Climate change response and the development agenda in Latin America and the Caribbean

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- Pillars of sustainable development and the region's progress
- Impacts of the decarbonization in the world economy on Latin America and the Caribbean
- Challenges and opportunities for Latin America and the Caribbean in the face of the climate crisis
- Policy priorities for the region's sustainable development agenda

Key messages

1 Latin America and the Caribbean has not overcome the challenges of low economic growth and high inequality. These pending challenges are compounded by the need to adapt to climate change, mitigate emissions, and preserve the region's biodiversity and natural capital.

2 Adaptation should be a priority for Latin America and the Caribbean due to its high exposure and vulnerability to climate hazards. These efforts should focus on the most vulnerable groups to avoid exacerbating existing inequities.

3 Adaptation policies can have positive synergies with the growth and inclusion agenda because they can lead to economic, environmental and social benefits. These policies include nature-based solutions (NbS), including sustainable agriculture and green infrastructure, and increasing the resilience of gray infrastructure.

4 There is a need to improve the information available on the specific adaptation needs of Latin American and Caribbean countries. So far, efforts have focused on food production, poverty reduction and health sectors. In general, there is little evidence on the effectiveness of these initiatives.

5 Another priority should be the preservation of ecosystems and biodiversity. Latin America and the Caribbean is a region relatively rich in natural capital, but that capital is degrading at an accelerated pace. This constitutes a risk to the sustainability of the region's own development process and the well-being of future generations, as well as negatively affecting the social inclusion of local communities.

6 Latin America and the Caribbean must contribute to the global mitigation effort. The priority should be to halt deforestation, which is the main cause of emissions in the region. This requires a credible commitment to curb the expansion of agricultural frontiers and increase sector productivity.

7 Latin America and the Caribbean can leverage its favorable conditions to advance in the energy transition by adopting renewable energy sources. This process will entail significant challenges for countries in terms of impacts on employment, financing, fiscal revenues, and external accounts. Three key determinants of the costs and benefits of the transition in each context are the productive structure, the energy matrix, and existing natural resources.

8 Latin America and the Caribbean can contribute to global decarbonization while capitalizing on the economic benefits of large reserves of natural gas and critical minerals for electrification, as well as monetizing efforts to preserve forest resources.

9 It is key to identify and prioritize policies with the triple dividend of adaptation, mitigation, and preservation of natural capital, while at the same time allowing progress in other dimensions of sustainable development. Examples of such policies are sustainable agricultural techniques and the conservation and regeneration of key ecosystems.

10 Due to their shared history and common interests, countries in Latin America and the Caribbean can greatly benefit from strong regional coordination to ensure that their voices and concerns are heard in international negotiations on climate change and biodiversity preservation.

11 The region is heterogeneous, and there is no one-size-fits-all formula for all countries. The optimal combination of climate and conservation policies will vary according to local conditions. In the pursuit of the most suitable policy portfolio, the costs and benefits of different alternatives (not only statically but also from a dynamic perspective), the political feasibility of actions, and their impacts on equity should be weighed.

Climate change response and the development agenda in Latin America and the Caribbean[1]

Introduction

The preceding chapters shed light on the enormous challenges posed by climate change and biodiversity conservation to the world. Global greenhouse gas (GHG) emissions must be rapidly reduced if global warming is to be limited in line with the goals of the Paris Agreement. Moreover, adaptation to the current and expected impacts of climate change must be redoubled to avoid excessive costs to the well-being of the world's population and to protect and restore natural capital, in order to restore the planet's ecological balance.

Latin America and the Caribbean (LAC) is not exempt from these challenges; on the contrary, the region is among the most affected by climate change and least prepared to withstand its impacts, making the need to enhance the resilience of its economies even more urgent. Additionally, the region's abundance of natural capital positions it as a key player in achieving global climate and conservation goals.

The region faces these challenges from a situation of economic and social fragility, characterized by meager economic growth, high levels of poverty and inequality, and limited institutional capacities, among other development deficits. These structural issues have been aggravated by the COVID-19 pandemic, which has not only imposed significant health costs but also reduced fiscal space and increased debt in most economies across the region.

In this context, investment efforts, reallocation of resources between sectors and reforms required by climate and conservation policies must be integrated with the still pending challenges of low

1 This chapter was written by Pablo Brassiolo, Ricardo Estrada, and Ernesto Schargrodsky, with research assistance from Daniela Goyheix and Florencia Buccari.

economic growth and limited social inclusion that characterize the region's economies. This implies that public policy decisions in the countries will have to overcome possible trade-offs between conflicting objectives and seek to capitalize on potential complementarities and synergies among agendas.

It is also important to bear in mind that these agendas are framed within a global context of profound transformation in production and consumption patterns, which may offer new opportunities for the region but also constrain the range of policy options. Key global trends include the energy transition driven by developed countries, the potential imposition of carbon border adjustment mechanisms, and the increasing international demand for ecosystem services, which may boost carbon credit markets.

This chapter discusses the challenges and opportunities arising from the integration of climate and conservation policies with the pending development agenda in Latin America and the Caribbean. The region is highly heterogeneous across multiple dimensions, so there is no one-size-fits-all approach to advancing along the path of sustainable development; rather, the most suitable policy alternatives must be sought in each context.

Development challenges in Latin America and the Caribbean

Sustainable development is understood as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. (Brundtland, 1987).[2] Under this paradigm, sustainable development is the result of the integration of economic and social dimensions, which have been the focus of the traditional view of economic development, with the environmental dimension, as illustrated in Figure 5.1.

Sustainable development requires two essential elements: promoting **economic growth** to meet the needs of the population and ensuring **social inclusion** so that improvements in living conditions reach all of society, particularly vulnerable groups. Moreover, sustainability demands that growth does not undermine nature's ability to provide the ecosystem services that support society and the economy. In order for future generations to thrive, it is crucial for present generations to pass down comprehensive and adequate capital, which entails considering not only physical and human capital but also natural capital (Dasgupta, 2021). In the context of climate change, the sustainability of economic and social progress also requires ensuring that these processes are resilient to climate impacts and compatible with climate system stabilization through the reduction of GHG emissions.[3] Therefore, the third pillar of sustainable development is **climate resilience and environmental sustainability**.

2 This document, also known as the "Brundtland Report," was elaborated by the United Nations World Commission on Environment and Development, whose creation resulted from the international community's concern about the need to integrate and jointly manage the notions of economic development and the environmental dimension.

3 The IPCC (Intergovernmental Panel on Climate Change) uses the concept of climate-resilient development, defined as a process of implementing adaptation measures to address the risks of climate change and reduce GHG emissions to promote sustainable development for all people (Schipper et al., 2022). In this sense, the paradigm of sustainable development used in this chapter includes the idea of climate-resilient development.

Figure 5.1
Pillars of sustainable development

Source: Authors using data from Munasinghe (1993).

The international community's growing concern for the sustainability of the development process led to the establishment of specific goals to guide countries' development strategies. In 2015, the Sustainable Development Goals (SDGs) were adopted, consisting of 17 goals with 169 targets for the period 2016-2030, encompassing economic, social, and environmental aspects. Defining specific indicators for each of these targets enables monitoring the progress made by countries in achieving these goals. However, progress in Latin America and the Caribbean has been uneven to date (see Box 5.1).

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The region faces the climate and biodiversity crisis coupled with its pending growth and inclusion agenda

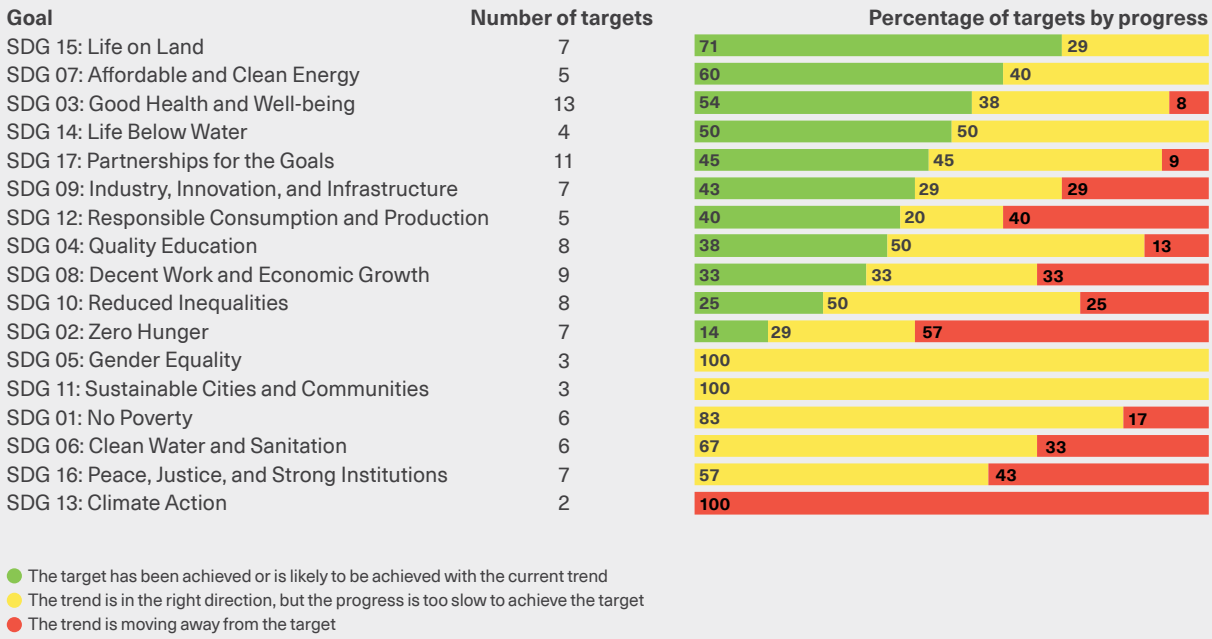
In summary, the climate and biodiversity crisis facing the world makes it increasingly urgent to prioritize environmental considerations in countries' development agendas. In the case of Latin America and the Caribbean, this implies a greater challenge than in the developed world because the region has not been able to make sufficient progress in their growth and inclusion agendas.

Box 5.1
Progress in Latin America and the Caribbean in achieving the SDGs

The Economic Commission for Latin America and the Caribbean (ECLAC, 2022b) has analyzed the region's progress in fulfilling the goals defined under the framework of the 2030 Agenda for Sustainable Development. The study evaluated trends corresponding to 111 out of the 169 established targets. The results are presented in Graph 1. To facilitate the interpretation of the findings, the status of each goal's fulfillment is classified into three groups: goals that have already been achieved or are expected to be attained by 2030 if the current trend continues (green), goals for which observed trends are heading in the right direction but with insufficient pace of progress (yellow), and goals with observed trends going opposite to expectations, requiring direction reversal for their fulfillment (red).

The region's progress so far varies by goal. SDG 3 (good health and well-being), SDG 7 (affordable and clean energy), SDG 14 (life below water) and SDG 15 (life on land) have at least half of the targets in green. At the other extreme, SDG 13 (climate action) has two targets and both are in red. At the aggregate level, only 32% of the targets are in green, while 46% are in yellow and the remaining 22% are in red.

Graph 1
SDG targets and fulfillment forecast for 2030 in Latin America and the Caribbean



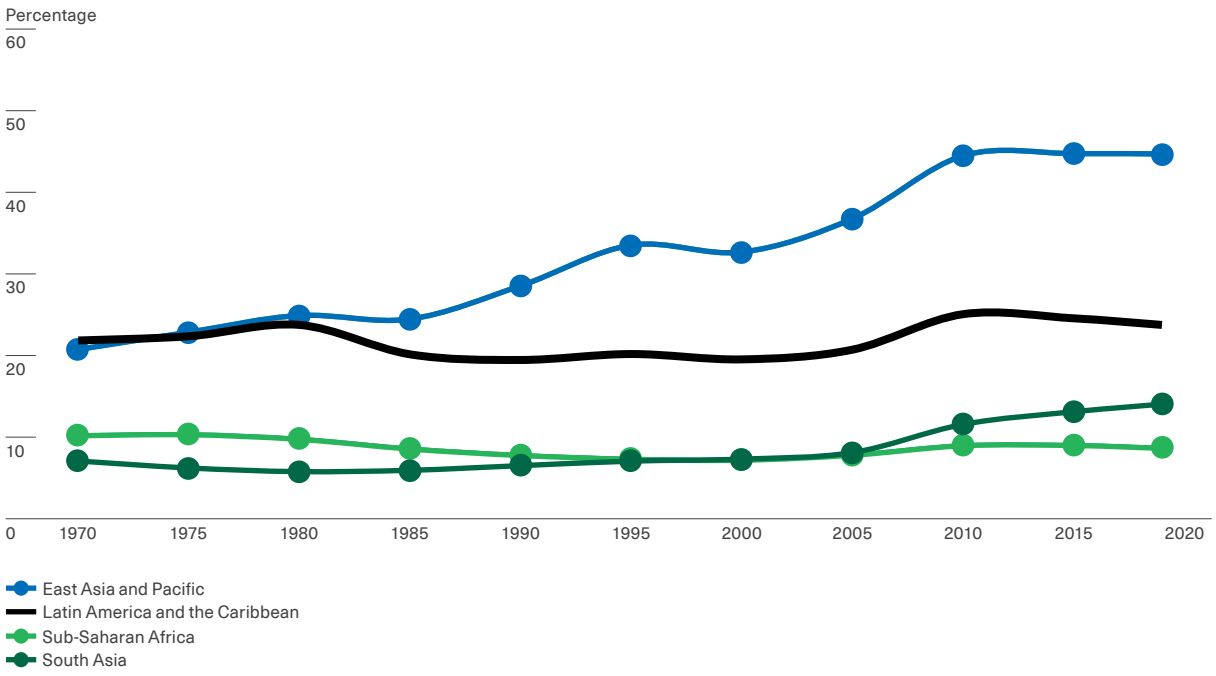
Note: Each color (red, yellow, and green) represents the level of goal fulfillment.
Source: ECLAC (2022b).

The pending agenda: low economic growth and limited social inclusion

Over the past 60 years, economic growth in Latin America and the Caribbean has been insufficient to bridge the development gap with wealthier countries. Between 1960 and 2021, the region's annual per capita GDP growth rate averaged 1.6%. This figure is lower than the world's average of 1.9% per year and the 2% per year of the United States, and it falls significantly below the 4% annual growth recorded by countries in East Asia and the Pacific (World Bank, 2023f).[4]

As a result, per capita income in the region continues to lag behind that of developed countries. Graph 5.1 shows the evolution of per capita income in different regions of the world as a proportion of per capita income in the United States from 1960 to the present. As observed, per capita income in Latin America and the Caribbean has remained close to 20% of the U.S. level, while some high-growth regions, such as East Asia and the Pacific, have made notable progress in reducing that gap.

Graph 5.1
GDP per capita relative to that of the United States



Note: The graph reports GDP per capita (adjusted to purchasing power parity) as a percentage of U.S. GDP per capita. The LAC countries considered in the graph are the countries belonging to the Community of Latin American and Caribbean States (CELAC), excluding Cuba due to lack of information. The countries that make up the other regions can be consulted in the appendix of the chapter available online.

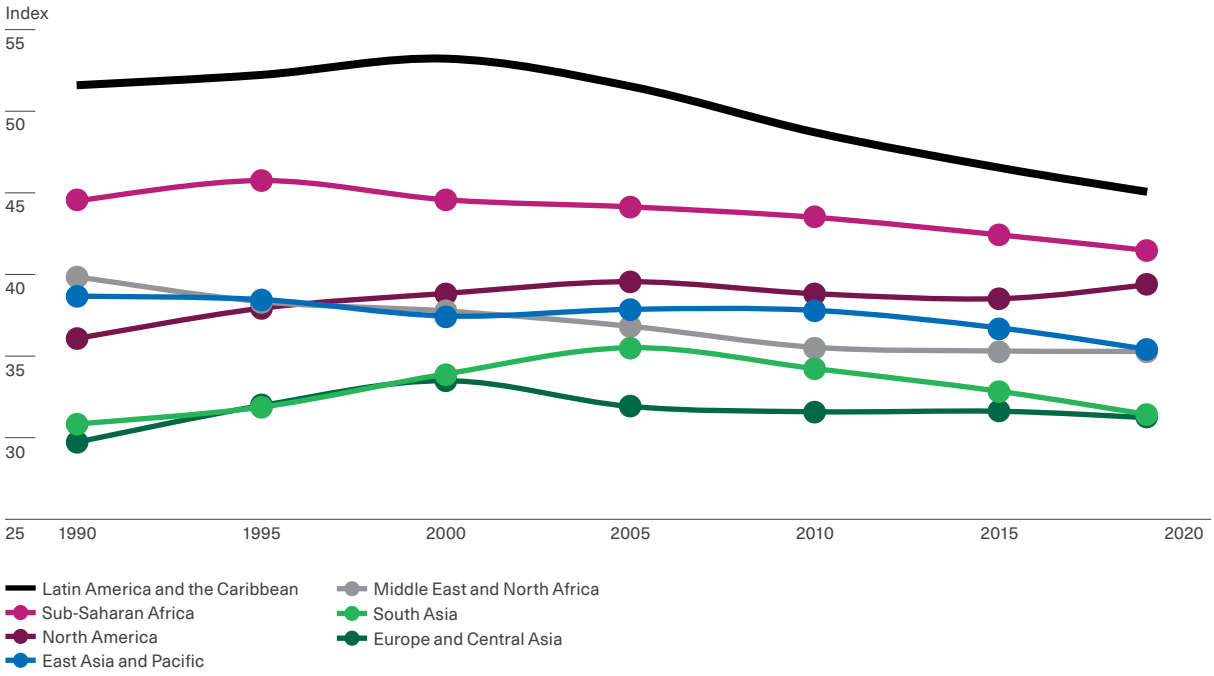
Source: Authors using data from Penn World Table 10.0 (Feenstra et al., 2015).

4 This low growth rate is also reflected in other economic performance indicators, such as the region's share of global trade and production. Indeed, the region accounts for 5.7% of world trade and 6.4% of world output, figures that are virtually unchanged from those of five decades ago (WTO, 2023; World Bank, 2023d).

The second dimension of development in which the region has made limited progress is social inclusion. For example, the bottom 50% of the population receives only 8% of the total income and possesses merely 1% of the total wealth (WID, 2023).[5] This high level of inequality is persistent over time. As shown in Graph 5.2, according to the Gini coefficient, an indicator of income distribution inequality, the region has been the most unequal in the world for several decades, even though this inequality has recently reduced. Other aspects of well-being, such as education, health, and employment opportunities, are also unevenly distributed among the population (Berniell et al., 2022; UNDP, 2019).

