are interdependent elements of development. Therefore, the energy security and development of countries will depend on the availability and security of supply of water resources. For the Latin America countries (LA), water security is a social, political, and economic challenge for maintaining sustainable development.

The Economic Commission for Latin America[1] defines water security as the capacity of a territory to guarantee equitable access in quality and quantity to resilient water services that allow the sustainable human and economic development of its population. Thus, a condition of water insecurity occurs when a territory faces water poverty and/or access risks or water stress.

The purpose of this article is to identify the challenges and recommendations for strengthening water security in ten countries in the region: Chile, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, and Peru. The document is divided into three sections. The first section contextualizes the assessment of water and energy in the framework of the Sustainable Development Goals, followed by the conceptualization of the water-energy nexus. The second section describes and analyzes the current situation of water resources and their interrelations with the energy sector and climate change, while the third section summarizes the challenges faced by the countries and proposes recommendations for strengthening water security.

1 Urquiza y Billi. (2020).

01

Context

1.1 Water and the Sustainable **Development Goals (SDGs)**

In 2015, the UN adopted the 2030 Agenda for Sustainable Development, which defines 17 SDGs aimed at protecting the planet and improving the living conditions of people around the world. With the approval of the agenda, the countries analyzed in this technical note committed to direct resources and institutional capacities to achieve the SDGs.

Photography by Gallery DS, source: www.unsplash.com

Although water resources are linked with most of the SDGs, only the closer goals to the water-energy nexus are described below.

The list of relevant goals for this technical note starts with SDG N°6 which seeks to "*Ensure availability and sustainable management of water and sanitation for all*". Its implementation includes eight global goals that are universally applicable in the context and reality of each country and that contribute to resolving fundamental issues associated with access to drinking water: (6.1) achieve universal and equitable access to safe and affordable drinking water for all, (6.2) Access to sanitation and hygiene services, (6.3) Water quality, (6.4) Efficient use of water resources, (6.5) Integrated water resources management (IWRM), (6.6) Conservation of water-related ecosystems, (6.a) International cooperation for capacity building, and (6.b) community participation in water and sanitation management. The achievement of SDG N°6 targets translates into improved water security, which conceptually consists of achieving: i) water availability that is adequate in quantity and quality for human supply, subsistence uses, ecosystem protection and production; ii) institutional, financial and infrastructure capacity to access and use water resources sustainably and manage the interrelationships and externalities between different uses and sectors in a coherent manner; iii) an acceptable level of risks to people, the environment and the economy associated with water resources[2].

SDG N°7 "*Affordable and clean energy*" is closely linked to the water use and sustainable resource consumption under SDG N°6. This goal establishes five targets: (7.1) ensure universal access to affordable, reliable, and modern energy services, (7.2) increase the share of renewable energy in the energy mix, (7.3) double the global rate

2 UNESCO (2020).

of improvement in energy efficiency. (7.a) Increase international cooperation to facilitate access to research and technology, (7.b) expand infrastructure, and improve technology to provide modern and sustainable energy services.

At the level of infrastructure and services in populated areas, SDG N°11 "*Sustainable Cities and Communities*" guides the rapid urbanization of countries with policies that support the development of inclusive, safe, resilient and sustainable cities. These commitments recognize the impact that economic activities have on natural resources and climate change and, consequently, on the well-being of the population and ecosystems. With a vision of employment and technology as an engine of economic development, SDG N°8 proposes to "*promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*". Actions under this goal aim to increase productivity levels and technological innovation as well as stimulate entrepreneurship and job creation and eradicate forced labor and slavery. The following table shows part of the indicators related to the SDGs mentioned.

Table 1. Indicators associated with the SDGs.

Country	Population without access to safely managed water services[3] (2017)	Population without access to electricity (2018)	Per capita emissions tCO_2 (2016)	GDP growth % (2019)	Projected GDP growth % 2021[4]
Panama	251.351	251.351	0	4,71	5
Chile	13.091.490	13.091.490	30.204	2,03	5
Colombia	306.759	306.759	0	1,64	2,9
Cota Rica	No information	No information	0	1,13	3,5
El Salvador	7.079.947	7.079.947	880.013	1,06	3,5
Guatemala	No information	No information	790.410	1,06	4,5
Honduras	71.284.899	71.284.899	0	3,94	3,8
Mexico	3.090.237	3.090.237	780.224	0,89	1,3
Nicaragua	No information	No information	0	2,65	5,5
Peru	15.611.889	15.611.889	1.560.502	1,86	9,2

Source: Own elaboration based on World Bank statistics.[5]

3 The availability and quality (physical and chemical) of water for human consumption is not guaranteed.
4 ECLAC (2021).
5 World Bank data. https://datos.bancomundial.org/.

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The water - energy nexus has a more complex interaction with the environment in which energy production takes place, including economic, environmental, and socio-cultural aspects.

1.2 Water - Energy **Nexus**

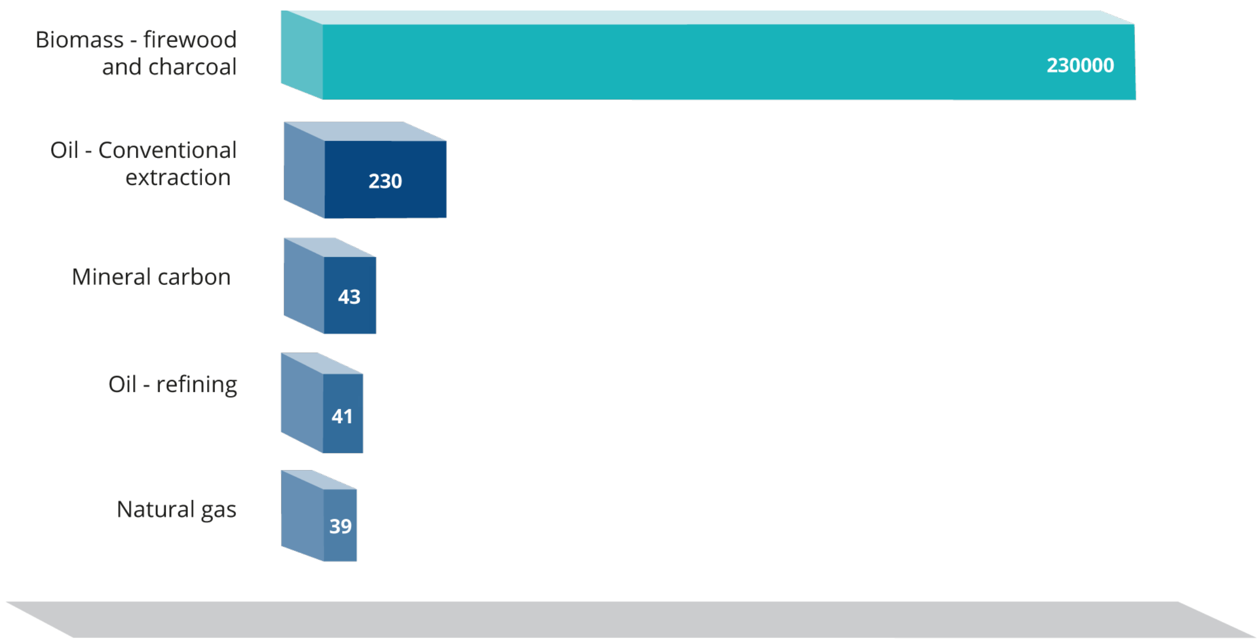
The water- energy nexus gained prominence as a topic of international debate at the 2008 World Economic Forum (WEF) Annual Meeting, which emphasized the need to develop a better understanding of how water is linked to economic growth[6]. The water-energy nexus has a more complex interaction with the environment in which energy production takes place, including economic, environmental, and socio-cultural aspects. At the sectoral level, water enables energy production processes: the extraction and processing of fossil fuels, thermoelectric generation, hydroelectric generation, and the production of raw materials for biofuels. The energy used to produce water defines the interdependence between these elements and has its application in the water supply systems that require energy, highlighting the pumping for the extraction, transport and distribution of water, desalination of seawater, wastewater treatment and irrigation, among others.

6 WEF (2011).

The primary energy matrix of Latin American countries is highly dependent on fossil fuels used for energy processes linked to water consumption. The main sources of consumption come from hydrocarbons (34% natural gas and 31% oil of total energy consumption), while renewable sources, also dependent on the use of water, are composed of hydropower, with the largest contribution to the matrix (8% of the total), followed by solar energy (6%), geothermal energy (1%) and nuclear energy (1%). The remaining 19% comes from various energy sources such as charcoal, bagasse or firewood[7].

Water consumption for energy production and transformation is variable and depends mainly on the type of resource or technology used (Jin, et al., 2019; Lee et al., 2017; Spang et al., 2014 and Bakken et al., 2013). In fuel production, biomass has the highest demand for water, with cultivation being the stage that concentrates its highest consumption. In the case of biomass used for firewood and charcoal, the average consumption is 230,000 liters (l) of water per Gigajoule (GJ) of energy produced. It is followed by the extraction of conventional oil, coal, and natural gas with the lowest average water consumption, as shown in the figure below.

Figure 1. Water consumption per GJ produced (liters per GJ).



Source: Own elaboration

In the electricity generation matrix, there is a high technological concentration in hydroelectric and combined cycle thermoelectric power plants. These two technologies produce between 70% and 98% of the total electricity consumed in eight of the

7 OLADE (2019).

ten countries under analysis (see Figure 1).

Faced with episodes of decreasing water availability, countries with a reduced portfolio of power generation technologies pose greater risks to preserve their energy security and macroeconomic stability.

At different levels, droughts have influenced security of supply and public spending on the installation of high-cost auxiliary generation stations, while the volatility of oil prices affects the balance of payments mainly of those countries that maintain subsidies in their electricity tariffs and have a high dependence on fossil fuel imports.

