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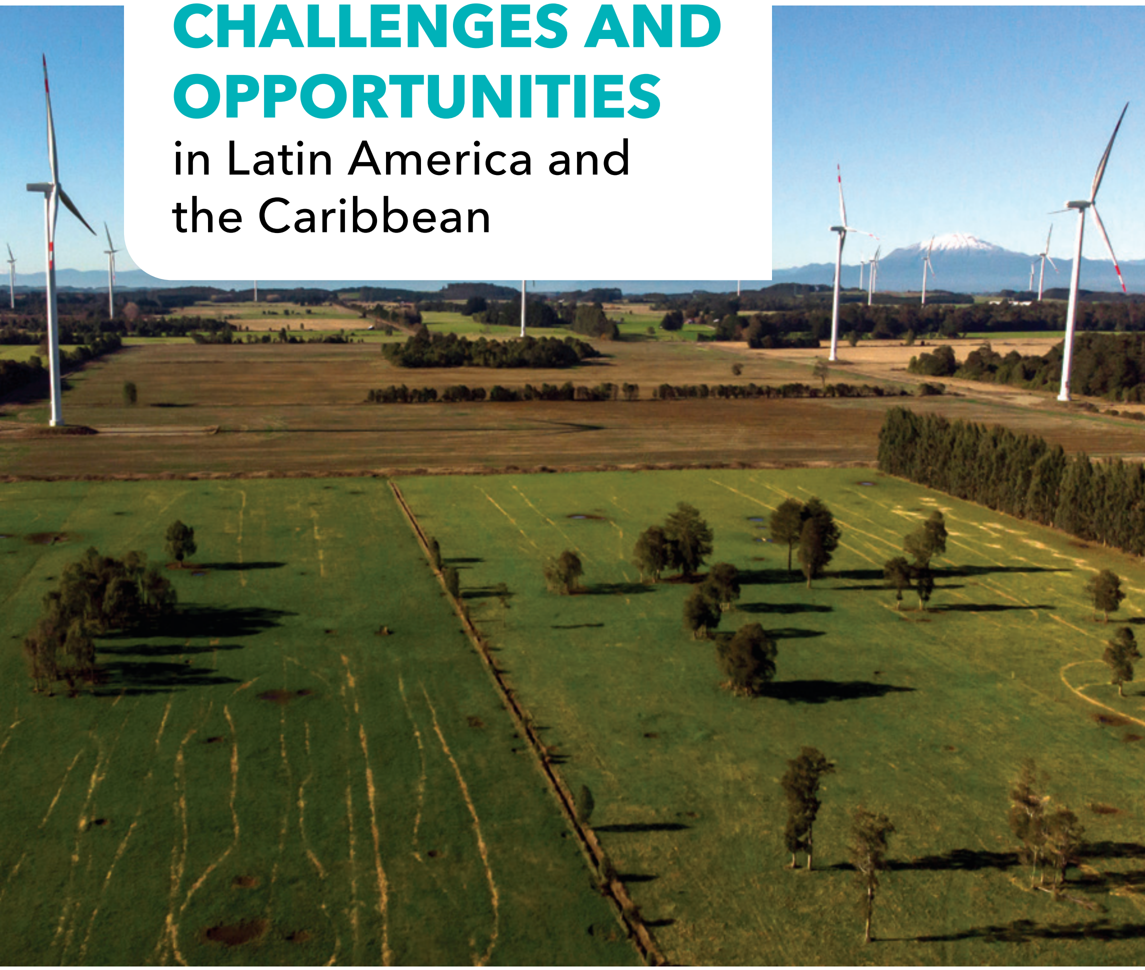
CLIMATE CHANGE CHALLENGES AND OPPORTUNITIES
in Latin America and the Caribbean



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Foreword

Faced by the climate crisis, we must act with all the force we can muster to change the direction of our societies. For the IMF and our partners in central banks and finance ministries, that means designing policies to cut emissions, increase climate finance, and boost resilience at the scale that is needed.

There is no time to waste. We are already seeing climate change hit households, businesses, and communities around the world—from droughts, wildfires, and floods to impacts that are less immediately noticeable in areas such as supply chains and insurance markets.

The good news is the new climate economy also means green investment, growth, and jobs. As is the case everywhere, the task for policymakers in Latin America and the Caribbean (LAC) is to harness these opportunities while managing climate-related risks.

This book takes stock of the steps being taken in LAC to address climate change and offers guidance on further measures countries can take. Throughout, it stresses the regional and national characteristics of the climate challenge in a region where a large share of emissions arises from agriculture and change in land use and where in a number of countries' vulnerability to climate shocks is profound.

For policymakers tasked with reducing emissions, the book provides a comprehensive taxonomy of mitigation tools and illustrates the impact of two specific policies: carbon pricing and fuel-subsidy reform. It also explores broader approaches that may be needed to reach and exceed current climate goals, while safeguarding growth and employment.

For example, governments across the LAC region have already made considerable efforts to expand the use of renewable energy, but the public sector continues to play a key role in the production of fossil fuels. Determined action will be crucial to align oil and gas production plans with climate objectives, while ensuring a just transition for communities that are most affected.

For some countries, a key focus will be maximizing the economic and social benefits of their natural endowment of "green" commodities—such as lithium, copper, nickel, and cobalt—needed in the energy transition. Governments will need to carefully regulate the extraction of these commodities to balance incentives for private investment against the need to raise public revenue to finance government priorities.

The book also investigates policy options for countries that are highly vulnerable to the impact of climate change and natural disasters, a reality across much of Central America and the Caribbean. This vulnerability is compounded by limited fiscal space and capacity constraints, hence the importance of a comprehensive medium-term strategy for climate adaptation. The long-term benefits of such strategies can be significant, particularly if they include infrastructure investment to build structural resilience.

At the same time, policymakers must pay attention to financial sectors that will increasingly be asked to support adaptation investments. Strengthening regulatory and supervisory frameworks against climate change risks can help build financial system resilience, while comprehensive insurance schemes also have a key role to play.

Finally, the book puts attention on two issues that underpin effective policies across all aspects of the climate challenge: finance and cooperation.

Given domestic resource constraints and the large investment needs, countries in the LAC region will need to attract climate finance from external sources, both public and private. The IMF can play a crucial role by not only providing resources from the Resilience and Sustainability Trust, but also by helping catalyze investment from private, bilateral, and other multilateral sources.

This underlines the importance of cooperation in meeting the climate challenge. Dialogue on climate policies between national, regional, and global stakeholders can yield higher climate dividends while avoiding domestic opposition or negative spillovers across countries. Again, the IMF has a key role to play by acting as a global and regional transmission line for good policy, while supporting countries as they pursue their climate goals. After all, it's only by working together that we will solve the planetary challenge of climate change.

Kristalina Georgieva
Managing Director
International Monetary Fund

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Abbreviations

ACCTS	Agreement on Climate Change, Trade and Sustainability
AFOLU	Agriculture, Forestry and Other Land Use
BAU	business as usual
BOGA	Beyond Oil and Gas Alliance
CA	current account
CAPDR	Central America, Panama, and the Dominican Republic
CARIB	(Caribbean) Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago
CCPA	climate change policy assessment
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CGE	computable general equilibrium
CH_4	methane
CIM	construction, installation, and manufacturing
COP	United Nations Climate Change Conference
CPAT	Climate Policy Assessment Tool
CTO	Caribbean Tourism Organization
DB	doing business
DD	difference-in-differences
DRS	disaster resilience strategy
ECCU	Eastern Caribbean Currency Union
ECLAC	Economic Commission for Latin America and the Caribbean
ECLP	Chilean Government's Long-Term Climate Strategy
EIB	European Investment Bank
EM-DAT	International Disaster database
EPA	Environmental Protection Agency
ESG	environmental, social, and governance
ETS	emissions trading system
FAIRR	collaborative investor network that raises awareness of the environmental, social, and governance risks and opportunities in the global food sector
FAO	Food and Agriculture Organization
FTE	full time equivalent
G	goods
G20	Group of 20
GFANZ	Glasgow Financial Alliance for Net Zero
GHG	greenhouse gas
GPAT	Global Trade Analysis Program
GWh	gigawatt hour

GWP	global warming potential
IADB	Inter-American Development Bank
IAM	integrated assessment model
IAMC	Integrated Assessment Modeling Consortium
IEA	International Energy Agency
IEPS	Impuesto Especial Sobre Producción y Servicios
IISE	Electricity Sector Innovation Index
I-O	input–output
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISO	International Organization for Standardization
LA-5	Latin America five; includes Brazil, Mexico, Colombia, Chile, and Peru
LAC	Latin America and the Caribbean
LPG	liquefied petroleum gas
LULUCF	land use, land-use change, and forestry
MCCR	El Mecanismo de Compensación de Costa Rica, or the Costa Rican offsetting mechanism
MDB	multilateral development bank
MDC	Mercado doméstico de carbono
MWh	megawatt hour
NbS	nature-based solution
ND	natural disaster
NDC	nationally determined contribution
ND-GAIN	Notre Dame Global Adaptation Initiative
NFA	net foreign asset
NOAA	National Oceanic and Atmospheric Administration
NPL	nonperforming loan
OECD	Organisation for Economic Co-operation and Development
O&M	operation and maintenance
O*NET	Occupational Information Network
PBMP	price-based mitigation policy
PES	payment for ecosystem services
PV	photovoltaic
R&D	research and development
RPS	renewable portfolio standard
RST	Resilience and Sustainability Trust
S	services
SOE	state-owned enterprise
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value-added tax
WHD	Western Hemisphere Department (of IMF)
WTO-UN	World Trade Organization–United Nations

Introduction

Anna Ivanova, Julie Kozack, and Sònia Muñoz

For Latin America and the Caribbean (LAC), climate change presents both challenges of managing climate-related risks as well as opportunities for economic and social development in the region.