The region's high level of poverty reflects both the low economic growth and limited social inclusion. Around 30% of the population in Latin America and the Caribbean lived below the poverty line of USD 6.85 per day in 2021 (World Bank, 2023h).

Graph 5.2
Evolution of the Gini index of income distribution



Note: Each line represents a local polynomial smoothing of the Gini index, which measures average income inequality by region and year. The list of countries included in LAC can be found in the appendix of the chapter available online. The other aggregates are based on the World Bank's regional classification. The set of countries included in the regional averages may vary depending on the availability of data for each year.

Source: Authors using World Bank data (2023g).

5 These figures refer to the average for Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Mexico, Peru, and Uruguay, which are the Latin American and Caribbean countries for which information is available.

Nearly 30% of LAC's inhabitants were living below the poverty line in 2021 with less than USD 6.85 per day in income

These challenges are linked to several structural characteristics of the region that can hinder the implementation of the climate resilience and sustainability agenda: 1) a low productivity that affects all sectors of activity (Álvarez et al., 2018); 2) deficits in investment in both productive and social infrastructure, leading to reduced quantity and quality of infrastructure services (Cavallo et al., 2020; Cont et al., 2022; Sanguinetti et al., 2021); and 3) limited State capacities, both for policy design and implementation, and for providing adequate quantities and qualities of public goods and services (Fajardo et al., 2019; Sanguinetti et al., 2015).[6]

The third pillar of development: Climate resilience and environmental sustainability

Climate resilience and environmental sustainability are part of the sustainable development agenda, pursuing three interconnected objectives: adapting to climate change risks, contributing to global emissions reduction, and preserving the region's natural capital.

Firstly, Latin America and the Caribbean must adapt to confront the risks associated with climate change. The increasing occurrence of extreme weather events and gradual changes in climate conditions endanger entire populations, livelihoods, as well as the region's rich ecosystems and biodiversity. The urgency to prevent or minimize damages related to climate change justifies placing adaptation investments at the top of the sustainability agenda.

The adaptation priorities of countries are often reflected in the adaptation goals contained in their Nationally Determined Contributions (NDCs) and, in some cases, in National Adaptation Plans to Climate Change (NAPCCs).[7] The analysis of these documents conducted in Chapter 4 finds that, in general, these goals are not precise enough and are not always linked to concrete projects. This is partly due to the fact that adaptation needs vary according to the local context based on the exposure and vulnerability of specific territories and populations to various climate hazards. Identifying adaptation needs and concrete measures to address them with greater precision must be a priority task for countries' agendas. This task would allow for a more accurate estimation of adaptation costs and financing needs.[8]

Identifying adaptation needs and concrete measures to address them with greater precision is a priority task on the agenda of the region's countries

6 These structural characteristics of the region have, in turn, deep and complex roots, the analysis of which is beyond the scope of this chapter.

7 As of February 2023, only 13 countries in Latin America and the Caribbean had submitted a NAPCC to the UNFCCC: Brazil, Chile, Colombia, Costa Rica, Grenada, Guatemala, Haiti, Paraguay, Peru, St. Vincent and the Grenadines, St. Lucia, Suriname, and Uruguay.

8 As of December 2022, only eight countries in Latin America and the Caribbean had included an estimate of the financing needs specifically associated with their adaptation targets in the most recent version of their NDCs: Belize, Colombia, Dominican Republic, El Salvador, Guyana, Haiti, St. Kitts and Nevis, and Suriname.

The second essential objective of the region's resilience and environmental sustainability agenda should be climate mitigation. As shown in Chapter 4, achieving the targets in the Paris Agreement requires all regions to contribute to emissions reduction, even those whose historical contribution to CO_2 accumulation in the atmosphere is relatively low, such as Latin America and the Caribbean. In line with this collective effort, the mitigation targets contained in the NDCs of Latin American and Caribbean countries aim, as a whole, for a reduction of approximately 10% in the region's emissions by 2030 compared to the 2015 level. These goals are likely to become more ambitious in the successive quinquennial revisions the countries have committed to, as the current commitments are insufficient to meet the broader goals of the Agreement.

The third objective of the region's resilience and environmental sustainability component is the preservation of its vast natural wealth. As highlighted in Chapter 3, nature provides people with ecosystem services such as food, energy, freshwater, medicine, and materials; climate regulation, hydrological cycles, and air quality; as well as opportunities for recreation and other cultural benefits. Ecosystem services facilitate adaptation to the effects of climate change and are vital for climate regulation and valuable for economic activity and human development directly.[9]

Latin America and the Caribbean is relatively rich in natural capital, but it is being rapidly depleted. This is evident from a recent initiative to measure and monitor the evolution of capital in all its forms: produced, human, and natural (Managi and Kumar, 2018).[10] As shown in Graph 5.3, between 1990 and 2014, per capita natural capital in the region contracted by around 40%. The decline in natural capital is not unique to Latin America and the Caribbean (OECD countries also saw their natural wealth fall during this period), but the rate of loss is higher than levels observed in other parts of the world. Moreover, all components of the region's natural capital (forest, agricultural, fishing, fossil and mineral resources) decreased in value during that period.

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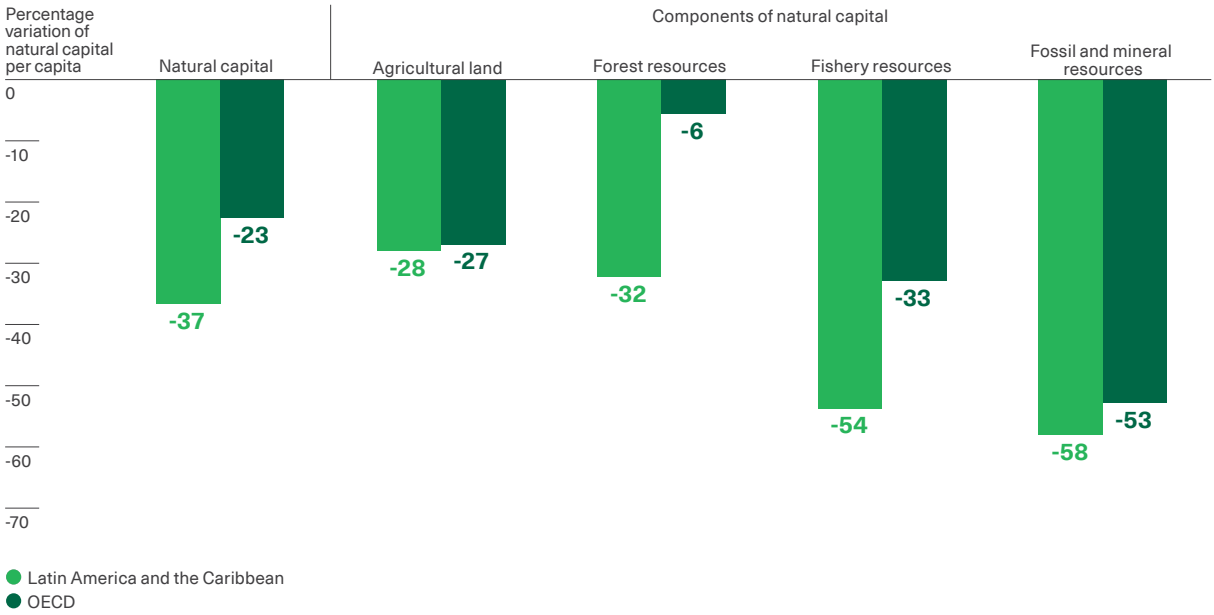
Between 1990 and 2014, natural capital per capita contracted in the region by about 40%

As highlighted in Chapter 3, the two main channels through which human activity degrades nature in Latin America and the Caribbean are changes in land use, largely driven by the expansion of agricultural frontiers, and the overexploitation of natural resources. These results are, in turn, explained by the occurrence of market failures associated with the protection of nature's services to people (such as externalities, public goods, or information problems) and limited State capacities to correct resulting inefficiencies. As the degradation of the region's natural capital poses a risk to the sustainability of its own development process, designing effective conservation policies must be a fundamental part of the sustainable development agenda for Latin America and the Caribbean.

9 Natural wealth has been and continues to be a source of economic growth in most Latin American and Caribbean countries. For example, in the 1960s, natural resources represented, on average, more than 90% of exports and almost 6% of regional GDP. More than half a century later, in 2017, these figures were around 80% and 10%, respectively (Meller, 2020).

10 Concern about nature's ability to continue providing essential services for human development has led to the development of methodologies to obtain more inclusive measures of the wealth of nations that incorporate natural capital (Managi and Kumar, 2018; World Bank, 2021).

Graph 5.3
Percentage change in natural capital per capita and its components in 2014 relative to 1990



Note: Rates of change for the respective years are computed for each country and then aggregated by a simple average. Changes in natural capital per capita are calculated using 2005 international dollars (PPP). The list of countries included in LAC can be found in the appendix of the chapter available online.

Source: Authors using data from Managi and Kumar (2018).

Lastly, it is worth mentioning that the methodological challenges associated with measuring natural wealth are significant, so these estimates are not without issues. Nevertheless, they provide valuable contributions to the discussion of the sustainability of the countries' development process.[11] Moreover, the importance of considering natural capital in the decision-making process has led many countries to launch initiatives to incorporate measurements of natural wealth into their national accounts (see Box 5.2).

11 In a study prepared especially for this report, Vial (2023) reviews the difficulties in the measurement of natural capital, taking as a reference the estimates of the World Bank's "The Changing Wealth of Nations" project (2021). One of the main challenges is the incorporation of those ecosystem services that do not have a market value. The work highlights the need to generate more scientific knowledge to understand all the benefits provided by nature to humans and the complex interrelationship between these services, as well as to develop valuation methodologies for those benefits for which there is no reference market price.

Box 5.2
Initiatives to incorporate natural capital into national accounts

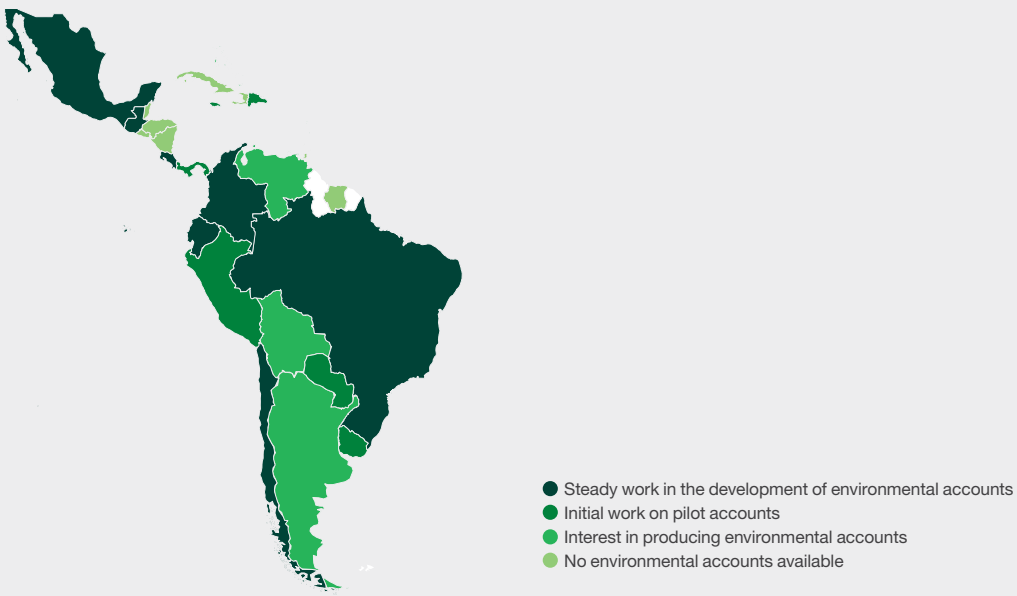
By incorporating a measure of natural capital into national accounts countries can value their natural resources and design policies focused on sustainable development that evaluate the competing uses of these resources. This is particularly relevant for countries with economies based on the exploitation of natural resources (World Bank, 2012).

Considerable progress has been made in natural capital accounting over the last decade. The Wealth Accounting and Valuation of Ecosystem Services (WAVES) project, which received support from the United Nations and the World Bank, led to the emergence of regional initiatives. Also, the implementation of the System of Environmental-Economic Accounting (SEEA) provided a standard international framework.

By 2019, seven countries in Latin America and the Caribbean had made systematic progress in developing environmental accounts, another seven had piloted natural capital accounts, and five showed interest in doing so (Graph 1). The analysis of the implementation in each country shows that the focus has been on accounting for water resources, forests, and land use and cover. Additionally, six countries had made progress in implementing experimental ecosystem accounts. However, only five countries (Brazil, Chile, Colombia, Costa Rica, and Mexico) had formally institutionalized the development of environmental accounts and had stable specialized statistical teams with budgets and assigned personnel (Carvajal, 2017; ECLAC, 2022a).

Despite this progress, there is still much work to be done for the development and implementation of environmental accounts in a large number of countries in the region, mainly in the Caribbean and Central America. Furthermore, the main limitation of the project in countries where progress has already been made is that the results and indicators of natural accounts have yet to be incorporated into economic analyses.

Graph 1
Levels of implementation of environmental accounts in the region in 2019



Note: Data are unavailable for Antigua and Barbuda, Barbados, Guyana, and St. Kitts and Nevis.
Source: Authors using data from Carvajal (2017) and ECLAC (2022a).

Considerations for integrating agendas on the path to sustainable development

From a decision-making perspective, the pursuit of sustainable development demands that policy choices strike a balance among the agendas of economic growth, social inclusion, and environmental sustainability. In the concurrent pursuit of these interconnected agendas, synergies and trade-offs can emerge that need to be managed. For instance, if a power plant fueled by fossil fuels generates local pollutants, replacing it with renewable energy sources not only reduces emissions, contributing to the sustainability agenda, but also enhances the health of nearby populations, favoring advances in the social dimension. However, if workers from the fossil fuel plant struggle to transition into new roles at the renewable plant, there will be winners and losers, whose well-being must be considered in policy evaluation. Similarly, when deforesting an area to cultivate land for food production, trade-offs can arise between ecosystem regulation services and biodiversity conservation, and food production. In the case of mining exploitation, trade-offs can also surface between economic opportunities and potential environmental impacts, as well as negative effects on local communities.

Additionally, it's crucial to bear in mind that these synergies or trade-offs in achieving interconnected objectives are shaped by the current state of technology. For example, the trade-off between economic growth and environmental sustainability caused by the energy needed to meet human needs via fossil fuel combustion could diminish in the not-too-distant future due to technological advances making clean energy sources economically more viable (see Box 5.3).

An important criterion for determining the most suitable policy portfolio is cost-benefit analysis. Policies must also be politically feasible and consider distributional effects

In essence, the integration of climate policy into the development agenda requires making decisions about the use of scarce resources to attain multiple goals. An important criterion for determining the most suitable policy portfolio is cost-benefit analysis, but it is not the sole consideration. Policy decisions must also have sufficient social support to be politically feasible and consider their distributive impacts to ensure fairness.[12]

12 Fabra and Reguant (2023) offer an excellent conceptual discussion on the aspects to be considered in the definition of an optimal portfolio of climate policies, applied to the case of the energy transition in Europe.

Box 5.3
The relationship between economic growth and GHG emissions

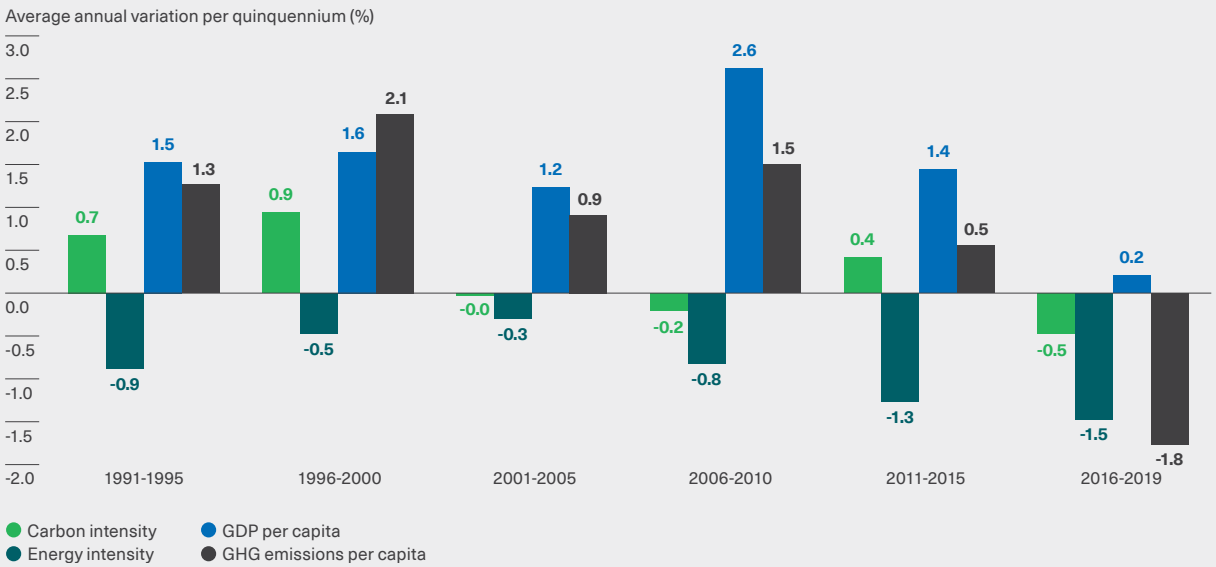
The disassociation between the evolution of GHG emissions and economic performance (known as decoupling) occurs when the emissions of a country or region increase less than GDP, as defined by Hubacek et al. (2021). In their analysis of 116 countries during the 2015-2018 period, these authors found that emissions decreased or remained constant in 32 of them, while GDP increased (absolute decoupling). In turn, 41 experienced emission growth lower than their GDP growth (relative decoupling). The countries falling into either of these categories account for 89% of global emissions. On the other hand, 36 countries did not experience any decoupling, and 6 others underwent economic recessions during the analyzed period and were therefore excluded from the analysis.