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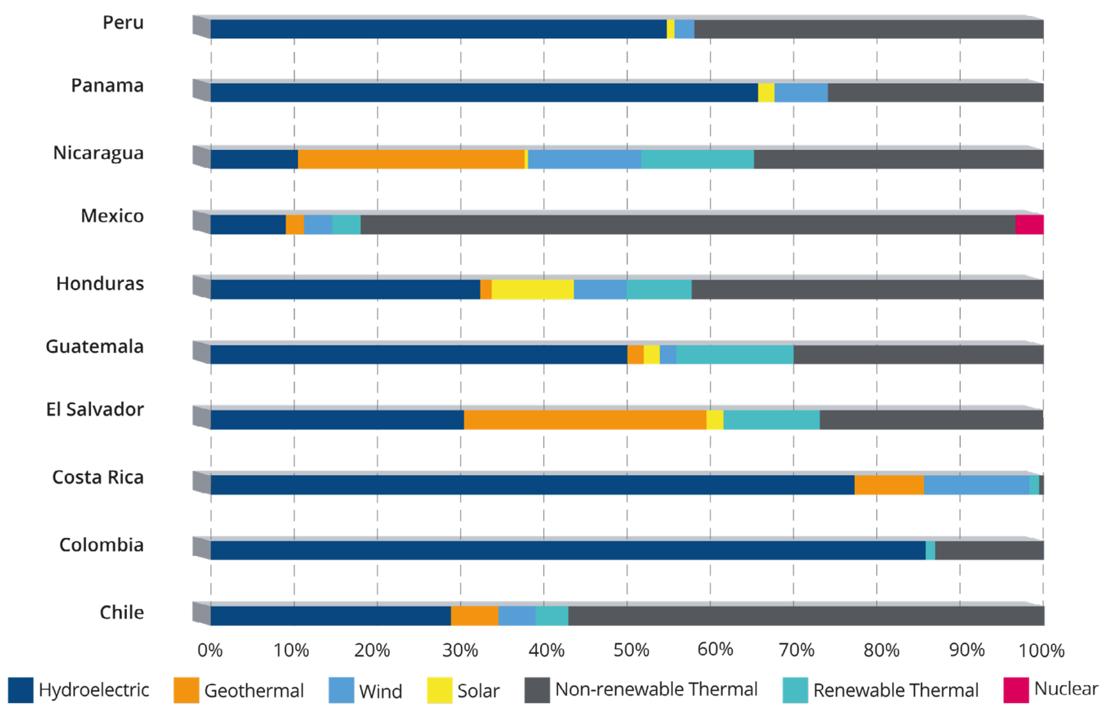
> *Faced with episodes of decreasing water availability, countries with a reduced portfolio of power generation technologies pose greater risks to preserve their energy security and macroeconomic stability.*

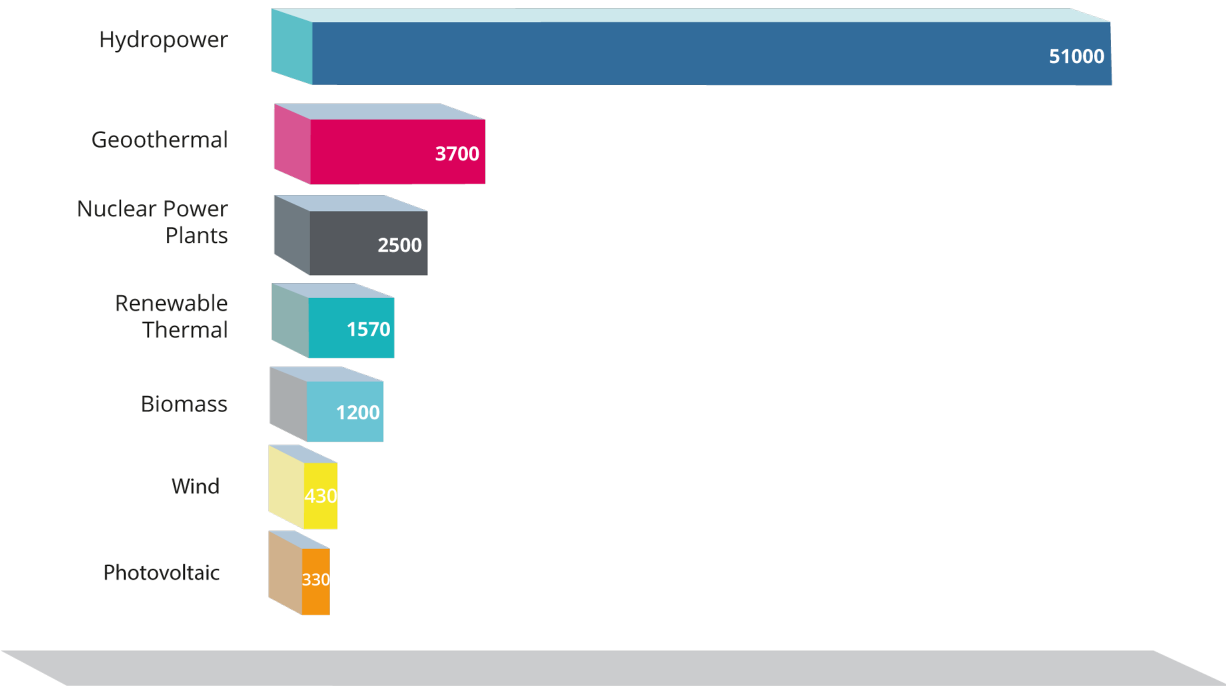
Figure 2. Share of technologies in electricity generation (2017).



Source: Own elaboration based on OLADE (2019).

Among the selected countries, water consumption for electricity production is mainly related to the transformation of hydropower into electricity and the cooling of thermoelectric power plant turbines. In this regard, the high-water consumption of hydroelectric power plants per MWh produced stands out, with an average magnitude of 51,000 liters per MWh, compared to the average of 1,190 liters per MWh of traditional thermal power plants. The figure below compares water consumption by technology used to produce electricity in the selected countries.

Figure 3. Water consumption per MWh produced (liters per MWh).



Source: Own elaboration

Projections from the Inter- American Development Bank (IDB) indicate that the countries under analysis will have to increase their water storage capacity by 56% to sustain their growth by 2050. Specifically, Chile, Colombia, Costa Rica, Guatemala, Mexico, and Peru would expect to face a water deficit sooner if they do not increase their storage capacity and demand management[8].

8 BID (2019).

02

Characterization and analysis of the current situation

2.1

Water resources **availability**

LA region has abundant water resources. The region groups 13% of the planet's total surface area and gathers one third of rivers, which represents an average supply of 22 thousand cubic meter per inhabitant per year (m^3/inhab/yr), exceeding by far the world average of 6 thousand m^3/inhab/yr[9]. From the local perspective, the selected countries face factors that limit the availability of water including: variability in the spatial and temporal distribution of water resources. The imbalance of territorial development, characterized by the expansion of large cities and industries in areas with scarce water resources.

Peru, Chile, Colombia, Panama, Nicaragua, and Costa Rica have high per capita water availability with unequal distribution and availability throughout the territory. The central valley and northern region of Chile has a high population density and concentrates important productive sectors; however, its semi-arid and arid climate limits the availability of the resource. The same applies on the

9 Peña (2016).

Peruvian coast, the Cauca and Tolima valleys in Colombia and the Central American dry corridor, which covers the lowlands of the Pacific coastal zone and most of the central foothills of Chiapas (Mexico), Guatemala, El Salvador, Honduras, and Nicaragua, as well as the province of Guanacaste in Costa Rica, and the dry arc of Panama. In this context, the limited availability of water in areas with high population density hinders its provision, which depends on the existence and optimal condition of the infrastructure for the use, treatment, distribution, and even conservation of water resources.

The development of storage infrastructure (reservoirs), artificial infiltration of aquifers, desalination, and the transfer of water from basins with greater availability to basins with water deficits are the main measures to guarantee the availability and increase the supply of the resource. However, the challenges on water availability are not only confined to the arid or semi-arid areas. Climate change is negatively impacting the distribution of precipitation and increasing temperatures, reducing the availability of water resources in areas that were characterized of having water surplus. This is in addition to the contamination of groundwater. The discharge of domestic and industrial wastewater into surface water bodies negatively affects water quality, limiting the options for its use and consequently its availability. The water resources[10] per capita is measured using the countries' water resources and their population, as shown in the following table.

Table 2. Internal water resources of the countries under analysis

	Internal water resources 10^9 m^3/yr	Water resources per capita m^3/inhab/yr (2017)
Peru	1.641	52.188
Chile	885	47.914
Colombia	2.145	43.856
Panama	137	33.262
Nicaragua	156	24.466
Costa Rica	113	22.828
Honduras	91	9.615
Guatemala	109	6.456
Mexico	409	3.278
El Salvador	16	2.447
Average	570	24.631

Source: FAO statistics (AQUASTAT).

10 Corresponds to the volume of water available in the territory (surface and subway) from endogenous precipitation.

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The extraction of a volume of water that exceeds the natural use of the countries affects the resource reserves in surface and subway spaces.

