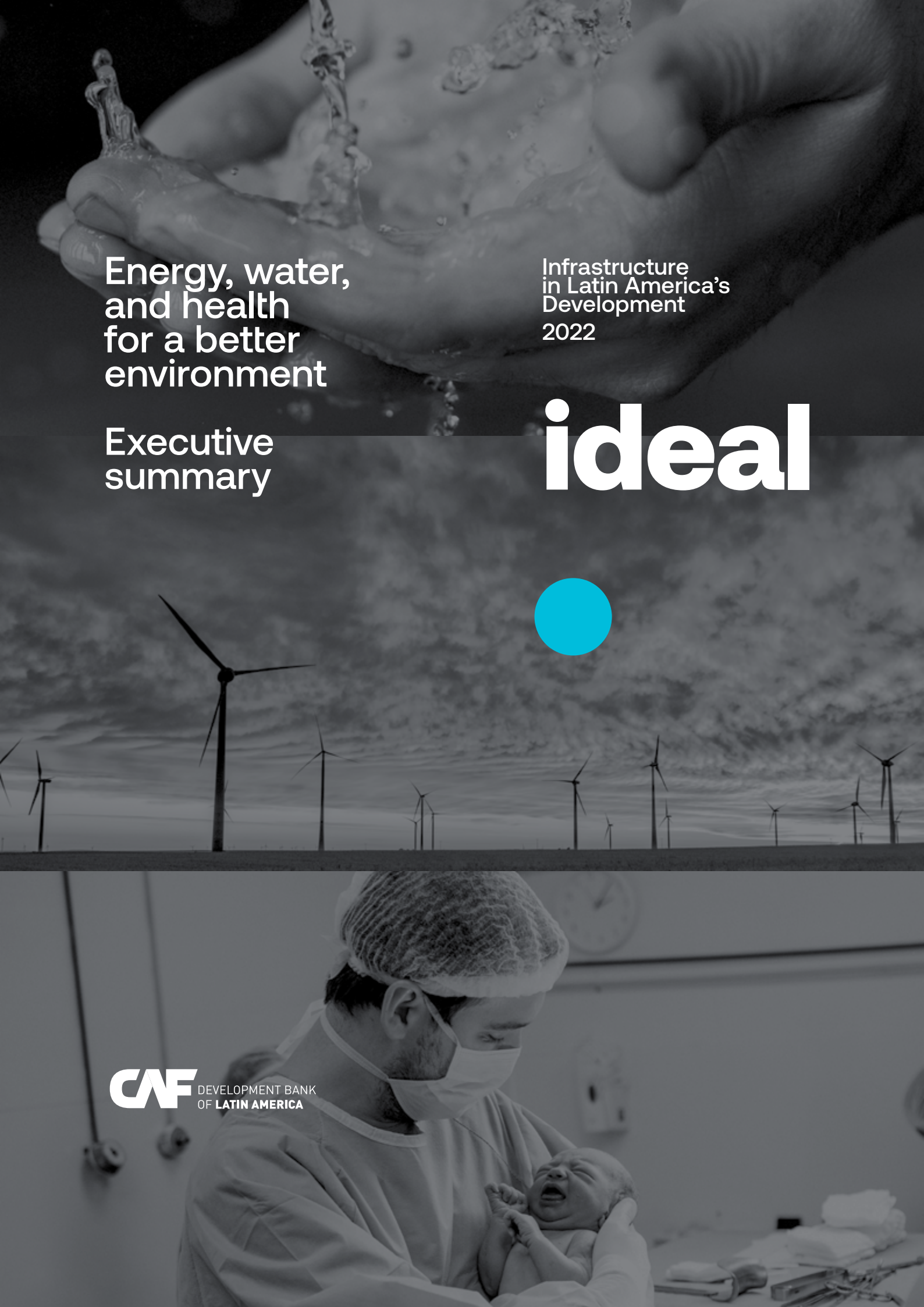

Energy, water, and health for a better environment

Executive summary

Infrastructure in Latin America's Development 2022

ideal

CAF DEVELOPMENT BANK OF LATIN AMERICA

Infrastructure in Latin America's Development
2022

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Executive summary

The health of the planet and the ecological balance of ecosystems are increasingly determining factors in assessing the present and envisioning the future. Since the first United Nations Conference on the Human Environment in 1972, countries have recognized environmental care as a key element for their economies' survival and sustainable development.

Climate change is the biggest global challenge that society faces. The last few decades have shown that the situation is critical, highlighting the urgent need for the implementation of mitigation and adaptation solutions, especially in Latin America and the Caribbean (LAC). Since the 1980s, the rise in average planet temperature has accelerated, with the prospect of continued rises if concrete and drastic actions are not taken to adjust patterns, behaviors, and forms of production. Over the period 2010-2021, the number of natural disasters[1] worldwide was 2.8 times higher than that recorded in 1970-1980. In the same timeframe, material damages increased fivefold. Over the past 12 years, natural disasters have cost the planet USD 2.4 trillion (in 2021 constant values) (CRED, 2021), equivalent to 0.2% of gross domestic product (GDP). In LAC, the number of disasters and damages increased 2.6 and 3.6 times, respectively, costing the region USD 231 billion (in 2021 constant values), equivalent to 0.32% of its GDP. The sustained temperature rise projected at least until mid-century is expected to exacerbate extreme events both in frequency (number of events) and intensity (IPCC, 2021). Wake-up calls to transform the current economic paradigm into sustainable, low-emission, and resilient development are growing louder and more frequent. They warn of catastrophic impacts if decisive and conclusive actions are not taken to change the course of the "business-as-usual" path.

This edition of the Infrastructure in Latin America's Development (IDEAL) report takes an in-depth look at the role of two strategic economic infrastructure sectors in sustainable development, in the context of the environmental and climate change challenges they face. The sectors are water and energy, including transportation because of its share of energy consumption. The report examines the impact of these sectors on the fight against climate change and the conservation of natural capital. It also analyzes the response capacity of the health care industry to potentially disruptive events. Although the origin of the disruption caused by COVID-19 was epidemiological, future health events of the same type of origin or caused by vectors altered by climate change could arise. For each of these sectors, the report goes through the expected changes regarding environmental concerns, sectoral challenges as a result of these changes, and possible actions to address them. It also marks the path for sustainable development through these infrastructure sectors.

In the energy sector, although the region's electricity matrix is relatively clean—given the high percentage of hydropower generated, including important projects based on large power plants—it accounts for a small proportion of total energy consumption. As such, transitioning to a low-carbon energy sector brings multiple opportunities as well as several

1 Data included in the report are for biological, climate, geophysical, water, and meteorological natural disasters.

challenges.[2] Decarbonization in the energy sector has become a structural objective. It involves a set of interventions to convert energy systems based on coal and fossil fuels to low-emission systems that based on primary sources, with higher share of electricity, lower energy intensity, and complemented by carbon capture, use and storage (CCUS) mechanisms that can supplement traditional methods, such as storing carbon as standing forests. The greatest environmental energy challenge is to undertake this transition while balancing the region's environmental, economic, and social needs with its capacity to achieve a certain momentum in this process.

This report reviews energy policy interventions to tackle climate change and highlights changes in primary sources. These include increasing the number of renewable energy sources; natural gas as a substitute for coal and oil derivatives; the potential role of hydrogen (H_2) as an energy vector; opportunities to capture and use carbon; and the role of gas as a source of energy during the transition. Moreover, it highlights changes in the final demand for energy and transformation processes, focusing on transport electrification and energy efficiency measures, with their consequent regulatory requirements. Additionally, the need to complement decarbonization with actions to adapt to climate is contemplated. Actions analyzed in this report include diversifying the energy matrix, enhancing energy demand forecasts—with global warming implications—, conducting a comprehensive assessment of climate risks in the electricity sector, and developing technologies to improve the resilience of generation capacity and infrastructure.

For the water sector, the conservation of water resources requires enhancing cooperation, coordination, and integration; controlling contaminating activities; improving efficiency; developing the circular economy; and implementing an integrated water resources management approach. These aspects must be strengthened in the context of climate change, which will limit the quantity and quality of available water. Along these lines, the goal of these interventions must go beyond achieving water security through the resource's integrated management. They should contemplate green infrastructure investments, cost-reflective pricing that encourages efficient use without neglecting affordability, and policies and regulations that ensure the system's sustainability.

Finally, for the health care sector, the COVID-19 pandemic unveiled system deficits and difficulties to adapt to disruptive events that trigger a peak and temporary demand for health care services. However, it also showed positive aspects regarding resilience, i.e., adaptation. At the same time, the health care network was strengthened, and full advantage was taken of available physical resources (owned or third-party infrastructure) and immunization coverage. In light of this situation, having a more flexible system will ensure a better adjustment to future disruptive events caused by either transmissible or climate factors. Interventions associated with adequate financing, the quality and quantity of human resources, infrastructure, planning for scenarios and resources, and data management and quality, among other aspects, will help achieve such a system.

2 In this report, sources of contamination mean sources that emit substances such as particulate matter and sulfur oxides (SOx), which mainly affect the local environment. Clean or low-emission sources do not produce or only generate minimal amounts of greenhouse gases (e.g., CO_2, CH_4).