One way to approach the drivers of emission growth is through the Kaya identity (Kaya and Yokobori, 1997). This mathematical expression breaks down per capita CO_2 emissions into three components, as outlined in Equation 1.

$$\Delta \frac{Emissions}{Population} = \Delta \underbrace{\frac{Emissions}{Energy\ Consumption}}_{\text{Carbon intensity}} + \Delta \underbrace{\frac{Energy\ Consumption}{GDP}}_{\text{Energy intensity}} + \Delta \underbrace{\frac{GDP}{Population}}_{\text{GDP per capita}} \quad (1)$$

Graph 1 illustrates that per capita emissions in Latin America and the Caribbean decreased during the 2016-2019 period. Notably, the carbon intensity and energy intensity were components that contributed to the reduction in per capita emissions since 2015. However, this decrease occurred during a period in which the region's per capita GDP remained stagnant.

Graph 1
Average annual variation over five-year period of Kaya identity components for Latin America and the Caribbean



Note: The graph displays the annual average variation over the five-year period of the Kaya identity components and the total variation in per capita emissions. Per capita GDP is presented in constant dollars and adjusted for purchasing power parity. The list of countries considered in the graph can be found in the appendix of the chapter available online.

Source: Authors using data from IEA (2021a), World Bank (2023b), and Minx et al. (2021).

Decarbonization of the global economy: Progress, projections, and impacts.

The world economy is undergoing a transition aimed at decarbonizing the energy matrix and increasing energy efficiency. As expected, this process has advanced more rapidly in developed countries. These countries are responsible for the greatest amount of historical CO_2 emissions, their emissions structures are heavily reliant on fossil fuels, and they have the most resources to finance the substantial investments required for this transition.

The global energy transition will have a profound impact on the economies of Latin America and the Caribbean, affecting many economic sectors, in addition to the energy sector. The advancement of decarbonization in the developed world entails shifts in global hydrocarbon demand, alterations in prices and technological feasibility of renewable energy sources and electricity-based goods, and potential constraints on international trade. Furthermore, an increased demand for goods and services essential to the energy transition is expected, some of which may hold particular relevance for the region (e.g., critical minerals and carbon offset markets).

The global energy transition will have a profound impact on the economies of Latin America and the Caribbean

In contrast to past energy transitions (e.g., substituting coal with oil as the dominant energy source), the origin of the current transition is not rooted in technological improvements driving households and businesses to adopt a cheaper or more convenient energy source. Instead, this transition emerged due to the necessity of reducing fossil fuel usage due to its impact on climate change, at a time when emerging energy sources—renewables—were not yet competitive alternatives. Consequently, the energy transition has been driven by policies demanding substantial fiscal resources and initiatives aimed at promoting renewable adoption. These policies have led to higher energy prices, particularly at the transition's outset (see Box 5.4).

The drive toward electrification and the adoption of renewable sources has contributed to a virtuous cycle where technological adoption and development mutually reinforce each other, propelled by economies of learning and scale. As a result, the costs and technological feasibility of the main renewable energy sources and electricity-dependent goods have become comparable or expected to become equal to those of fossil fuels in the coming years.

Nevertheless, the required investment to achieve global energy transition remains considerable. The International Energy Agency (IEA) estimates that the annual energy sector investment needed to achieve net-zero emissions by 2050 ranges from USD 4.5 trillion to USD 5 trillion (IEA, 2021c). Other studies place this figure between USD 3 trillion and USD 6 trillion annually (BNEF, 2021; IRENA, 2022). In the 2016-2020 period, which has already witnessed an increase compared to previous years, global energy sector investment was around USD 2 trillion or 2.5% of global GDP (IEA, 2021c). These sums include the costs of new infrastructure construction and decarbonization of existing infrastructure, yet they do not take into account other relevant costs associated with the energy transition, such as stranded assets, job losses in carbon-intensive sectors, and higher energy prices for consumers.

Box 5.4
Lessons from Germany's energy transition

Germany is as a pioneer in the energy transition, having implemented a reform known as Energiewende since 2010, aimed at shifting from a fossil-fuel and nuclear energy-based system to one rooted in renewable energy sources. To achieve this, Energiewende planned the progressive closure of nuclear power plants and the implementation of economic incentives to increase the share of renewable energy sources in the electricity matrix to 50% by 2030 (recently updated to 80%).

As a result of this reform, Germany has emerged as a global leader in the development and adoption of renewable energy technologies, transitioning from supplying 3% of electricity demand through renewables in 1990 to 42% in 2021 (Agora Energiewende, 2022). However, this transition has been costly. Estimates of financial support required from implementation to 2030 (including renewable energies and grid expansion costs, among others) range between EUR 600 billion and EUR 700 billion solely for the electricity sector (excluding funding needed for the transformation of building and transportation sectors) (Unnerstall, 2017). To finance the transition, German households and businesses contend with some of the highest electricity tariffs within OECD countries, contributing to growing opposition to the reform within German society. Additionally, the closure of nuclear power plants eventually led to an uptick in the use of fossil fuels.

The Energiewende experience is often cited as a cautionary example of an energy transition. However, a recent study estimates that 75% of the incurred costs stem from two particular aspects of this reform, which other countries can potentially sidestep (Unnerstall, 2017). First, the closure of nuclear power plants exerted significant strain on the energy system, underscoring the importance of not reducing the supply of alternative energy sources before renewables have sufficient installed capacity. Second, Germany undertook a massive expansion of renewables when they were still expensive, paying a high price to do so but significantly contributing to technological advancement and cost reduction in these energy sources. In a sense, the Energiewende subsidized low-cost renewable energy for the rest of the world.

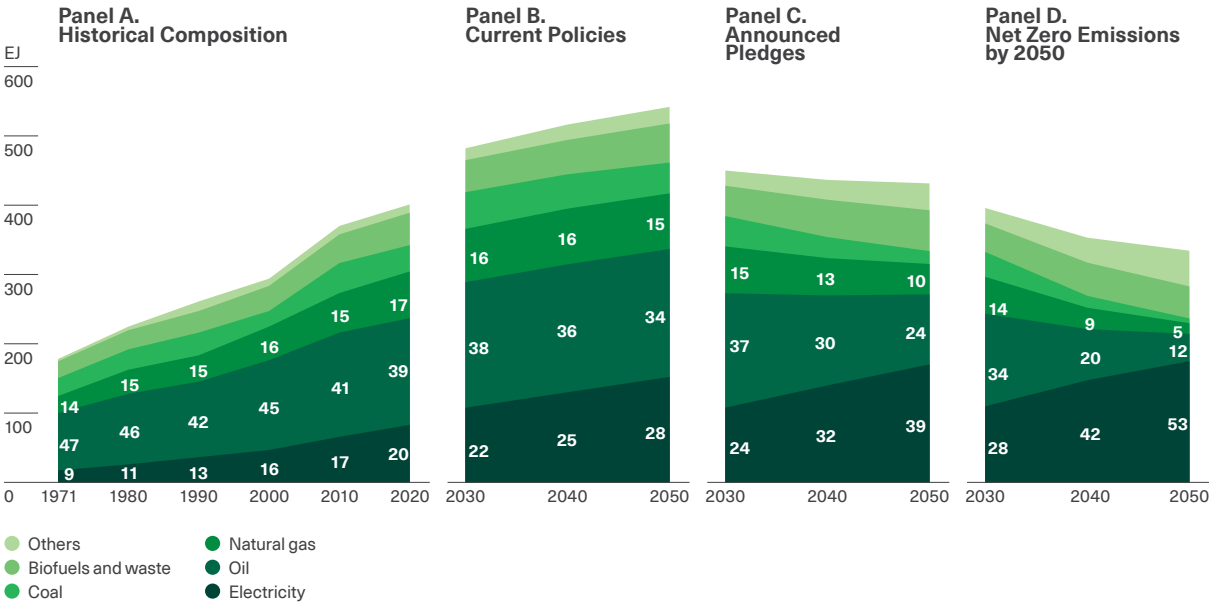
Electrification and renewable energy sources

Electrification of the world's energy matrix is an ongoing process. As shown in Graph 5.4, the contribution of electricity to global energy consumption rose from 9% to 20% between 1971 and 2020. This increase occurred within a context of growing energy demand, resulting in a five-fold increase in the amount of electricity consumed during this period. Looking ahead, electrification is expected to continue, although the pace will greatly hinge on the course of climate policies. Following the presentation of historical energy consumption trends in Panel A, Graph 5.4 shows three forecasts developed by the IEA (2022d). In the business-as-usual or current policies scenario (Panel B) electricity would constitute 28% of energy consumed by 2050. In a scenario where countries meet their announced climate and energy transition pledges (Panel C), the share of electricity in energy consumption would reach 39% by 2050. Lastly, in a scenario characterized by policies aligned with achieving net-zero emissions by 2050, the electricity share would need to rise to 53% (Panel D). In all cases, a substantial increase in global electricity consumption is

expected by 2050 (between 84% and 115% higher than that of 2020), driven primarily by economic growth in developing countries and tempered by expected enhancements in electrical consumption efficiency.

In the future, electrification is expected to continue, although its pace will hinge on the course of climate policy

Graph 5.4
Global final energy consumption



Note: The Stated Policies Scenario (STEPS) represents the trajectory implied by current policies. The Announced Pledges Scenario (APS) assumes that all government-declared objectives are fully met and on schedule, including energy access and long-term zero-emission targets. The Net Zero Emissions by 2050 Scenario (NZE) outlines the path to achieve both global temperature stabilization at 1.5°C and universal access to electricity and modern energy systems by 2030. Labels indicate the share relative to the total in the year of the change of the decade.

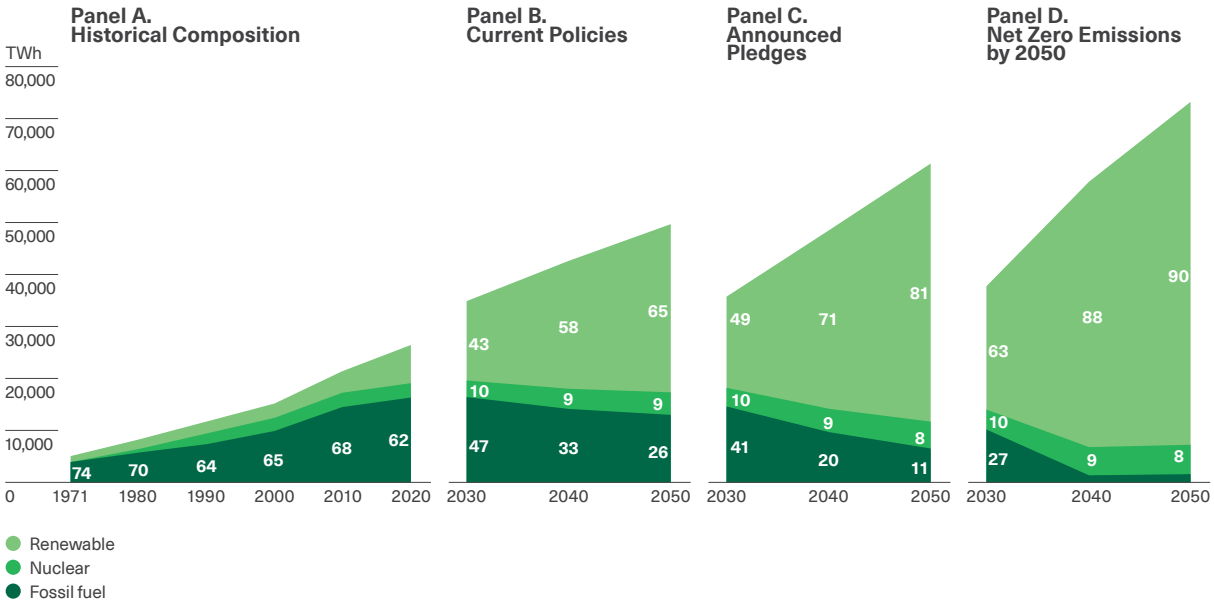
Source: Authors using data from IEA (2022d; 2022e).

Electricity is primarily generated from fossil fuels and renewable sources. Decarbonizing the electricity matrix involves replacing the use of fossil fuels, particularly oil and coal, with clean renewable energy sources. There has been clear progress in this process. As seen in Graph 5.5, the amount of electricity generated from renewable sources increased significantly (by 503%) between 1971 and 2020. The expansion of renewable sources accelerated over the last two decades, largely due to the development of solar and wind energy (IEA, 2022b; 2022c). The graph also presents IEA's projections for electricity generation by source, using the same scenarios as in Graph 5.4. In the scenario where current climate policies are maintained, 65% of electricity generated in 2050 would come from renewable energy sources, a 37-percentage point increase from 2020. If the climate targets already announced by countries are achieved, the share of renewable energy sources in

electricity generation would reach 81% in 2050. In a scenario aligned with the objective of achieving net zero emissions by 2050, it would reach 90%. While there are differences among scenarios, all cases anticipate a significant growth in electricity generation from renewable sources, driven by the expected decrease in the costs of these energy sources.

The largest reduction in the cost of renewable sources has been observed in photovoltaic solar energy, with unit costs decreasing by around 85% between 2000 and 2018 (see Chapter 2). By 2030, the unit cost of wind energy is expected to decrease by 20% to 25%, and that of solar energy by 40% to 55%. According to projections, the cost of wind energy would then stabilize, while the cost of solar energy would continue to decrease, reaching 75% less than that of 2019 by 2050, although there is great uncertainty over these scenarios (BP, 2022). However, it is important to highlight the significance of higher financing costs in developing countries. Estimates suggest that the capital cost required to construct a photovoltaic solar plant in a developing country is two to three times higher than in developed countries (IEA, 2022d).

Graph 5.5
Total electricity generation in the world



Note: The Stated Policies Scenario (STEPS) represents the trajectory implied by current policies. The Announced Pledges Scenario (APS) assumes that all government-declared objectives are fully met and on schedule, including energy access and long-term zero-emission targets. The Net Zero Emissions by 2050 Scenario (NZE) outlines the path to achieve both global temperature stabilization at 1.5°C and universal access to electricity and modern energy systems by 2030. Labels indicate the share relative to the total in the year of the change of the decade.

Source: Authors using data from IEA (2022d; 2022e).

The expansion of renewable energy sources worldwide still faces significant challenges, mainly in terms of transmission and intermittency. The cost of transporting electricity is considerably higher than that of fossil fuels. This is due to the lower energy-carrying capacity of electrical transmission lines compared to transporting gaseous and liquid fuels via pipelines. The cost of transmitting one megawatt-hour (MWh) of electricity can be up to 8 times higher than the cost of delivering the same amount of energy via hydrogen pipelines, 11 times more than natural gas transport, and between 20 to 25 times higher than liquid fuel transport costs (DeSantis et al., 2021; Hausmann, 2021).

Electricity transportation requires the availability of high-voltage transmission lines linking generation centers with consumption sites. This is relevant because areas with the greatest potential for renewable energy generation are often far from major population centers. The challenge is that the construction of these lines is expensive and often faces social opposition, particularly when inhabited areas are nearby, as shown by the experience of developed countries. For instance, in the United States, 53 renewable energy generation projects have been postponed or canceled since 2008 due to opposition from local residents and other stakeholders (Susskind et al., 2022). While the reasons vary, concerns about potential negative health effects and the impact on property prices appear to be predominant (Komendantova and Battaglini, 2016; Cain and Nelson, 2013; Cotton and Devine-Wright, 2013).

The expansion of renewable energy sources still faces significant challenges worldwide, mainly in terms of transportation and intermittency

Intermittency issues with renewable energy sources such as wind and solar arise because their availability varies with weather conditions rather than demand. Intermittency is costly because it increases the likelihood of not using generated electricity during supply peaks and forces power systems to invest in higher backup capacity and interconnection to manage demand spikes. The challenge of intermittency is compounded by the current absence of technically and economically viable large-scale electricity storage technologies.

The importance of these factors is evident in a recent study that evaluates one of the major policies implemented in the United States—known as Renewable Portfolio Standards—for promoting renewable energy (Greenstone and Nath, 2020). Managed at the state level, this policy obliges utility companies to derive a portion of the electricity they generate from renewable sources. The authors find an average 11% increase in electricity prices after seven years of policy implementation, primarily due to higher transmission and intermittency costs. On the positive side, they observe a decrease of between 10% and 25% in carbon emissions.

Long-term fossil fuel demand

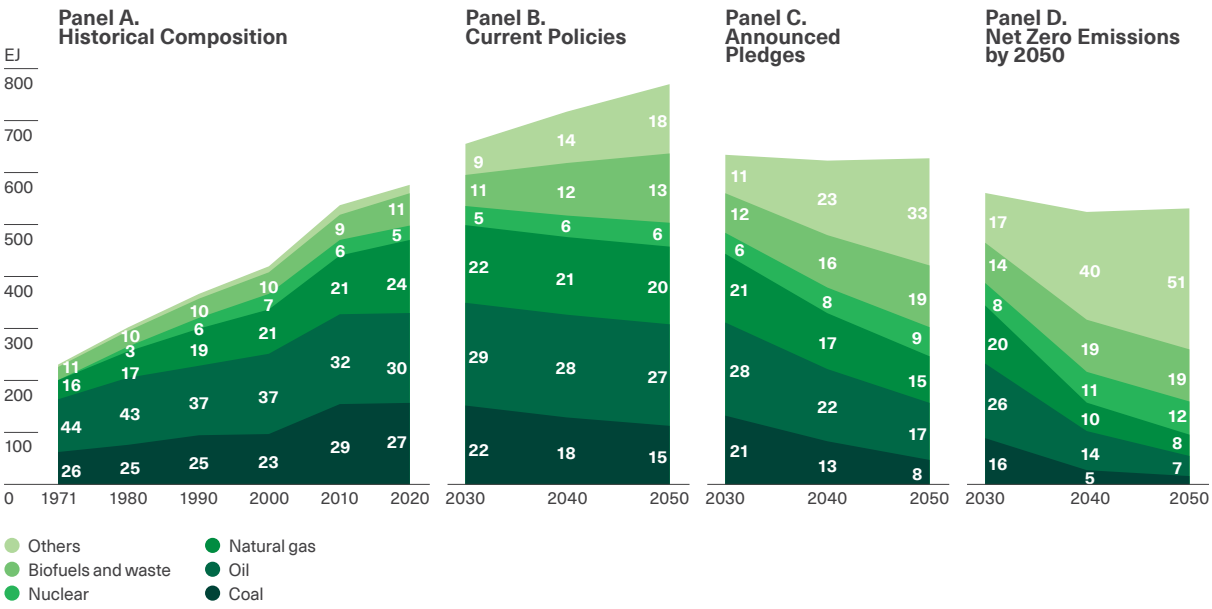
The energy transition entails the gradual abandonment of fossil fuels as a significant global energy source, with coal and oil being phased out initially, followed by natural gas, given its lower emissions. This contrasts with the previous energy transition, in which oil displaced coal as the dominant source, but coal usage did not decrease; instead, it increased due to growing global energy demand (Bhutada, 2022).