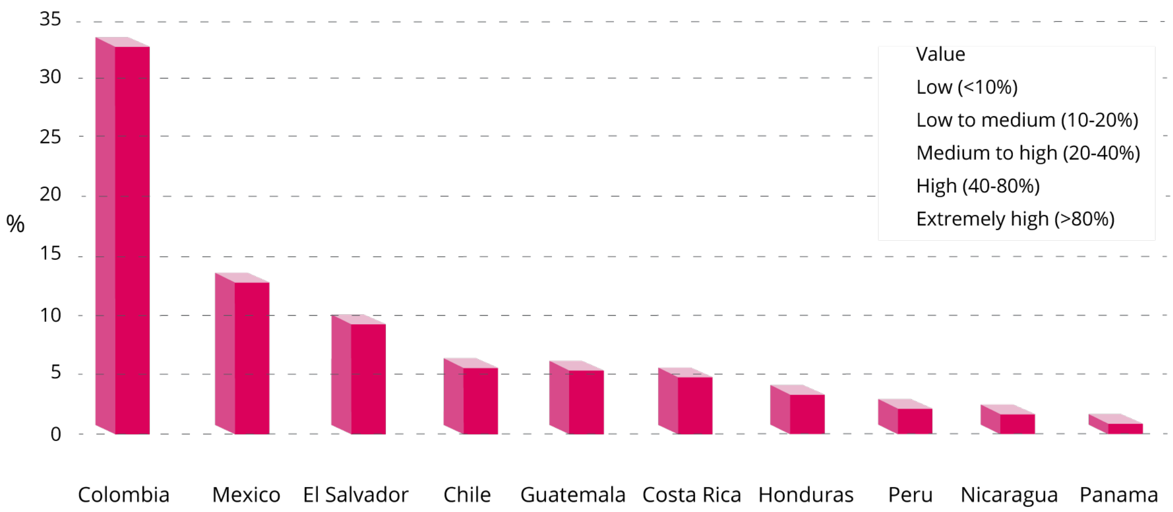
2.2 Pressure over **water resources**

The exhaustion on water resources can be explained by factors that limit water availability in terms of quantity and quality, particularly those associated with overexploitation and contamination of aquifers and water use efficiency. The extraction of a volume of water that exceeds the natural use of the countries affects the resource reserves in surface and subway spaces.

This imbalance, called water stress, is evaluated as a percentage of the annual extraction in relation to the total water suitable for direct uses. The higher the percentage, the higher the level of stress on the resources and the lower their sustainability over time. International organizations estimate that the demand for water, energy and food in Latin America will increase significantly in the coming decades, and it is estimated that several cities in the region will face water supply risks to meet the demand from productive sectors. The increase in water stress levels can lead to migration; local, interregional, intra-country and international conflicts as a result of the multiplicity of demands over limited water resources that cannot be fulfilled[11].

In 2017, Latin America reached a low level of stress on water resources, with an average value of 4%. However, within the countries analyzed, Colombia, Mexico and El Salvador reached moderate to high levels of stress, as shown in the figure below.

Figure 4. Stress on water resources in different countries of the region (2017)



Source: FAO statistics (AQUASTAT).

In the LA region, the predominant water use corresponds to irrigation in agriculture, with withdrawals equivalent to an average of 70% of the total flow used per country. This is followed by domestic use, which accounts for 19%, and mining and industrial uses, which account for the remaining 11%. Although statistics do not

11 Martín y Bautista (2015).

disaggregate the share of water use in the energy sector, it is estimated that this sector will double its pressure on water resources by 2040[12].

Photography by Phil DuFrene, source: www.unsplash.com

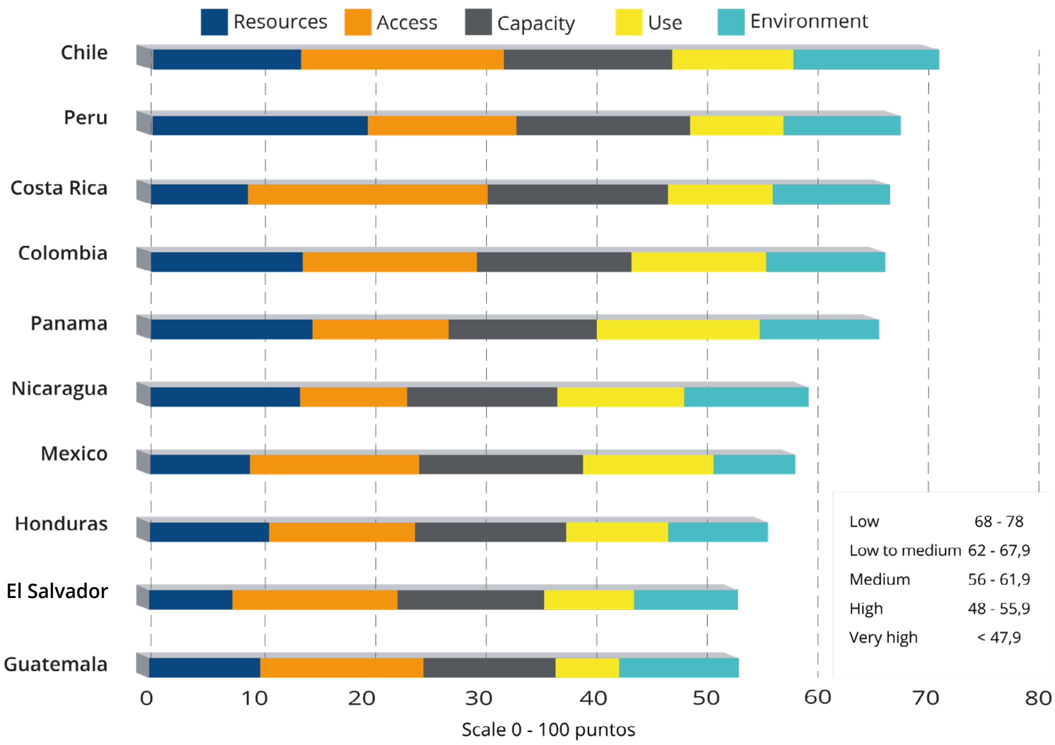
12 BID (2019).

2.3 Water Poverty **and Water Use**

People or sectors in a situation of water poverty face issues related to water scarcity, polluted resources not apt for its consumption or restricted access to certain users. The Water Poverty Index (WPI)[13], assesses the level of water scarcity in countries by evaluating five components: resource (water availability), access (water of sufficient quality and quantity for various uses), capacity (of the population to manage water efficiently), use (meeting demand for various uses), and environment (sustainable water use and environmental degradation). Lower values reflect greater water poverty and, therefore, less availability or capacity to access water resources to meet the basic needs of the population and the productive sectors. The figure below shows the WPI the selected countries.

13 UNESCO (2002). http://ihp-wins.unesco.org/layers/geonode:wpif/metadata_detail

Figure 5. WPI for the countries under analysis



Note: Each component is evaluated on a scale of 0-20 points for a total rating sum of 0-100 points.

Source: UNESCO (2002).

The countries of the region show a medium to medium-low WPI, except for Guatemala and El Salvador, which have high water poverty. For most of the countries, two determining pressure factors are identified: water use and environment. The first is interpreted as conflicts over the diversity of uses, particularly in Guatemala, Honduras, El Salvador, and Costa Rica, where it is estimated that unsatisfied water demands prevail for some sectors. The second factor is associated with water degradation due to pollution[14] and its inefficient use. In relation to capacity, Central American countries (except for Mexico) have the lowest values in this component, which translates into a lower capacity of the population to efficiently manage water, which is generally linked to low levels of income, education, and organization in the population. A similar situation occurs with the access component, with Nicaragua and Panama registering the lowest level of access to water. Access to water has a potential for improvement, particularly in rural areas where is located the largest proportion of the population without access to drinking water and sanitation services.

14 The uncontrolled growth of urban areas with precarious infrastructure and informal economic activities increases groundwater contamination. Part of the development policies of the countries analyzed exclude measures to strengthen the preservation and improvement of water quality for human consumption, irrigation, and industrial use, among others. According to the IDB 2021 platform «How is Latin America in terms of sanitation?», the main source of contamination of the region's water resources comes from wastewater containing chemical and organic pollutants.

It should be considered that both the Water Poverty Index and Water Stress Index are national averages that make it difficult to illustrate contrasts between different regions of the same country. For example, towns of La Ligua and Los Choros in Chile reached extreme stress levels with values of 129% and 824%, respectively, showing evidence of overexploitation of water resources. A similar case is recorded in the Aguas del Valle hydrographic region in Mexico, which in 2014 reached a stress level of 138%[15] .

Development strategies in the selected countries position water resources as an indispensable input for sustaining economic growth and consolidating new value chains in all production processes. In this sense, the UN-Water initiative estimates the economic value from water resources to assess the progress of SDG 6.4.1 "Change in the efficient use of water resources over time"[16]. This indicator determines the wealth created per country for each cubic meter of water consumed (US$/m^3). In 2017 this indicator reached for LA an average of US$13/m^3, close to the world average of US$15/m^3. Among the selected countries, Panama has the highest contribution to its economy per cubic meter consumed, with an average of US$47/m^3; while Chile has the lowest value, with US$6/m^3, which means that the country consumes more water than Panama to generate the same economic value to its GDP. It should be noted that this indicator can be interpreted as the efficiency on water use since, as it increases, the economic contribution of a sector per cubic meter of water consumed is greater than the water uses and, therefore, a more efficient use of water resources is made. The following figure shows the contribution to economic growth per cubic meter of water consumed in the countries under analysis[17] .