On the challenges side, two broad climate-related risks need to be managed:

- *Physical risks* arise from the high vulnerability of some of the economies to the impact of climate-related phenomena such as higher temperatures, weather-related natural disasters, sea-level rise, coastal erosion, and loss of biodiversity, as well as risks related to the high reliance on climate-sensitive sectors such as tourism and agriculture. Such physical risks can adversely affect both aggregate supply (destruction of physical capital, dislocation of labor markets, and disruption of supply chains) and aggregate demand (reductions in consumption and investment and disruption of trade flows), leading to lower growth and employment and threatening fiscal sustainability and financial stability.
- *Transition risks* arise from the significant structural changes in domestic and foreign economies needed to achieve climate sustainability goals by reducing reliance on high greenhouse gas (GHG) activities and improving land-use practices. If not managed properly, the global transition to a low-carbon/low-GHG economy[1] could lead to significant economic dislocations due to sectoral shifts in employment, comparative advantage, and trade patterns with repercussions for short- and long-term growth, fiscal positions, inflation, external positions, and financial systems.

On the opportunities side, the transition to greener and more resilient economies could help achieve economic, social, and environmental sustainability:

- *Mitigation efforts* could bring substantial domestic environmental and health benefits even in the short term (for example, Bollen and others 2009; Grossman and others 2011), including reductions in air pollution mortality and morbidity and in road fatalities. They may also yield direct economic savings (such as reduced road damage and traffic congestion).

[1] We use the term low-carbon and low-GHG emissions economies interchangeably. GHG emissions include several gases other than carbon dioxide, including some that do not contain carbon. However, the term low-carbon economy is commonly used to loosely define all the economic activities that aim at delivering goods and services while minimizing emissions of GHGs (see, for example, Department for Business Innovation & Skills 2015).

- *Investment* in green technologies and infrastructure could help boost growth and generate new jobs (IMF 2020). Efforts to foster green innovation in the energy sector could also generate positive spillovers to the rest of the economy and reduce energy security risks.
- *Sustainable farming* can bring benefits by releasing fiscal resources that are currently used for subsidies (although these resources may be partially used to subsidize sustainable farming, at least initially), increasing external resilience by developing sustainable produce for which global demand has been increasing, contributing to food security, and increasing domestic income sources (Boltvinik and Mann 2016). A shift away from livestock agriculture could free up land that could be used to grow plant-based proteins or for reforestation (Batini 2021), helping to mitigate the risks from transition and contributing further to emissions reduction.
- *The shift to green technologies* could benefit some countries in the region due to their natural endowment of metals such as copper, nickel, cobalt, and lithium, which are needed in low-GHG technologies, including renewable energies, electric cars, and hydrogen and carbon capture and storage (IMF 2021).
- *Investing in resilient infrastructure and insurance* could yield significant growth and fiscal benefits over time in countries vulnerable to climate disasters. Deeper involvement of the private sector will be needed while strengthening financial sector resilience.

To manage climate-related risks, LAC countries can take actions on three fronts: (1) climate mitigation, which refers to policies that help reduce GHG emissions; (2) climate adaptation, which refers to efforts to adapt to the effects of climate change including through minimizing damages from climate-related natural disasters; and (3) transition management, which refers to policies to adapt to the effects of economic transformations at home and abroad aimed at reducing reliance on carbon-intensive activities.

This book assesses the LAC region's climate change challenges and opportunities and explores a range of policy options for confronting these challenges and taking advantage of these opportunities.

Chapter 1 takes stock of the main climate change challenges facing the region. The authors find that, with respect to climate-related risks, LAC is one of the most diverse regions in the world. Some LAC countries face challenges related to containing and reducing GHG emissions while others have an urgent need to build resilience given their exposure to weather-related natural disasters and climate change more broadly. Yet a third group is highly vulnerable to the risks stemming from the transition to a low-emissions economy globally, particularly fossil-fuel and agricultural commodity exporters. While the region's net GHG emissions are in line with its economic size and population, the composition differs notably from that in the rest of the world, with the larger share of emissions coming from agriculture and change in land use and forestry, presenting a unique set of challenges.

Chapter 2 takes stock of climate strategies to date. The authors find that LAC countries have made important strides in addressing climate mitigation and adaptation challenges. Almost all LAC countries have submitted and ratified their nationally determined contributions' (NDCs) commitments under the Paris Accords of 2016 aimed at reducing GHG emissions. LAC countries are also supporting the goal of carbon neutrality by 2050, and 14 LAC countries have committed to generating at least 70 percent of their electricity from renewable sources by 2030. Many countries have made commitments to implement the Kigali Amendments to phase out climate-warming hydrofluorocarbons. Most LAC countries have also taken first steps toward formulating national climate strategies by devising action plans for specific sectors or national action plans to address adaptation challenges. Experience to date suggests that strategies are more likely to be successful if they take into account macroeconomic implications of climate change and climate policies, identify financing sources, and aim at reaching broader social goals. So far, national climate strategies that comprehensively tackle both mitigation and adaptation challenges as well as include action plans to address social repercussions are few in LAC. Shifting the focus from ambition to implementation is a priority.

Chapter 3 takes stock of the policy options for climate mitigation in LAC countries. To curb GHG emissions, LAC policymakers have a variety of tools at their disposal, including price-based mitigation policies (such as reduction in fossil fuel subsidies, introduction of carbon taxes, establishment of emissions trading systems, and feebates) and non–price-based mitigation policies (such as public investment in low-GHG emissions technologies and infrastructure, fiscal incentives, direct current public spending aimed at making low-carbon energy sources more abundant and affordable, as well as supportive regulations). Given the large share of emissions from change in land-use practices and agriculture, cost-effective nature-based solutions (NbSs) can play an important role in LAC. A broad range of mitigation tools is likely to be needed, taking into account the extensive use of renewable energy in the region, societal preferences, and political economy considerations. Countries should adopt the policy mixes that best suit their specific circumstances, ideally articulated as national strategies.

Political economy considerations will have to be taken into account when designing climate mitigation strategies. A national climate mitigation strategy affects multiple sectors, activities, and vested interests to various degrees. Climate policies should be phased in gradually, clearly anchored to improve predictability, and their social impact should be accounted for ex ante to secure public support. Advanced public consultation, international cooperation, and careful communications strategy would help secure broad-based buy-in for climate mitigation policies. Strengthening social safety nets early on could foster trust and help secure household support for climate policies and reforms. While compensatory measures should facilitate the transition, eventually, carbon-related support to households should be folded into the country's broader social safety net and standard labor market transition mechanisms. Cooperation among countries for a synchronous move would not only yield global climate dividends but also mitigate the political cost of climate policies at the individual country level.

The authors of Chapter 4 provide an illustration of the macroeconomic impact of price-based mitigation policies in LAC. An illustrative assessment of the impact of an increase in the price of carbon up to $75 per ton by 2030 using IMF's Climate Policy Assessment Tool suggests that it could help close NDC gaps in many LAC countries, although some countries in the region would remain far from their NDC goals, and the NDC goals are not ambitious enough to achieve broader climate mitigation objectives of containing the temperature increase to 1.5 to 2 degrees Celsius. The increase in the price of carbon to $75 per ton would raise fuel prices substantially in some cases and will have a differential impact across households and countries. However, this increase would also mobilize significant fiscal revenues that could be used to compensate vulnerable groups. Workers in carbon-intensive sectors may have an additional loss of income or employment. Policies to reduce GHG emissions could also adversely affect livestock farmers.

Chapter 5 analyzes implications of the green transition for the labor market; the renewable energy industry could be an important source of green jobs in the region. The net impact of the green transition on labor markets will depend on the labor intensity of high-emission sectors, the potential for job creation of green or greener sectors, and the impact of gains in energy efficiency on the labor market. A tax on carbon is expected to reduce the overall consumption of electricity and to increase the share of lower-emissions technologies in the electricity generation matrix. However, there could be employment gains due to the green transition in the electricity sector, though the size of the gains and the distributional consequences depend on the type of electricity generation sources. A shift to plant-based agriculture would also present employment and income opportunities. A policy mix that balances carbon pricing with a green investment push to support the shift to cleaner energy and green technologies is likely to have positive long-term effects on activity and employment.

Chapter 6 lays out policy options for climate adaptation. The authors find that while building resilience to natural disasters is important throughout the region, it is a priority for Caribbean and Central American economies that are highly vulnerable to the impact of climate change. A comprehensive medium-term approach would yield significant long-term benefits for countries in these subregions. In particular, this approach could be based on three pillars needed to help LAC's most vulnerable countries prepare for climate-related disasters: structural resilience, financial resilience, and postdisaster resilience.

Enhancing structural resilience requires infrastructure and other ex ante investments to limit the impact of disasters, including "hard" policy measures (such as upgrading infrastructure) and "soft" measures (such as early warning systems). Scaling up investment in structural resilience would yield not only significant long-term benefits to the most climate-vulnerable countries but also important output and fiscal gains in the aftermath of a natural disaster.

Because building structural resilience takes time, financial resilience would also be needed to ensure funding for reconstruction while safeguarding public finances. Financial resilience in the form of comprehensive layered insurance should aim to provide adequate coverage against the expected capital and revenue losses after major natural disasters, and internalize the expected fiscal costs of postdisaster support. Ranked by their incremental costs, the layers include (1) building a precautionary government savings fund for immediate postdisaster liquidity needs against relatively less damaging but more frequent natural disasters, (2) scaled-up access to parametric insurance against less frequent but larger natural disasters with damages beyond the scope of the savings fund, and (3) issuance of state-contingent bonds to provide debt relief for extreme events. While comprehensive insurance coverage is expensive, estimates suggest that insurance needs and fiscal costs would decline significantly over time.

Postdisaster and social resilience requires contingency planning and related investments ensuring a speedy response to a disaster. The near-term fiscal costs of building resilience would open a transitional financing gap for governments since the benefits of climate resilience accrue over the medium and long terms. Deeper private sector contributions to adaptation investment could ease the burden on public finances and can be facilitated by incentives and policies to improve access to financial services.