To analyze the evolution of fossil fuel usage, it is useful to observe the energy matrix disaggregated by primary energy sources, as a portion of hydrocarbons and their derivatives are used directly, while another portion is used for electricity generation. As reported in Graph 5.6, global fossil fuel usage increased by 135% over the last 50 years; gas usage increased by 274%, coal usage by 162%, and oil usage by 69%. During this period, the contribution of gas to the global energy supply increased from 16% to 24%, coal remained relatively

stable (moving from 26% to 27%), and oil decreased from 44% to 30% (as a result of its slower growth compared to other energy sources). Looking ahead, all three scenarios analyzed by the IEA envision a reduction in the contribution of oil, coal, and natural gas to the global energy supply between 2020 and 2050, but not necessarily in absolute usage terms. The scenario of continuing current policies anticipates growth in oil and gas usage (14% and 7% respectively) and a substantial decline in coal usage (28%). Achieving the scenarios of announced pledges and net-zero emissions by 2050 requires a decrease in the usage of these three fossil fuels, with more pronounced reductions in the latter scenario.

How will oil prices evolve in the long term? The answer depends on the projected scenario. For instance, in the aforementioned continuity scenario, the price of a barrel of oil in 2050 would reach USD 95 in real terms (as a reference, the price was USD 69 in 2021 and USD 96 in 2010). Instead, in the scenario of meeting announced pledges, the price of a barrel of oil would be USD 60 in 2050, and in the net zero emissions by 2050 scenario, it would be USD 24 (and as low as USD 35 as early as 2030) (AIE, 2022e). The second and third projections from the IEA assume a decrease in oil supply accompanied by an increase in renewable energy supply of similar magnitude. If the latter does not occur, there might be a scenario of high prices and reduced oil supply (due to carbon taxes and supply restrictions) for an extended period.

Graph 5.6
Total energy supply worldwide



Note: The Stated Policies Scenario (STEPS) represents the trajectory implied by current policies. The Announced Pledges Scenario (APS) assumes that all government-declared objectives are fully met and on schedule, including energy access and long-term zero-emission targets. The Net Zero Emissions by 2050 Scenario (NZE) outlines the path to achieve both global temperature stabilization at 1.5°C and universal access to electricity and modern energy systems by 2030. Labels indicate the share relative to the total in the year of the change of the decade.

Source: Authors using data from IEA (2021e; 2022d).

Effects on other economic sectors

The disparity in the progress of energy transition between the developed world and other regions could give rise to tensions in international trade (see Chapter 4). Countries with higher carbon prices might introduce tariffs or import restrictions to counterbalance the competitive disadvantages caused by these price disparities for their businesses (Blanchard et al., 2022). Under the objective of global emissions reduction, the European Union (EU) passed the Carbon Border Adjustment Mechanism (CBAM) in May 2023. This mechanism entails imposing a fee on imported goods to the EU equivalent to the emissions cost that would have been incurred if those goods were produced within its member countries. This is not the sole instance where environmental policies of developed nations can influence international trade. In early 2023, the EU approved a regulation called Deforestation-Free Products, aiming to prohibit the import of agricultural and forestry products originating from deforested areas. Affected products include palm oil, livestock, soy, coffee, cocoa, timber, rubber, and derivatives of these products (European Commission, 2022a).

In addition, the global energy transition entails increased demand for goods and services affected by this process. Among these, critical minerals and carbon offset credits stand out due to their significance for the region.

Critical minerals are essential for low-emission electricity generation, the construction of power grids, and the production of lithium batteries for energy storage. The five key materials for battery production are lithium, nickel, cobalt, graphite, and manganese. Lithium, being the most important metal for electric vehicles, currently lacks a viable commercial substitute. In a scenario aligned with the fulfillment of the Paris Agreement goals, lithium demand would rise 40-fold by 2040, while nickel, cobalt, and graphite demand would increase by 20 to 25 times (IEA, 2021d). Copper and aluminum are critical inputs for power grids, being the primary materials for cables and wires. In addition, copper is widely used in renewable energy generation systems (as it is a highly efficient conductor). Meeting the Paris Agreement targets would lead to a 160% increase in copper demand by 2040 (IEA, 2023).

The world's energy transition entails increased demand for goods and services affected by this process, such as critical minerals and carbon offset credits

High carbon prices and corporate decisions to adopt environmentally friendly policies can stimulate the demand for GHG emission offset credits (see Chapter 4). The establishment of international carbon markets would enable companies in developed countries with high mitigation costs to purchase offset credits from projects in developing nations. These projects typically involve the adoption of renewable energy sources and the preservation and regeneration of forests (García and García, 2023). The evolution of these markets requires robust governance to ensure the integrity, transparency, and additionality of the projects undertaken in this area.

Challenges and opportunities for Latin America and the Caribbean in the face of the climate crisis

Adapting to the risks of climate change, reducing GHG emissions, and safeguarding the region's natural capital pose significant challenges for the region's economies and the prioritized allocation of resources. However, these endeavors also hold the potential to unlock valuable opportunities and expedite progress.

Accelerating climate change adaptation

The elevated exposure and vulnerability to climate-related hazards in Latin America and the Caribbean places adaptation policies at the forefront of priorities. Climate change risks to populations and ecosystems are numerous and diverse in nature. As exemplified in Chapter 1, over 7 million people are affected annually by extreme weather events linked to climate, such as tropical storms, floods, droughts, wildfires, and heat waves.

Floods and prolonged droughts impose substantial costs on economies and ecosystems alike. In cities, inadequate urban infrastructure often fails to mitigate significant damage caused by heavy rainfall and river overflow. An extreme case of vulnerability in cities pertains to informal settlements—housing a quarter of the region's urban population—typically located in flood-prone or landslide-prone areas.

On another front, approximately 45 million individuals (7% of the region's population) reside in low-lying areas exposed to flood risks from storm surges and severe storms. The population inhabiting low-lying zones accounts for about 12% of the total in the Caribbean and spikes to a staggering 90% in the Bahamas, Guyana, and Suriname. In the Caribbean, hurricanes are often catastrophic, affecting entire populations and damaging infrastructure, disrupting production and impacting public accounts for many years.

Extreme heat is becoming increasing more frequent and intense (in the last decade, six out of ten cities in the region experienced heat waves, nearly half of which were severe), jeopardizing the lives of the most vulnerable groups—including the elderly, children, and people with chronic diseases—while also impacting labor productivity in sectors like agriculture and construction.

In the Caribbean, hurricanes are often catastrophic, affecting entire populations and affecting infrastructure, means of production and public accounts for many years

Rising temperatures, shifting precipitation patterns, and increased soil aridity reduce agriculture productivity, which heavily relies on rainfall to meet crop water needs. This landscape presents a dual challenge: it threatens the growth potential of the region, which is the world's leading net food exporter, and it imperils food and nutritional security, particularly in rural areas of Central America and the Caribbean where subsistence family farming prevails. It also places the region's water resources under strain, affecting agriculture, hydroelectric generation, and human consumption.

Uneven impacts of climate change

The urgency of adaptation is further underscored by the realization that climate change can exacerbate existing inequalities in an already highly uneven region. On one hand, exposure to climate hazards can stem from socioeconomic deprivations; this is evident in households residing in flood-prone lands or lacking basic services due to financial constraints prohibiting relocation to safer areas or areas with superior infrastructure (Baldauf et al., 2020).

Poverty, lack of access to basic services like water and sanitation, or health services, and other development gaps are associated with diminished capacities to confront and adapt to climate hazards

On the other hand, poverty, lack of access to basic services like water and sanitation, or essential healthcare, and other development gaps, are associated with diminished capacities to confront and adapt to climate hazards (Gu, 2019; Hallegatte et al., 2016). In essence, socioeconomic vulnerability translates to climate vulnerability, creating a potential cycle that becomes self-perpetuating if not broken through requisite adaptation measures. Vulnerability may be notably high within certain socioeconomic and demographic groups, such as women, children, the elderly, ethnic and religious minorities, or indigenous communities. Gender is one of the dimensions that has received abundant attention in the literature on climate change impacts and policies to address them (see Box 5.5).

An estimate of how climate change can exacerbate existing vulnerabilities is provided by the study conducted by Jafino et al. (2020). These researchers find that, in the absence of adaptation measures, climate change could result in between 2.4 million and 5.8 million people in Latin America and the Caribbean falling into extreme poverty by 2030. In this context, focusing adaptation policies on the most vulnerable populations, which have contributed minimally to global warming, becomes a crucial aspect of climate justice.

An overview of adaptation and measuring its impact

Measuring progress and impacts achieved in terms of adaptation faces the challenge of obtaining systematic and comprehensive information on implemented adaptation projects. The diversity of adaptation options, specific contexts in which they are deployed, and the lack of consensus on what constitutes an adaptation policy (and how it differentiates from policies addressing socio-economic vulnerabilities characteristic of underdevelopment) are some of the obstacles in defining metrics to evaluate progress in adaptation.

A valuable effort in this direction is the Global Adaptation Mapping Initiative (Berrang-Ford et al., 2021). Drawing from over 48,000 academic articles published during the period 2013-2019 concerning climate initiatives, 1682 studies were selected that met the criterion of referring to adaptation actions that were effectively implemented.

Box 5.5
Differential impacts of climate change on women and gender-responsive climate policy

A substantial body of literature underscores the disproportionate impact of climate change on women (Casas Varez, 2017; Chitiga-Mabugu et al., 2023; Schipper et al., 2022). In the absence of gender-focused adaptation policies, climate change could exacerbate existing gender gaps.

The heightened vulnerability of women stems, in part, from their overrepresentation within impoverished populations, coupled with the fact that poverty is a primary determinant of exposure and vulnerability to climate hazards. Gender norms, which dictate societal roles, are also associated with differential gender-affected responses to climate change. For instance, a study in rural communities in Bolivia reveals that floods and droughts, by affecting access to potable water supplies, undermine the productivity and health of women—who are typically responsible for water collection (increasing the time and physical effort required) (Ashwill et al., 2011). Another study in the Caribbean illustrates that displacement due to extreme weather events and climate-induced migration disproportionately impacts women and girls, as these situations reinforce and perpetuate preexisting gender roles (Bleeker et al., 2021).

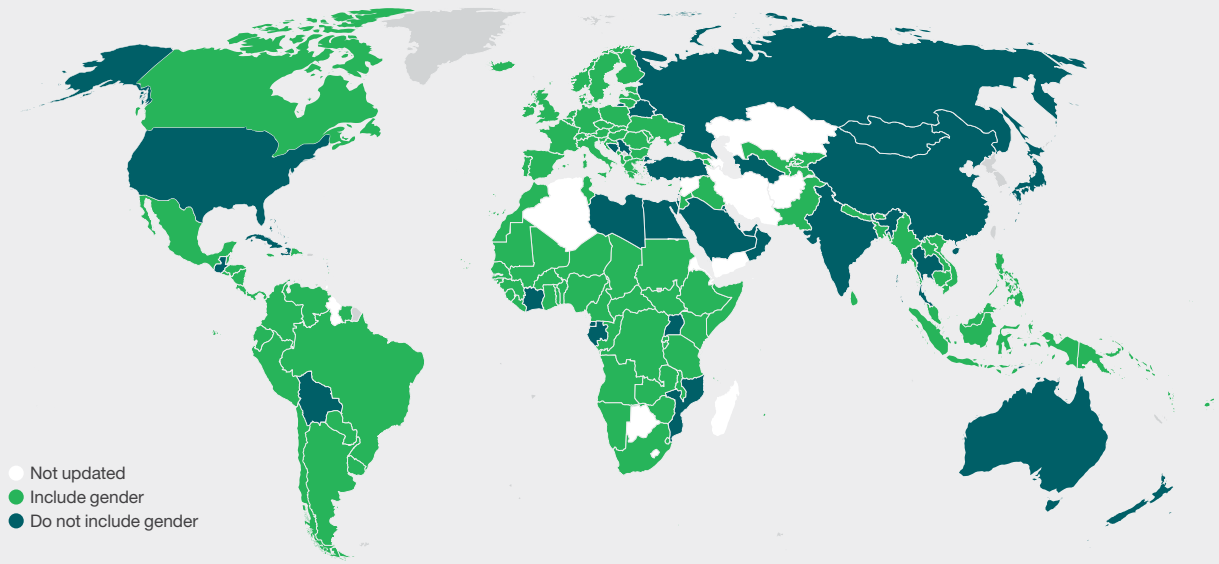
Gender roles can also limit the adaptation strategies available to women. A study conducted in Peru demonstrates that women (as well as Quechua-speaking individuals and migrants) are underrepresented in irrigation committees within communities, where community adaptation strategies in the face of diminishing water availability resulting from glacier retreat are defined (Erwin et al., 2021).

These differential effects on women warrant the integration of a gender perspective into climate policies. An initial step in this direction is the incorporation of a gender dimension into the Nationally Determined Contributions (NDCs). Latin America and the Caribbean are among the leading regions in this endeavor, as indicated in Graph 1.

Recently, the consideration of gender in NDCs has evolved from characterizing women as a vulnerable group to recognizing them as agents of change (IUCN, 2021). Two pivotal milestones in this regard were the adoption of the First Gender Action Plan (2017) and the Second Gender Action Plan (2019) within the framework of the United Nations Framework Convention on Climate Change (UNFCCC).

In addition to the integration of gender into NDCs, certain countries in Latin America and the Caribbean have begun to enact regulatory environmental actions with a gender focus. These efforts encompass the integration of climate change aspects into Gender Equality Plans, the formulation of national and subnational Gender and Climate Change Action Plans (GCCAPs), and the inclusion of gender and climate change considerations within policies, plans, strategies, and communications (Aguilar Revelo, 2022).

Graph 1
Gender inclusion in NDCs



Note: The graph indicates whether respective countries address gender-related issues or include mentions of women in their most recent NDCs. The label "not updated" identifies countries that have not updated their NDCs within the past five years. In LAC, the only countries that have not updated their NDCs within the last five years are Guyana, Saint Vincent and the Grenadines, and Trinidad and Tobago.

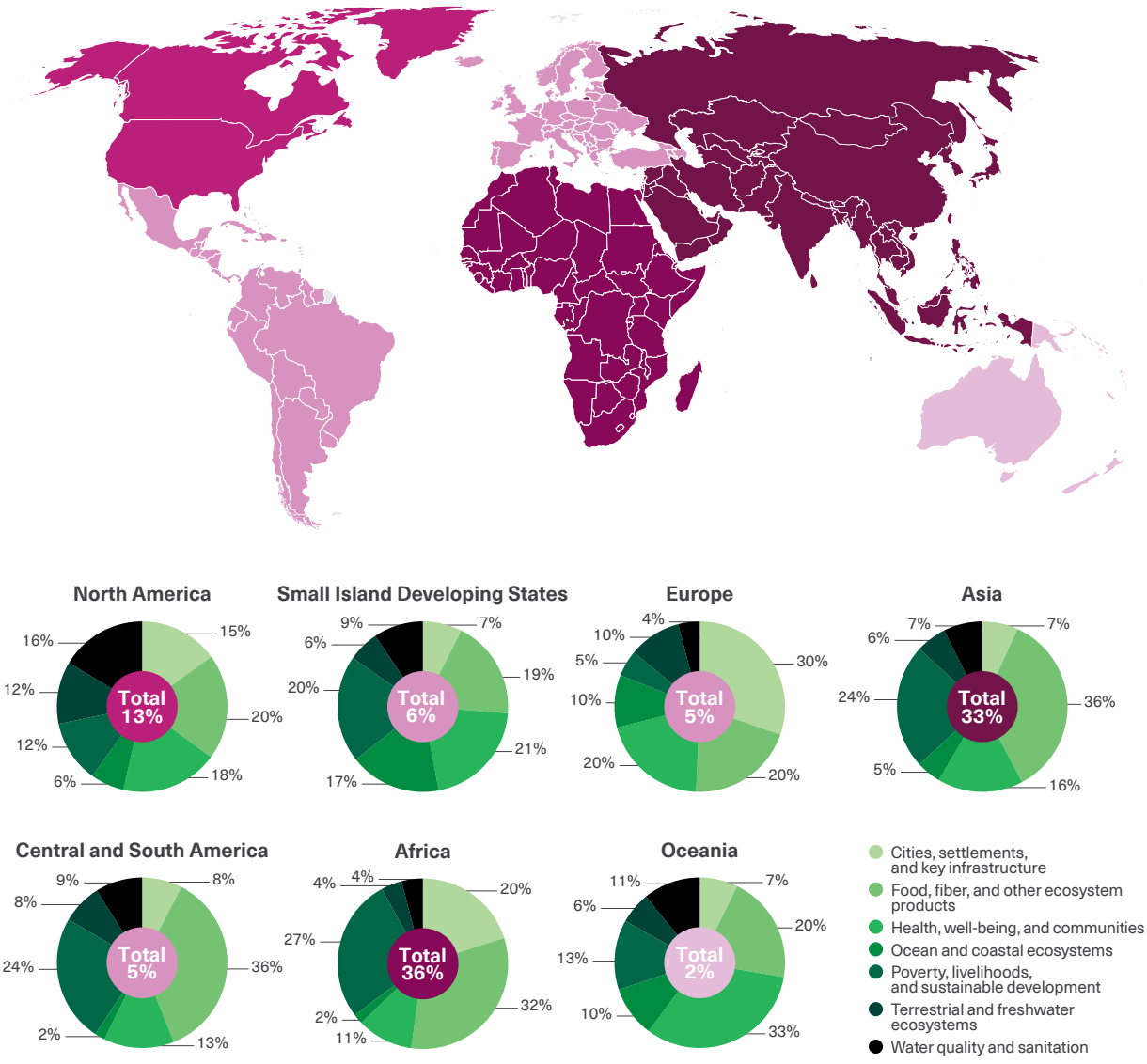
Source: Authors using data from Climate Watch (2023) and WEDO (2023).

Graph 5.7 depicts the distribution of these initiatives by region and sector of activity.[13] As observed, Central and South American countries account for merely 5% of the total documented adaptation responses, while small island states, including Caribbean islands, contribute to 6%. Both these percentages seem low when compared to those of other regions like Asia (33%) and Africa (33%). Therefore, a noteworthy initial result is that, according to this measure of adaptation progress, countries in the region are relatively underrepresented in the documented responses.