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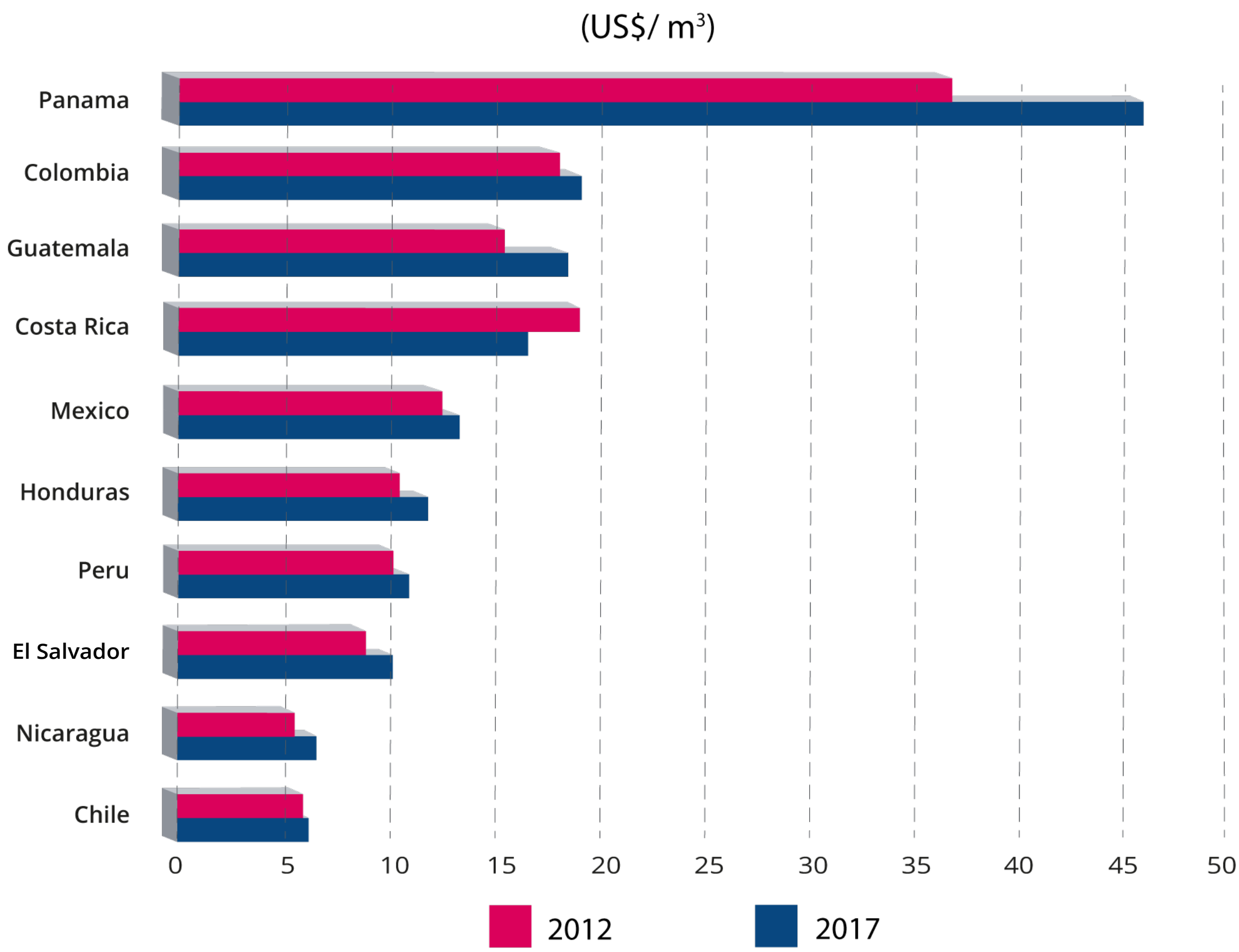
Panama has the highest contribution to its economy per cubic meter consumed, with an average of US$47/m^3; while Chile has the lowest value, with US$6/m^3, which means that the country consumes more water than Panama to generate the same economic value to its GDP.

15 Water pressure. https://apps1.semarnat.gob.mx:8443/dgeia/informe_resumen14/06_agua/6_1_2.html#.

16 The concept of efficient use is not equivalent to water productivity. In this case, the productivity of the water used in each activity is not taken into account as an input used in production.

17 Corresponds to the weighted average efficiency of the agriculture, industrial, and service sectors, using the water withdrawal of each sector as a percentage of total withdrawal.

Figure 6. Contribution to the economy per cubic meter of water consumed (2012, 2017)



Source: Prepared by the author based on FAO statistics (AQUASTAT).

The efficiency of water use varies greatly among the productive sectors of the countries analyzed, particularly in agriculture. In 2017, this sector averaged US$0.35/m^3, well below the US$47/m^3 of Central and Western European countries. The levels of water use in Europe achieve higher contributions to the Euro Zone economy because of a culture of saving water as well as public initiatives and regulations that promote water reuse and the adoption of efficient technologies in existing infrastructure.

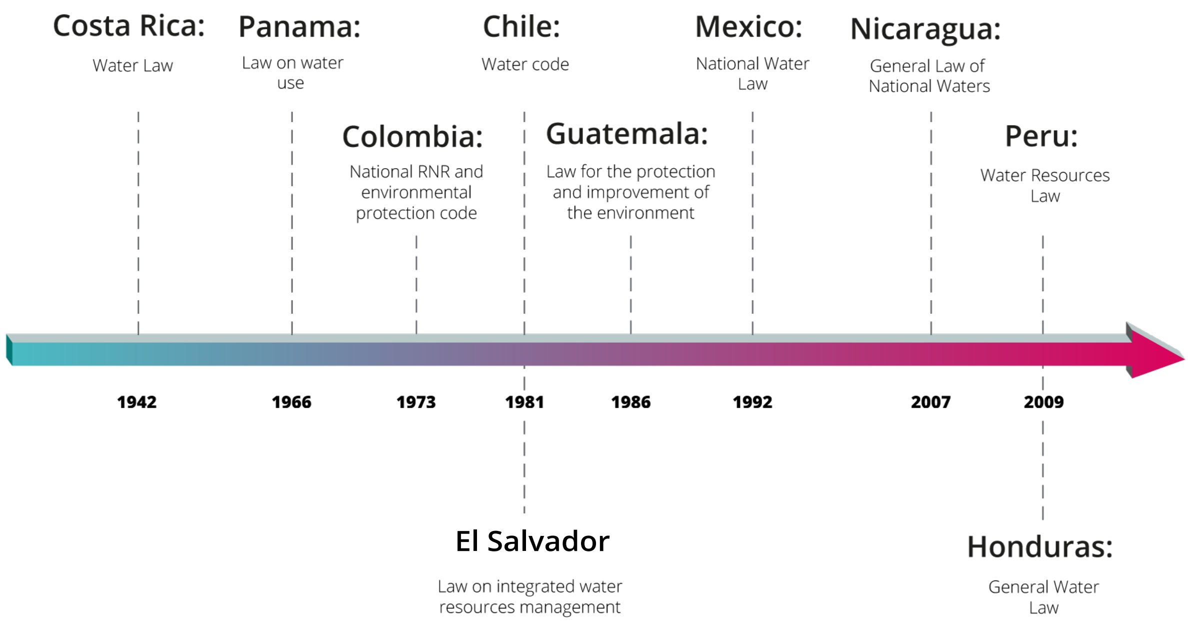
> *Overall water laws focus on regulating the right to use water, its conditions of use and services and, to a lesser extent, address issues related to water supply and conservation.*

2.4

Laws and policies on **water resources in LA countries**

Overall water laws focus on regulating the right to use water, its conditions of use and services and, to a lesser extent, address issues related to water supply and conservation. More recent laws, such as those of Peru and Honduras, incorporate the concept of management, which broadens the traditional scope of the laws by including the principles governing their use and resource management. Other countries without water laws have opted to establish guidelines through regulations or ministerial decrees to rule the sector. For instance, in Colombia, the National Code of Renewable Natural Resources and Environmental Protection regulates the use, conservation and preservation of water, and describes the obligations of users and the State in the prevention and control of surface and groundwater pollution. The following figure shows the existing legal framework in the countries under analysis.

Figure 7. Legislation related to water resources in the countries under analysis.



Source: own elaboration.

> *In most of these countries, the legal framework aims to provide the conditions to allow the sustainable exploitation of water resources while guaranteeing the economic growth, environmental protection, and social welfare.*

In most of these countries, the legal framework aims to provide the conditions to allow the sustainable exploitation of water resources while guaranteeing the economic growth, environmental protection, and social welfare. Common principles across countries include actions for strengthening governance, and defining multiple water uses and standards. The most relevant weaknesses in the legal and policy framework are the insufficient resources allocated for implementing ambitious public policies that include fiscal incentives and measures to promote the participation and ownership of local governments.

The existing laws and decrees in these countries usually are accompanied by plans and programs with objectives that can be categorized into two groups. The first group seeks to guarantee access to water as a human right, ensuring the availability of water and sanitation, especially for the most vulnerable population; while the second group focuses on efficient management and use, in addition to promoting land use planning and the conservation of ecosystems. The figure below shows the policy instruments of the countries under analysis.

Figure 8. Water resources policies and plans

Source: own elaboration.

The laws analyzed have some legal flexibility to integrate practices like those of countries with high performance in the efficiency and sustainability of the use of their water resources. Some of the opportunities for improvement include strengthening coherence with other sectoral policies, which involves an integrated water resources management (water - energy - environment - food nexus), the allocation of funds for infrastructure financing, improving the availability of information, and defining institutions in charge of promoting the participation of local governments with competence in water resources management.