Chapter 7 takes stock of the efforts of LAC governments in tackling climate-related challenges facing the region to date and the role of the public sector in tackling transition to a low-carbon economy. The authors find that LAC governments have already made considerable efforts to expand the use of renewable energy. A mix of enabling policies, largely focused on non–price-mitigation tools, supported the region's energy transition toward renewables. However, the public sector continues to play a key role in the production of fossil fuels. In fact, state-owned enterprises have plans to expand their oil and gas production despite government pledges. While lucrative in the past, investments in fossil fuels are at risk of becoming stranded assets as technological advances make renewables cheaper and undermine the competitiveness of fossil fuels. As such, the governments in LAC countries will have to choose between backing fossil fuels that bring revenues in the short term and a just energy transition in line with climate change targets. In this regard, stronger action on the part of governments and state-owned enterprises to align oil and gas production plans with the climate objectives is needed.

In addition, the shift to green technologies could benefit some countries in the region due to their natural endowment of metals needed in the energy transition. With increasing prices of energy transition metals translating into higher gains for LAC metal exporters, it could also increase input costs and delay the energy transition. Reserves will be a supply-side constraint in the transition to renewables. Hence, a push for green investments will be key to reaping the benefits from existing demands and expanding reserves to meet future demands. But not all LAC countries will benefit from the boom in green metals because reserves are concentrated in only a few in the region. Governments will need to regulate the extraction of green commodities to ensure efficient use while extracting the maximum sustainable return from scarcity rents.

Chapter 8 analyzes experience with tackling climate change in Chile, Costa Rica, and Honduras. Most LAC countries have taken first steps toward formulating national climate change strategies by devising climate change action plans for specific sectors (such as forestry, energy, agricultural, and water sectors) or national action plans to address adaptation challenges (predominantly in the Caribbean). However, national climate strategies that comprehensively tackle both mitigation and adaptation challenges as well as include action plans to address social repercussions are few. Chile and Costa Rica, for example, have adopted comprehensive national strategies. Successful strategies take into account the likely macroeconomic implications of climate change and the implications of climate mitigation policies; they also identify financing sources; and aim at reaching broader social goals.

Chapter 9 analyzes the implications of climate risks for financial stability in the most vulnerable countries in LAC. The impact of natural disasters on the financial systems in those countries has often been modest compared to the economic damages. The impact on the financial system was mitigated by moderate direct physical risk exposures (due to high insurance coverage gaps and credit access constraints), high reinsurance cession rates, and significant collateral requirements for insuring property. This benign risk profile would change with greater use of local financial services to scale up private sector adaptation investment. Both insurance penetration in percent of GDP and nonlife insurance premiums in USD increase after natural disasters. Insurance penetration is also positively associated with financial development indicators such as private credit growth and bank deposits. This indicates that financial deepening could stimulate insurance penetration in countries with sizable climate risks.

Moreover, climate change may also intensify indirect disaster risks, including through their impact on the broader economy. Authors' simulations show that under a scenario with extensive damage to critical tourism infrastructure and/or impact from successive major storms, the impact on bank portfolios in the most vulnerable countries in LAC can be very severe and result in pronounced effects on bank asset quality. Such indirect risks from physical disasters may be amplified by financial institutions' public sector exposures in countries where the sovereigns' or state-owned companies' balance sheets are stretched, as well as financial institutions' holding counterparty risks to some regional insurers. Transmission channels for indirect risk may include abrupt changes to reinsurance pricing or even the tail risk of reinsurers' exit from the market. Strengthening supervision, reporting, and regulatory frameworks against climate change risks can further build financial system resilience.

Chapter 10 lays out issues related to climate financing in LAC. Mitigation and adaptation policies will require significant upfront financing. External financing for both goals will be essential for LAC given the limits to domestic resource mobilization in the region. On the private funding side, the rapidly developing markets for sustainability-linked debt and equity as well as state-contingent instruments have the potential to support climate efforts in LAC. Bilateral and multilateral support will also continue to be important, including the IMF's recently established Resilience and Sustainability Trust (RST).

Moreover, the private sector can play an important role in building resilience against climate risks and help reduce the financing gap. To unleash full benefits of private sector participation, governments could foster private sector adaptation investment through technical support, incentives, and policies to improve access to financial services, especially private insurance. Small Caribbean and Central American countries have on average low private insurance coverage but high susceptibility to major disasters. Financial deepening could stimulate insurance penetration in countries with sizable climate risks.

The analysis in this book suggests that LAC countries are facing substantial challenges related to climate change but have tools at their disposal to seize the opportunities that climate change presents. To maximize opportunities and minimize the risks, LAC countries will need to improve flexibility and adaptability of their economies. Policies aimed at supporting the reallocation of labor and capital across sectors, investing in basic skills and human capital, improving transparency and economic governance to encourage investment in technology and capacity building, and creating fiscal space to manage the climate transition would help LAC countries position themselves to take advantage of the opportunities afforded by the climate transition.

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CHAPTER 1

Climate Change Challenges in Latin America and the Caribbean

Leo Bonato, Diane C. Kostroch, and Huidan Lin

Latin America and the Caribbean (LAC) is one of the most diverse regions with respect to climate-related risks. Some LAC countries face challenges related to containing and reducing greenhouse gas (GHG) emissions (mitigation); some others have an urgent need to build resilience to natural disasters (adaptation); and others are exposed to the risks stemming from the transition to a low-emissions economy globally (transition), particularly fossil fuel and agricultural commodity exporters. The region's net GHG emissions are in line with its economic size and population, but the composition of emissions differs notably from that in the rest of the world, with cleaner sources of energy supply than in most other regions. In contrast, LAC stands out for its large share of net GHG emissions from agriculture and land-use change and forestry.

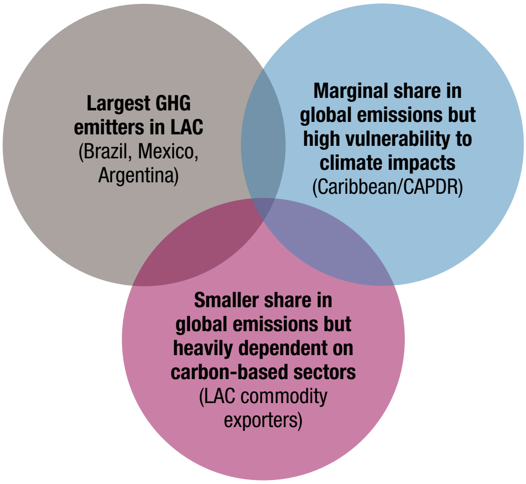
A DIVERSE REGION

LAC is one of the most diverse regions with respect to climate-related risks (Figure 1.1). Although Brazil and Mexico do not stand out in terms of per capita net GHG emissions, each of these countries, together with Argentina, contributed more than 1 percent to total net GHG or net non-CO_2 emissions globally in 2020 just due to their sheer size (Figure 1.2 and Annex 1.1).[1] LAC is also home to countries that are especially vulnerable to the impact of climate change (notably in the Caribbean and Central America) and to countries that do not contribute significantly to global GHG emissions but are sensitive to transition risks arising from global efforts to reduce GHG emissions (that is, fossil fuel and agricultural exporters). Climate change is macrocritical for the region (Box 1.1), and both climate mitigation and adaptation are relevant.

The region's net GHG emissions are in line with its economic size and population. LAC's share of global net GHG emissions, which includes emissions from land-use change and forestry, of 8.3 percent is broadly consistent with the size of LAC economies (about 8 percent of global GDP and population) so that per

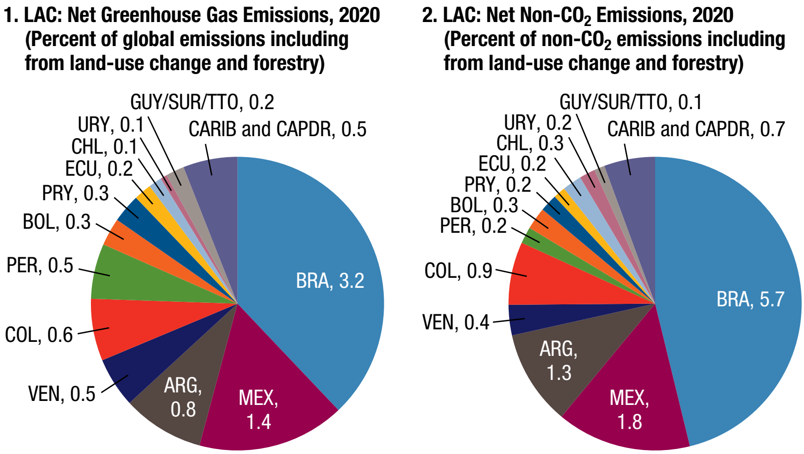
[1] Total emissions characterize a country's contribution to climate change because emissions constitute an externality that is related to climate change globally.

Figure 1.1. Latin America and the Caribbean: Region's Climate Risk Diversity



Source: IMF staff calculations.
Note: CAPDR = Central America, Panama, and the Dominican Republic; GHG = greenhouse gas; LAC = Latin America and the Caribbean.