Sustainable development, the environment, and infrastructure

Recent trends in sustainable development: The environmental challenge

Although sustainable development has long been on the public agenda, the unification toward a global holistic agenda that comprises all aspects of the balance between the environment, society, and the economy is quite recent. In 2015, the UN member states adopted 17 goals as part of the 2030 Agenda for Sustainable Development. At the end of 2015 , 196 countries adopted the Paris Agreement on Climate Change at the COP21.[3] In addition, the Conference of the Parties to the Convention on Biological Diversity was held in 2022. During this conference, 23 targets were adopted within the Global Biodiversity Framework (GBF) to reverse the loss of biological diversity, restore ecosystems, and promote positive actions for human behavior. In this context, the Sustainable Development Goals (SDGs) acted as an integrating framework, incorporating these environmental agendas and extending the analysis to include the other dimensions of sustainability (society and the economy).

Climate change

Climate change is affecting all geographic regions by increasing the Earth's average surface temperature, and the frequency and severity of natural disasters such as heat waves, floods, droughts, and tropical cyclones, among others. The planet's temperature has risen rapidly since the 1980s. Therefore, during the second decade of the 21st century, the temperature was 1.1°C above pre-industrial levels. If this trend continues and no specific and concrete actions are adopted to adjust patterns, behaviors, and modes of production, the temperature is expected to reach or exceed the 1.5°C difference within the next 20 years (IPCC, 2021).

The consequences of climate change for the LAC region include especially those stemming from the occurrence of natural disasters. For the period 2010-2021, the total impact of natural disasters is estimated to account for 0.32% of the region's GDP, the Caribbean sub-region bearing the largest portion of economic costs (2.5% of its GDP) and mortality rates, with 94% of all deaths (CRED, 2021).

LAC countries are not more vulnerable to climate change than the rest of the world's countries. However, comparatively, they lack adequate and timely responsiveness. If this trend continues, the region will face greater adaptation challenges (according to the University of Notre Dame Global Adaptation Index).

Ecosystems, biodiversity, and climate

The current negative trend in biodiversity conservation of terrestrial and aquatic ecosystems is an issue associated with sustainable development and climate change. In addition to protecting all forms of life, ecosystems are a natural source of CO_2 absorption. Based on the Living Planet Index, the region has recorded the largest decline in the animal population, with a 94% drop from 1970 to 2016, compared to 68% worldwide. Livestock farming, oilseed production, and forest overexploitation pose the biggest threats to biodiversity (Maxwell et al., 2016). These industries account for 73% of global deforestation in the past 30 years (Ritchie and Roser, 2021). Based on information from the Food and Agriculture Organization of the United Nations (FAO, n.d.a), forest area in LAC was reduced by 13% in this period, compared to 4.2% worldwide, contributing to the loss of natural habitats.

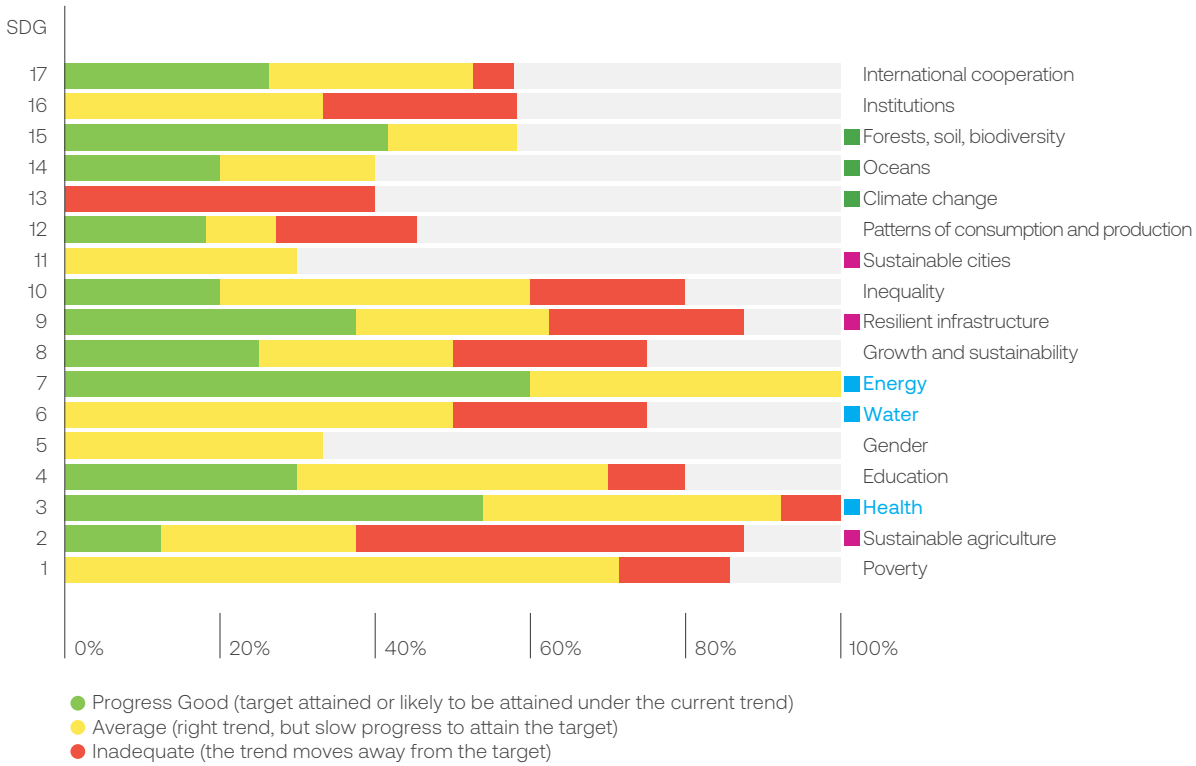
3 COP21 refers to the 21st Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) held in Paris in 2015. During the Conference, 196 countries and territories signed the agreement. It was a historical event because it was the first international agreement on climate ever reached.

Infrastructure in Latin America's Development 2022: Sector challenges

The Sustainable Development Goals (SDGs) have specific objectives for the infrastructure sectors prioritized in this report: health, water, and energy. Not only are they goals in themselves (SDGs 3, 6, and 7, respectively, and SDG 9 as a cross-cutting goal), but they also strongly interrelate with other goals, reflecting their paramount role in country development.

Graph 1 shows the progress achieved by LAC countries in meeting the 17 SDGs based on scenario simulation exercises and indicator trends for each goal until 2030. The degree of progress attained for the different targets reflects dissimilar performances, which have been moderate or even inadequate in many cases. This, coupled with undefined indicators (all the indicators have been established only for two goals: health and energy), indicates the need for immediate action.

Graph 1
Progress on SDG achievement in Latin America and the Caribbean
Source: Authors based on ECLAC (n.d.).



Chapter 1 of this report identifies a set of sector and environmental challenges. These are listed in Box 1 and result from an analysis of the three direct goals collectively (SDGs 3, 6, and 7), the links of these sectors with other objectives covered by the SDGs, and the climate (Paris Agreement) and environmental (Global Biodiversity Framework) commitments.

Box 1
Challenges faced by Latin America and the Caribbean to meet the health, water, and energy SDGs
Source: Authors.

Challenge 1: Renewable energy.

Challenge 2: Energy efficiency.

Challenge 3: Conservation of aquatic ecosystems.

Challenge 4: The role of local communities in water management.

Challenge 5: Access to drinking water, and sanitation and hygiene services.

Challenge 6: Efficiency in freshwater use and withdrawal.

Challenge 7: Flexible health care system to adapt to extreme events.

Challenge 8: Implementation of climate policies: reduce emissions, foster adaptation.

Challenge 9: Management and protection of marine and coastal ecosystems to strengthen their resilience.

Challenge 10: Conservation and sustainable use of inland freshwater and terrestrial ecosystems.

Strategies to face climate change and the conservation of natural capital

Mitigation and adaptation

Mitigation policies aim to encourage the reduction of greenhouse gas (GHG) emissions through the implementation of less intensive or carbon-neutral activities (or activities that have a carbon-neutral trend). This report highlights actions to decarbonize the energy matrix or increase energy efficiency (SDG 1, 2, and 8).

However, even if a drastic reduction in GHG emissions is achieved, temperatures will not stabilize immediately due to the climate system's inertia. Therefore, the response to climate change also calls for efforts to **adapt** to adverse impacts that cannot be avoided. Nationally determined contributions (NDC) and national adaptation plans in developing countries reflect that the LAC sectors in greater need of finance for adaptation are agriculture, infrastructure, water, and natural disaster risk management (SDG 8).

Infrastructure plays a key role in any adaptation strategy aimed at making communities less vulnerable to climate change. Despite this, studies of alternative climate adaptation projects including cost and benefit estimates are limited. In addition, improving the resilience of current systems involves costs. Therefore, climate adaptation also presents huge **financing** challenges.

Conservation of natural capital

The analysis shows that **ecosystem** conservation is a major environmental challenge for the region (SDG 3, 9, and 10), coupled with efficient water management, access, and use (SDG 4, 5, and 6). Actions to promote ecosystem conservation globally also include spatial conservation, such as the creation of protected areas. At present, 15% of the world's land and 7.74% of its oceans are in protected areas (Dasgupta, 2021).

While there is still no consensus as to biodiversity's productive or enabling role (quality of the asset that increases the value of other assets), there are partial valuations included in the natural capital (World Bank, 2021; Dasgupta, 2021).