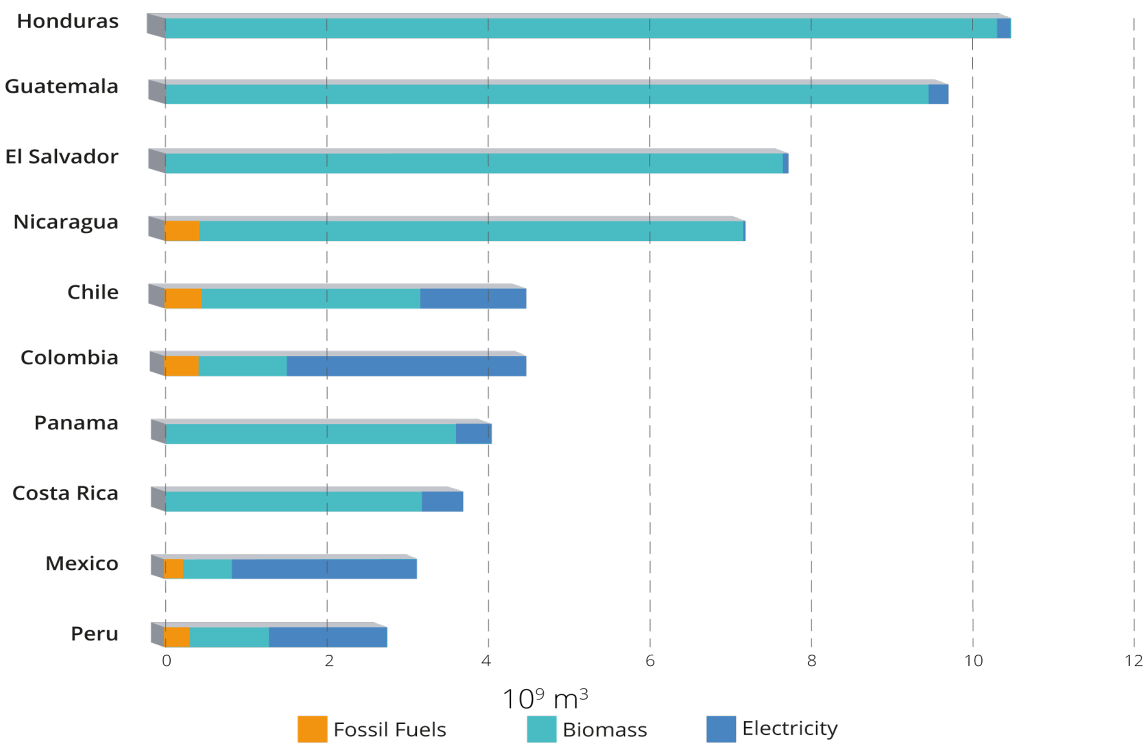
2.5 Quantifying the **water-energy nexus**

Energy production requires water for almost all energy production and conversion processes. The International Energy Agency (IEA) estimates that energy production in LA countries will triple its water consumption by 2035, based on the amount needed in 2010.[18] Honduras, Guatemala, El Salvador, and Nicaragua have the highest dependence on water consumption in their energy matrix, with 98% of the total allocated to biomass production, while Colombia, Mexico and Peru allocate between 50% and 70% of their consumption to electricity generation. The figure below shows the water consumption in the energy sector of the countries under analysis.[19]

18 World Energy Outlook, 2012. International Energy Agency.

19 Biomass consumption is considered for energy purposes. Fossil fuels include oil, natural gas, and coal production. Electricity generation considers Hydroelectric, Geothermal, Solar, Wind, Renewable Thermal, Non-renewable Thermal and Nuclear.

Figure 9. Water consumption in the energy sector (primary energy and transformation), 2017.

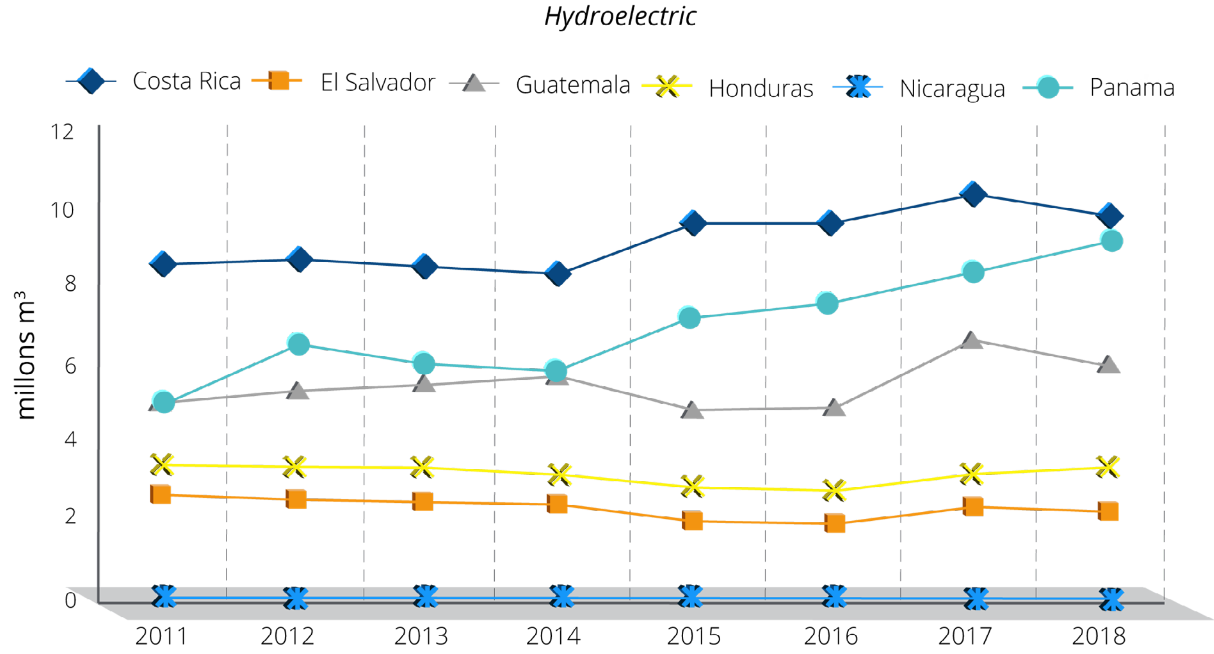


Source: own elaboration

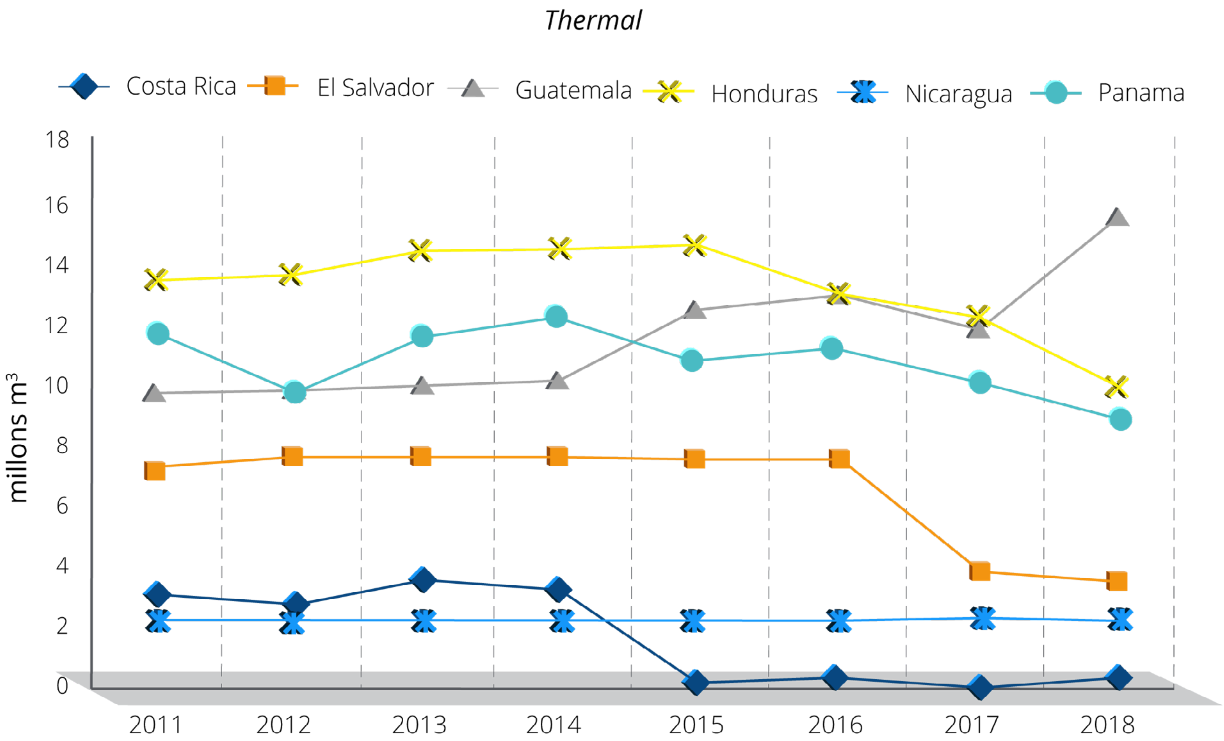
Water demand from the energy sector is determined by the portfolio of technologies composing the countries' energy mix. Countries with high biomass consumption have higher water dependency for energy production directed to energy crops, such as bagasse and firewood. Nicaragua, El Salvador, and Honduras are far from the average of water consumption of the countries analyzed (640.6 m^3 per inhabitant), with an average over 1,100 m^3 per inhabitant.

One of the limitations in quantifying the water-energy nexus is the lack of studies and statistics that provide data on water consumption in the energy sector by type of technology used for power generation. The statistics only refer to consumptive water use in the agriculture, industrial, and service sectors; therefore, water used for cooling in thermoelectric and nuclear plants is not disaggregated, nor is the use in hydroelectric and other renewable technologies. In this sense, the water consumption was estimated for the two most relevant power generation technologies in the analyzed countries: hydroelectric and thermal. The information available for six of the ten countries analyzed is shown below.

Figure 10. Evolution of theoretical water consumption (2011 - 2018).



Source: Own elaboration.



Source: Own elaboration

WATER SECURITY
THE CURRENT SITUATION IN LATIN AMERICA

WHAT IS WATER SECURITY?

It is the capacity of a territory to guarantee equitable access in quality and quantity to resilient water services that allow the sustainable human and economic development of its population.