The categories that concentrate the majority of adaptation responses in Central and South America include food, fiber, and other ecosystem products (36%), poverty, livelihoods, and sustainable development (24%), and health and community well-being (13%). This sectoral composition of adaptation is relatively similar to that observed in other developing regions like Africa and Asia, contrasting more with that of Europe and North America, where initiatives addressing climate change impacts in cities (such as those related to water supply infrastructure resilience or wastewater treatment) receive more attention.

13 The percentages shown in Graph 5.7 and discussed in the text are calculated with respect to the total combinations of regions and sectors covered by the surveyed initiatives, which is different from the total number of articles included in the study. For example, an article referring to the construction of an early warning system for tropical hurricane risks by actors from the Caribbean and Central American countries is counted in both the region of small island states and Central and South America. Likewise, an article about a freshwater storage system for both human consumption and agricultural use is counted in both the urban and food sectors. For simplicity, throughout the discussion, the total number of articles is referred to instead of combinations of sectors and regions.

Graph 5.7
Adaptation initiatives to climate change by region and sector



Note: The graph displays the distribution of implemented adaptation initiatives in each region (percentage at the center of each ring chart) and, within these, the sectoral distribution (percentages in the ring charts). An initiative represents a combination of sector and region covered by the surveyed studies. The total number of initiatives is 3478.

Source: Authors using data from Berrang-Ford et al. (2021).

Most of the initiatives implemented in Central and South America seek to respond to the risks of drought and rainfall variability. An example of adaptation initiatives in the food sector in the region is the introduction of climate-smart agriculture practices and technologies for small farmers in Guatemala's dry corridor (Sain et al., 2017). Among these, the most widely adopted practices are conservation tillage (including no-till farming), agroforestry, crop rotation, and the adoption of stress-tolerant crops against water scarcity, high temperatures, and pests. An important finding is that these practices have a positive net present value.

Most of the initiatives implemented in Central and South America seek to respond to the risks of drought and rainfall variability

In the case of Andean countries, actions have been taken to address the reduced availability of freshwater resulting from the decline of the cryosphere. These initiatives include building water storage infrastructure and efficient water management in Chile, Ecuador, and Peru; changing cropping patterns in Bolivia; generating capacity for resource supervision and integrating a global glacier monitoring network in Colombia, Ecuador, and Peru; using drip irrigation in Chile; various policies promoting efficient water use in Chile and Ecuador; and regulating tourism activities in response to glacier retreat in Peru (Rasul et al., 2020). A distinctive feature of many of these initiatives is the participation of actors from private and public sectors alike. As expected, various levels of government, particularly subnational ones, have engaged in infrastructure placement and the establishment of regulations and institutions, while individuals and local communities play a vital role in policies for changing water consumption practices (Berrang-Ford et al., 2021).

In Caribbean countries, initiatives addressing risks related to extreme weather events stand out, including floods caused by storm surges associated with hurricanes and rising sea levels. Some of these initiatives involve the construction of protective infrastructure (such as seawalls to prevent coastal erosion along the southwest coast of Barbados and severe flooding in Georgetown, Guyana), early warning systems, risk mapping, and land-use zoning (Mycoo, 2018).

Central and South America, along with Africa, stand out for their high percentage of nature-based solutions (NbS). This type of adaptation strategy, also known as ecosystem-based adaptation or green infrastructure, encompasses diverse actions like restoring and conserving natural cover (forests, mangroves, grasslands, and wetlands), revitalizing riverbank and coastal ecosystems, sustainable agriculture practices, and urban green space development (for more on urban NbS potential, see Box 5.6). Besides facilitating adaptation to specific risks, NbS often yield multiple benefits, including mitigation through carbon capture, increased agricultural productivity, air and water purification, soil restoration, and biodiversity conservation. This partly explains why NbS are highly cost-effective adaptation alternatives.

Box 5.6
The Latin American and Caribbean Network of Biodivercities

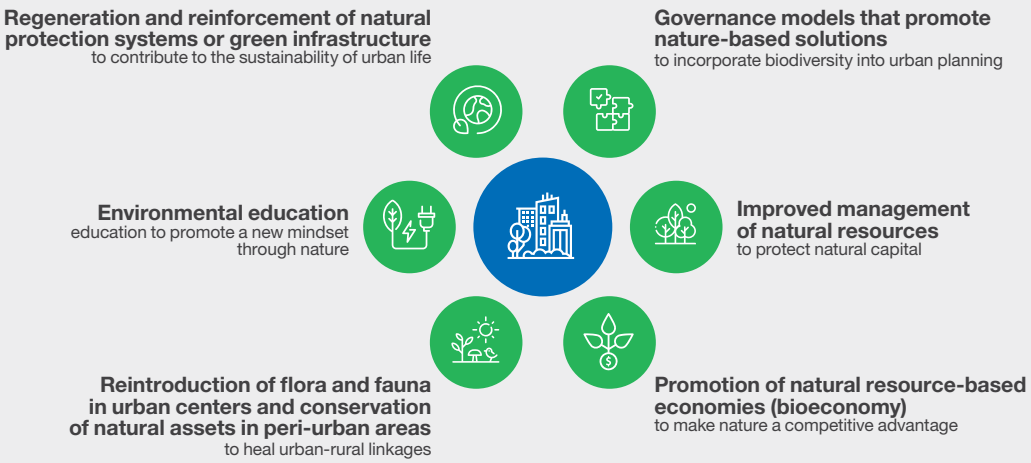
Cities serve as the primary engines of national development, hosting complex and value-added production processes, along with the greatest number of economic opportunities. However, urban growth also involves congestion costs, such as increased pollution levels, impacting the quality of life for inhabitants and the environment (Daude et al., 2017). Furthermore, climate change presents significant challenges for cities in terms of adapting to extreme weather events and contributing to GHG mitigation (see Chapter 1).

For cities, NbS represent a dual dividend tool: enhancing the quality of residents' lives (by, for example, reducing climate change adaptation challenges) and lessening their impact on the ecosystems they inhabit (see Chapter 3). Within this context, the term "biodivercity" refers to a city that effectively and holistically incorporates local and regional biodiversity into its urban planning and management for socio-economic development (Mejía Pimienta and Amaya Espinel, 2022).

In February 2021, CAF launched the Biodivercities Network initiative with the goal of creating a network of local governments advocating for a new urban management model in harmony with nature. The initiative proposes a comprehensive environmental approach in which cities work in harmony and balance with the ecosystems they are a part of, they benefit from the services and contributions nature provides and, simultaneously, return elements that strengthen it. The latter requires integrating a framework that includes biodiversity considerations into transportation, housing, water, and electricity systems within cities.

As of May 2023, 122 local governments from 17 countries in the region have joined this network.

Figure 1
Some examples of projects being carried out by Biodivercities



Source: Authors using data from Mejía Pimienta and Amaya Espinel (2022).

The adaptation agenda: Lessons learned and pending challenges

From the studies and initiatives undertaken in the realm of adaptation, significant lessons can be drawn, which also shed light on some of the challenges still facing the region. A noteworthy conclusion arising from the study by Berrang-Ford et al. (2021) is the limited evidence on the effectiveness of adaptation efforts: only 3.4% of the documents reviewed by the authors assessed the impacts in terms of reducing risk and vulnerability associated with referenced policies. Methodological challenges to assess risk reduction and attribute impacts to implemented policies are prominent among the reasons for this deficit. As for the findings, only half of those evaluations found that risks decreased.

Another pertinent conclusion is that coordination among various stakeholders is crucial in defining adaptation initiatives to minimize potential trade-offs and strengthen synergies. For instance, in the case of projects aimed at mitigating variability in water flows, actions taken upstream can adversely affect downstream communities (Rasul et al., 2020).

Lastly, supporting greater investment in NbS in the region can be an efficient way to address climate change risks while advancing other dimensions of sustainable development. For instance, mangroves, wetlands, and sandbanks serve as natural coastal barriers against storm surges. Their restoration and conservation not only reduce flood risks and control erosion but can also benefit local communities by generating employment, enhancing fishing resources, or promoting tourism (Browder et al., 2019).

●●

Evidence on the effectiveness of adaptation efforts is limited: only 3.4% of the documents reviewed assessed the impacts in terms of reducing risk and vulnerability associated with referenced policies

An adaptation strategy related to the above is investments in traditional (or grey) infrastructure, such as dams for water storage or jetties for coastal protection. This also includes investments to increase the resilience of existing infrastructure not designed to withstand the impacts of climate change, as seen in the energy sector across much of the region. When feasible, grey infrastructure investment can be integrated with NbS (or green infrastructure) to achieve more resilient, cost-effective, and higher-quality services (Browder et al., 2019).

Stopping deforestation and consolidating a sustainable agricultural sector

A second component of the environmental sustainability agenda is the reduction of GHG emissions. This primarily involves limiting deforestation, which, along with agricultural practices, is the main source of emissions in the region (58% of total emissions). Deforestation in Latin America and the Caribbean is mainly caused by changes in land use, i.e., converting forested areas into agricultural land.

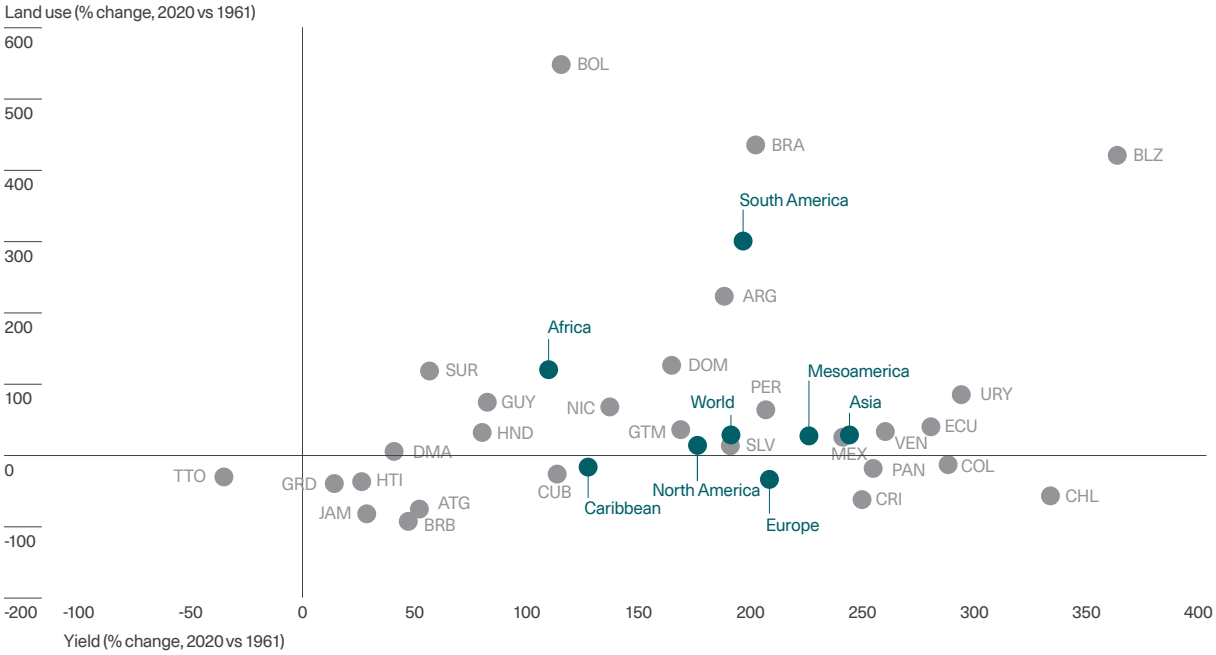
The agricultural sector is crucial for local and global food security and is an important source of foreign exchange in many countries in the region. However, deforestation simultaneously leads to the loss of highly valuable ecosystem services necessary for climate change adaptation, economic activities, and overall human well-being. This process even impacts other agricultural production as it reduces services such as pest control, natural pollinators, soil erosion prevention, and water cycle regulation.

Deforestation in Latin America and the Caribbean is mainly caused by land use changes that convert forest-covered areas to agriculture land

At present, deforestation is concentrated in tropical forests, most notably in the Amazon. This pattern is highly inefficient. Tropical forest soils tend to degrade rapidly after the loss of their natural cover, diminishing agricultural productivity. Furthermore, these forests are known for their biodiversity and their capacity to capture and store carbon. Internationally, concerns about the impact of agricultural product consumption on deforestation have led to trade barriers, such as those stipulated in the EU's new legislation on deforestation-free products.

The challenge of halting deforestation is thus closely linked to strengthening the sustainability of the region's agricultural sector, which, in turn, relates to growth and inclusion agendas. Two major avenues for action stand out in this regard. On the one hand, making a credible commitment to halting the expansion of agricultural frontiers. On the other, enhancing agricultural productivity and implementing sustainable practices within this sector.

Graph 5.8
Yield and land use for cereal and soybean production



Note: The graph shows the percentage change in yield (measured as metric tons per hectare) and land use in 2020 relative to 1961 for Latin American and Caribbean countries with available information and selected regions. Cereals include oats, rye, millet and sorghum. The FAO's definition of regions is used.

Source: FAO (2023; 2022b).

Most Latin American countries—and to a lesser extent those in the Caribbean—have made significant strides in improving agricultural productivity. Productivity improvements are necessary for building a sustainable sector that can provide food for the region and the world (a growing challenge due to climate change itself), but they are insufficient to halt deforestation. As seen in Graph 5.8, productivity growth has been accompanied by a considerable increase in the agricultural production area, particularly in South America.

Halting deforestation is challenging because, from a private perspective, it is economically profitable. For landowners with forested land, conservation is often less profitable than converting the land for agricultural purposes, especially when it involves illegal deforestation and occupation of public lands. Weak rule of law and lack of institutional capacity of agencies responsible for monitoring and enforcing environmental regulations play a significant role in this process.

Most governments in the region have passed legislation that severely restricts deforestation on both public and private lands. Consequently, much of the deforestation currently taking place is illegal (Ferreira, 2023). These measures contrast with prevalent economic development policies prevalent since the mid-20th century, which incentivized deforestation through infrastructure projects, credit programs, and weakening property rights on public and indigenous lands (facilitating their invasion and use by private producers).

Chapter 2 analyzed various sustainable agricultural techniques that promise a triple dividend: increased productivity, reduced emissions, and climate change adaptation. Prioritizing solutions to information and credit access challenges that limit their implementation is critical. Likewise, reforming production subsidies (typically energy-related, but also for other inputs like fertilizers) is necessary to remove distortions causing overexploitation of natural resources in the agricultural and fishing sectors. However, some subsidies may cover a significant portion of the low-income population, so eliminating them could have negative effects on poverty. An alternative is decoupling subsidies from social assistance, substituting production-linked subsidies with direct transfers to low-income households. Other subsidies address market failures inhibiting growth (e.g., incomplete credit markets). In such cases, an option is to condition subsidy access on compliance with environmental safeguards.

The fight against deforestation should be part of a broader strategy against ecosystem degradation and biodiversity loss in Latin America and the Caribbean. The path to sustainable development and well-being for future generations requires protecting natural capital. In addition to negatively affecting long-term economic growth, its loss also impacts social inclusion. Lower-income communities, such as rural and indigenous ones, often rely most directly on the services provided by nature in their surroundings.

Challenges of the energy transition in Latin America and the Caribbean

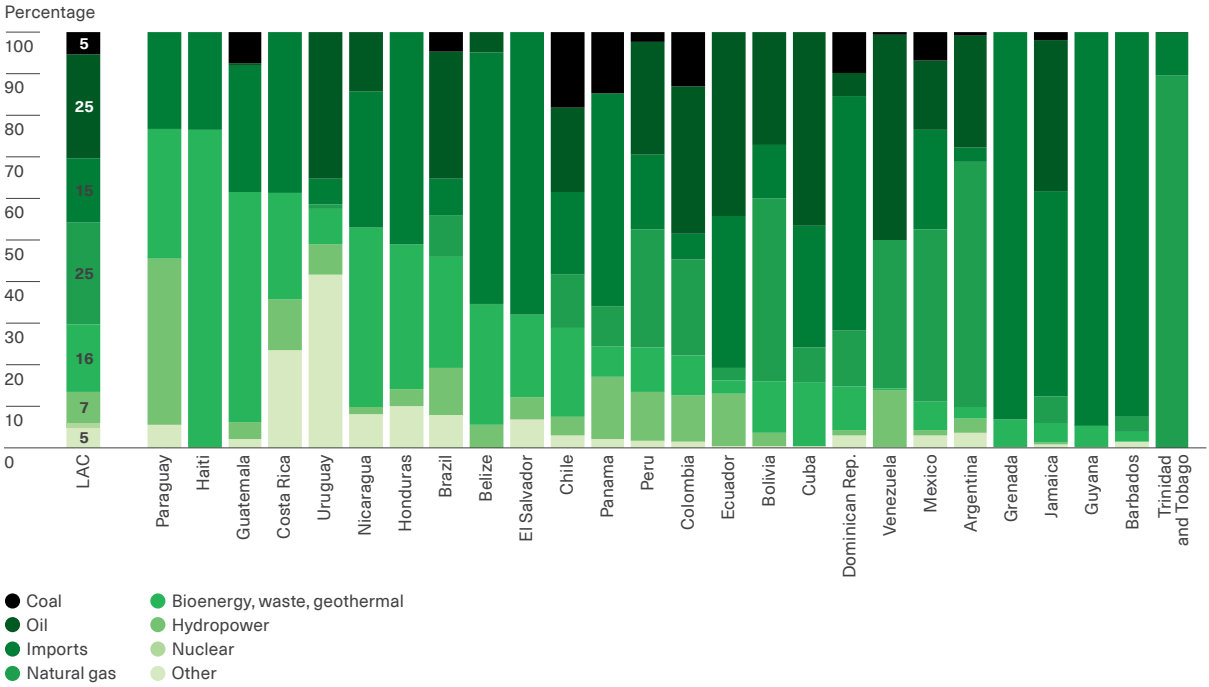
Around 40% of the region's GHG emissions stem from sectors related to fossil fuel production and consumption (electricity generation, transportation, industry, and buildings). Thus, the region must also advance in the energy transition process. Currently, 55% of the region's energy matrix uses fossil fuels.

As a priority, efforts should focus on reducing coal and oil consumption, which still account for 30% of Latin America and the Caribbean's energy matrix. Although natural gas is a fossil fuel, its CO_2 emissions are much lower than those generated by other fossil energy sources.