Figure 1.2. LAC: Region's Climate Risk Diversity



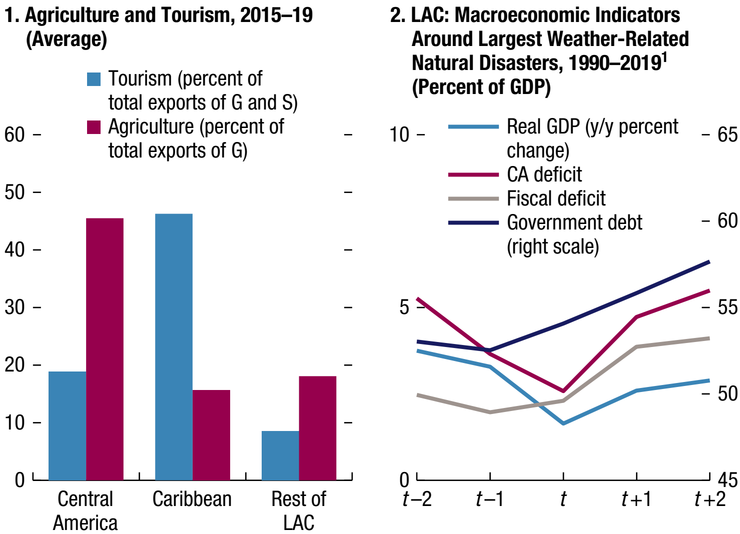
Sources: United Nations Framework Convention on Climate Change; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Climate Data Explorer; and IMF staff calculations.
Note: Greenhouse gas emissions include CO_2, CH_4, N_2O, and F-gases sourced from energy, industry, agriculture, land use, land-use change, and forestry (LULUCF), waste, and others. Data labels use International Organization for Standardization (ISO) country codes. CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago; LAC = Latin America and the Caribbean.

Box 1.1. Climate Change Is Macrocritical in Latin America and the Caribbean

Climate change is macrocritical in Latin America and the Caribbean (LAC)—a region home to some countries that are vulnerable to climate change and some that face significant transition costs from policies that reduce greenhouse gas emissions.

Severe and frequent weather-related natural disasters and global warming represent considerable macroeconomic shocks, particularly in the Caribbean and Central America. Moreover, many economies depend on climate-sensitive activities such as tourism and agriculture, which contribute significantly to output, employment, and foreign exchange earnings. Event analysis suggests that growth declines when a severe weather-related natural disaster strikes. Although growth recovers the following year, possibly reflecting reconstruction efforts, the fiscal deficit and debt level rise and remain higher thereafter (Box Figure 1.1.1). Over the longer term, global warming affects the region's economies mainly through lower tourism flows, agriculture production, and labor productivity due to health effects (IMF 2016).

Figure 1.1.1. Reliance on Agriculture and Tourism and Macroeconomic Impact of Weather-Related Natural Disasters



Sources: Emergency Events Database; IMF, World Economic Outlook database; UN Comtrade; World Bank, World Development Indicators database; World Trade and Tourism Council; and IMF staff calculations.
Note: CA = current account; G = goods; LAC = Latin America and the Caribbean; S = services; y/y = year over year.
[1]One largest natural disaster is identified for each country over 1990–2019, in a sample of countries where fatalities plus 0.3 times the affected persons (reported in the Emergency Events Database) exceed 1 percent of the population.

This box was prepared by Leo Bonato and Huidan Lin.

Box 1.1. *(continued)*

Policies to advance transition to a low-emission environment impose costs on many LAC countries, although the costs of inaction are even greater.

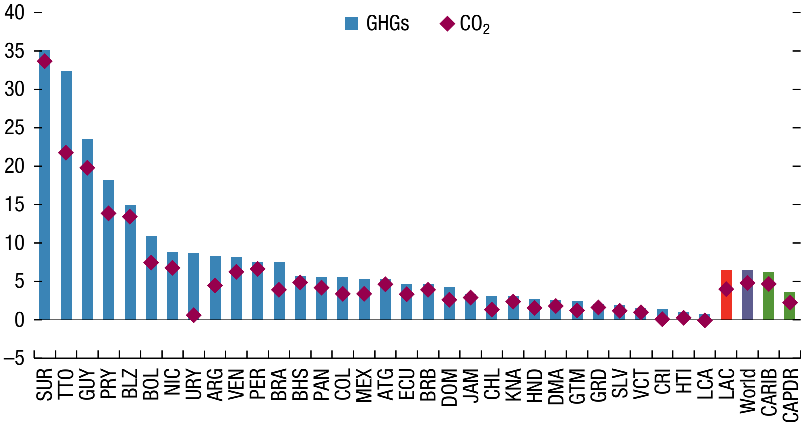
- Fossil fuel industries and their associated value chains will decline globally, directly affecting producer countries with job losses and lower tax revenues. Lower foreign exchange generation may affect external sustainability, hinder the ability to service debt, and complicate defending currencies under pegged or managed exchange rate regimes.
- As clean technologies advance and decarbonization gathers pace, companies along value chains of "dirty" industries may lose competitiveness to "clean" ones. For instance, declining upfront investment for an electric bus promotes greater use of this means of transportation, thus affecting producers of nonelectric buses and relevant parts. Governments may have to play a role in facilitating this transition.
- Policies to reduce nonenergy emissions, which may include measures to gradually replace nonsustainable farming and forest management practices, may also have significant transition costs for countries reliant on these practices. For example, policies to reduce deforestation may involve opportunity costs for the loss of incomes from alternative activities in the short to medium term but have larger long-term benefits.
- Climate change exacerbates poverty and inequality because lower-income groups are particularly vulnerable to food price increases, health shocks, and falling agriculture- and ecosystem-related incomes. Migration (already a policy challenge, particularly in the Northern Triangle) may increase further because of rising sea levels, floods, food insecurity, water scarcity, and falling incomes.
- Climate change events pose challenges to financial stability (see Chapter 9) through property damage and business disruptions if proper insurance is not already in place, whereas financial institutions exposed to sectors going through transition could face higher nonperforming loans or a drop in asset values. In either case, profitability and solvency could subsequently deteriorate, thus constraining lending and hampering investment. Financial exposure to agriculture and tourism varies, whereas resident banks of LAC commodity exporters do not appear to have large exposures to fossil fuel sectors, which possibly reflects the large use of external financing (or from the parent company). Harmonized and granular data on banks' exposures are essential to assessing credit and liquidity risks more thoroughly and call for stepped-up compilation efforts at the international and national levels.

capita net GHG emissions of 6.6 metric tons carbon dioxide equivalent (CO_2-eq)[2] are close to the world average (Figure 1.3, panel 1). In contrast, gross GHG emissions per capita (4.9 metric tons CO_2-equivalent), which exclude emissions from land-use change and forestry, are below the world average (6.4 metric tons CO_2-equivalent). Higher net (relative to gross) emissions in LAC reflect a positive contribution to net GHG emissions from land use practices largely on the account of deforestation in the region (Figure 1.3, panel 2). Across countries, LAC's contribution to global net GHG emissions is driven primarily by the three largest emitters in the region (5.3 percent, Figure 1.2, panel 1). Although fossil fuel

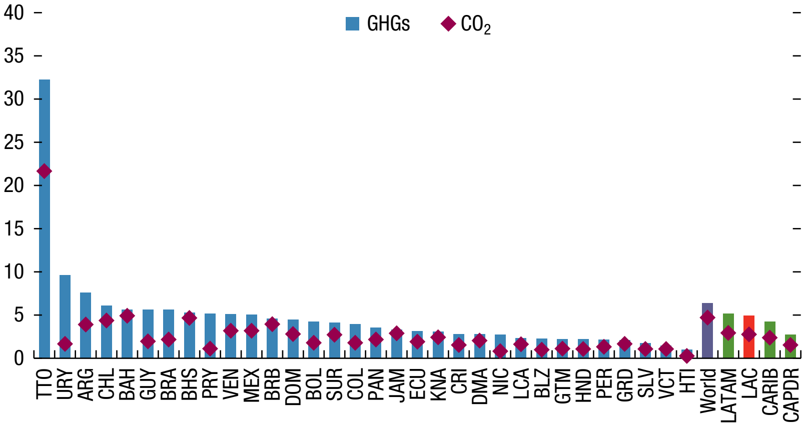
[2] CO_2-eq, or carbon dioxide equivalent, stands for a unit based on the global warming potential of different GHGs. The CO_2-eq unit measures the environmental impact of 1 metric ton of these GHGs in comparison to the impact of 1 metric ton of CO_2.

Figure 1.3. LAC: GHG and CO_2 Emissions per Capita

1. Greenhouse Gas and CO_2 Net Emissions per Capita, 2020[1]
(Metric tons CO_2 equivalence including emissions from land-use change and forestry)



2. Greenhouse Gas and CO_2 Gross Emissions per Capita, 2020[2]
(Metric tons CO_2 equivalence excluding emissions from land-use change and forestry)



Sources: United Nations Framework Convention on Climate Change; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Climate Data Explorer; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago; CO_2 = carbon dioxide; GHG = greenhouse gas; LAC = Latin America and the Caribbean; LATAM (Latin America) = South America, Mexico; LULUCF = land use, land-use change, and forestry; NA (North America) = Canada, United States.
[1]Net GHG emissions include gross GHG emissions (see footnote 2) plus LULUCF, which can be positive or negative.
[2]Gross GHG emissions include CO_2, CH_4, N_2O, and F-gases, sourced from energy, industry, agriculture, waste, and others.

exporters (Bolivia, Colombia, Ecuador, Guyana, Suriname, Trinidad and Tobago, and Venezuela) represent a total of only 1.7 percent of global net GHG emissions, their exports of fossil fuels contribute to emissions in importing countries.

The composition of net GHG emissions in LAC, however, differs notably from that in the rest of the world. The energy sector—still the top single driver of emissions—accounts for 38 percent of GHG emissions in LAC, well below the world average of 72 percent (Figure 1.4, panel 1), and reflects cleaner sources of energy supply than in most other regions (except sub-Saharan Africa) (Figure 1.5, panel 1). In particular, LAC countries (outside of the Caribbean) have limited use of fossil fuels in electricity generation (Figure 1.5, panel 2) and extensive use of hydropower[3] and other renewable sources.[4] Where the contribution of the energy sector exceeds the world average, it may reflect significant efforts of reforestation (Chile, Costa Rica), which have reduced the share of nonenergy GHG emissions, or the large dependence on fossil fuels for energy production (some Caribbean countries) (Figure 1.4, panel 2). In general, however, LAC stands out for its large share of net GHG emissions (49 percent of total) from agriculture and change in land use and forestry combined, compared to the world average of 15 percent. This is true for most LAC economies and largely reflects rapid deforestation in the Amazon and other areas, with the conversion of tropical forest to beef and soybean production.