Therefore, water insecurity is the condition of a territory when it faces situations of risk of access or when it presents a state of water poverty.

AND HOW THE WATER - ENERGY NEXUS DEVELOPES?

Water enables energy production processes:
- Thermoelectric and hydroelectric generation.
- The extraction and processing of fossil fuels.
- The production of raw materials for biofuels.

Energy makes it possible to develop water supply systems:
- Desalination of seawater.
- Wastewater treatment and irrigation.
- The pumping for the extraction, transport and distribution of water.

Energy production requires water for almost all energy production and conversion processes. The International Energy Agency (IEA) estimates that energy production in LA countries will triple its water consumption by 2035, based on the amount needed in 2010.

Water poverty is the condition of territories that lack a nearby source of water or it does not have the conditions for its consumption. The Water Poverty Index (WPI) assesses the level of water scarcity considering: access to water in quality and quantity, capacity of the population to manage water efficiently and sustainable water use. Most of the countries of the continent show a medium to medium-low WPI.

International organizations estimate that the demand for water and energy in the region will increase significantly in the coming decades. Considering that in Latin America the predominant use of water corresponds to irrigation in agriculture, different territories would face water supply risks to meet the demand of the productive sectors, which could cause migration and social conflicts.

Latin American region has abundant water resources, with an average supply of 22 thousand cubic meters per inhabitant per year (m^3/inhab/yr), exceeding the world average of 6 thousand m^3/inhab/yr. Nevertheless, the region face factors that limit the availability of water, caused by the imbalance of territorial development, characterized by the expansion of large cities and industries in areas with scarce water resources.

In most cases, the legal framework aims to provide the conditions to allow the sustainable exploitation of water resources guaranteeing the balance between the economic growth, environmental protection, and social welfare. The insufficient resources for implementing public policies that include fiscal incentives and measures to promote the participation of local governments is also a common element.

The climate change and the increase in GHG concentration will continue to have negative impacts on energy generation as a result of increased variations in the amount, intensity and frequency of precipitation, the occurrence of hurricanes in the tropical zone and more frequent snowmelt in the Andes and on the Pacific slope.

Countries are committed to working to achieve the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development approved by the UN.
The closer SDGs to the water- energy nexus are:

- SDG 6: Ensure access to water and sanitation for all.
- SDG 7: Ensure access to affordable, sustainable, reliable and modern energy.
- SDG 8: Promote inclusive and sustainable economic growth, employment and decent work for all.
- SDG 11: Make cities inclusive, safe, resilient and sustainable.

2.6 Climate change and **availability of water for energy**

The increase in GHG concentration will continue to have negative impacts on energy generation as a result of increased variations in the amount, intensity and frequency of precipitation, the occurrence of hurricanes in the tropical zone and more frequent snowmelt in the Andes and on the Pacific slope[20]. For example, in the last decade, Chile recorded a 30% reduction in precipitation compared to historical records, which reduced the glaciers and water flows in the summer seasons to supply the reservoirs used for electricity production.[21] Long-term climate trends in the region show seasonal variations and a rise in annual average temperatures that reduce the electricity production capacity of the main hydroelectric power plants in the countries under analysis. The IEA projects that during the period

20 IPCC (2014). https://www.ipcc.ch/report/ar5/wg2/.
21 Stehr et al. (2019).

2020 to 2060 the average hydropower capacity factor of Chile, Colombia, Costa Rica, Guatemala, Panama, Peru, and Mexico will decrease by 9%. Hydropower plants in Central America and Mexico are likely to experience the highest inter-annual variability of firm capacity factors in the Latin American region during the last 40 years of this century, especially under a scenario of global temperature increase above 4°C by 2100.

On the other hand, the region's traditional thermoelectric plants (gas, coal, and fuel oil) use water to cool their electricity production turbines during operation. Within the countries analyzed, these plants are generally located along rivers or lakes that are vulnerable to climatic phenomena. Moreover, the increase in temperatures makes the cooling process of power generators less efficient, while the occurrence of droughts jeopardize the continuity of operation of these plants.

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The IEA projects that during the period 2020 to 2060 the average hydropower capacity factor of Chile, Colombia, Costa Rica, Guatemala, Panama, Peru, and Mexico will decrease by 9%.

03

Challenges and recommendations

Countries face difficulties in creating the conditions to increase water security and implement a management model that guarantees universal access to water, maximizing equitable, social, and economic development without compromising the sustainability of natural resources. There are at least seven areas to strengthen water security: (i) sustainability of water resources and access, (ii) economic efficiency in water use, (iii) legal and regulatory framework, (iv) coordination and institutional capacity, (v) availability of information, and (vi) management instruments and infrastructure.

To address these opportunities, the recommendations were prioritized considering the context of selected countries. The level of preponderance is disaggregated depending on the local conditions that limit the distribution of water resources (extreme precipitation, type of climate and climate variability) and the indicators derived from the state of progress in the Sustainable Development Goals related to water (SDG N°6). In addition, the recommendations consider principles to be included in policy instruments to address the high dependence on water consumption for energy production and transformation. The following table summarizes and prioritizes the recommendations for the countries under analysis.

Table 3. Summary of recommendations by level of priority

Recommendations	Chile	Colombia	Costa Rica	El Salvador	Guatemala	Honduras	Mexico	Nicaragua	Panama	Peru
2.1 Water resources sustainability and access										
Implement measures aimed at managing water supply and demand	✓ high	✓ high	✓ high	✓ medium	✓ high	✓ medium	✓ medium	✓ medium	✓ medium	✓ high
Expanding safe drinking water management	✓ medium	✓ high	✓ medium	✓ medium	✓ high	✓ medium	✓ high	✓ high	✓ medium	✓ high
2.2 Economic efficiency of water use										
Implement measures to decouple water consumption from economic growth	✓ high	✓ medium	✓ medium	✓ high	✓ medium	✓ high	✓ high	✓ high	✓ low	✓ high
2.3 Legal and regulatory framework										
Enact water laws with a multi-sectoral approach aimed at guaranteeing WS*		✓ high		✓ high	✓ high					
Update water laws with a multisectoral approach aimed at guaranteeing WS	✓ high		✓ high			✓ low	✓ high	✓ low	✓ high	✓ low
2.4 Coordinación y capacidad institucional										
Strengthen institutional coordination capacity for integrated WR management	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high
Promote training for the development of new technologies for research, monitoring and decision making for WR management	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high
2.5 Availability of information										
Implement national information systems for WR	✓ high					✓ high		✓ high		
Strengthen and/or improve national WR information systems		✓ low	✓ low	✓ low	✓ low		✓ low		✓ low	✓ low
2.6 Management tools										
Formulate and/or update WR management policies.	✓ low	✓ low	✓ low	✓ low	✓ high	✓ high	✓ low	✓ low	✓ low	✓ low
Design and implement economic and fiscal tools to guarantee the effectiveness of actions in WS	✓ high	✓ low	✓ low	✓ low	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high
Encourage the participation of local governments	✓ low	✓ high	✓ high	✓ low	✓ high	✓ high	✓ high	✓ high	✓ low	✓ high
2.7 Infrastructure										
Increase water storage infrastructure	✓ high	✓ medium	✓ medium	✓ medium	✓ high	✓ medium	✓ medium	✓ low	✓ medium	✓ high
Increase and improve infrastructure for wastewater treatment and reuse	✓ high	✓ medium	✓ medium	✓ medium	✓ medium	✓ medium	✓ high	✓ medium	✓ medium	✓ high
Improve infrastructure to increase water use efficiency in the productive sectors	✓ high	✓ medium	✓ medium	✓ high	✓ medium	✓ high	✓ high	✓ high	✓ low	✓ high
Develop and improve existing infrastructure to cope with droughts	✓ high	✓ medium	✓ medium	✓ medium	✓ medium	✓ medium	✓ high	✓ medium	✓ medium	✓ high
Develop and improve existing infrastructure to cope with flooding	✓ medium	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high	✓ high

Priority level: ✓ = high, ✓ = medium, ✓ = law
*WS= Water Safety. *WR = Water Resources.

Source: Own elaboration.

3.1 Water resources **sustainability and access**

The expected water demand as of 2025 indicate that the countries analyzed will face significant difficulties in meeting their water needs. The existing storage infrastructure (reservoirs) [22] is not enough to supply the demand of the productive sectors. Chile would be the most affected country in the region, with a deficit of 64 x 109 m^3, followed by Peru (22 x 109 m^3), Colombia (6 x 109 m^3), Guatemala (5 x 109 m^3) and Costa Rica (1 x 109 m^3).

In Chile, the droughts cause significant reductions in the levels of its water reservoirs during the first four months of each year. For the countries of the Central American region, climatic phenomena introduce a variability in the flow of tributaries between 10% and 20%, reducing the potential for electricity generation[23].

22 Bretas et al. (2020).
23 National Plan for the Integrated Management of Water

Photography by Zoe Schaeffer, source: www.unsplash.com

Part of climate change impacts in agriculture activities include the decrease in topsoil moisture, which increase the demand for irrigation systems, adding further pressure on water resources and use conflicts.

To guarantee the sustainability of water resources the selected countries must implement urgent measures aimed at managing water supply and demand, including those to increase the availability of surface and ground water source such as i) the implementation of gray infrastructure (construction of ponds and reservoirs) and green capacity (establishment of vegetation cover and vegetative measures for soil conservation and water catchment)[24], ii) water harvesting (from residential roofs or another waterproof); iii) reuse of wastewater (through plants for the recovery and transformation of resources such as sludge, fertilizers, biosolids and drinking water)[25] ; and and iv) water protection against pollution (wastewater treatment prior to discharge to natural sources).