The reduction of coal and oil consumption will pose considerable challenges to production, investment, employment, fiscal revenues, external accounts, and the stock of wealth of the region's economies. These challenges will not be evenly distributed among different economies due to disparities in each country's energy matrix. As shown in Graph 5.9, oil and imports of petroleum derivatives represent a significant portion of the energy supply in most countries, with Argentina, Paraguay, Uruguay, and some Central American countries (Costa Rica, Guatemala, Honduras, and Nicaragua) being the main exceptions. Notably, Chile, Colombia, Panama, and the Dominican Republic still rely on coal for a substantial part of their energy mix.

Reducing the use of coal and oil will pose considerable challenges for production, investment, employment, fiscal revenues, external accounts, and the stock of wealth of the region's economies

Graph 5.9
Relative composition of primary energy supply by source and by country in 2020

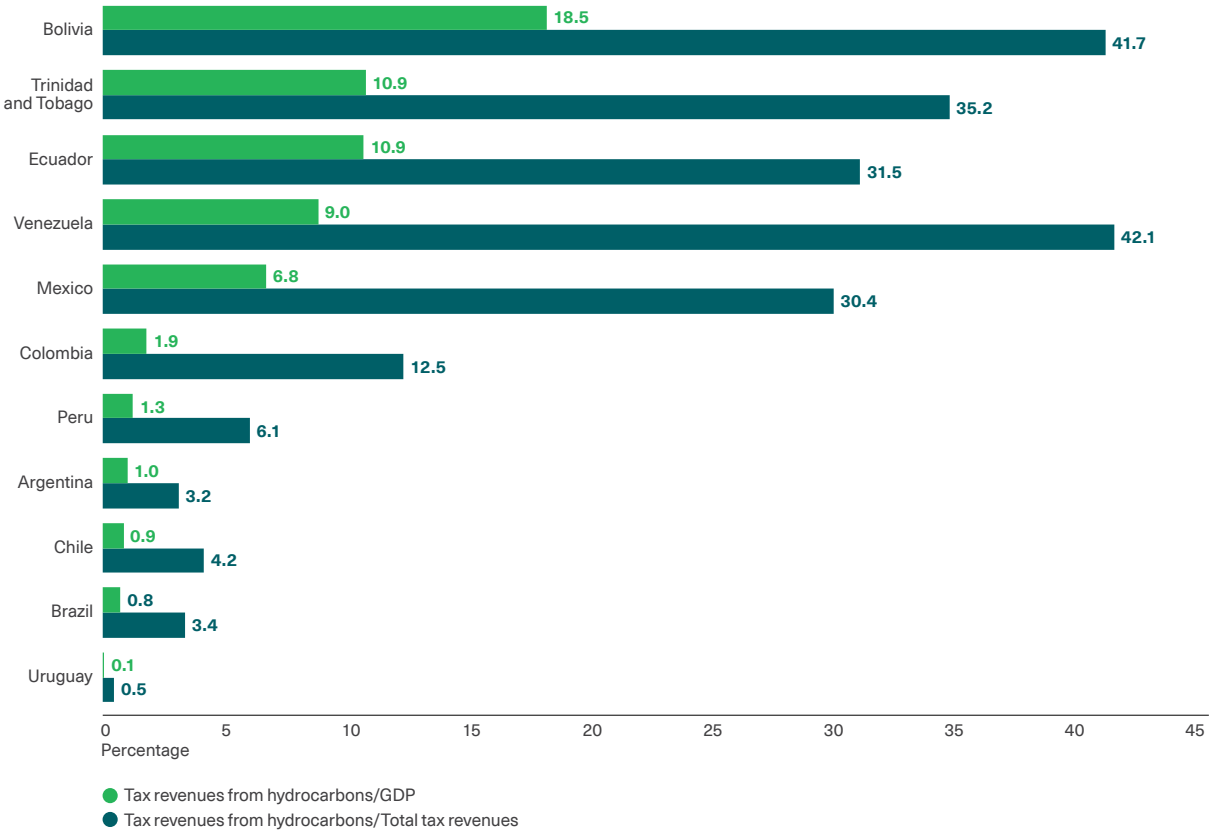


Note: The graph displays the total primary energy supply (production + imports - exports + inventory changes - unutilized) plus net imports of secondary energy (electricity, liquefied petroleum gas, gasoline/alcohol, kerosene/jet fuel, diesel oil, fuel oil, coke, charcoal, gases, other secondary energy sources) by source and country. The component of secondary energy imports generally consists of petroleum derivatives that have undergone a transformation process. Bioenergy and waste refer to the "firewood, sugarcane, and derivatives" category. The "other" category includes biogas, organic waste solar, and wind energy. ALC refers to the simple average of the countries included in the graph. Countries are ordered in increasing order based on the share of natural gas, imports, oil, and coal.

Source: Cont et al. (2022).

Transitioning to renewable energy sources in each country and the global decrease in hydrocarbon demand will impact the fiscal revenues of oil and gas-producing countries. These countries typically receive a significant portion of their revenue from oil and gas production through mechanisms such as state ownership, royalties, taxes, and concession fees. Graph 5.10 shows that countries like Bolivia, Trinidad and Tobago, Ecuador, Venezuela, and Mexico receive substantial fiscal revenues (between 7 and 18 percentage points of GDP) from oil and gas production. Colombia and Peru also rely heavily on these revenues as a proportion of their total fiscal revenues. The decrease in these revenues will generally lead to the need to reduce public spending. This reduction could be mitigated by increased fiscal revenues from new renewable energy sources (or by new taxes on other sectors). However, fiscal revenues from renewables are typically lower due to initial subsidies or deductions and the fact that they do not rely on the exploitation of a natural resource, such as an oil field, which are generally state-owned in Latin America and the Caribbean.

Graph 5.10
Importance of hydrocarbon tax revenues for public accounts



Note: The graph illustrates countries' economic and fiscal exposure, measured by the average percentage for the period 2005-2019 that hydrocarbon tax revenues represent in relation to GDP and total revenues.

Source: Cont et al. (2022).

One way to counteract these negative fiscal impacts is to reduce or eliminate the energy subsidies that often exist in Latin America and the Caribbean, as shown in Chapter 2. Energy subsidies can take various forms, including reductions in the fuel cost for transportation, tariffs applied to high-emission transportation modes, electricity or gas prices, or direct subsidies to state-owned fossil fuel companies (e.g., coal). In some cases, the amount of these subsidies is so significant that their financing has macroeconomic impacts. By directly or indirectly lowering the final price for consumers, these subsidies increase consumption, which is counterproductive for carbon emissions mitigation. Their reduction could allow for simultaneous decreases in fiscal expenses and carbon emissions.

However, reducing energy subsidies can have significant redistributive impacts. In fact, in many countries in the region, the persistence of subsidies is mainly due to the fact that attempts to reduce them have been extremely socially contentious, as seen in Chile, Colombia, and Ecuador. Similar to production subsidies, at least subsidies implemented through price reductions—which induce consumption increases and often suffer from imprecise targeting, benefiting groups that don't necessarily need them—should be eliminated and replaced with lump-sum transfers to lower-income households, aiming to decouple distorting incentives from social assistance.

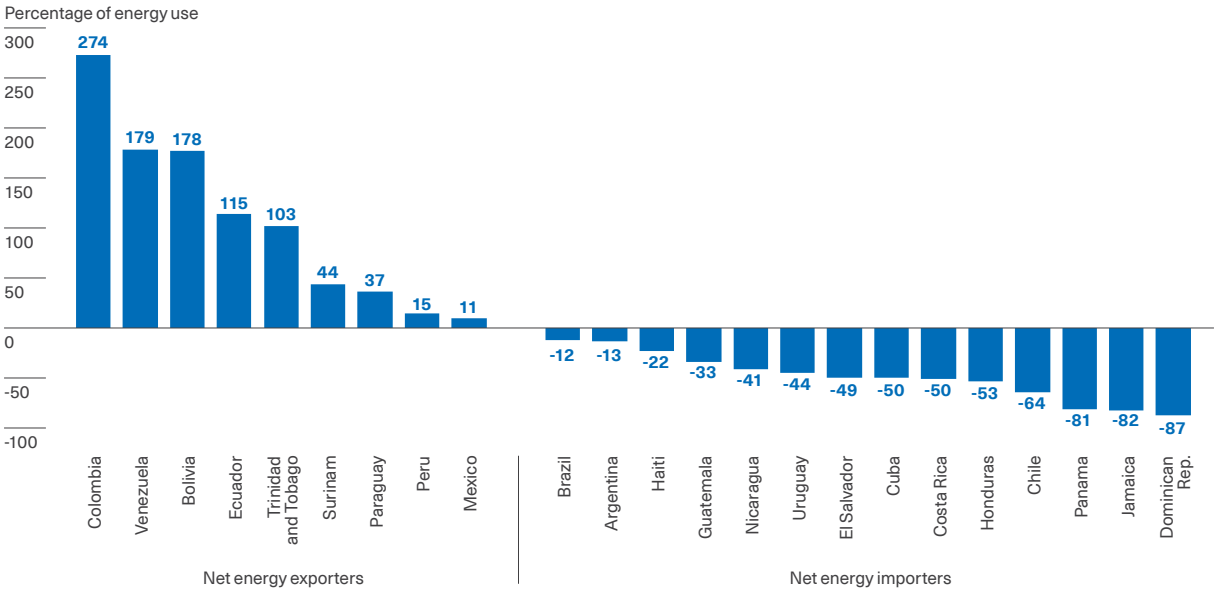
The energy transition can also have a significant impact on external accounts. As shown in Graph 5.11, several countries in the region, such as Bolivia, Colombia, Ecuador, Mexico, Peru, Suriname, Trinidad and Tobago, and Venezuela, are net energy exporters. Except for Paraguay, which exports excess electricity from its binational dams, the rest of the countries primarily export hydrocarbons. The reduction in these exports will have a direct impact on their foreign exchange availability, as fuel exports represent a significant proportion of total goods exports in several countries in the region (World Bank, 2023c).

As Graph 5.11 also illustrates, other countries in the region, such as Chile, Uruguay, and some Central American and Caribbean nations (Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Nicaragua, Panama, and the Dominican Republic), are net energy importers. Since, as mentioned earlier, this energy transition process is not guided by market forces incorporating lower-cost energy technologies but by the goal of emissions reduction, at least in the short term, those countries seeking to clean their energy matrix will have to allocate more resources to replace hydrocarbon imports with higher-cost alternatives.[14] Moreover, countries that are net fossil fuel importers will have to make substantial infrastructure investments to accommodate the shift from hydrocarbon imports to renewable energy production or imports.

In addition to these direct effects on fossil fuel exports and imports, the imposition of tariffs or other restrictions on international trade in developed countries based on carbon content (such as CBAM, explained earlier) may affect exports of other products from the region. While Conte Grand et al. (2023) find that the use of CBAM would initially have a moderate effect on exports from Latin America and the Caribbean, since tariffs are currently only being considered on a narrow set of industrial products (see Chapter 4), a fall in exports for these direct or indirect reasons will likely require adjustments in real exchange rates and import levels.

14 The effects of the global energy transition could be ambiguous for hydrocarbon-importing countries that choose to continue to do so, as they could benefit from continuing to import a product whose relative price could fall if global demand falls more than supply.

Graph 5.11
Net energy exports in 2014



Note: Net energy exports are calculated by subtracting energy use from production, both measured in oil equivalents. A positive value implies that the country is a net energy exporter, whereas a negative value indicates it is a net energy importer. Energy use refers to the use of primary energy before its conversion into other end-use fuels. This encompasses national production, imports, and stocks changes, minus exports and fuels supplied to ships and aircraft engaged in international transportation. Data for Venezuela is from 2013.

Source: World Bank (2023e).

The imposition of tariffs or other restrictions on international trade in developed countries based on carbon content may affect exports of other products from the region

The energy transition could also trigger a race, both globally and in the region, to accelerate the exploitation of reserves and the amortization of assets so they do not become stranded assets. The temporal dimension is key. On the one hand, there is an ongoing process of cost reduction for alternative energy sources. This process can eventually render fossil fuels obsolete simply because they have higher production costs. However, these resources can also become obsolete due to usage restrictions, even if they are economically viable. The expected drop in future demand can create incentives for the accelerated exploitation of hydrocarbon deposits (and other specific assets such as gas pipelines, oil pipelines, and refineries) to prevent that wealth from being permanently wasted. However, this accelerated exploitation will, in turn, generate more emissions in the short term. The shorter time horizon can also induce lower levels of investment and maintenance in these assets.

This process of accelerated obsolescence will also affect workers with specialized human capital in the hydrocarbon sector, who will see the reduction and closure of their activities. Of course, there will be, in turn, other sectors expanding in renewable energy production, but this process is likely to have redistributive effects on specific human capital. As illustrated by Blanchard et al. (2022), the skills of a

miner do not easily transfer to those of a windmill technician. The labor market may undergo costly and heterogeneous transformations due to the displacement of workers from high-emission sectors, the difficulty of relocating them to green sectors requiring different skills, and the different geographical location of resources (ECLAC et al., 2022).

Additionally, the use of carbon taxes and emissions permits or the implementation of stricter regulations and prohibitions to protect the environment and biodiversity can exacerbate the incentives for informality that already exist in the region. One of the characteristic features of underdevelopment in Latin America and the Caribbean is its high levels of informality. The introduction of taxes and regulations, which entail costs and controls whose compliance is always higher in the formal sector than in the informal one, may not only be ineffective but may also provide, counterproductively, an economic incentive to migrate to the informal sector or remain in it.[15]

The energy transition will have distributional effects among localities, economic sectors, and employees

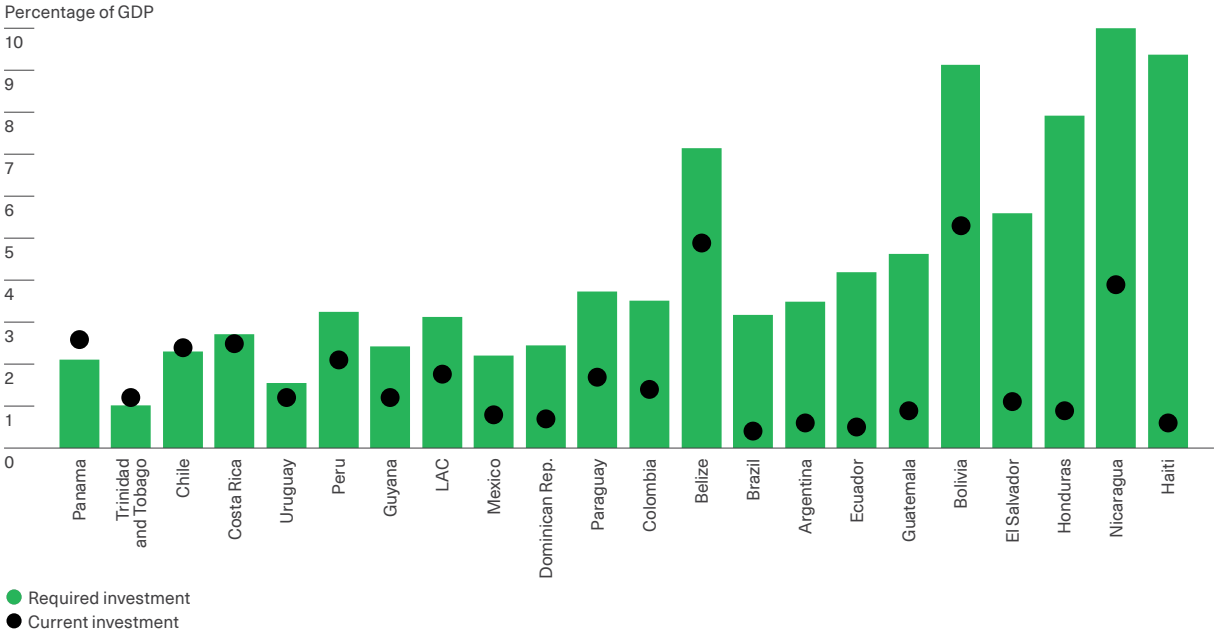
Financing challenges

Adaptation and mitigation efforts in the face of climate change, including the energy transition, will entail additional investment needs on top of existing ones. Although estimates made so far are subject to a high degree of uncertainty, they all point to the same outlook: the required investment effort will be enormous. Rozenberg and Fay (2019) calculate that Latin America and the Caribbean will need to make supplementary investments equivalent to 4.3% of GDP per year to develop and maintain new infrastructure in the energy, flood protection, irrigation, transportation, and water supply and sanitation sectors that will enable the region to achieve the SDGs and attempt to limit the temperature increase to 2°C. Graph 5.12 presents the infrastructure gaps for each country, contrasting current investment levels with the estimated annual investment effort needed to meet the SDGs related to infrastructure services. In addition to these gaps, further investment needs arise because part of the existing infrastructure is not resilient to the effects of climate change. These gaps indicate strong future investment needs.

Additional investment needs are even greater if, instead of being estimated to achieve the SDGs, the goal is compliance with the NDCs. Chapter 4 detailed the financing requirements declared by some Latin America and the Caribbean countries necessary to fulfill their NDCs. This analysis also broke down these needs into investment objectives for both mitigation and adaptation efforts, in the cases for which data was accessible. These additional financing needs amount to 7% of the countries' GDP on average, of which more than 75% corresponds to mitigation financing. Graph 5.13 shows estimated annual investment ranges of around 9% of GDP for the larger countries in the region (except Mexico) to meet their NDCs.

15 Levy (2009) shows how levels of informality respond to incentives. Higher taxes and regulations, typically controllable only in the formal sector, can end up inducing greater informality.

Graph 5.12
Gap between current infrastructure investment and investment needed to meet the SDGs in the period 2019-2030



Note: The data refer to the annual investment effort as a percentage of each country's GDP required to make progress toward the SDGs. The study considers only SDGs 6, 7, 9, and 11, and thus excludes complementary investments required to achieve all SDGs related to climate change. Infrastructure needs are calculated as the total investment over GDP for the period 2019-2030 in millions of constant dollars. Required investments encompass new infrastructure, maintenance, and asset replacement. The included sectors are electricity, water and sanitation, telecommunications, and transportation. Current investment represents the average of public and private infrastructure investment between 2008 and 2019. Countries are ranked based on the size of their gap.

Source: Authors using data from Brichetti et al. (2021)..