Natural capital is particularly relevant for LAC. According to estimates published in a recent World Bank report (2021), built capital stock in LAC is limited compared to other regions, but the natural capital stock is relatively abundant. However, projections reported by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) on biodiversity indicators (e.g., the Living Planet Index above) warn about the loss and degradation of biodiversity under business as usual (BAU) scenarios, with South America being the region that would suffer the greatest loss of species richness (IPBES, 2019). **Global pollution** levels caused by different production processes and consumption and efficiency patterns challenge the preservation of water as natural capital. This situation is aggravated by climate change.

Energy, water, and health—the three infrastructure sectors prioritized in this report—are the only ones with specific SDG-related objectives. Furthermore, the report focuses on the sectors that interact the most with the environmental issues discussed, i.e., climate change and the conservation of natural capital. The energy sector plays an important role in climate change mitigation through decarbonization. The transportation sector is examined as a specific case due to the energy consumption necessary to provide mobility services for people and goods. Water, in turn, is an essential natural capital for economic development, while water conservation is necessary for the wellbeing of present and future societies. The health sector is key to minimizing the impact on human lives caused by catastrophes associated with climate change. In light of the recent COVID-19 epidemic, it is pertinent to analyze how prepared this sector is to face extreme events. Finally, although the information and communication technology (ICT) sector is not explicitly analyzed in this document (for a detailed analysis, see the IDEAL 2021 report), relevant ICT trends and recommendations are presented when they are pertinent to the context of this report.

Energy for a better environment

Climate change and the energy agenda

The immediate need to reduce emissions puts the energy sector at the forefront of climate change action. In 2015-2019, the energy sector generated 76% of GHG emissions and more than 90% of CO_2 emissions worldwide. In LAC, 46% of GHG emissions and 62% of CO_2 emissions originate in this sector.

Although the levels of CO_2 emissions in the region are low compared to the global average, and, in particular, to that of developed countries, the trend over the past 50 years indicates that per capita emissions in LAC have risen, while the marked difference in emissions per unit of gross value added (GVA) in relation to other regions has decreased.

Given this scenario, the decarbonization of the energy sector is a structural objective of the energy transition process. Energy transition involves a set of interventions to convert a fossil fuel- and coal-based energy system into a system based on low-GHG emission primary sources, with a higher share of electricity and lower energy intensity, complemented by carbon capture, use and storage (CCUS) mechanisms.

Starting point: The energy matrix in LAC

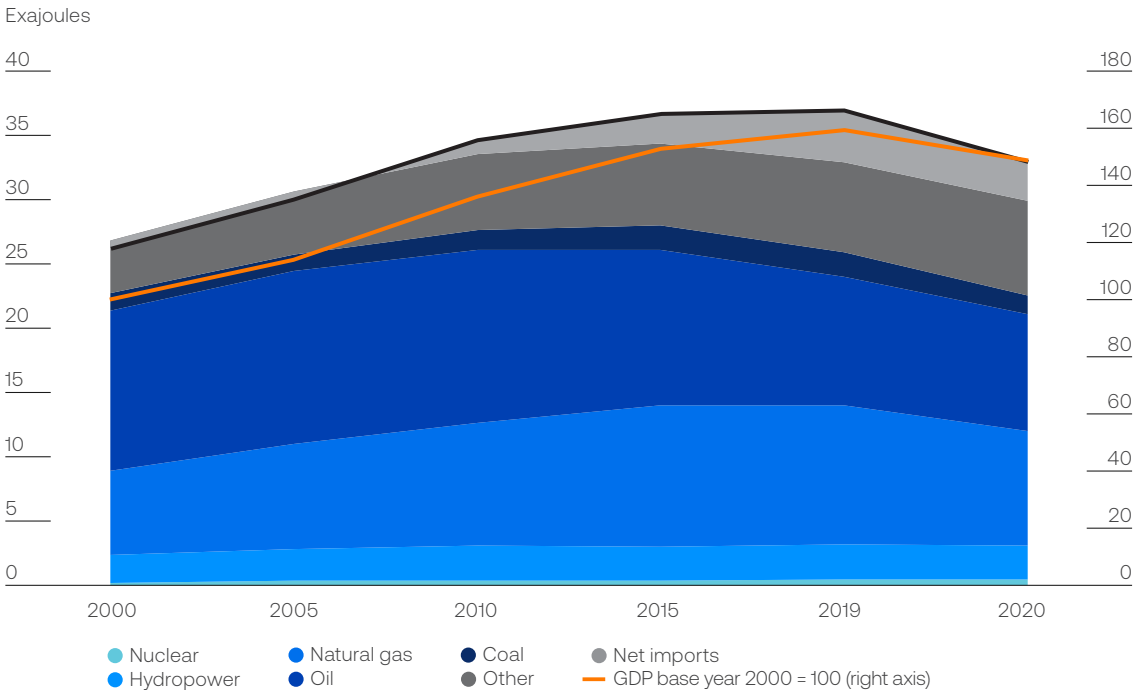
Graph 2 shows the evolution of the total energy supply (primary energy plus net imports of secondary energy), which rose from 26.2 exajoules (EJ) in 2000 to 36.9 EJ in 2019. In this period, the region's GDP grew by 59%, while final consumption increased from 17.3 EJ to 24.7 EJ. In addition, over the same period, natural gas and renewable energy sources began to replace oil. Moreover, net imports of secondary energy (which are mainly oil derivatives) rose.

Confronting the total primary energy supply plus the net import of fuels with domestic demand in 2000-2019, system efficiency (i.e., the resources necessary to generate a level of consumption) has remained constant, while energy intensity (i.e., the energy consumption per unit of gross value added) improved 10%. Evidence for the region suggests that lower use—improved energy efficiency and response to prices, among others—was the main contributing factor, rather than changes in production or consumption that favor less energy-intensive activities.

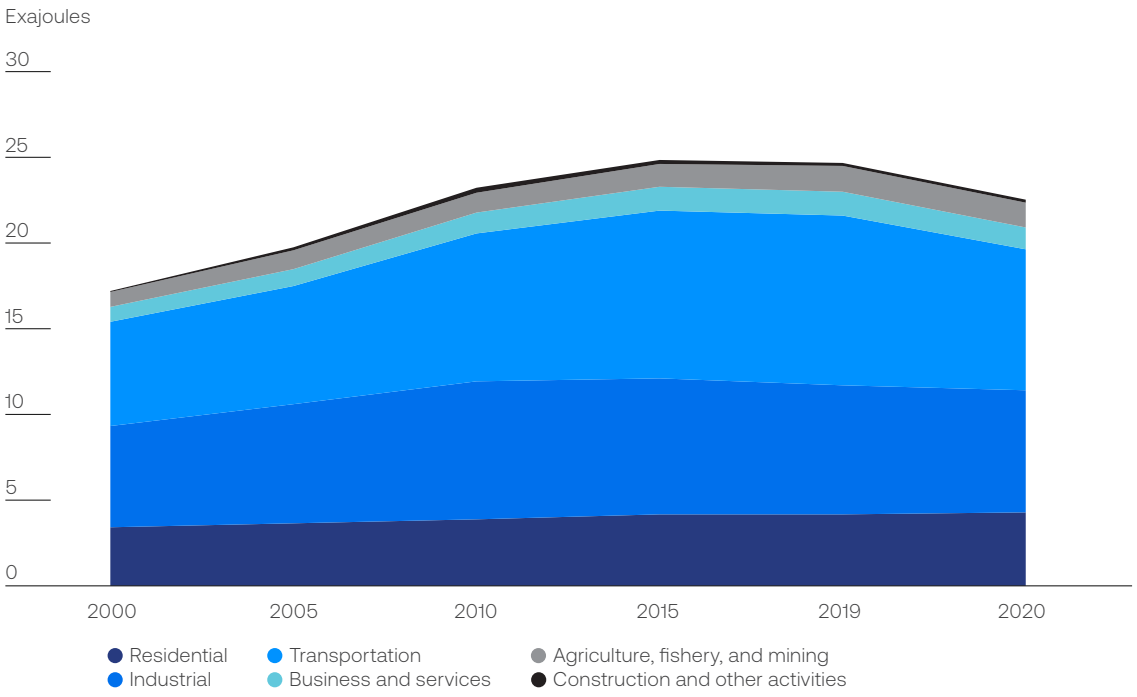
Graph 2
Energy supply, consumption, and GDP evolution in Latin America and the Caribbean, 2000-2020

Source: Authors based on information from OLADE (n.d.) and the World Bank (n.d.).