Water demand management includes measures to control and reduce water demand. Actions with high impact include i) control of domestic and industrial use by reducing the pressure of distribution systems, use of metering instruments, monitoring system leaks, and implementation of education programs to create awareness on the

Resources Costa Rica (2008)

24 These include contour cultivation, infiltration ditches, living barriers, terraces, among others.

25 Wastewater: from waste to resource. https://www.bancomundial.org/es/topic/water/publication/wastewater-initiative

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To guarantee the sustainability of water resources the selected countries must implement urgent measures aimed at managing water supply and demand, including those to increase the availability of surface and ground water source.

importance of saving water, ii) reducing water demand in the agriculture sector by increasing efficiency in the distribution networks, irrigating crops with lower water requirements, and establishing tariffs that reflect the opportunity cost of saving water.

In addition, the LA region faces the challenge of increasing access to reliable and good quality water sources. Five of the selected countries have high rates of population without access to services that guarantee the continuity of supply and delivery of safe water[26]. Mexico ranks first, with 57% of the population lacking access to safely managed water, followed by Peru (47%), Nicaragua (48%), Guatemala (44%) and Colombia (27%). In this context, the countries must focus on establishing mechanisms to expand the safe management of drinking water and sanitation, which should include, among other aspects, the protection of natural sources, strengthening water treatment, sewerage and drainage infrastructure, and adequate urban and rural development planning. These actions must also be accompanied by the implementation of financing and feasibility analyses to identify economies of scale and guarantee a sustainable provision of services.

26 With physical and chemical parameters that guarantee people's health.

3.2 Economic efficiency **in water use**

The main challenge facing the countries of the region is to decouple economic growth from water consumption, particularly for Chile, El Salvador, Honduras, Nicaragua, Mexico, and Peru. These countries are urged to analyze opportunities to implement water saving measures and apply circular economy principles, which in the context of water resource management is materialized in the reuse of water to obtain greater added value to their economies. In cities, wastewater reuse can mitigate net water consumption for different applications such as garden irrigation, park maintenance, and cleaning, among others. In the industrial sector, wastewater can be reused for production processes to reduce the sector's demand for water from treatment plants; in addition to recovering and transforming valuable resources such as sludge, which can be used to produce fertilizers in the agriculture sector.

3.3
Legal and regulatory **framework**

The analyzed laws might need to enhance their conceptualization of water security. The selected countries address partially and sometimes exclude explicit actions to guarantee: i) water availability in quantity and quality for human subsistence uses, ecosystem protection and economic activities; ii) the institutional, financial and infrastructure capacity aiming to increase access, sustainability, and skills to manage coherently the interrelations and externalities between different uses and sectors; and iii) acceptable risks for the population, the environment and the economy[27].

In this sense, the reforms should address, in a multi-sectoral context, issues related to territorial, urban, and environmental planning, in addition to including clear

27 Peña (2016).

definitions regarding economic and financial mechanisms, regulations and guidelines to improve stakeholder coordination and encourage the engagement of regional and local governments in water management. New water legislations can define objectives and functions to guide actions of entities and end users, separating legal attributions according to their institutional mandate (planners, regulators, operators, among others). On the other hand, the regulations must include a vision of territorial organization and have flexibility to integrate local regulations that can complement unforeseen domestic conditions of the localities it controls and consider the interdependence of water and energy services.

3.4 Coordination and **institutional capacity**

Public institutions and agencies require further coordination and funding to improve their capacity to implement policies on water management. One of the challenges that remains in place is the strengthening of water-related institutions that have historically faced difficulties when managing water resources. Part of the observed weaknesses are related to a limited autonomy in the decision-making process, budget, and technical capacity to accomplish their mandate, resulting in difficulties to enforcing regulatory framework; coordinating actions with other national and local institutions; and achieving efficient hydrological planning. Countries could review the mandates of the institutions and legal frameworks that support them, to strengthen institutional competencies and coordination of their functions. Chile, for example, has more than 42 institutions with responsibilities for water resource management, which makes it difficult to coordinate the prioritization of resources and instru-

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One of the challenges that remains in place is the strengthening of water-related institutions that have historically faced difficulties when managing water resources.

ments for the management and administration of the country's water resources[28]. Chile also needs capacity building and financing programs for the adoption of low water consumption and environmental impact technologies and the strengthening of the General Water Directorate. Colombia might benefit from strengthening the coordination of the Ministry of the Environment and Territorial Development (MAVDT) to agree upon a holistic approach on the water resource management, and lead synergies with local environmental authorities and other ministries and institutions at the national level. Costa Rica can grant additional competencies and mandates in water security to divisions and agencies associated to the Ministry of Environment and Energy (MINAE). For El Salvador, it is a priority to order the allocation of water resources regulation and management powers through the enactment of a water law and defining the institutions in charge to enforce regulations and monitoring the sector. In Mexico, strengthening actions include inter-institutional coordination, improving transparency and water management at the local level[29]. The generation of capacities in the institutions can be accompanied by actions aimed at the adoption of new technologies to improve the mapping and monitoring of the status of water sources.

28 National Water Resources Policy Chile 2015.
29 Mexico National Water Program (2020-2024).

3.5 Information **availability**

The countries face obstacles in generating, updating, systematizing, and disseminating information on water resources and uses. In the selected countries, the information is scattered across institutions which makes it difficult to assess the availability and quality of water resources at the local level, as well as the actual water demand by sector or monitoring current threats and stress for specific water resources. Chile has difficulties in obtaining reliable and timely information on the amount of water resources available, the rights assigned for authorized uses and their active use at the basin level. Colombia emphasizes the importance of deepening research on water resources and strengthening a water information system integrated with the Environmental Information System. For Costa Rica, it is a priority to ensure the collection and dissemination of climatic, meteorological, cartographic, and hydrological information, complemented by measurements of end users. Moreover, this country requires strengthening water-related warning systems for extreme weather and climate change events. In El Salvador, the priorities might include developing a Water Information System (WIS) to provide continuity in data collection and analysis; while Panama, should accelerate the implementation of a National Water Information System in parallel with the creation of the Hydrological, Atmospheric, Geophysical and Oceanographic Information Service (SIHAGO). Finally, Peru can direct additional funds to the National Water Quantity Information System for increasing the information on risks to water resources, current uses, and projected demand at the sectoral level.

It is recommended that those countries without a national water resources information system, such as Chile, Nicaragua, and Honduras work in the design and responsible institutions responsible to monitoring social and economic risks associated to water resources. It is suggested to review the experience of Colombia, which has a Water Resource Information System (WRIS) organized into five components: surface and groundwater supply, demand, quality, risk, and water resource management. These three countries might benefit from modernizing the meteorological and hydrometric capacity to monitor the availability of surface and groundwater resources and the risks associated with current water consumption and extreme events[30].

30 Status of groundwater monitoring in Latin America and Introduction to the GGMN program. https://www.un-igrac.org/es/resource/estado-actual-del-monitoreo-de-agua-subterranea-en-america-latina-e-introduccion-al.

3.6 Management **tools**

The countries of the region face the challenge of designing and implementing effective tools that will enable them to balance the growth in water demand with the sustainable supply of water resources. These tools must contribute to maximize the use, conservation, and protection of water resources. It is recommended that the selected countries consider some (if not all) of following options:

- Diagnostic tools: aimed at generating, gathering, and analyzing inventory data, projections, maps, information systems, among others;

- Regulatory and promotional instruments: to develop infrastructure, as well as to control and mitigate the negative externalities associated with the development and use of water resources;

- Organizational instruments for management: including the review and assignment of roles, attributions, technical equipment, capacity building, and stakeholder coordination;

- Direct intervention tools: including the design and development of infrastructure for water control, use and treatment.

International experience shows that it is difficult to have all the instruments available for integrated water resource management. Therefore, the countries under analysis must ensure that there is a balance in the design and application of this set of instruments, incorporating the principles expressed in public, private and social policies, such as environmental conservation, equity, the right to water, transparency, participation, security, among others. In this sense, it is important to encourage the engagement of local governments to guarantee the implementation of actions. Municipalities are traditionally in charge of providing water supply and sanitation services, although their participation in water resources management is scarce because it is beyond the scope of their municipal attributions. Giving municipalities the authority to manage water resources would help to increase the proximity of actions, within the framework of the promotion of socioeconomic development at the local level, particularly at the basin level [31].

The selected countries can assess the creation of additional fees for water rights, effluent discharges, and payments for environmental services[32]. For this purpose, it will be necessary to have an adequate cadastre, as well as a registry of rights and the appropriate institutional control capacity to ensure transparency in the processes of approval of concessions and operation of tariff systems and payment of fees for water use (discharges or discharges), drinking water and sanitation services and the use of certain infrastructures. Costa Rica has been a pioneer in the region in establishing a system of water tariffs for environmental services, which has brought additional social benefits in raising awareness of the population in the rational use of water and

31 Municipalities and water resource management. https://www.cepal.org/sites/default/files/publication/files/6429/S0310753_es.pdf

32 Bretas et al. (2020).

strengthening the empowerment of communities. Colombia has established the collection of retributive rates for certain discharges implemented under an autonomous institutional structure that has made it possible to reduce the polluting load of its aquifers[33].

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[...] it is important to encourage the engagement of local governments to guarantee the implementation of actions. Municipalities are traditionally in charge of providing water supply and sanitation services [...].

33 Echeverría y Cantillo (2013).

3.7
Infrastructure

Infrastructure crosscuts the recommendations previously addressed and is the main direct intervention mechanism traditionally used to ensure availability and access to water resources. Infrastructure modernization should aim to improve resource use efficiency, increase supply to meet the growing demand for water, and expand sanitation networks and infrastructure that is resistant and resilient to climate events.