Many LAC countries are vulnerable to climate change because of their exposure to weather-related natural disasters, which are bound to increase in frequency and intensity.[5] The Caribbean stands out in terms of the frequency and economic impact of weather-related natural disasters per land area. In the Caribbean, damages from natural disasters are estimated at 2.5 percent of GDP annually, affecting vast segments of the economy and population and putting significant pressure on public finances. Central America is also vulnerable in this regard, with estimated annual average damages of 0.8 percent of GDP (Figure 1.6). In addition to weather-related natural disasters, LAC countries are expected to be exposed to higher temperatures, sea-level rise, and possible changes in precipitation because of climate change. These may result in lower agricultural production, reduced availability and lower quality of water resources, loss of forested areas and biodiversity, and adverse health effects (Intergovernmental Panel on Climate Change 2021; Bárcena Ibarra and others 2020).

[3] Hydropower, despite contributing little to GHG emissions, may give rise to other environmental problems (for example, related to the dam construction) and, due to its high reliance on water, may also face challenges if water resources become more volatile—another climate change risk—in the region.

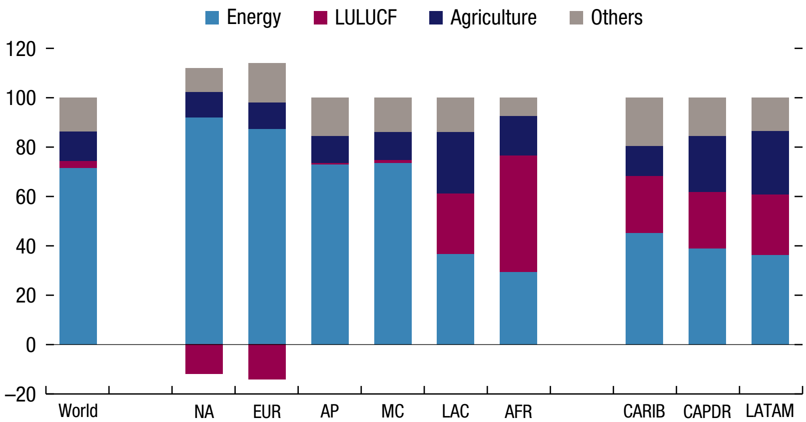
[4] Electricity production in the Caribbean is tilted toward nonrenewable sources, which constitute 88 percent of electricity generation, in contrast to about 40 percent in the rest of LAC.

[5] More than 11,000 reported disasters were attributed to these hazards globally during 1970–2019, with more than 2 million deaths and $3.64 trillion in loses (World Meteorological Organization 2021). The WMO Secretary-General Professor Petteri Taalas (https://wmo.int/media/news/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer-deaths) noted that the number of weather, climate, and water extremes is increasing and that these extremes will become more frequent and severe in many parts of the world as a result of climate change.

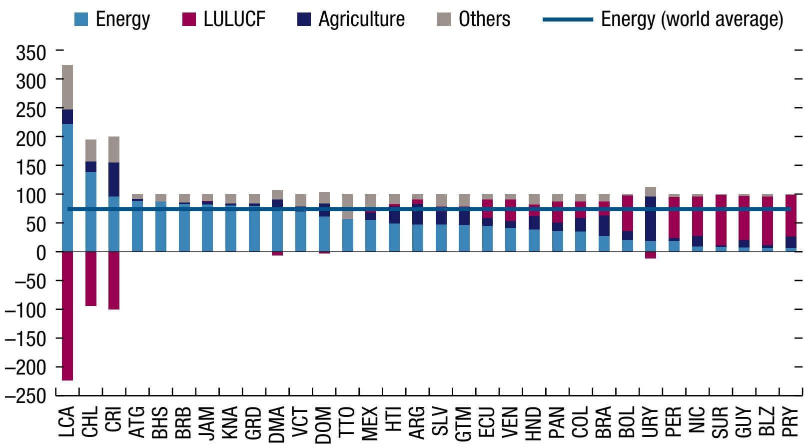
Figure 1.4. LAC: Greenhouse Gas Emissions

(Percent of total)

1. GHG Emissions by Sector, 2020



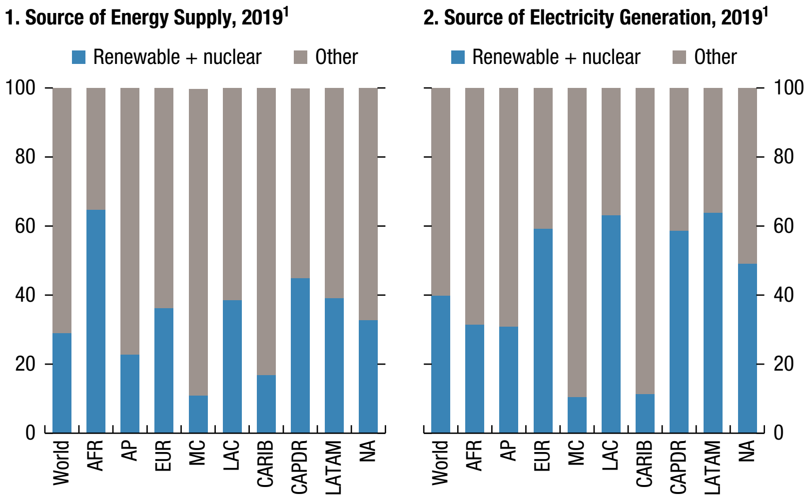
2. GHG Emissions by Sector and Country, 2020



Sources: IMF, Climate Policy Assessment Tool; International Energy Agency; Organisation for Economic Co-operation and Development; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Climate Data Explorer; and IMF staff calculations.

Note: Negative values of LULUCF for Chile, Costa Rica, St. Lucia, and Uruguay reflect reductions in GHG emissions from LULUCF in these countries. All shares reflect emissions by sector relative to total net GHG emissions. The category "Others" includes emissions from industrial processes and product use, waste, and other emissions that are not categorized. Data labels use International Organization for Standardization (ISO) country codes. AFR = Africa; AP = Asia and Pacific; CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago; EUR = Europe; GHG = greenhouse gas; LAC = Latin America and the Caribbean; LATAM (Latin America) = South America, Mexico; LULUCF = land use, land-use change, and forestry; MC = Middle East and Central Asia; NA (North America) = Canada, United States. Category "Others" refers to Industrial Processes and Waste.

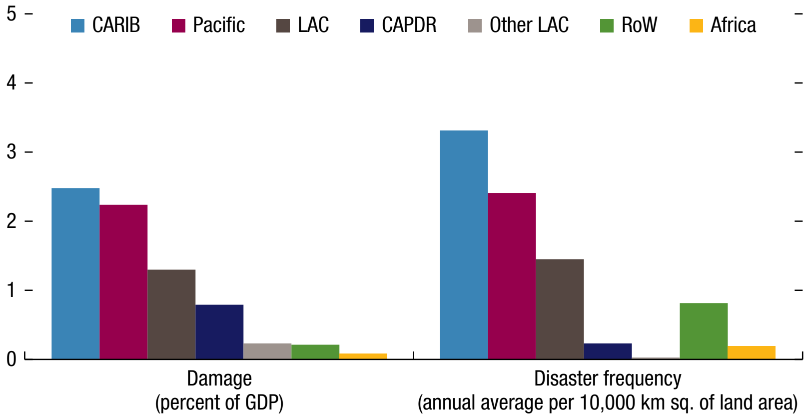
Figure 1.5. LAC: An Overall Cleaner Energy Matrix
(Percent of total)



Sources: International Energy Agency; Organisation for Economic Co-operation and Development; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. AFR = Africa; AP = Asia and Pacific; CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago; EUR = Europe; LAC = Latin America and the Caribbean; LATAM (Latin America) = South America, Mexico; MC = Middle East and Central Asia; NA (North America) = Canada, United States.
[1]Energy supply in a country includes total supply of energy for use in four economic sectors (residential, commercial, transportation, and industrial) from both renewable and nuclear sources (wind, solar, hydro, nuclear, biomass, heat, and other renewable energy) and other sources (coal, natural gas, gasoline, diesel, kerosene, LPG, jet fuel, and other oil products). Energy supply is computed as production + imports – exports ± stock and bunker changes; for the world, it is defined as production + imports – exports ± stock changes.

Some LAC countries are highly vulnerable to the impact of climate change more generally. The index of vulnerability to climate change produced by the Notre Dame Global Adaptation Initiative (ND-GAIN) assesses the vulnerability of a country to climate change risks by looking sperately at exposure, sensitivity, and adaptation capacity. Although the LAC region is below the world average (Figure 1.7, panel 1), pockets of high vulnerability exist. The most vulnerable LAC countries are located either in the Caribbean (one of the most vulnerable regions in the world; Figure 1.7, panel 1) or in Central America. For some of them, high exposure is somewhat offset by limited sensitivity (Trinidad and Tobago, Grenada) or by high capacity (Barbados, Costa Rica, Panama), but others (Haiti, Antigua and Barbuda, Belize, Honduras, Guyana) combine high exposure and sensitivity with low capacity (Figure 1.7, panel 2). By controlling for GDP levels, several countries show higher-than-normal vulnerability (Haiti, The Bahamas, Antigua and Barbuda, Bolivia) (Figure 1.7, panel 3).