Panel A. Primary energy plus imports of secondary energy and GDP in LAC



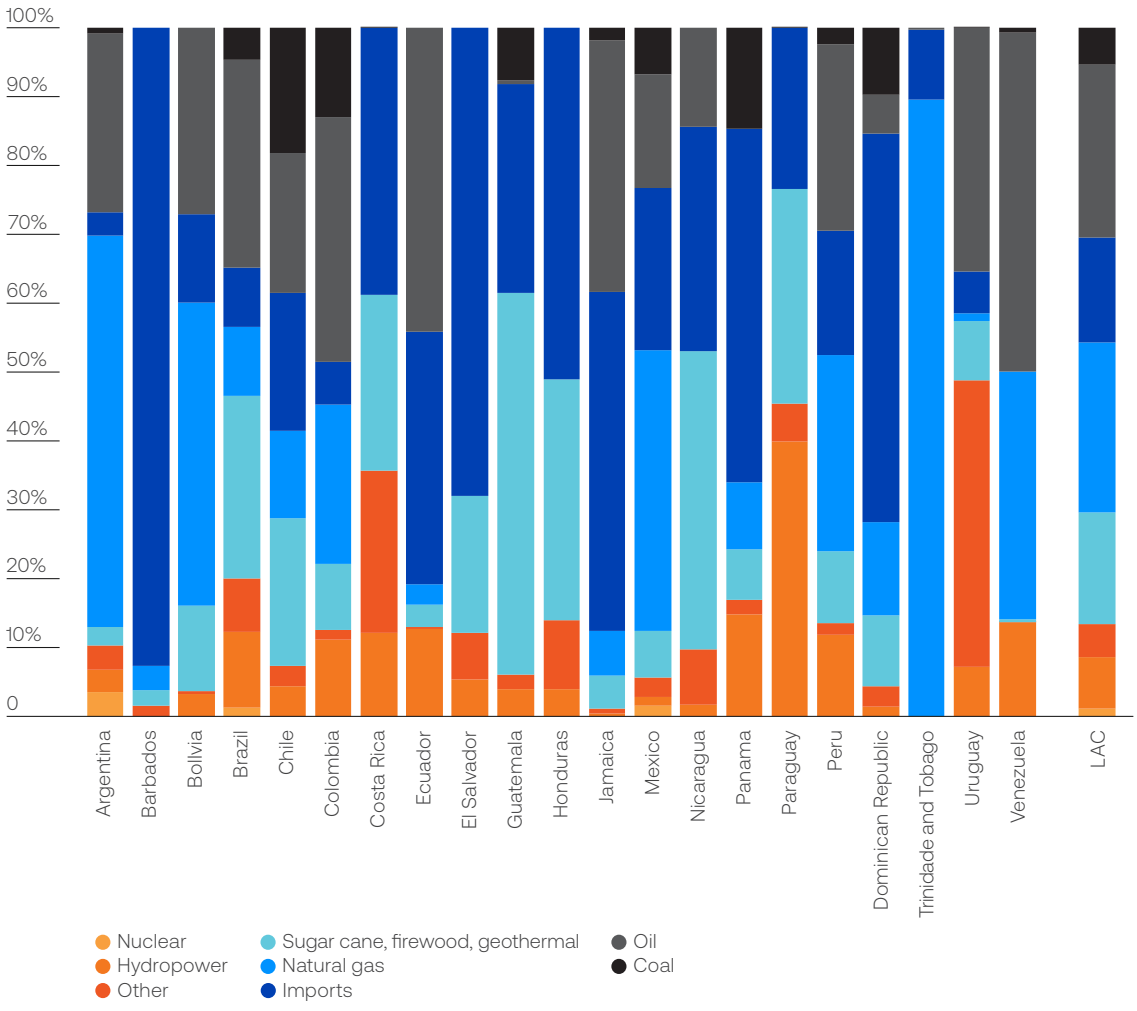
Panel B. Evolution and relative composition of final consumption in LAC



Note: GDP values are expressed in constant currency (constant 2015 USD). GDP base year 2000 = 100.

In LAC, electricity consumption accounts for nearly 20% of energy consumption. The difference between the energy matrix and the electricity sub-matrix is key to understanding energy transition policies. An electricity matrix in the region may be relatively "green;" however, this does not mean that the energy supply comes from clean sources. This is the case if a country imports large quantities of fuel or if the energy consumed by the remaining 80% of the energy comes from high-GHG emission sources. In addition, the analysis can be biased if the primary supply of energy resources is considered in isolation, disregarding imports (which, in LAC, are generally fossil fuels). On the other hand, even if the electricity sub-matrix has a high share of energy from clean sources, any increase in power use (as a result of consumption substitution policies) must be met with new energy generation.

Graph 3
Relative composition of primary energy by source and country in 2020
Source: Authors based on data from OLADE (n.d.).



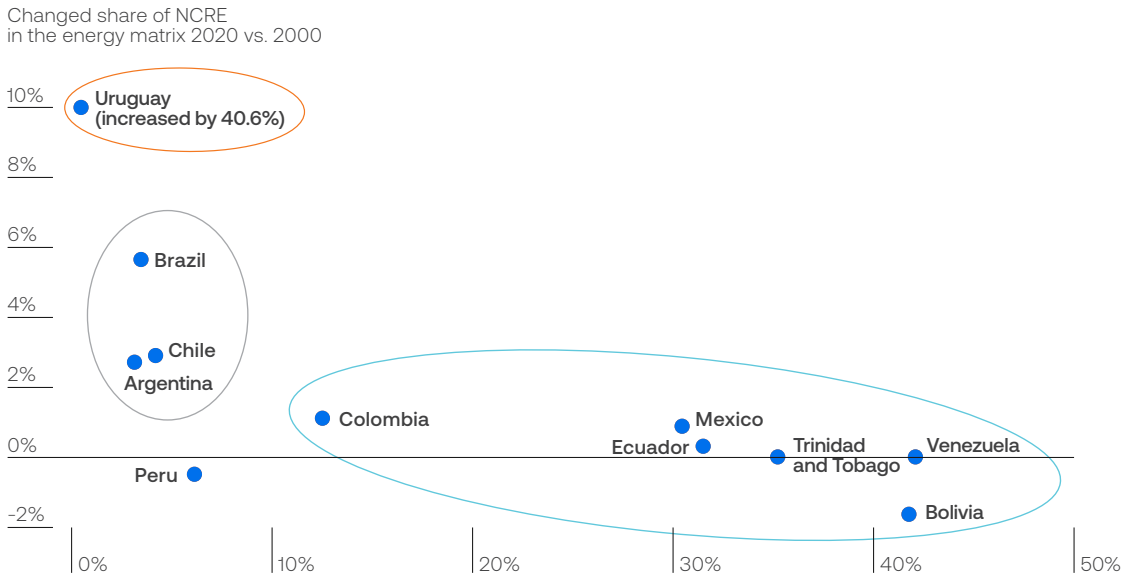
Heterogeneities in Latin American and Caribbean countries

Renewable sources account for a significant share of generation in the region's electricity matrix. However, this good regional performance hides broad heterogeneities between countries. Two stand out: the level of initial decarbonization (estimated based on the share of renewable sources in the matrix) and the commitments assumed by each country in terms of activities involving hydrocarbons (estimated based on the volume of tax revenues originating from the hydrocarbon sector, as shown in Graph 4).

Given these different country contexts, the necessary evolution of the energy transition from an environmental perspective may contrast with dissimilar levels of development, inequality, and poverty, including the region's economic reliance on the tax revenues generated from fossil fuels, among others. This balance between needs and capacities will, in turn, define the feasibility of the speed of a regional energy transition that is environmentally sustainable and fiscally viable.

Graph 4
Comparison between non-conventional renewable energy (NCRE) growth in the energy matrix for the period 2000-2020 and tax revenues from hydrocarbons

Source: Authors based on data from OLADE (n.d.) and information provided by CAF's Direction of Macroeconomic Studies in the Knowledge Department



Dimension of service gaps and other sectoral challenges

It is clear that the energy sector will face profound changes and challenges in the coming years, which will have to address existing gaps in electricity and natural gas services. In line with the approach outlined in the IDEAL 2021 report, infrastructure service gaps can be estimated based on access, cost-affordability, and quality. Table 1 presents these dimensions for the electricity and natural gas sectors.

Table 1
Electricity and natural gas service gaps
Source: Authors.

Dimension	Electricity	Natural gas
Access	Levels close to universal access, with some exceptions in rural areas.	Few LAC countries have developed natural gas markets. Less natural gas is consumed compared to developed countries.
Cost/affordability	Disparities between countries and between regions within a country. Low nominal rates, but high relative to income.	The wholesale price is lower than the global average, although this difference has shrunk in recent years. For users, spending on natural gas from the grid accounts for a large portion of income compared to the situation in developed countries.
Quality	Higher frequency and duration of power outages compared to developed countries.	Most countries do not have systematic indicators.

Note: Data presented in the table correspond to the most recent year (from 2019 to 2021, according to the indicator).

The energy sector in climate change mitigation and adaptation initiatives

Different methodologies are used to reflect the combination of the dimensions of the energy system performance and countries' readiness for energy transition. Taking the Energy Transition Index (ETI) published by the World Economic Forum (WEF, 2021) as an example, LAC ranks slightly below the world average (ETI = 58.6 vs. 59.3, respectively) and well below advanced economies (ETI = 68.4).

Energy mitigation policies: Decarbonization and efficiency

Energy policy interventions against climate change target:

Changes in primary energy. Multiple LAC countries showed changes in this field over the 2000-2019 period, increasing the share of low-emission sources. However, not all countries moved in the same direction or equally fast.

- Increased use of renewable energy sources. At the regional level, hydropower accounts for a large share of electricity generation. Non-conventional renewable energies (solar and wind power) have now become competitive and, at the same time, more efficient compared to energies that use coal, natural gas, and other fossil fuels (Lazard, 2021). In 2019, the region was a global leader in renewable energy expansion. However, the requirements for a sustainable development scenario are much greater.

Moving forward with the energy transition calls for internalizing challenges. First, a large share of renewable energies generates

different sources of intermittency in systems, especially because large-scale storage technologies are not yet available at competitive prices. Therefore, complementary measures may be required, such as international energy exchanges (whenever possible) or relying on low-emission energy sources to provide the necessary backup. Second, waste from discarding photovoltaic (PV) panels and wind turbines that reach the end of their useful life or are replaced must be taken into account. Finally, the replacement of sources may lead to the premature retirement of some power plants, in terms of their economic lifetime.