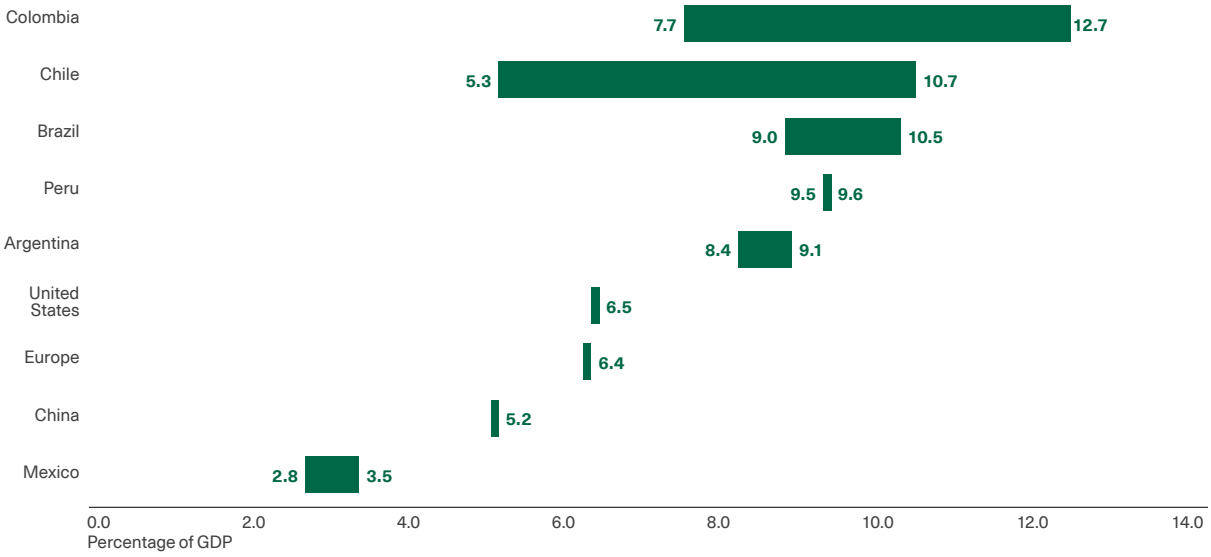
Beyond the uncertainty surrounding these estimates, these additional needs will undoubtedly represent an immense challenge in a region where savings and investment rates are traditionally low, and where significant infrastructure deficits already exist. Since most countries are not in a position to add these additional costs to their other needs, external financing—from multilateral organizations, the private sector, and other governments—will be essential. Furthermore, the low levels of historical emissions in Latin America and the Caribbean justify that this financing effort be shared with developed economies.

Moreover, a significant portion of this financing should be concessional. Latin American and Caribbean countries must undertake mitigation efforts collectively and seek a fair distribution of the cost of these efforts in international forums. On the other hand, given that each country tends to internalize most of the benefits of its adaptation investments, developing countries should prioritize their resources for these types of investments .

In Latin America, an average person from the top 10% of the population emits nearly nine times more each year than a person from the poorest 50%

The climate justice debate is not only relevant on an international scale but also on a national level. The poorest households contribute the least to global warming. In Latin America, an average person from the top 10% of the population emits nearly nine times more each year than a person from the poorest 50% (Chancel et al., 2022). As poorer households tend to spend a larger portion of their income on energy expenditures (Blanchard et al., 2022), an increase in prices as a result of the energy transition may reinforce existing inequalities and decrease social support for this process. Therefore, it is important to consider compensations schemes that allow progress in emissions mitigation without aggravating existing inequalities. Furthermore, the poorest households, mainly due to their location, are often more affected by climate risks. Investment allocation should therefore consider climate justice in distributive terms within each country, taking into account which labor and social sectors and locations are most affected by these phenomena.

Graph 5.13
Required annual spending to achieve nationally determined contribution (NDC) goals



Notes: The bars in the graph represent estimated annual investment ranges corresponding to the period 2020-2050 for each country or region.

Source: Cardenas and Orozco (2022) based on REMIND-MAgPIE and MESSAGEix-GLOBIOM models, using emission reduction costs calculated by McKinsey & Company. (Krishnan et al., 2022)..

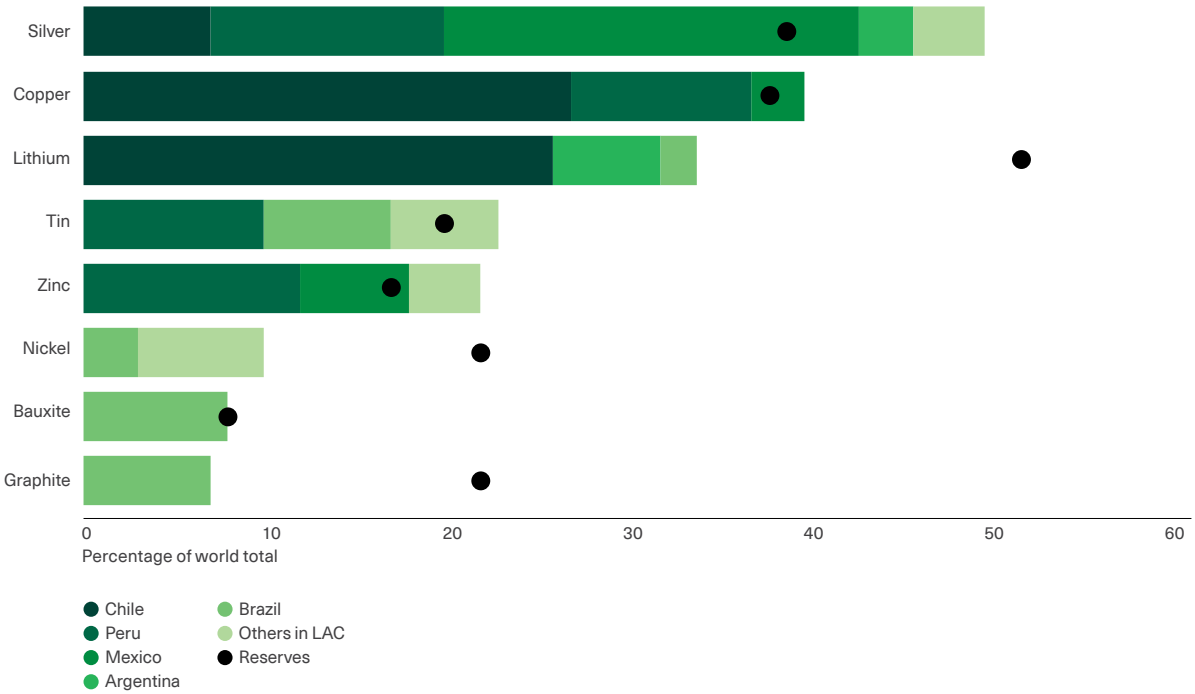
Opportunities of the energy transition and climate change response

As previously explained, the energy transition and environmental protection will bring significant challenges for Latin America and the Caribbean. However, this very process can open up opportunities to harness the region's resources and competitive advantages.

First, the electrification process will lead to a massive increase in demand for minerals crucial for the energy transition, in which the region is rich. The increase in demand for these products has already begun, as evidenced by the rise in their international prices. For instance, the price of copper has increased by over 50%, and lithium by more than 250% since late 2019.

Graph 5.14 illustrates the region's significant share in global production and reserves of silver, copper, lithium, and other critical minerals. Alternative estimates also indicate that Chile and Peru are two of the world's top three countries with the largest proven copper reserves, while Argentina, Bolivia, and Chile exhibit substantial potential for lithium production (USGS, 2023).

Graph 5.14
Latin America's share of production and reserves of selected minerals in 2021



Note: The graph refers to the production (in bars) and reserves (dots) of the different minerals in the countries of the region. Bolivia is not included in the graph, since it has lithium resources, but no reserves. Resources are the total estimate of the quantity of a geological asset. Reserves are the subset of a resource that has been discovered, has a known size and can be extracted at a profit.

Source: IEA (2023).

The exploitation of these minerals can represent a significant contribution from the region to the global energy transition process, as well as an important source of resources. However, to achieve this, a proper balance must be struck so that mining is carried out under regulations and standards that protect the environment and ensure that local communities are the primary beneficiaries, thus preventing environmental degradation, a decline in their living conditions, and the emergence of conflicts that could deter investments. These mineral resources can also provide valuable

opportunities for the creation of skilled jobs and for the location in the region of industrial processes along the lithium and copper value chains, beyond mere extraction.

The exploitation of these minerals can represent a large contribution of the region to the global energy transition process, as well as an important source of resources

A second opportunity lies in the exploitation of natural gas as a transitional fuel.[16] As Chapter 2 showed, Latin America and the Caribbean is a region rich in natural gas, primarily due to significant deposits in Argentina, Brazil, Peru, Trinidad and Tobago, and, above all, Venezuela. Substituting coal with natural gas reduces CO_2 emissions by 50% in electricity generation and 33% in heat production (IEA, 2019). Regarding diesel or fuel oil, the reduction percentage is approximately 30% in both cases (EIA, 2022).[17] Natural gas is also less polluting than firewood when used for heating and cooking[18] and less so than diesel in transportation (lower NOx and SOx emissions), which can reduce air pollution in densely populated urban areas. It is also less polluting than heavy oils in industrial processes (lower SO2 emissions), including fertilizer production (Schmidt-Hebbel et al., 2020; OLADE 2023).

Given its abundance in the region, as well as its relatively lower emissions, natural gas can serve as a valuable "bridge" during the energy transition process, providing fiscal resources from its exploitation and preventing them from becoming stranded assets. This can be particularly important in a context where global energy demand is expected to increase, without renewable energies being mature enough to close that gap. In such a case, natural gas can help support the growth in demand without increasing the use of coal and oil.

The region's abundant natural gas reserves can serve as a bridge during the energy transition

In the short term, natural gas could facilitate the decarbonization of certain sectors in the region that are more challenging to decarbonize, such as transportation, especially in countries where the use of compressed natural gas as a vehicular fuel is more widespread (e.g., Argentina, Brazil, Colombia, and Peru) (González et al., 2023). A successful case in the region is the replacement of diesel buses with compressed natural gas-powered units in Bogotá's Bus Rapid Transit system, which not only reduced GHG emissions but also significantly decreased travelers' exposure to air pollution (see Box 5.7).

16 In 2022, natural gas was included within the taxonomy of green energies by the European Commission (2022b); Fabra and Reguant (2023).

17 However, natural gas can be a source of methane emissions if gas venting and losses in its production and transportation are not controlled. While some countries in the region, such as Argentina and Colombia, have managed to control the flaring and venting of natural gas, Venezuela is the largest emitter of energy-related methane in the region and one of the world's largest contributors (Cont et al., 2022).

18 The expansion of the natural gas network for household use (cooking and heating) can offer additional benefits to low-income sectors, including cost reduction and decreased health risks compared to other alternatives currently in use, such as fossil fuels, firewood, or gas cylinders.

Box 5.7
Passenger transportation and air pollution: Natural gas as an alternative fuel in Bogotá's TransMilenio

Air pollution is one of the leading causes of premature death and a wide range of respiratory, oncological, cardiovascular, and cerebrovascular diseases. One of the atmospheric pollutants with the most significant negative impacts on health is fine particulate matter (PM 2.5). Forty percent of cities in Latin America and the Caribbean have an average PM 2.5 concentration that exceeds the recommended limit set by the World Health Organization (Gouveia et al., 2019).

Combustion-based transportation is one of the primary contributors to poor air quality in cities. Therefore, policies promoting the use of low-emission vehicles and fuels, in addition to contributing to GHG emission reduction, can have health benefits for the population.

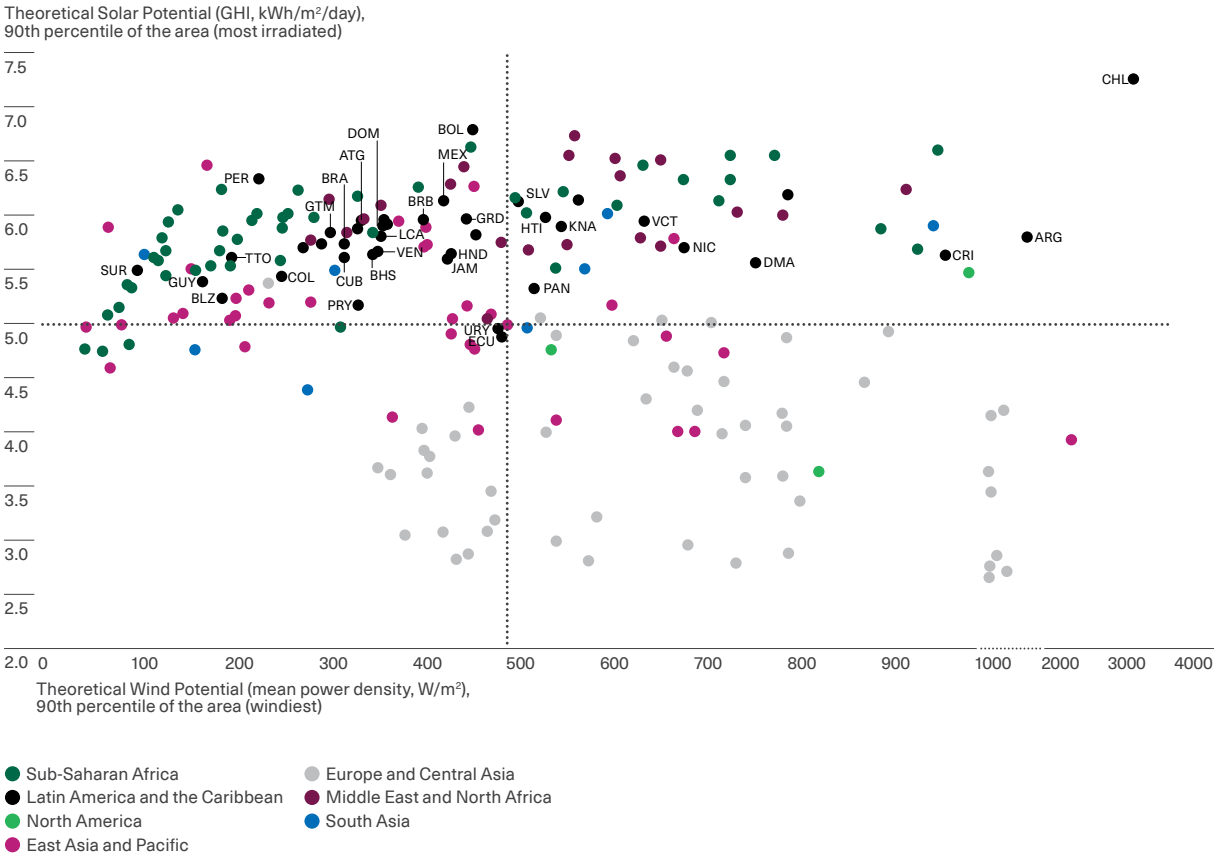
One such policy was the overhaul of the TransMilenio fleet in Bogotá between 2019 and 2020. It involved replacing over 1,000 diesel buses with compressed natural gas-powered units equipped with emission filters.

According to a study by Morales Betancourt et al. (2022), this renewal of the TransMilenio fleet significantly reduced passengers' exposure to air pollution inside the buses and at passenger stations. The concentration of PM 2.5 in the air decreased by 78%, and soot (another highly harmful particulate matter for health) decreased by 80%. This policy benefited to a greater degree Bogotá's lower-income population, which relies most on public transportation and has longer travel times (Guzman et al., 2023).

A third opportunity for Latin America and the Caribbean arises from the region's favorable conditions for adopting renewable energy sources. On one hand, while the region's hydropower potential already meets half of its electricity needs, it is estimated that only about 20% to 25% of its total potential has been developed (Uribe, 2017). In addition to its hydroelectric potential, regional geography provides major competitive advantages for solar and wind energy production. Graph 5.15 illustrates how nearly all countries in the region have above-average solar energy generation potential compared to the global average, with approximately one-third of the countries surpassing the global average for wind power generation. Furthermore, Argentina and Chile are among the few countries globally with high potential in both solar and wind energy simultaneously. It is also worth noting the substantial geothermal generation potential in Central America and the Caribbean (IRENA, 2022a). While they require substantial investments, the development of these technologies could not only decarbonize the region's energy matrix but also generate exportable surpluses.

In addition to its hydroelectric potential, the region's geography provides major competitive advantages for solar and wind energy production

Graph 5.15
Theoretical potential in solar and wind energy



Source: Authors using Solargis (2023) and DTU (2023).

However, it is essential to highlight that Graph 5.15 merely represents theoretically available energy potential without weighing any constraints. While estimating the true capacity is challenging due to multiple factors involved in the calculation, the Energy Sector Management Assistance Program (ESMAP, 2020) has assessed the practical or technical potential for solar energy, incorporating real-world photovoltaic system performance and configuration, as well as topographical and land-use limitations. The results once again appear promising for the region. The Puna region (northwest Argentina, Bolivia, northern Chile, and southern Peru) boasts the world's highest practical potential for solar photovoltaic energy. In absolute terms, this potential is 15% to 20% higher than in other regions with similar theoretical potentials, such as North Africa or the Arabian Peninsula. This is due to a unique combination of factors like persistent clear skies, clean air, low air temperatures, and high altitudes. At the same time, the rest of Latin America, except for Ecuador, falls within a moderately favorable range (ESMAP, 2020).

The electrification process resulting from the energy transition can benefit the region not only through the exploitation of critical minerals, gas, and renewable energy sources but also by potentially altering the global geographic location of production processes. Presently, there are relatively economical ways to transport oil and its derivatives between countries and continents. However, as previously explained, the cost of transporting electricity per unit of energy is over ten times higher than that of natural gas and more than twenty times higher than liquid fuels. This increased transportation cost may lead to a less "flat" energy world, where regions with conditions for clean energy generation see their comparative advantages grow in attracting energy-intensive industries (e.g., fertilizers, steel, aluminum, chemicals, and cement) (Hausmann, 2021). This lower energy cost, combined with other post-COVID-19 trends of relocating production to nearby and friendly regions (known as nearshoring and friendshoring), could facilitate investment and production localization in Latin America, in a process of decentralization toward countries offering clean, cheap, and secure energy (powershoring). The region's abundant, albeit unevenly distributed, water availability (see Chapter 1) can complement these comparative advantages for the location of certain production processes.

Lastly, the global environmental and biodiversity protection process itself can create new economic opportunities for the region. One of these opportunities stems from the region's comparative advantage in reducing carbon emissions at a lower cost. The region's biggest emission sources—agriculture and land-use change—are also the sectors with the greatest opportunities for low-cost mitigation at the global level. Thus, the widespread adoption of carbon taxes, relevant in developed countries, combined with international carbon credit markets, could favor the export of environmental services from Latin America and the Caribbean due to its comparative advantage in mitigation costs. The challenges to realizing these opportunities are not insignificant. The integration of forest carbon offsets into voluntary and regulated carbon credit markets has been limited, as forest projects have historically faced difficulties in demonstrating additionality, ensuring permanence, and preventing carbon leakage. If the international institutional framework discussed in Chapter 4 were to develop, the region could monetize its carbon capture and biodiversity protection services provided to the world. A similar international institutional framework could also compensate the region for its significant biodiversity preservation services. There are also new opportunities related to biotrade, understood as a set of productive activities committed to biodiversity conservation and social inclusion, in ecotourism, food, cosmetics, and pharmaceuticals sectors (Vignati and Gómez-García Palao, 2014).