When grouping the key issues analyzed in Section 2, three key areas in infrastructure require additional actions: i) infrastructure to increase the availability and sanitation of water; ii) infrastructure to improve the efficiency of water use and iii) infrastructure to face climate change.

CHALLENGES AND RECOMENDATIONS TO STRENGTHEN WATER SAFETY

Countries face difficulties in creating the conditions to **increase water security and implement a management model that guarantees universal access to water.**

Part of **climate change impacts in agriculture activities** include the decrease in topsoil moisture, which **increase the demand for irrigation systems,** adding further pressure on water resources and use conflicts.

7 Recomendations by priority

- WATER RESOURCE SUSTAINABILITY AND ACCESS										
Implement meansures aimed and managing water supply and demand	Red	Red	Red	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Red
Expanding safe drinking water management	Yellow	Red	Yellow	Yellow	Red	Yellow	Red	Red	Yellow	Red
- ECONOMIC EFFICIENCY OF WATER USE										
Implement measures to decouple water consumption from economic growth	Red	Yellow	Yellow	Red	Yellow	Red	Red	Red	Green	Red
- LEGAL AND REGULATORY FRAMEWORK										
Enact water laws with a multi-sectorial approach aimed at guaranteeing WS		Red		Red	Red	Green	Red	Green	Red	Green
Update water laws with a multi-sectorial approach aimed at guaranteeing WS	Red		Red							
- COORDINATION AND INSTITUTIONAL CAPACITY										
Strengthen institutional coordination capacity for integrated WR management	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
Promote training for the development of new technologies for research and monitoring	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
- AVAILABILITY OF INFORMATION										
Implement national information systems for WR	Red					Red		Red		
Strengthen and/or improve national WR information systems		Green	Green	Green	Green		Green		Green	Green
- MANAGEMENT TOOLS										
Formulate and/or update WR management policies	Green	Green	Green	Green	Red	Red	Green	Green	Green	Green
Design and implement economics and fiscal tools to guarantee the effectiveness of actions in WS		Green	Green	Green	Red	Red	Red	Red	Red	Red
Encourage the participation of local governments	Green	Red	Red	Green	Red	Red	Red	Red	Green	Red
- INFRASTRUCTURE										
Increase water storage infrastructure	Red	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Green	Yellow	Red
Increase and improve infrastructure for wastedwater treatment and reuse	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Red
Improve infrastructure to increase water use efficiency in the productive sectors	Red	Yellow	Yellow	Red	Yellow	Red	Red	Red	Green	Red
Develop and improve existing infrastructure ot cope with droughts	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Red
Develop and improve existing infrastructure to cope with flooding	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red

Implement measures to increasing the availability of water is necessary: implementation of gray infrastructure and green capacity; water harvesting; wastewater reuse and protection against contamination. The main challenge is apply circular economy principles in order to manage the water reuse for all sectors.

The reforms should address, in a multisectoral context, issues related to territorial and environmental planing. In addition to include economic and financial mechanisms to get these actions.

Public institutions require further coordinationto improve their capacity to implement policies and water resources management. Weaknesses have been observed such as limited autonomy, budget and technical capacity to enforce by regulatory framework, lack of coordination with other institutions and achieve efficient hydrological planning.

Countries face obstacles in generating, updating, systematizing and disseminating information on WR and use. It is unknown the actual availability and quality of these resources at the local level, as well as the actual water demand by sector.

The countries of the region face the challenge of designing and implementing effective tools that will enable them to balance the growth in water demand with sustainable supply of the WR.

The infrastructure crosscuts all this and is the main direct intervention mechanism to ensure availability and access to water. The modernization of the infrastructure must aim to improve resource use efficiency, and increase supply to meet the growing demand for water and use.

Infrastructure to improve water availability and sanitation

Historically, reservoirs have been effective in covering shortages and controlling hydrological excesses. Their storage and flow control capacity helps to increase water availability, cope with droughts and floods, and even increase installed capacity for electricity generation. However, reservoirs have a high exposure to climatic impacts; therefore, it is recommended that their consideration include climate change risk assessments for different potential locations and a comparative cost-benefit analysis with respect to substitute options.

Ensuring a safe water supply requires advanced and environmentally acceptable processes to preserve water and reduce its consumption. For this reason, the initiatives to implement require innovation in the following potential actions:

- Reusing treated industrial and municipal wastewater. Productive sectors and cities have a high impact on the quality of water reservoirs. At the regional level, the coverage of households with treated wastewater averages 22%, with significant variations between countries. Chile exceeds the average with 80%[34], followed by Mexico with 37%. The rest of the countries under analysis reach a service coverage below 15%[35].

  Countries can drive a paradigm shift in wastewater management to ensure water security. Wastewater treatment not only reduces the negative externalities of polluted water on the environment

34 However, there is extensive incidence of contamination from mining effluents, liquid industrial waste and diffuse agricultural contamination of groundwater.

35 BID (2017).

and the health of the population, but also offers the possibility of reconsidering its reuse, representing a solution to the problem of water scarcity and security. In this area, four lines of action are proposed: i) develop wastewater initiatives as part of the watershed planning framework to maximize benefits, improve efficiency and resource allocation, and involve relevant stakeholders; ii) explore and support the development of innovative financing and sustainable business models in the sector; and iii) crafting and implement public policies and regulatory frameworks to promote innovation in the sector.

- Developing the water utility of the future. The countries should migrate from the concept of a wastewater treatment plant to one of resource recovery to take advantage of the added value of wastewater. It is recommended that countries consider supplying water of different quality considering its end use (drinking, washing, agriculture, irrigation, and industrial use). This can be achieved using parallel water distribution lines, each with the appropriate level of purification and optimization of the water distribution system.

- Desalinating of water sources. Although these processes use large amounts of energy, their technological evolution shows significant improvements in energy efficiency. There are currently more than 7,500 such plants worldwide, with 60% of them located in the Middle East.

Infrastructure to improve water use efficiency

There are opportunities to reduce water consumption for electricity generation by incorporating non-conventional renewable energy sources such as wind and solar power, among others, which reduce water consumption and environmental impact for electricity generation. It is important to note that countries in the region have high renewable energy potential and robust electricity markets, which are attractive to project developers and investors seeking geographic diversification with clean technologies.

For those countries that depend on thermal generation, such as Mexico, Chile and, to a lesser extent, Peru, it is recommended to develop a technological transformation process aimed at increasing the participation of renewable thermal energy and improving the efficiency of fossil fuel-based thermal plants, replacing, for example, wet cooling systems with dry (theses systems can reduce water consumption by 90%). The water demand from renewable-based technologies ranges from negligible to comparable to thermal generation using wet tower cooling. For this reason, it is recommended integrating a greater share of technologies such as wind and solar photovoltaics that use small amounts of water in compared to other technologies[36]. In addition, countries with high consumption of firewood and sugarcane bagasse for the production of residential and industrial heat can prioritize the implementation of initiatives to shift the demand for these biofuels by high-efficiency technologies based on renewable energies, for example, development of district heating and cooling systems based on geothermal energy or green hydrogen.

36 International Energy Agency, 2012.

> *It is important to note that countries in the region have high renewable energy potential and robust electricity markets, which are attractive to project developers and investors seeking geographic diversification with clean technologies.*

Within the agriculture sector, which exerts strong pressure on water resources, transformational measures will be needed to improve the efficiency of irrigation water use. The efficiency of this sector in the selected countries averages 50%, i.e., of the total water withdrawn, only 50% is used effectively and the remaining percentage is lost through evaporation and distribution losses. The average gross irrigation water demand in the region is considered moderately high when compared with other regions of the world[37]. Among the measures commonly implemented are the modernization of distribution systems and the deployment of drip irrigation and hydroponics infrastructure, which can reduce 40% to 60% of water consumption.

37 Irrigation in Latin America and the Caribbean in statistics. https://agua.org.mx/wp-content/uploads/2017/08/El-riego-en-america-latina-y-el-caribe-en-cifras.pdf

Infrastructure to address climate change

In the past, water infrastructure and management practices were developed based on assumptions of predictable weather conditions that are no longer valid. International experience indicates that reservoirs can help ensure water availability in the event of climate phenomena, but this does not offset their effects. For this reason, the development and modernization of the energy sector's infrastructure must incorporate climate change adaptation variables in the design and operation of its different energy production and transformation processes. In the electricity sub-sector, there is currently a significant gap between the knowledge of the traditional way of developing infrastructure and the climate change impact variables to consider during the design of hydroelectric and thermal power plants. For reducing uncertainty and identify potential risks, it will be essential to i) gather adequate information (at detailed temporal and spatial scales), where there are generally significant gaps among the countries of the region, and ii) design and implement new tools for modeling these instruments, including climate change variables with approaches that not only include the traditional analysis of events, but also consider non-stationary future scenarios.

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Half of the reservoirs used for hydroelectric generation are more than 30 years old, therefore, there is a high and urgent need for modernization.

In addition, the design of new power plants must incorporate a multisectoral approach that overcomes the challenges associated with conflicts of use with local communities and other productive sectors (particularly in areas with water deficit). This infrastructure development must consider the mitigation of the impacts associated with the construction and operation, such as, the alteration of the downstream flow and the losses of water to the atmosphere caused by evaporation. In this regard, the countries can conduct climate risk and impact assessments on existing (and projected) reservoirs to identify mitigation measures.

Finally, half of the reservoirs used for hydroelectric generation are more than 30 years old, therefore, there is a high and urgent need for modernization. The modernization of these facilities, such as improving spillway capacity, replacing equipment, and increasing dam safety, will reduce the water security exposure to future climate risks[38].

38 Climate risks to Latin American hydropower. https://www.iea.org/reports/climate-impacts-on-latin-american-hydropower/climate-risks-to-latin-american-hydropower#abstract

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