- Natural gas as a substitute for coal and oil derivatives. In the past 20 years, the share of natural gas in the region's energy matrix and electricity generation has increased significantly. Although it is a fossil fuel, it generates much lower CO_2 emissions than other hydrocarbons. Moreover, its benefits in terms of local emissions and impact on air quality are notable. Natural gas plays a strategic role in the region. In 2019, it accounted for 36% of electricity, 24% of industrial energy consumption, 8% of commercial users' energy consumption, and 12% of residential users' energy consumption.

  In addition, natural gas can ensure secure energy supplies for the LAC countries given the availability of proven reserves. In this regard, the Ministerial Declaration of the LI Meeting of Ministers of the Latin American Energy Organization (OLADE, 2021) recognizes that, in the context of Latin America and the Caribbean, natural gas "is an important source and a viable, affordable and reliable option to accelerate the decarbonization process of some economies."

  Natural gas is a reliable alternative providing energy security and system resilience in the event of high energy intermittency. In addition, it can complement hydropower generation and be a reliable backup to non-conventional renewable energy sources. Moreover, it acts as a substitute for high-emission energy sources and is a trusted source for thermal-intensive uses, with benefits in terms of local emissions and air quality. However, it requires minimizing gas flaring, venting, and loss.

- The potential role of hydrogen. Hydrogen seems to be a fuel with a huge potential to contribute to decarbonization in the region. It is not a pollutant; it does not cause acid rain; it does not reduce ozone or generate harmful emissions. H_2 from clean sources is an attractive alternative to replace fossil fuels, especially in industries that are difficult to substitute electricity for energy consumption. However, its green version (produced from zero-emission energy) is still under development, which makes it uncompetitive.

Changes in final demand and transformation processes. A second set of actions that contribute to the decarbonization of the energy sector consists of efficiency-improving interventions. In addition to fostering improvements in energy intensity, they also create spaces to enhance sector efficiency. For example, 9.6 EJ of primary energy and more than 1.1 EJ of secondary energy were committed to generating 6.0 EJ of electricity in LAC in 2019, resulting in an average conversion inefficiency of 44%. At the same time, final consumption rose to 4.8 EJ, implying transmission and distribution losses of 19%.

Sustainable transportation and energy transition. Transportation continues to be the sector of the economy with the highest reliance on fossil fuels. The use of low-emission electric vehicles offers the greatest decarbonization potential for land transportation based on the lifecycle of vehicles (IPCC, 2022). The environmental benefits of transportation electrification will materialize more conclusively as electrification is complemented by an additional generation of energy from renewable sources (i.e., by replacing the full well-to-wheel emission cycle). Moreover, urban mass transit systems will bring about other local benefits.

In this respect, two important elements to bear in mind are reducing battery costs and deploying the necessary grid-connected infrastructure for charge and discharge management.

Carbon capture, utilization, and storage (CCUS). If fossil fuel production persists, carbon neutrality could be achieved with a carbon capture and storage complement, especially for emissions from the industrial and electricity sectors.

A dual condition to develop these technologies is the measurement of (positive and negative) emissions, and the valorization of the activity they perform (CCUS) or replace (renewable energy sources vs. energy generation using fossil fuels or H_2 production).

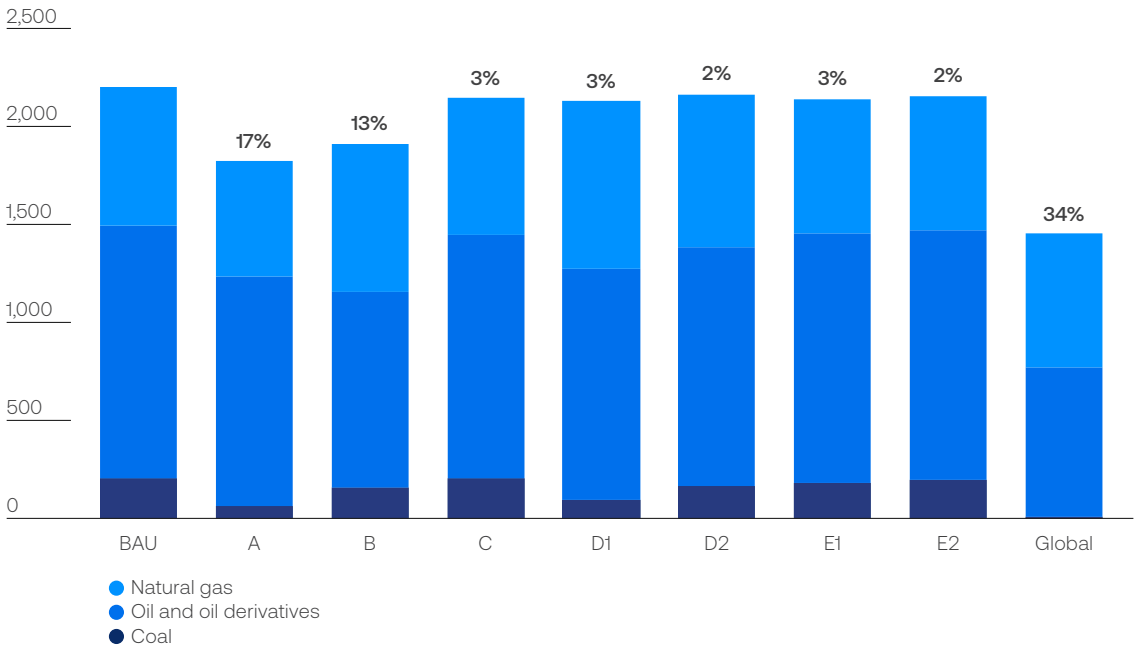
Simulations and sensitivities

To quantify the impact of different mitigation scenarios on the energy matrix and CO_2 emissions by sector, this report presents simulations based on commissioned work of Rodríguez Pardina et al. (2022).

Based on an organic growth scenario (business as usual o BAU), the effect on the energy matrix and emissions of an increasing generation of non-conventional renewable energies (A), transport electrification coupled with the introduction of zero-emission energy generation (B), decreasing energy intensity (C), natural gas as a substitute for oil in electricity generation and industrial use (D), and transformation and distribution efficiency improvements (E) were analyzed. The aggregate effect of these simulations by 2030 is presented in Graph 5.[4]

Graph 5
2030 projected CO_2 emissions and percentage decrease of emissions relative to BAU for the different scenarios (in millions of tons)

Source: Authors based on Rodríguez Pardina et al. (2022).



4 Energy transition simulations are based on the following scenarios: A) it is assumed that electricity produced by non-conventional renewable sources in 2030 will account for 30% of the electricity generated in each country; B) it is assumed that electricity as a substitute for oil derivatives used by transportation will account for 40% of the current consumption and that this electrification process is supplemented by increasing the volume of renewable energies to meet the incremental electricity demand in 2030; C) an improvement in energy intensity is assumed, simulated as a reduction in the historical GDP elasticity of energy consumption (nearly 20% by 2025 and an additional 30% by 2030); D) it is assumed that the share of coal, oil, and oil derivatives in the electricity matrix will drop at a yearly rate of 5% from 2021 to 2025 and 10% from 2025 to 2030; these can be replaced by natural gas, if necessary for industrial consumption and electricity generation; E) it is assumed that country losses arising from thermal transformation in 2030 will narrow the gap between the current level of losses and those of an internal combustion generator supplied with natural gas by 50% (scenario E1), and that distribution losses will narrow the gap between the current level of losses and the efficient minimum (defined as 10%) by 50% (scenario E2).

Although the magnitudes reported are based on the assumptions made, the implementation of decarbonization policies should not only aim to incorporate renewable sources but also decarbonize energy consumption via electrification or substitution with low-emission energy sources (illustrated scenarios) or other consumption-reducing measures (such as energy efficiency policies to reduce energy intensity). System efficiency improvements, such as reducing distribution losses or increasing the efficiency of oil derivative production, also support the overall goal. The concurrent implementation of a package of measures is the most effective way to reduce emissions, creating synergies among the different decarbonization scenarios.

Energy adaptation policies: Climate-resilient infrastructure

Although the goal is for the energy sector to contribute to mitigating the effects of climate change, there is no doubt that the sector must be prepared to withstand the expected consequences, especially if rising temperatures cannot be halted. Some of these consequences involve extreme weather events that pose a major threat to all power plants; changes in regional climate patterns that affect the water cycle supporting hydropower generation; and extreme weather events, especially strong winds, that affect power transmission and distribution systems, which would, in turn, impact the quality of the service.

In view of these consequences, there is a clear need to complement decarbonization with adaptation and resilience actions. This includes, among other actions, diversifying the energy matrix to reduce the risk of insufficient supply resulting from extreme events (climate events, epidemics, wars); incorporating into energy demand projections the implications of global warming on heating and cooling demands; conducting a comprehensive climate risk assessment of the electricity sector; and fostering technological development to continue to increase the resilience of solar technologies and wind energy turbines.

Environmental challenges for water resources

Given the role that water plays in human wellbeing (e.g., health and nutrition), production, and the ecosystem, it is an elemental resource to guarantee life on Earth. Its necessity for sustainable development highlights the importance of conserving this resource and related ecosystems.

Conservation of water resources and water-related ecosystems

Starting point: Water availability in Latin America and the Caribbean

The region is home to almost one-third of global freshwater and only 8.5% of the world's population. However, the distribution of these resources is unequal between and within countries.