Figure 1.6. Average Annual Effects of Weather-Related Natural Disasters, 1980–2020[1]

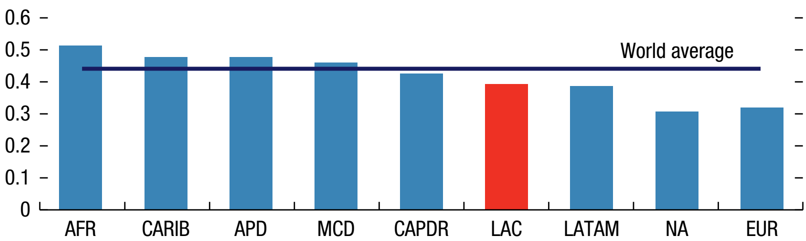


Sources: Emergency Events database; IMF, World Economic Outlook database; and IMF staff calculations.
Note: CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenadines, Suriname, Trinidad and Tobago; LAC = Latin America and the Caribbean; Pacific = Fiji, Marshall Islands, Micronesia, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu; RoW = rest of the world.
[1]Weather-related natural disasters include climatological (includes drought, wildfire), hydrological (includes flood, landslide), and meteorological (storm, extreme temperature). The whole sample covers countries that report at least one weather-related natural disaster incurring positive damage (countries that report the occurrence but with zero damage are excluded). Groups of Western Hemisphere Department, Pacific, and rest of the world are exclusive. A simple average is taken across country and year, after damage is scaled by GDP annually and disaster frequency is scaled by 2018 land area annually, for each group.

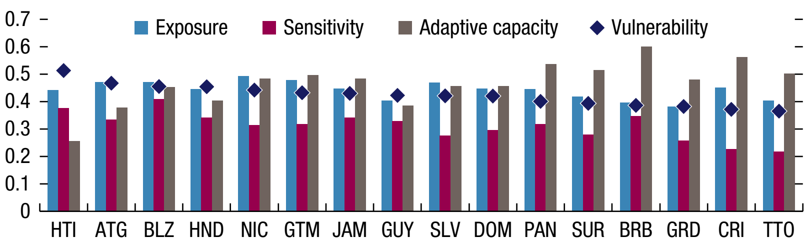
Risks stemming from the transition to a low-emissions economy are particularly important for large fossil fuel exporters. The transition risk is high if a country relies more on fossil fuels as a source of income, fiscal revenue, and foreign exchange, as in several LAC countries (Figure 1.8, panels 1 and 2). The sharp decline in demand for fossil fuels because of the global transition to low-carbon economies can have negative repercussions on fiscal and external sustainability in those countries, making climate change highly macrocritical (Box 1.1). For instance, reduced demand and the need to devote resources to emissions reduction by major oil-, gas-, and coal-producing companies will result in lower profits, productivity, and GDP growth. Banks highly exposed to these companies and their value chains will likely face higher nonperforming loans or a drop in asset values, with implications for profitability and solvency. Nevertheless, the transition to low-carbon economies will take time, and the impact on prices and assets will inevitably vary across countries (European Investment Bank 2021). Certainly, transition risks are higher for countries that are further away from the emission targets committed to in their nationally determined contributions, which implies significant decarbonization efforts

Figure 1.7. LAC: ND-GAIN Index of Vulnerability to Climate Change

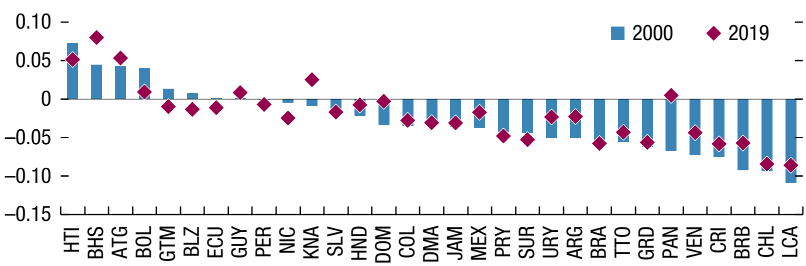
1. World: Vulnerability to Climate Change, 2021[1]



2. The Caribbean and Central America: By Subcomponent, 2021[1]



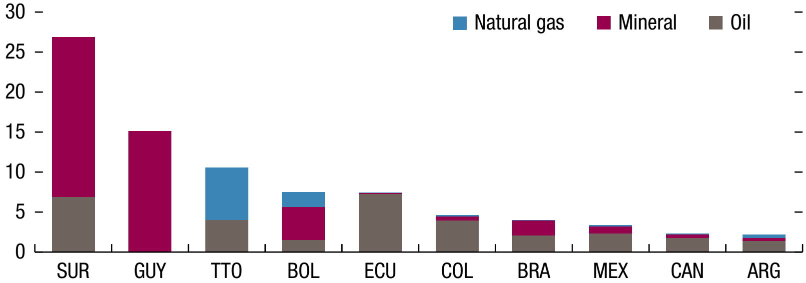
3. LAC: GDP-Adjusted Vulnerability, 2019[2]



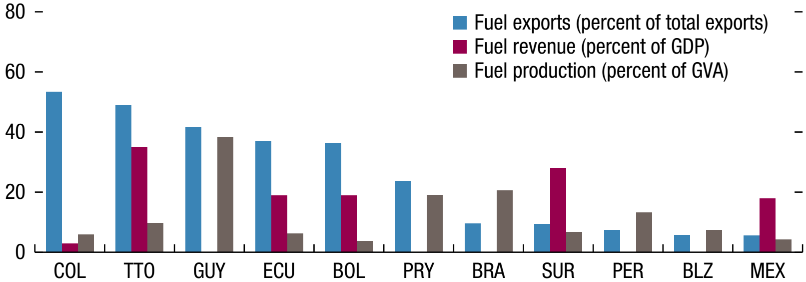
Sources: Emergency Events Database; IMF, World Economic Outlook database; Notre Dame Global Adaptation Initiative (ND-GAIN) database; IMF Adapted ND-GAIN; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. AFR = Africa; AP = Asia and Pacific; CAPDR (Central America, Panama, and the Dominican Republic) = Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Nicaragua, Panama; CARIB (Caribbean) = Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, St. Kitts and Nevis, St. Lucia, St. Vincent and Grenadines, Suriname, Trinidad and Tobago; EUR = Europe; LAC = Latin America and the Caribbean; MC = Middle East and Central Asia; NA (North America) = Canada, United States; Pacific = Fiji, Marshall Islands, Micronesia, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu; RoW = rest of the world.
[1]IMF Adapted ND-GAIN assesses the vulnerability of a country to climate change risks by considering the exposure to climate-related hazards, the sensitivity to the hazards' impacts, and the adaptive capacity to cope with or adapt to these impacts, in six life-supporting sectors: food, water, health, ecosystem services, human habitat, and infrastructure. Raw data are scaled to a range from zero to one, and the arithmetic average is used to construct each index. Regional average weighted by annual population as of 2021.
[2]To account for the correlation between ND-GAIN vulnerability scores and GDP per capita, the "GDP adjusted ND-GAIN vulnerability score" (ranging from –1 to 1) is defined as the distance of a country's measured ND-GAIN vulnerability score to the expected value for its GDP per capita, as represented by results from the regression of ND-GAIN vulnerability score and GDP per capita, for each given year. Positive values reflect lower vulnerability than expected, given a certain level of GDP per capita.

Figure 1.8. Vulnerability to Transition Risks

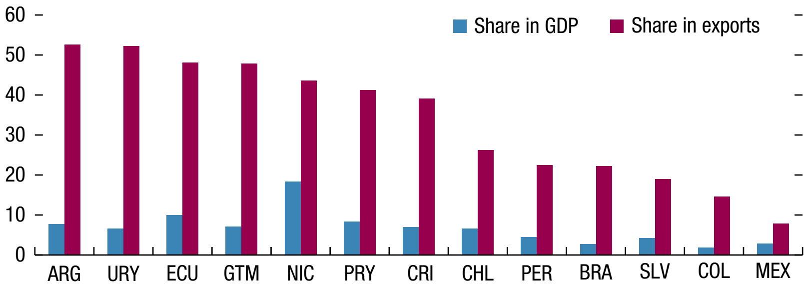
1. Natural Resources Rents, 2018[1]
(Percent of GDP)



2. Dependence of Fossil Fuels, 2015–19[2]
(Percent of total exports)



3. Agricultural Exports, 2019
(Percent of GDP and exports)



Sources: Carbon Tracker; Haver Analytics; national authorities; UN Comtrade; WDI; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes.
[1]Natural Resources Rents are estimated as the difference between the value of natural resources production at world prices and total costs of production.
[2]GUY: All 2020 data. Fuel exports cover exports of mineral fuels, lubricants, and related materials (Standard International Trade Classification Rev. 3, Section 3). Fuel production is proxied by mining and quarry if petroleum and/or natural gas extraction and/or refinement is not available. Fuel revenue estimates are not available for some countries. Fuel revenue data for some countries were not available.

down the road (see Chapter 2, Table 2.3), and lower for countries that have already made significant progress in deploying renewables and improved energy efficiency and export competitiveness (see Chapter 4).[6]

Some exporters of agricultural products are also vulnerable to transition risks (Figure 1.8, panel 3). The physical risk stemming from the agriculture sector's exposure to climate change and weather-related disasters results in food insecurity, heightened macroeconomic vulnerability, mitigation, and poverty risk. In addition, the sizable contribution of animal production to net GHG emissions globally exposes these countries to transition risks arising from the potential shift away from animal products[7] (see Chapter 3, Box 3.1). Accelerating the transition to a green food supply and sustainable farming will be essential to reduce GHG emissions and to minimize the risks connected with a shift in consumers' tastes.

ANNEX 1.1 IDENTIFYING THE LARGEST GHG EMITTERS IN LATIN AMERICA AND THE CARIBBEAN

The chapter identifies the three largest emitters in Latin America and the Caribbean (LAC) based on two criteria: a country's share in global total greenhouse gas (GHG) emissions and a country's share in global non-CO_2 GHG emissions (the latter criterion captures the importance of non-CO_2 emissions in the region). Total GHG emissions data cover six key sectors: (1) energy; (2) industrial processes and product use; (3) agriculture; (4) land use, land-use change, and forestry (LULUCF); (5) waste; and (6) others.[8] The data allow for evaluating gross and net GHG emissions, which are defined as follows:

Gross GHG emissions comprise CO_2, CH_4, N_2O, and F-gases, sourced from energy, industry, agriculture, waste, and others.

Net GHG emissions include gross GHG emissions plus LULUCF, which can be positive or negative.