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The region can export carbon capture and diversity protection services

Policy priorities for a sustainable development agenda in Latin American and Caribbean

Latin America and the Caribbean has not yet overcome the challenges of low economic growth and high inequality. To this pending development agenda, the region must add the challenges of mitigating emissions, adapting to climate change, and preserving biodiversity and its natural capital. As discussed in detail in the previous section, there are trade-offs between these new and longstanding challenges, either because scarce resources must be allocated among growing needs or because progress in one dimension implies setbacks in others. Furthermore, some interventions can harness synergies that enable simultaneous progress toward these various objectives.

This final section summarizes a non-exhaustive set of public policies with the specific objectives of adapting to climate change, mitigating emissions, protecting ecosystem and biodiversity, and seizing the opportunities arising from these processes, taking into account their interactions with the pending challenges of economic growth and social inclusion in the region.

Prioritizing adaptation policies

The costs to the well-being of the population associated with the current and expected impacts of climate change in the region justify prioritizing resource allocation for adaptation purposes. As discussed throughout this chapter, adaptation needs vary in nature and respond to specific contexts. One task for countries is to identify these needs and design the most suitable response strategies for each case. Part of this task is reflected in the NDCs and NAPs, but the analysis of these documents suggests a need to deepen the generation of knowledge to select the best portfolio of projects and specific measures to address adaptation needs. This is a necessary requirement to define the costs of adaptation and resulting financing needs with greater precision.

Climate adaptation has positive synergies with the components of economic growth and social inclusion in the development agenda. On one hand, adaptation policies help prevent losses; for example, early warning of a heat wave can save lives. On the other they have economic benefits due to risk reduction—for instance, building flood prevention infrastructure can increase the value of previously flood-prone land—or technological innovation—for example, introducing drip irrigation to combat water scarcity can simultaneously enhance agricultural productivity. They can also have social and environmental benefits, such as protecting natural resources that provide valuable ecosystem services (Global Commission on Adaptation, 2019).

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Climate adaptation has a triple dividend: it mitigates future losses; it reduces risks and drives innovation; and it creates social and environmental benefits

The overview of adaptation initiatives implemented in Latin America and the Caribbean, based on studies published in academic journals, shows that most policies focus on the food production and livelihoods and health sectors and emerge as responses to risks of droughts, floods, and other extreme weather events (Berrang-Ford et al., 2021).

Four groups of policies stand out. The first group comprises **sustainable agriculture practices**, which are cost-effective alternatives in response to rising temperatures, increased aridity, and changes in precipitation patterns. Challenges to promoting greater adoption of these practices in the region include financing shortages (some of these practices have a short repayment period, but others require more time) and a lack of information on their profitability (see Chapter 2).

The second group is **nature-based solutions (NbS)** which, as previously discussed, tend to be cost-effective strategies. The region, along with Africa, has the highest proportion of nature-based adaptation initiatives, although evidence suggests room for an increase in their use (Browder et al., 2019).

The third group of policies involves **investments in adaptation infrastructure**, including increasing the resilience of existing infrastructure. Notably, this includes infrastructure for water resource management, both for agricultural purposes and domestic consumption, and for hydropower generation. An important aspect in designing these interventions is coordination among stakeholders to avoid trade-offs between alternative uses of resources.

The fourth group consists of **disaster risk management policies**, including early warning systems and other information provision mechanisms, one of the most cost-effective adaptation options (Global Commission on Adaptation, 2019).

The main challenges to advance the region's adaptation agenda are financing and the generation of more evidence on the effectiveness of interventions. This would not only provide insights for improving resource management but also serve as a key element in mobilizing more financial resources for these purposes. An additional challenge is strengthening the capacities of the public sector for risk assessments and policy design.

Contributing to global mitigation

The world faces the challenge of reducing global emissions to levels that will help contain temperature increases in line with the goals set in the Paris Agreement. As part of this global effort, Latin America and the Caribbean has committed to reducing their emissions by 10% by 2030 compared to 2015 levels, a target that is likely to become more ambitious in the upcoming revision of commitments.

The region's contribution to global mitigation includes two central policy decisions: how to distribute mitigation efforts among sectors and in what sequence. How this is done is crucial because, as already discussed, synergies with the rest of the challenges of the region's development agenda arise in the decarbonization of the economy but so do trade-offs. The sequence is also key to prevent significant resources from becoming stranded assets. Countries must move at their own pace, considering a menu of policy alternatives that reduce emissions without neglecting their impact on other development goals. The menu should take into account the sectoral composition of emissions, the socio-economic importance of emissions-generating activities, the region's comparative advantages in low-carbon technologies, and global trends determining the evolution of the costs of these technologies.

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The region's contribution to global mitigation includes two central policy decisions: how to distribute mitigation efforts among sectors and in what sequence

Fifty-eight percent of the region's GHG emissions come from the agriculture, forestry, and other land uses (AFOLU) sector, which is in stark contrast to developed countries where this sector accounts for only 8% of emissions. This means that the region's decarbonization strategy must be significantly different from that of the developed world. Furthermore, two-thirds of emissions from the AFOLU sector primarily result from deforestation. Therefore, **controlling deforestation** must be a priority in the region. In addition to using real-time monitoring technologies, increasing sanctions for non-compliance, and strengthening the budget and capacity of enforcement bodies, it is important to introduce financial incentives, such as Payment for Ecosystem Services (PSE) programs. Halting the expansion of the agricultural frontier will, of course, come at a cost in terms of agricultural production, but this cost will be lower in the cases where deforestation is directed toward low-productivity activities.

Beyond the priority of controlling deforestation, the **large-scale development of renewable energy sources** (hydro, solar, wind, etc.) should be part of the long-term strategy for emissions reduction and energy transition. As discussed in the previous section, the region has significant geographical advantages for the development of these renewable energies. However, these projects require large capital investments, and in Latin American and Caribbean economies, savings are low, and financial costs are high. While these developments can attract private investments and create jobs, they may likely have a crowding-out effect on other investments and require fiscal incentives.

On the other hand, **the use of small-scale solar and wind energy sources** can be a cost-effective way to reach isolated areas in the vast geography of the region.[19] Instead of developing an extensive power grid, producing electricity locally with fuel generators, or using firewood for cooking or heating, the use of solar panels and windmills can simultaneously contribute to emissions reduction and social inclusion in remote areas. These small-scale projects do not require large capital investments but suffer from limitations related to their intermittency, as time and weather conditions affect their availability, requiring backup solutions such as energy storage batteries.

The portfolio of policies that seek to mitigate emissions without interrupting the processes of economic growth and social inclusion should include strategies to achieve greater economic efficiency, allowing the decoupling process to reduce emissions while lessening the impact on economic activity levels. As explained in Box 5.3, to reduce per capita emissions while simultaneously increasing per capita income, emissions per unit of output must be reduced. This requires the **adoption of more energy-efficient equipment and processes**, including a process of electrification of energy demand in production processes, transportation, building operations, and household appliances. The difficulty in this adoption lies in the fact that installing lower energy-consuming equipment will require significant investments that, at least in the short term, will compete with other investment needs.

Mitigation strategies should include the **reduction or elimination of energy subsidies**, particularly for fossil fuel consumption. These subsidies often operate through reductions in the cost of public transportation or public utility rates. Reducing these subsidies increases the final price and should lead to decreased consumption (or slow its growth), simultaneously mitigating emissions and reducing fiscal costs. However, reducing (or eliminating) these subsidies can have significant regressive effects on social inclusion. Cutting these subsidies that raise emissions by distorting the price system could be compensated through cash transfers via the various aid and social security programs in place in most countries in the region.[20]

In the same direction as eliminating subsidies for energy costs, **the implementation of carbon pricing** (either as a tax or through the development of an emissions permit market) can be considered. This instrument will increase the relative price of emissions-intensive goods and services, reducing their consumption (especially in the long term) while internalizing the costs of negative externalities from carbon emissions. Again, it must be considered that by raising the cost of fossil fuel energy, carbon pricing will disproportionately affect poorer households that allocate a larger portion of their income to energy consumption.

19 There is evidence that off-grid renewable energy, in addition to enabling cost-effective reductions in electricity consumption and emissions, supports greater energy security and local economic development in islands (IRENA, 2014) and isolated rural areas (Kieffer et al., 2016).

20 As pointed out by Missbach et al. (2022), the implementation of this type of compensation should take into account that existing cash transfer programs in the region target low-income households, often imperfectly, while the impact of subsidy reductions may be diffuse across income groups.

Preserving and regenerating ecosystems and biodiversity

Latin America and the Caribbean possesses an extraordinary wealth of ecosystems and biodiversity, despite the loss of natural capital evident in recent decades. The preservation and regeneration of this wealth must be a priority for the region's sustainable development, not only because of its importance in climate adaptation and mitigation, but also for its contribution to economic growth and social inclusion.

The preservation and regeneration of its natural wealth should be a priority for the region, not only because of its importance for climate adaptation and mitigation, but also because of its contribution to economic growth and social inclusion

Various policies can promote the preservation and regeneration of natural capital in the region. On one hand, there are command and control policies that regulate deforestation and activities with an impact on ecosystems. Among these policies are **protected areas**, which are one of the most commonly used tools for conservation. However, protected areas can be costly, both in terms of the resources needed for them to operate effectively and the limitations they impose on economic activities. The **co-management** of publicly owned natural resources with local communities and other key stakeholders is an alternative to leverage synergies between conservation and local development goals. Multiple-use protected areas, which allow both sustainable productive activities and smaller-scale population centers, are an example of this approach.

Market-based mechanisms also play a significant role in preserving natural capital. One notable approach is **payments for ecosystem services**, in which the region has been a pioneer. Evidence shows that such programs can be effective as long as they are designed to ensure the principle of additionality. Payments for ecosystem services are closely connected to **voluntary carbon offset markets**, which link businesses seeking to offset their emissions with producers who, through preservation and regeneration actions, provide carbon capture services.

Industry agreements under which companies commit not to purchase products or services from suppliers that do not comply with environmental safeguards are another type of policy for preserving natural capital. The soy moratorium in Brazil is a successful example. **Eco-certifications** are another approach aimed at providing consumers with information about the environmental impact of certain goods or services. The region leads in adopting eco-certifications for products like bananas, coffee, and cocoa. However, the evidence regarding their effectiveness is still limited.

Currently, most deforestation in the region is illegal. Prohibiting deforestation alone is insufficient; institutions with monitoring and sanctioning capacities for violations are required. It is also essential to create conditions where individual and societal incentives for preserving ecosystems and biodiversity are aligned.

Of course, in addition to policies aimed at protecting ecosystems, promoting sustainable practices in production and consumption is essential to achieve a new balance between human activity and its impact on nature.

Strengthening regional coordination

Addressing climate change and preserving biodiversity are issues that require international cooperation because they involve significant international externalities, meaning that the actions of each country affect others. This is reflected in the formation and role of the UNFCCC (United Nations

Framework Convention on Climate Change), the Convention on Biological Diversity, and the Global Biodiversity Framework.

Despite the existing heterogeneity in Latin America and the Caribbean, countries in the region can benefit considerably from **strengthening regional coordination** to address international negotiations on climate change and biodiversity. Therefore, they should adopt a common position that recognizes the overlap between the two agendas and the needs and strengths of the region.

Countries in the region can benefit considerably from strengthening regional coordination to address international negotiations on climate change and biodiversity

Climate financing is central to aligning parties and striking a balance between the need for a global mitigation effort and the demands of climate justice. In this regard, international financing flows must have a compensation component that goes from the major historical emitters to the smaller ones. A challenge in the negotiations is that industrialized countries prioritize financing for mitigation, while the region's greatest need is for adaptation.

International cooperation for the conservation and regeneration of ecosystems offers significant synergies for addressing deforestation's role in GHG emissions and enhancing the regional and global services (including climate regulation) provided by the ecosystems of Latin America and the Caribbean. One mechanism for this is **conservation funds**, which can help strengthen the financial viability of policies such as protected areas and ecosystem services payment programs. **Carbon offset markets** (voluntary or integrated into carbon pricing plans) are also a channel for financing the conservation and regeneration of the region's ecosystems, with an impact on climate change response and the well-being of the population. The experiences of Colombia and Mexico can provide valuable lessons for the rest of the region (Garcia and Garcia, 2023).

Seizing the opportunities of transition

Energy transition and environmental protection will entail significant challenges for production, employment, investment, tax revenue, and other relevant variables in the region's economies. However, not all these challenges will represent additional costs for these countries. This same process can open opportunities to exploit the region's resource endowment and competitive advantages.

On one hand, **tapping the large natural gas reserves** of several countries in the region, before they become stranded assets, would allow for emissions reduction compared to current oil and coal consumption (the most polluting fossil fuels). Eventually, the use of natural gas must also be phased out, but its utilization can provide a valuable bridge in the energy transition process. The exploitation of natural gas as an energy transition fuel will have positive effects in terms of emissions reduction, as well as positive impacts on fiscal resources and exports of both liquefied natural gas and electricity generated using gas.

In addition, taking advantage of the energy potential of gas and the development of renewable energy sources, for which the region has particularly favorable geographical conditions, could create comparative advantages for the **installation of energy-intensive industrial processes,** facilitating the relocation of investments and production to Latin America and the Caribbean.

Another significant opportunity for the region arises from the **exploitation of critical minerals** that will be in demand for energy transition and electrification processes. The mining of copper, lithium, and other critical minerals, abundant in the region, to meet the increasing global demand, can be an important source of fiscal resources and

foreign exchange. Of course, these activities must be carried out under conditions that protect the environment and local communities.

Finally, the relative abundance of forests and other natural cover in the region could make it possible to **monetize efforts to preserve forest resources**. Offering emissions offset credits from forest projects would enable the export of carbon capture services to regions where mitigation costs are relatively high, constituting a source of revenue for the region and promoting more efficient global mitigation. To achieve this, it is essential to build robust governance that ensures the additionality of projects, enabling greater use of forest sector offsets in international carbon markets.

Global challenges, regional solutions

Climate change and biodiversity loss are real phenomena—the result of human action—threatening the well-being of humanity and the continuity of all forms of life on the planet. The Industrial Revolution significantly improved the well-being of the world's population, with an unprecedented increase in life expectancy and material conditions. However, the associated economic and population growth, the increasing demand for food, energy, and materials, and the prevalence of forms of production with a negative impact on nature have led to an environmental crisis that includes, but exceeds, climate change. This crisis manifests itself in major losses of biodiversity and degradation of ecosystems, i.e., in a loss of natural capital that in itself compromises the sustainability of the economic development process and the well-being of future generations.

Climate change and biodiversity loss are global challenges, the solution to which requires the participation of all countries. Given their shared history and interests, the countries of Latin America and the Caribbean stand to benefit significantly from strong regional coordination to ensure that their voices and concerns are heard in international negotiations.

This report emphasizes three key messages relevant to all countries: the importance of adaptation, the need to contribute to mitigation, and the urgency of preserving natural capital for sustainable development. However, responses to these challenges may vary among regions. At the risk of oversimplification, it is possible to distinguish four major groups of countries based on their characteristics and the nature of their responses.

The first group consists of countries in South America with high emissions from the agricultural sector (Argentina, Bolivia, Brazil, Guyana, Paraguay, and Uruguay), stemming from changes in land use (except Argentina and Uruguay) and livestock farming (except in Guyana, where rice cultivation is the primary activity). For these countries, floods and droughts are the primary climate change hazards. Controlling the expansion of agricultural frontiers and introducing more sustainable practices in sector management are among policy priorities. Moreover, these policies synergize with natural capital conservation. These countries can also benefit from emerging opportunities associated with the increasing demand for critical minerals for the transition (Argentina and Bolivia), their natural gas reserves (Argentina, Brazil, and Guyana, and favorable conditions for renewable energy (Argentina).

The second group consists of the remaining South American countries (Chile, Colombia, Ecuador, Peru, Suriname, and Venezuela), along with Mexico, where the bulk of emissions come from the energy and industrial sectors. These countries also stand out for their greater fiscal and external sector dependence on hydrocarbons (except for Chile, which is a net energy importer). Thus, they face the additional challenge of promoting greater diversification of their production structures. Major risks include floods and water management issues due to the rapid loss of glaciers, especially in the Andean countries. In these countries, the energy transition is a more immediate challenge, while opportunities for the transition will arise in critical minerals for Chile and Peru, natural gas for Peru and Venezuela, and solar energy for Chile.

The third group is composed of Central American countries, with relatively low emissions due to their lower relative development and the predominance of clean sources in their energy matrix. Agriculture represents approximately one-quarter of emissions (except in Nicaragua, where it accounts for 60%), while industrial and transportation sectors account for the rest. The main vulnerability for these economies arises from food security and poverty issues in the face of climate change, given the importance of family farming. Therefore, the introduction of sustainable agricultural practices is a priority.

There is no one-size-fits-all formula: countries must respond differently to the challenges posed by the climate and environmental crisis

The fourth group consists of the Caribbean countries (with the exception of Trinidad and Tobago, which has high emissions from oil and gas production and the chemical industry). As for the sources of these emissions, there are two subgroups: the large island countries (Cuba, Haiti, and the Dominican Republic) emit approximately one third in agriculture, another third in energy and a similar amount in industrial processes, while in the small islands, emissions come mainly from electricity generation, transport and waste. The main risks arise from the interaction between their high exposure to extreme weather events and sea level rise with vulnerability factors, such as the low diversification of the economies (in some cases, highly dependent on tourism) and the concentration of population and infrastructure in a small area.

Given the still incomplete knowledge on the impacts of climate change and the heterogeneities in each country's resources and risks, the only certainty is that there is no one-size-fits-all formula. Each country must allocate investments and efforts toward adaptation, mitigation, and conservation, taking into account the trade-offs and constraints discussed in this report. In pursuing the optimal policy portfolio, it will be necessary to weigh the costs and benefits of different alternatives, as well as the political feasibility of actions and their impacts on equity and growth.

Picture of Cuenca, Ecuador. Cuenca is one of the cities that belongs to the Latin American and the Caribbean Network of Biodivercities. Scan this code to learn more about this initiative.