Globally, water withdrawal increased by about 1.1% per year during the period 1970-2010 (FAO, n.d.b). In Latin America and the Caribbean, agriculture (including irrigation, livestock, and aquaculture) is by far the largest water consumer, accounting for 80% of annual water withdrawals in the region (vs. 67% globally), followed by households (14% vs. 20% globally), and industry (6% vs. 13% globally). Water withdrawal for productive or economic purposes has put pressure on water availability.

Country indicators regarding the protection and conservation of water-related ecosystems reflect dissimilar experiences. In the period 2000-2021 (especially the last five years), perennial lake and river water areas shrank in Bolivia but grew in Chile, Ecuador, and the

Dominican Republic. Total mangrove cover decreased in all reporting countries. Wetlands (as a percentage of the total land surface) are particularly concentrated in South America's landlocked countries. A fourth indicator—which measures the average proportion of key freshwater biodiversity areas within protected zones—puts over 80% of these areas within protected zones in Honduras, El Salvador, the Dominican Republic, and Venezuela. Whereas, in Brazil, Jamaica, and Uruguay, it is only 28%.

Reduced contamination

In many Latin American and Caribbean countries, contamination—mostly resulting from untreated urban sewage discharges—is compromising the availability of usable water. Other sources of contamination are mining and industrial wastewater, and poor management by the agricultural sector (metal, chemical waste, and antibiotic contamination).

In general, the region lags in terms of safely treated wastewater flow (41%) compared to the world average (60%). Countries such as Colombia, Costa Rica, and El Salvador present even lower values (23%, 21%, and 12%, respectively). In addition, LAC has a lower proportion of bodies of water with good ambient water quality (57%) compared to the world average (72%).

Sustainable use

One of the key SDG challenges is freshwater use and withdrawal efficiency (SDG 6). Water-use efficiency is calculated as the ratio between the volumes of water used by the different sectors and the gross value added of these sectors. LAC generates a lower GDP value per m3 of water (USD 13/m3 in 2019) than the rest of the regions (world average: USD 19/m3). The main economic activities strongly influence these regional efficiency values. Particularly, primary activities, which demand a greater volume of water for production, are the most prevalent industries in the region.

An important activity in LAC is irrigated agriculture, for which water-use efficiency is essential. However, LAC efficiency values stand below global figures: USD 0.3/m^3 versus USD 0.6/m^3 worldwide on average in 2019. There are technologies that aim to improve agriculture efficiency; for example, hydroponics, with closed recirculating systems, and closed and semi-closed greenhouses. However, modern technologies that promise large water savings are costly and used in activities with high added value.

Water loss in drinking water systems or production processes is one of the main barriers to efficiency improvement. In most Latin American and Caribbean countries, unaccounted-for-water in urban systems exceeds 35%. Moreover, on average, production processes use 36% of this resource.

Dimensions of service gaps and other strategic sector challenges

In addition to environmental challenges, the region still has to face sector-specific challenges, such as addressing the gaps in access and quality of drinking water and sanitation. Table 2 presents these dimensions, along with the cost dimension, for water and sanitation.

Table 2
Drinking water and sanitation service gaps
Source: Authors.

Dimension	Drinking water	Sanitation
Access	Levels close to universal access to basic drinking water service. At the rural level, there are still deficits.	Basic access: 88%, far from universal access.
Cost/affordability	Heterogeneity between and within countries/ Rates range from USD 0.53/m^3 to USD 2.11/m^3. Low or medium affordability (the share of income allocated to this service doubles that in developed countries).	
Quality	Only 75% of the population has access to safely managed water, far below developed countries. This deficit is even more evident in rural areas.	One in three people has access to quality sanitation services in the region.

Note: The data on which this table is based correspond to the most recent year available (between 2019 and 2021, depending on the indicator).

Tackling water management from a sustainability approach

Circular economy. As part of the environmental challenge of using resources sustainably, reducing contamination, and preserving ecosystems, it is important to increase and improve recycling and reuse practices. Wastewater treatment plants are the most visible examples in this sector. Once treated, wastewater can be reused in agricultural and industrial activities, while by-products can be used to generate energy and improve soils.

This model is gaining acceptance across the region, despite some unmet challenges, including i) regulations: in many countries sludge is considered to be hazardous waste and must be confined in special sanitary landfills; therefore, the reuse of biosolids entails revising and supplementing current regulations; ii) institutional frameworks: lack of accredited laboratories and the inability of the responsible entity to supervise or monitor irrigation; iii) investment: who invests and who finances investments; and iv) environment: more definitions of quality standards are required.

Integrated Water Resources Management (IWRM). This conceptual management framework includes key concepts such as integration, decentralization, participation, and sustainability, and addresses water uses from an integrated perspective to manage, withdraw, and conserve water under a water basin logic unit. Integration can be either horizontal—involving every sector that uses or impacts water resources—or vertical—coordinating efforts between local, regional, national, and international institutions.

Under an IWRM approach, local communities play a key role in water conservation and management, mainly in terms of small-scale actions. LAC has ample experience in water community management (led by local stakeholders, providing small-scale services).

At present, most LAC countries have started laying the foundations for IWRM. However, according to the last measurement (for 2020), regional progress is considered to be in the mid-low range, lagging behind other global regions. The most advanced country in terms of the incorporation of this management model is Brazil (the only one in the region considered to have the potential to meet this target in 2030), followed by Bolivia, Colombia, and Costa Rica (United Nations Environment Program [UNEP] and Cepei, 2018).

Water and climate change

Climate change has a strong impact on freshwater systems and their management, affecting freshwater availability, quality, and quantity. It also jeopardizes human wellbeing and the economy. This report reviews a set of adaptation actions for the water sector.

Climate-resilient infrastructure takes into account the risks and opportunities that different climate scenarios impose on the water sector (e.g., dams as buffers against extreme water flows, absorbing water during flooding and releasing it in times of drought). Digital innovations, in turn, play a significant role in processes such as infrastructure monitoring, customer portfolio management, and service quality controls. Prediction and early warning systems enable homes, businesses, and governments to adopt timely measures in anticipation of extreme events. Nature-based solutions (NbS), using or mimicking natural processes, can help improve water management while providing ecosystem services and a broad range of secondary co-benefits. Ozment et al. (2021) reviewed over 150 projects at different progress stages, of which more than half included water and sanitation as a primary sector and involved, among others, reforestation, agriforestation, and best agricultural practice actions, e.g., miParamo in Bogota (Colombia); Drenaje Urbano Sostenible (Sustainable Urban Drainage) in Merida (Mexico); or NbS to generate hydropower in Yauyas (Peru), which also covers the energy sector. Finally, the development of the insurance market to mitigate the impact of floods and droughts is another relevant adaptation strategy to reinforce resilience in case of natural disasters and incentivize investments in water infrastructure improvements.

Resilient health care systems

For the first time, the IDEAL report will address the social infrastructure sector. The aim is to analyze the health care system's capacity to handle extreme shocks (such as a pandemic or climate catastrophes), minimizing victims and response times. This analysis considers short-term events that can disrupt the system. Therefore, its approach complements the research work conducted for RED 2020 on long-term changes expected from health care systems as a consequence of population aging (Álvarez et al., 2020).

The context of the COVID-19 pandemic

The COVID-19 pandemic has had a strong impact globally, and LAC has been no exception. In July 2022, the number of accumulated cases in the region reached over 73 million, while more than 1.7 million people died from coronavirus. During the first year of the pandemic, regional GDP fell 6.8%, before recovering by a similar percentage in 2021, although with differences between countries. The experience provides some lessons on the changes needed to develop a health system that is better prepared for stressful events of this magnitude, whether epidemiological or climatic.

Health systems: Characterization and response to extreme events

The havoc caused by the COVID-19 pandemic has unveiled the need for changes in the health sector to tackle any other situation that may require a rapid and effective response system. The preparedness of health systems to face potential shocks should take into account weaknesses of all health care sector-related areas, from the governance to the management capacity of sanitary systems, infrastructure and resources (material and human), costs and financing, among other aspects.

Institutional framework, financing, and public health

Governance and management to implement health policies. The degree of decentralization, together with the fragmentation of health systems, explains in part the weak steering role of these systems in LAC countries.

Organization: Fragmented health systems. Although some countries have made progress in integrating their health sub-systems in the past decade, fragmentation and segmentation persist. Different levels of fragmentation and segmentation are observed in the public system, financed with taxes; social security, financed with contributions by employers, workers, and the state; and private systems. This situation conditions the dissimilarities in health care coverage, quality, and quantity received by different population strata.

Health system financing. LAC countries also differ in health financing profiles, mainly due to the fragmentation and segmentation of their systems. The pandemic found LAC countries in such dire need of resources, with limited investments in the sector that, in response to the health emergency, they had to prioritize budgets or find new sources of resources (contingency funds or debt).

Public health and pandemic management. An appropriate response to a problem that affects public health, especially an event that could become an epidemic, implies having mechanisms in place to detect it in a timely manner, identify causes and risk factors, and propose effective intervention measures to control it. The general objective of COVID-19 surveillance, implemented by the countries within the framework of their health information systems (HIS), was to monitor the spread of the disease in order to identify patterns and apply prevention and control measures. A common denominator of these countries was the drafting or constant updating of their standards and procedures for COVID-19 surveillance and control of entry points to the countries (ports and airports), health facilities, stores, educational and work centers, prisons, and others. However, countries' early warning and response systems could not prevent the pandemic from spreading worldwide.

Health care service gaps

The region is facing multiple challenges associated with the provision of health care services. These can be sorted into a three-dimensional analysis, summarized in Table 3: access, cost and affordability, and quality.