Brazil, Mexico, and Argentina are the three largest emitters in LAC, using the threshold of 1 percent contribution to the global total GHG emissions (gross or net) or the global non-CO_2 GHG emissions (gross or net). Annex Table 1.1.1 lists the top 10 LAC countries based on their share in global total GHG emissions, and Annex Table 1.1.2 lists the top 10 LAC countries based on their share in non-CO_2 GHG emissions.

[6] See also European Investment Bank 2021 for ranks of countries' transition risks according to GHG emissions performance and revenues stemming from fossil fuel exports, counterbalanced by mitigation factors (such as the deployment of renewables, energy efficiency improvements, and level of commitment of countries as per their nationally determined contributions).

[7] More people recognize the health benefits of plant-based diets (reflected in increasing numbers of vegetarian restaurants and sales of meat and dairy alternatives). In addition, the Food and Agriculture Organization urges governments to advertise sustainable proteins and plant-based options to help curb the consumption of meat and dairy products. More than 80 countries issued food-based dietary guidelines (Food and Agricultural Organization 2016).

[8] The underlying data sources are the World Resources Institute, United Nations Framework Convention on Climate Change (UNFCCC), and the Climate Analysis Indicators Tool (CAIT) Climate Data Explorer.

ANNEX TABLE 1.1.1.

Top 10 Largest Emitters Considering the Share of Total GHGs, 2020

(In percent)

Country	Gross GHGs	Country	Net GHGs
Brazil	2.4	Brazil	3.2
Mexico	1.3	Mexico	1.4
Argentina	0.7	Argentina	0.8
Colombia	0.4	Colombia	0.6
Venezuela	0.3	Venezuela	0.5
Chile	0.2	Peru	0.5
Peru	0.2	Bolivia	0.3
Ecuador	0.1	Paraguay	0.3
Bolivia	0.1	Ecuador	0.2
Dominican Republic	0.1	Chile	0.1

Sources: United Nations Framework Convention on Climate Change; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Climate Data Explorer; and IMF staff calculations.

Note: Greenhouse gas emissions (GHGs) include CO_2, CH_4, N_2O, and F-gases sourced from energy, industry, agriculture, land use, land-use change, and forestry (LULUCF), waste, and others.

ANNEX TABLE 1.1.2.

Top 10 Largest Emitters Considering the Share of Non-CO_2 GHGs, 2020

(In percent)

Country	Gross Non-CO_2 GHGs	Net Non-CO_2 GHGs
Brazil	5.8	5.7
Mexico	1.9	1.8
Argentina	1.3	1.3
Colombia	0.9	0.9
Venezuela	0.4	0.4
Chile	0.3	0.3
Bolivia	0.2	0.3
Peru	0.2	0.2
Paraguay	0.2	0.2
Uruguay	0.2	0.2

Sources: United Nations Framework Convention on Climate Change; World Resources Institute, Climate Analysis Indicators Tool (CAIT) Climate Data Explorer; and IMF staff calculations.

Note: Greenhouse gas emissions (GHGs) include CO_2, CH_4, N_2O, and F-gases sourced from energy, industry, agriculture, land use, land-use change, and forestry (LULUCF), waste, and others.

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CHAPTER 2

Climate Strategies to Date

Diane C. Kostroch

Countries in Latin America and the Caribbean (LAC) continue to refine their climate plans. Almost all LAC countries have submitted and ratified their nationally determined contribution (NDC) commitments under the Paris Accords of 2016 aimed at reducing greenhouse gas (GHG) emissions. Most LAC countries also support the goal of carbon neutrality by 2050, and 14 LAC countries have committed to generating at least 70 percent of their electricity from renewable sources by 2030. Many countries have made commitments to implement the Kigali Amendments to phase out climate-warming hydrofluorocarbons. Most LAC countries have also taken first steps toward formulating national climate change strategies by devising climate change action plans for specific sectors or national action plans to address adaptation challenges. However, national climate strategies that comprehensively tackle both mitigation and adaptation challenges, as well as include action plans to address social repercussions, are few. Experience to date suggests that strategies are more likely to be successful if they consider the likely macroeconomic implications of climate change and climate policies, including financial stability implications, identify financing sources, and strive to reach broader social goals. Shifting the focus from ambition to implementation, while completing the Paris rule book, will help achieve climate goals faster by transparently monitoring countries' progress and holding them accountable for delivering on their targets.

LAC COUNTRIES' CLIMATE AMBITIONS

Almost all LAC countries[1] have submitted and ratified their NDC commitments under the Paris Accords of 2016 aimed at reducing GHG emissions. In addition to NDCs, 25 LAC countries support the goal of carbon neutrality by 2050,[2] and 14 LAC countries have committed to generating at least 70 percent of their electricity from renewable sources by 2030.[3] Many countries have made commitments

[1] Aruba has not yet submitted its NDCs.

[2] Canada and the United States also support the goal of carbon neutrality. All LAC countries that made net-zero pledges are listed in Table 2.1.

[3] Based on 2018 International Energy Agency World Energy Statistics and Balances, eight LAC countries already generate at least 70 percent of their electricity from renewables. However, for these countries, this did not constitute a formal commitment under their NDCs.

TABLE 2.1.

Countries That Pledged Net-Zero Emissions by 2050	
Antigua and Barbuda	Haiti
Argentina	Jamaica
Barbados	Nicaragua
Belize	Panama
Brazil	Peru
Chile	Saint Kitts and Nevis
Colombia	Saint Lucia
Costa Rica	St. Vincent and the Grenadines
Dominica	Suriname
Dominican Republic	The Bahamas
Ecuador	Trinidad and Tobago
Grenada	Uruguay
Guyana	

Source: Net Zero Tracker.

to implement the Kigali Amendments[4] to phase out climate-warming hydrofluorocarbons by cutting their production and consumption. Only some strategies (for example, those for Chile and Costa Rica; see Chapter 4) encompass both mitigation and adaptation policies and integrate sectoral action plans into a broader strategy that includes actions to protect the vulnerable.[5]

Governments have also supported their mitigation and adaptation strategies with a range of policy actions. In addition to measures aimed at expanding renewable energy sources mentioned previously, sectoral measures are becoming increasingly common in LAC. They include measures related to land-use change and forestry, transport, waste management, sustainable agriculture, livestock practices,[6] and health. These measures aim to reduce GHG emissions (mitigation)

[4] The Kigali Amendment to the Montreal Protocol on Substances That Deplete the Ozone Layer is an international agreement that countries ratified to gradually phase out powerful GHGs called hydrofluorocarbons that deplete the ozone layer.

[5] Climate mainstreaming on the national and subnational levels historically followed a sector-by-sector approach, as in Germany, France (Mathy 2007), India (Dubash 2011; Atteridge and others 2012), and Brazil (da Motta and others 2011; La Rovere and others 2011). The incorporation of sector-specific targets into a comprehensive greenhouse gas (GHG) reduction plan occurred subsequently. In Germany, for instance, the Federal Climate Change Act (approved in 2019 and amended in 2021) outlines annual GHG emissions reduction objectives for six sectors (energy, industry, buildings, transportation, agriculture, and waste and others) from 2022 to 2030. These targets align with European GHG reduction plans, with the rate of emissions reduction varying across sectors.

[6] The Food and Agriculture Organization defines food and agricultural systems as sustainable if they meet the needs of present and future generations while ensuring profitability, environmental health, and social and economic equity. Sustainable food and agriculture practices follow five key principles: (1) increase productivity, employment, and value addition in food systems; (2) protect and enhance natural resources; (3) improve livelihoods and foster inclusive economic growth; (4) enhance the resilience of people, communities, and ecosystems; and (5) adapt governance to the new challenges (Food and Agriculture Organization 2018). Low-emission sustainable farming has both mitigation and adaptation benefits—mitigation due to the reduction in GHG emissions from agriculture and livestock practices (for more details, see Chapter 3, Box 3.1) and adaptation due to reductions in negative externalities (such as pollution of ground water, soil conservation, and reductions in deforestation).

and to build resilience to climate change effects (adaptation). On the adaptation side, other actions under LAC countries' NDCs include measures geared toward coastal protection, disaster risk management, strengthening food and water security, and conserving biodiversity. Given the large share of GHG emissions from agriculture and land use, as well as the region's many unique ecosystems and species, several LAC countries have included explicit actions targeting nature-based solutions (NbSs) in their NDCs with a view to reduce emissions through carbon capture and sequestration and biodiversity protection.

LAC countries continue to submit updated NDC targets[7] ahead of the United Nations Climate Change Conferences (COPs), but global commitments fall short of the 1.5 degrees Celsius (1.5°C) ambition.[8] COP27 called on countries to raise their ambitions in cutting emissions, mobilizing climate finance, and stepping up climate adaptation efforts.[9] One hundred fifty countries announced their net-zero ambitions after COP27, including 25 LAC countries, but a near-term mitigation gap remains. One-third of parties, mostly advanced economies, raised their targets substantially. In LAC, 46 percent of countries improved their economy-wide targets, 43 percent remained unchanged, and 11 percent even reduced their ambitions.[10] Table 2.3 shows the latest and first-round NDC targets relative to 2022 and 2030 business as usual. Not surprisingly, since the end of COP27, countries have been revisiting and strengthening their climate pledges to close the ambition gap annually.

REDUCTIONS IN AGRICULTURAL AND CHANGE IN LAND USE AND FORESTRY EMISSIONS.

Some LAC countries made updated sectoral pledges covering coal, deforestation, and methane during the latest COPs. To date, over 150 countries accounting for nearly 50 percent of methane emissions made pledges to reduce their methane

[7] Eight LAC countries submitted updated or new NDC targets leading up to COP27 and one country in the run-up to COP28. For COP26, 20 LAC countries submitted updated or new NDC targets. Some LAC countries have pledged methane reductions during COP26 without sending updated NDC targets (for example, Ecuador, El Salvador, Guatemala, Suriname, and Uruguay). However, all except for Suriname subsequently updated their NDCs.