Table 3
Health care service gaps
Source: Authors.

Gap dimensions		Health care
Access	Human resources	Most countries studied have met the minimum skilled health care professionals (SHP) density value established by the WHO. Distribution within countries is highly inadequate.
	Infrastructure	Countries strengthened and expanded their health care infrastructure, but it was not sufficient.
	Supplies and equipment	Just a few countries exceed the minimum levels set out by the WHO. Getting these products depends on international trade.
Cost/affordability/spending		The percentage of public spending is low. The private sector's contribution is almost double OECD values and is above WHO recommendations (low affordability).
Quality		Barely more than half of LAC countries reach the minimum levels of immunization recommended by the WHO. High levels of user dissatisfaction are observed due to organizational problems or the perception that the health system does not solve their health problems.

Access

The availability of health services is based on the existence of health care professionals (human resources), sanitary infrastructure, and equipment (including medical supplies and medicines).

Human resources. To measure the adequacy of the volume of health care professionals, the skilled health care professionals density indicator can be used. Taking a minimum threshold of 44.5 professionals per 10,000 inhabitants as a condition to reach SDGs in 2030 (WHO, 2016), most countries studied have already met this minimum value established by the World Health Organization (WHO). However, the distribution within the countries is another overall indication of the geographic gap in health care resources. Additionally, the supply of the health care workforce does not necessarily ensure meeting any special needs of the population (e.g., the demands recorded in 2020 and 2021).

Sanitary infrastructure. LAC governments reoriented public resources to make up for the deficiencies in health services. They also increased their capacity to care for COVID-19 patients. In some cases, this entailed expanding health care infrastructure (OECD, 2020) by implementing planned projects in advance. In other cases, field hospitals were temporarily set up, and the capacity of medical centers, hospitals, and hotels was used (something similar happened at testing and immunization centers in 2021). Despite this, and although sanitary infrastructure was strengthened and expanded in most countries, it was insufficient to care for the number of their inhabitants affected by the pandemic, especially at the peak of the crisis.

Medical equipment, supplies, and medication. The report compares countries' availability indicators for equipment considered essential for health care services in response to the health emergency during the pandemic: hospital beds, intensive care unit (ICU) beds, mechanical ventilators, and diagnostic equipment.

In almost all LAC countries, the number of hospital beds did not exceed the minimum recommended by the WHO (between 2.4 and 4.0 per 1,000 inhabitants). Just six of the countries studied surpassed the WHO minimum recommendation for ICU beds (between 6 and 8 per 100,000 inhabitants) and most countries were far below the average number of ICU beds available in OECD countries (12 per 100,000 inhabitants). On the other hand, the number of mechanical ventilators surpassed the minimum recommended by the WHO (between 6 and 8 per 100,000 inhabitants) in nine of the countries analyzed. During the pandemic, stock increased by 53%, for an average of 16.7 ventilators per 100,000 inhabitants. In some countries, despite substantial increases, there were not enough to care for all patients affected by COVID-19.

The pandemic underscored how dependent countries in the region are on the production of inputs, medicine, and technology by multinational companies and, therefore, associated imports (ECLAC, 2021). As net importers, countries were forced to develop other strategies to improve market access, such as provisions for the purchase, manufacturing, and adaptation of ventilators, and the issuance of import and export permits for all medical supplies, among other measures.

Quality

Estimating the quality of health service performance is complex, especially in the absence of consensus as to which indicators should be used for measurement and comparison. For example, the quality measure used by the OECD is based on basic service supply indicators (vaccine schedules for children, in-hospital mortality caused by acute myocardial infarction and stroke, cancer survival, and avoidable admissions). In this regard, just over half of LAC countries met the WHO's minimum vaccination coverage recommendations for the prevention of diphtheria, tetanus, and pertussis (DTP) (90%) and 30%, the target set for measles (95%) in 2018.

Another approach to measuring quality is user perception. A review of different sources showed levels of user dissatisfaction associated with the cost of care, organizational problems (communication, inability to get appointments for medical assistance or follow-ups), or the perception that their health problem was not solved. The pandemic further aggravated this scenario. A collateral impact of the decision to prioritize medical assistance for COVID-19 patients was that traditional patients received care under very restrictive conditions and treatments were postponed or interrupted.

Cost and affordability

The cost of providing health care can be estimated based on total health spending, measuring the final consumption of health care goods and services, including health care infrastructure, medicine, and human resources (OECD, 2021). Total public and private health spending as a share of GDP rose during the 21st century from 6.4% in 2000 to 8.0% in 2019. Still, this level remains below the 12.5% in OECD member countries (Álvarez et al., 2020).

A large percentage of health spending is made by the public sector. According to the WHO (2010), it should be above 6% of GDP. However, before the pandemic, the average health spending in the region was 4%, well below this threshold, and a little more than half of OECD public sector spending (7.7% on average).

Contributions to the private system (private health insurance) and out-of-pocket expenses complement total health spending. The latter can be used to estimate the economic barriers that the population faces to use these services, as higher out-of-pocket expenses hinder universal access to health care. Taking as a reference the WHO recommendation (2010) that out-of-pocket expenses should represent less than 20% of total health spending, the averaged private contribution (incorporating health insurance payments) accounted for 49.3% of total spending in the region, and 28.4% for out-of-pocket expenses. These numbers are above the world average (39.9% for total private contributions and 18.1% for out-of-pocket expenses), and almost double OECD values (38.3% and 13.9%, respectively). These values reflect the low affordability of the health care system in the region, underscored in sector surveys: one of the main reasons why sick people avoid or postpone using services is the cost of care.

Health care infrastructure to face climate change

The fifth report of the Intergovernmental Panel on Climate Change (IPCC, 2013) sounded a warning against the increase in demand for health services due to global climate change. More recently, the WHO (2021b) also warned that countries with weak health infrastructure will be the least able to prepare and respond unaided to the effects of climate change. In addition, a compilation by the World Meteorological Organization (WMO) on behalf of the United Nations claims that COVID-19 infections, heatwaves, wildfires, and poor air quality combine to threaten human health worldwide, putting vulnerable populations at higher risk. It also states that COVID-19 recovery efforts should be aligned with national climate change strategies (WMO/UN, 2021).

Despite these health risk warnings, currently, only half of the 95 countries surveyed by the WHO (2021a) have conducted climate change health vulnerability and adaptation assessments. Of these, 58% developed some type of relevant adaptive response (updating or incorporating plans and programs updated or introduced, or allocating health care resources for climate change). In LAC, only seven of the 26 countries surveyed have conducted assessments (of which five have already launched some type of program or resource allocation response), while another five countries are in the process of conducting an assessment.

Infrastructure interventions for a better environment

Based on the institutional context of the sectors under analysis, a brief detail of the areas of intervention explored in the report is presented for three dimensions: investments, regulations, and public policies.

Investments

Organic growth and changes in supply and demand. Projected economic growth for the coming decades indicates a growing trend in the demand for infrastructure services, such as water and energy. At the same time, climate change and the increase in and greater variability of temperatures point to a likely acceleration in demand for these services in the future (for energy, in particular, at both temperature extremes). In order to respond to higher demand, investments will be needed to expand systems. Changes are also expected on the supply side; in energy, the replacement of high GHG emission sources or, in water, triggered by reduced availability of this resource as a result of climate change. For the energy sector, these changes, based on the decarbonization of the energy matrix, can also be implemented with the support of new energy generation technologies (such as H_2) and other technologies supplementing high GHG emission sources (such as CCUS). Both applications will demand investments in infrastructure for their production and use. It should be noted that the right investment planning can enable the use of transmission interconnections to help mitigate variability in renewable energy sources and partially replace investment needs.

Sustainable infrastructure investment gap. The traditional approach to infrastructure gaps was updated in recent years by international bodies and agencies. To attain the universal coverage in basic services and attain climate goals by 2030, Latin America and the Caribbean's annual infrastructure investment needs represent 3.3% of GDP, supplemented by 1% of GDP for maintenance spending (Rozenberg and Fay, 2019). Other sources have also estimated investment needs for infrastructure to meet the SDGs. For the sectors prioritized in this report, on the basis of investments in the region for the period 2014-2019—reaching 0.6% of GDP in energy (0.5% of GDP if Mexico is excluded) and 0.2% of GDP in water—these needs exceed recent water investments by 50% to 150%, and recent energy investments by 100% to 300% (Rojas, 2022; GIH and Oxford Economics, 2017; IEA, 2020; Brichetti et al., 2021).

Efficiency and sustainable use of resources. Pursuing this objective requires investing in new wastewater treatment plant infrastructure, distributed on-site water treatment and reuse models, and the review and maintenance of distribution systems to reduce levels of water loss. It will also be necessary to invest in new technologies to detect leakage and increase irrigation efficiency and micro-metering, as an alternative for water leak detection.

Resilient infrastructure. Resilient infrastructure refers to assets that can withstand external shocks, especially those caused by natural hazards.

Hallegatte et al. (2019) note that improving the resilience of hazard-exposed assets alone would increase average annual investment needs for electricity by USD 20 billion (0.02% of global GDP) and slightly less than USD 5 billion for water (0.005% of global GDP). The authors also conclude that the benefit of investing in more resilient infrastructure in low and middle-income countries would be four times the cost.

Nature-based solutions and green and blue infrastructure. A report presented by the United Nations Environment Programme (UNEP, 2021) claims that, if the world is to meet its environmental targets (in the matter of climate change, biodiversity, and land degradation), investments in NbS ought to at least triple by 2030 and increase four-fold by 2050 in real terms.

Investment challenges. Given the multiple dimensions of the concept of sustainability in terms of development—economic, social, and environmental—, actions to tackle environmental challenges, including investments, should

take into account potential trade-offs that may arise in economic and social dimensions. These include potential displacement effects of investment, especially if the investment affects the universal access goal; financing needs, for which the private sector can be very useful with the right incentives in place; and compatibility between the environmental objective and investment projects' business cycles to avoid supporting new ones that may entail environmental hazards or to accelerate the ones with a positive impact on economic or social dimensions.

Economic regulations

The following section identifies and analyzes changes that will take place in the energy and water sectors, with implications for the respective regulatory frameworks to move toward compliance with environmental objectives.

Cost changes. Environmental issues and the solutions proposed to address them will bring about changes in the cost levels and composition in infrastructure sectors. These changes will make it necessary to modify service regimes, tariff levels, and/or tariff structures. For example, in the energy sector, one of the first changes will be a decreased marginal cost of the power supply with the expected increase in the penetration of non-conventional renewable energy sources (NCRES) in coming years. The cost of capital may also be affected. The need for climate change adaptation and mitigation actions increases the intensity of capital and, therefore, the economic cost of the service. Reduced availability of water resources in quantity and quality due to climate change or the overexploitation and pollution of water sources tends to increase the cost and affect service affordability or require additional public resources. However, the sector can work to reduce existing inefficiencies.

Trends toward distributed systems. In recent years, some processes have been decentralized along the value chain of energy and water services. In the case of electricity, decentralization is happening at the end-user level through innovations in distributed generators and storage devices. There are several factors to take into account. First, efficient pricing rules; second, avoidance of dual subsidy policies, incentivizing distributed generation projects in the contexts of aggregate subsidies; and, third, revision of cross-financing schemes. In the case of water, distributed systems are in different geographical locations, but are physically linked to a central system by management. From a regulatory standpoint, the challenge the electricity sector agenda must address is achieving preparedness to create incentives for the development of distributed activities, adapt electricity tariffs to the new context, and secure funding for infrastructure operation.

Development and inclusion of new technologies. The transition toward compliance with environmental objectives will require monitoring and, in some cases, revising existing regulations to ensure that they facilitate competition and do not become barriers to new technologies or unduly protect more traditional methods of delivering services. Regulation should also establish clear rules that can create favorable environments for investments and private sector participation.

Climate risks. Climate change increases the probability of more intense extreme weather events, leading to changes in the distribution of these risks. This situation makes it much more difficult to ensure an efficient allocation of risks among the different stakeholders. Climate-risk insurance can help the most vulnerable economies reduce uncertainty surrounding extreme climate events, thus favoring higher investments. Another alternative in the context of risk transfer mechanisms is the development of catastrophe or resilience bonds, which transfer the risk to the capital market.

Stranded assets. Achieving the environmental objectives assumed by countries in the framework of international agreements may lead to rethinking programmed investments and retiring certain assets before the end of their economic lifetime. One of the strategies to reduce the risk of stranded assets is to make complementary investments that extend the useful life of these assets (for example, in CCUS).

Public policies

Solutions to environmental problems may have negative economic and social impacts. Therefore, public policies should consider these trade-offs, assess situations holistically, and take responsibility for balancing the different effects to maximize the present and future wellbeing of the population.

For example, climate change and the measures proposed to address it can have significant redistribution effects. In these cases, the design of social tariffs or well-targeted subsidies (in favor of the affected population) is especially important. The restrictive fiscal situation in almost all countries requires a better-targeted subsidy design and implementation.

Other policies can have positive impacts. For example, NCRE penetration and reduced costs of off-grid photovoltaic technologies are important tools available to countries to guarantee power access in rural areas located far from distribution networks in a sustainable manner.

The projects discussed in this report to facilitate addressing the challenges described in Chapter 1 have environmental benefits (positive externalities) that may not be considered by a private actor assessing the convenience of making certain investments. Therefore, it is the State's role to align **private incentives with environmental benefits** in each country, along with the other social and economic effects.

Carbon pricing (in its multiple forms) is a typical way to internalize the social cost of GHG emissions in private decision-making processes. Carbon taxes or carbon capture subsidies can be used to put a price on emissions. Alternatively, carbon pricing can be established under an emissions trading system (ETS), in which the government sets a cap on emissions and issues tradeable emission permits. So far, countries have found it hard to set prices high enough to generate significant reductions in the use of fossil fuels: values do not exceed USD 10/tCO_2, compared to values estimated to achieve the Paris Agreement temperature targets of at least USD 40-80/tCO_2 by 2020 and USD 50-100/tCO_2 by 2030 (Carbon Pricing Leadership Coalition, 2017).

Carbon pricing can be a strong instrument to align private sector incentives with environmental goals tied to climate change. In fact, CAF—development bank of Latin America—is actively supporting the development of carbon markets. Regardless of this issue and until these measures can be implemented, there is room to design complementary instruments that foster energy transition (penetration of renewable energies, distributed generation, smart grids, reduced fossil fuel use, energy efficiency, and electrification of consumption), and the conservation of water resources (efficient water use, reduced pollution, and caring for water resources).

Finally, governments play a central role in planning, organization, and implementation of **resilience plans**, particularly for infrastructure. The definition of resilience objectives, standards, and regulations in infrastructure plans, together with regulations consistent with other environmental plans, define the framework, while the provision of financial incentives plays a complementary role in ensuring the provision of resilient services (Hallegatte et al., 2019).

Areas for improvement in the health care sector

The COVID-19 pandemic exposed the region's health care systems' degree of preparedness to face disruptive events that put extreme stress on them. The experience revealed a set of challenges that the sector must address to tackle other situations that also demand a rapid and effective response: reduced funding, regional coordination and institutional strengthening, projection of future disruptive events, reliance on international trade, and data management and quality.

A chronic lack of health funding. Given the COVID-19 pandemic experience, characterized by improvised searches for funding from budgetary reallocations, contingency funds or debt, it is important to create more agile financing mechanisms, either national or regional, that can respond to countries' needs in the event of health care emergencies. One example is a dedicated health emergency fund for disruptive events. In Mexico, the Wellbeing Health Care Fund (*Fondo de Salud para el Bienestar*) provided flexible and timely financial support during the pandemic.

Supranational cooperation and institutional strengthening. A supranational approach can add value by strengthening timely information, surveillance, early warning and response systems or health care emergencies. It can also help set up a permanent mechanism that provides technical and eventually logistic support for the adoption of best practices for the development of temporary emergency health infrastructure. For example, the European Centre for Disease Prevention and Control of the European Union created the European Health Emergency Preparedness and Response Authority in September 2021. This authority assesses threats, exchanges information, supports research, establishes a close dialogue with industry, and promotes financing and emergency measures, among others. By interacting with these types of entities, national institutions can gather relevant information, action mechanisms and systems for anticipating and managing disruptive events.

Future extreme scenarios to anticipate epidemiological and environmental risks, and resource needs (human capital, infrastructure, medical equipment and supplies). Sector needs will depend on the type of future disruptive event. Therefore, applied research and improved evidence-based decision-making processes are necessary developments to contribute to the monitoring and assessment of the environmental factors that pose a risk for the emergence of pandemics, estimating needs, and evaluating the effectiveness of interventions in the face of diverse climatic situations.

Reliance on international trade for health care technology and medical supplies. Dependence on imported technology and medical supplies in a context of a global crisis can be a major constraint in terms of the resilience of the health care system. Promoting research and development applied to medical supplies, equipment, and laboratories is critical, along with the development of local industries in these areas. Finally, coordinated negotiation mechanisms can be established in advance to improve the conditions in the region and avoid the need to set them up during a crisis.

The rise of digital health care: Data management and quality. The COVID-19 pandemic crisis opened up an opportunity to develop mechanisms for the digitalization of health care processes. These mechanisms must be further developed to preserve data and information security, foster interoperability, and strengthen human resources training. Initiatives can be coordinated under a public surveillance framework defining standard regional indicators to monitor the number of cases according to diagnostic tests, along with the number of hospitalized patients and deaths. These numbers can then be contrasted with indicators of the supply of human resources, health infrastructure, equipment, inputs (including vaccines), and laboratory tests. For example, the European surveillance system, known by its acronym TESSy, integrates information from several surveillance networks that used to be independent. During the pandemic, the ECOVIDNet European surveillance network was created to provide decision-makers and public health experts with information required to assess COVID-19 activity and take appropriate action (ECDC, 2022).

Flexible infrastructure to meet demand peaks. During the COVID-19 pandemic, most LAC countries attempted to confront the crisis with short-term, improvised palliative measures, using field hospitals, infrastructure from other sectors, e.g. different areas in hospitals or health care centers, or hotels (the capacity of which was highly underused during the first year of the pandemic). Conducting studies dedicated to the development of contingency plans based on the lessons learned in the region will help the health care system and facilities adjust to different shocks.

Countries are conducting assessments to measure the health care sector's vulnerability and adaptive capacity to climate change. Gradually, they are updating or introducing plans and programs and reallocating resources to the sector to deal with climate change events. In this context, it is important that the lessons learned during the recent pandemic about surveillance, financing, infrastructure, coordination, scenario and resource planning, data management and quality, among others, are included in the public agenda so that the region and the world are better prepared to face any future epidemiological or climate events.

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