[8] As per IPCC (Masson-Delmotte and others 2022), the global ambition of limiting warming 1.5°C can be interpreted through the lens of 'avoided impacts' relative to higher temperature scenarios. Reducing the global temperature increase above pre-industrial levels corresponds to a decrease in risks for both human societies and natural ecosystems.

[9] All outcomes of the COP26 can be found on the United Nations Framework Convention on Climate Change website (https://unfccc.int/process-and-meetings/conferences/glasgow-climate-change-conference-october-november-2021/outcomes-of-the-glasgow-climate-change-conference) and on the COP27 website (https://unfccc.int/process-and-meetings/conferences/sharm-el-sheikh-climate-change-conference-november-2022/five-key-takeaways-from-cop27).

[10] Table 2.3 shows LAC countries' latest targets as submitted to the United Nations Framework Convention on Climate Change. Relative changes are influenced by a country's ambitiousness of its first NDC submissions.

TABLE 2.2.

Climate Change Mitigation and Adaptation Policies in the Western Hemisphere

M = Yes, mitigation measures taken; A = Yes, adaptation measures taken; No = No, or no efforts made to IMF staff's knowledge

	Carbon tax	Other PBMP		Non-PBMP					Structural resilience			Financial resilience					
	Carbon tax	Other carbon price measures	Phasing out energy subsidies	Environmental taxes	Tax incentives	Land-use practices	Reforestation/Afforestation (National Bureau of Statistics)	Blue economy	Resilient infrastructure	Adaptive afforestation, fight deforestation	Biodiversity	Climate finance for adaptation	Disaster fund	Insurance for disasters	Publicly financed insurance schemes	Climate adaptation into policymaking	Escape clauses
Costa Rica	No	No	M	M	M	M	M	M	A	A	A	A	A	A	No	A	A
Barbados	No	No	No	M	M	M	M	M	A	No	A	A	No	A	A	A	A
Dominican Republic	No	No	M	M	M	M	M	No	A	A	A	A	A	A	No	A	No
Jamaica	No	No	No	M	M	M	M	M	A	A	A	A	A	A	No	A	A
Peru	No	No	No	No	M	M	M	M	A	A	A	A	A	A	A	A	A
Grenada	No	No	No	No	No	M	M	M	A	A	A	A	A	A	A	A	A
Panama	No	No	No	No	M	M	M	M	A	A	A	A	A	A	No	A	No
Brazil	No	No	M	M	M	M	M	M	A	A	A	A	No	No	No	No	A
Guyana	No	No	No	M	M	M	M	M	A	A	A	A	A	No	No	A	No
Nicaragua	No	No	No	No	M	M	M	M	A	A	A	A	No	A	No	A	No
Argentina	M	No	M	M	M	M	M	M	No	A	A	A	No	No	No	No	No
Canada	M	M	No	No	M	M	M	No	A	A	A	No	No	No	No	A	No
Dominica	No	No	No	M	No	No	M	M	A	A	A	A	A	A	No	A	A
Honduras	No	No	M	M	M	M	M	M	A	A	A	No	No	No	No	No	A
Mexico	M	M	M	No	No	M	M	M	A	A	A	No	A	No	No	No	No
El Salvador	No	No	No	No	M	M	M	No	A	A	A	A	A	A	No	A	A
Antigua and Barbuda	No	No	No	No	No	M	No	No	A	No	No	A	No	A	No	A	A
Bolivia	No	No	No	No	No	M	M	No	A	A	A	A	No	No	No	A	No
Guatemala	No	No	No	No	M	M	M	No	A	A	A	A	A	A	No	No	No
St. Lucia	No	No	M	No	M	M	No	M	A	No	A	A	No	A	No	A	No
Trinidad and Tobago	No	No	M	M	No	No	No	No	No	A	A	A	A	A	No	No	A
Bahamas	No	No	No	No	No	No	No	M	A	A	A	A	No	A	A	No	A
Aruba	No	No	No	M	M	M	No	No	A	A	A	No	No	A	No	A	No
Belize	No	No	No	M	No	M	No	M	No	A	A	No	No	A	No	A	No
Ecuador	No	No	M	No	No	M	M	M	No	A	A	No	No	No	No	No	No
United States	No	M	M	M	M	No	No	No	A	No	No	No	A	No	No	No	No
Chile	M	No	No	No	No	No	No	No	No	A	A	No	No	No	No	No	No
St. Vincent and the Grenadines	No	No	No	No	No	M	No	No	A	No	No	No	A	A	No	A	No
Colombia	M	No	No	No	No	No	M	No	No	A	No	No	No	No	No	No	No
St. Kitts and Nevis	No	No	No	No	M	M	No	No	No	No	A	A	No	A	No	No	No
Uruguay	M	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
Paraguay	No	No	No	No	No	No	No	No	No	A	No	No	No	No	No	No	No
Suriname	No	No	No	No	No	No	No	No	No	A	No	No	No	No	No	No	No
Haiti	No	No	No	No	No	No	No	No	No	No	No	No	No	A	No	No	No
Venezuela	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

Sources: NetZero Tracker by Climate Watch; Western Hemisphere Development Climate Change Desk Questionnaire; and IMF staff calculations.
Note: PBMP = price-based mitigation policies.

TABLE 2.3.

Improvements in Climate Ambitions: Comparison of the Latest and First NDC Submissions, with 2030 Baseline

Country	Latest NDC, Relative to 2030 Baseline	First NDC, Relative to 2030 Baseline	Difference between Latest NDC and First NDC	Result
Argentina	−9	0	−9	▲
Bahamas, The	−30	−30	0	▬
Barbados	−34	−9	−25	▲
Belize	0	0	0	▬
Bolivia	0	0	0	▬
Brazil	−29	−19	−10	▲
Chile	−24	0	−24	▲
Colombia	−38	−7	−30	▲
Costa Rica	−13	−10	−3	▲
Dominica	−37	−7	−30	▲
Dominican Republic	−14	−50	37	▼
Ecuador	−1	−1	0	▬
El Salvador	0	0	0	▬
Guatemala	0	−18	18	▼
Guyana	0	0	0	▬
Haiti	0	−18	18	▼
Honduras	−16	−15	−1	▲
Jamaica	−49	0	−49	▲
Mexico	−36	−11	−25	▲
Nicaragua	0	0	0	▬
Panama	−12	−12	−1	▲
Paraguay	−23	0	−23	▲
Peru	−13	0	−13	▲
St. Lucia	0	0	0	▬
St. Vincent and the Grenadines	−22	−22	0	▬
Suriname	0	0	0	▬
Trinidad and Tobago	−15	−15	0	▬
Uruguay	−3	−3	0	▬
Canada	−45	−32	−12	▲
United States	−36	−6	−30	▲

Sources: Climate Policy Assessment Tool (CPAT); and IMF staff calculations.

Note: NDC = nationally determined contributions. Positive numbers indicate that mitigation pledges in the latest NDC submitted are to increase emissions in 2022 or 2030 levels compared with the first NDC submitted for respective levels (characterized as red arrow down, which indicates worse). Negative numbers indicate that mitigation pledges in the latest NDC submitted are to reduce emissions if expressed in either 2022 or 2030 levels compared with the first NDC submitted for respective levels (characterized as green arrow up, which indicates improvement). Zero indicates that mitigation pledges in the latest NDC submitted in 2022 or 2030 levels compared achieve the same reduction or increase as the first NDC submitted for respective levels (characterized as a yellow horizontal bar, which indicates no change). "Nonbinding pledges" refers to mitigation pledges where the target is above projected business as usual (BAU). In estimating total reductions, these are either taken as given (nonbinding pledges > BAU) or set to equal BAU. The latter case implies an assumption that countries do not raise emissions above BAU by, for example, reversing existing mitigation policies.

The list includes countries in Western Hemisphere Development with an NDC submission, except for Antigua and Barbuda, Grenada, and Venezuela.

TABLE 2.4.

Methane Emissions, by Country Pledging Reductions (2022)

	Emissions including LULUCF	Percent of Global Emissions
Brazil	544.5	6.0
Mexico	135.0	1.5
Argentina	113.3	1.3
Canada	89.7	1.0
Peru	24.2	0.3
Chile	21.6	0.2
Uruguay	21.5	0.2
Ecuador	17.4	0.2
Guatemala	15.9	0.2
Trinidad and Tobago	13.6	0.1
Dominican Republic	12.9	0.1
Honduras	8.5	0.1
Costa Rica	4.6	0.1
Panama	4.3	0.0
El Salvador	3.2	0.0
Guyana	1.6	0.0
Jamaica	0.9	0.0
Suriname	0.8	0.0
Belize	0.5	0.0
Barbados	0.2	0.0
Saint Lucia	0.1	0.0
Antigua and Barbuda	0.0	0.0
United States of America	606.5	6.7
Colombia	85.3	0.9

Sources: Climate Policy Assessment Tool (CPAT); and IMF staff calculations.
Note: LULUCF = land use, land-use change, and forestry.

(CH_4) emissions by 30 percent by 2030 compared to 2020, which implies a 13 percent global cut. However, these pledges fall short of the 45 percent reduction suggested by the United Nations Environment Programme to be aligned with 1.5 degrees Celsius. This included 24 LAC countries, accounting for 11.4 percent of methane emissions (Table 2.4). In fact, LAC countries pledged the largest global cut in methane emissions by 2030 compared with other regions (Figure 2.1).

However, given the notably different composition of GHG emissions in LAC compared to the rest of the world—with energy sector emissions below the world average and agricultural and change in land use and forestry emissions well above—even stronger commitments would be desirable to reduce methane emissions. Twenty-one LAC countries were also among the 141 countries that agreed to work together to stop and reverse the loss of forest and land degradation by 2030 (see Table 2.5). The declaration covers 90.1 percent of forests of the endorsers and envisages a transition to sustainable land use and forest management, as well as forest conservation and restoration, as a crucial component to meet the Paris Agreement goals. The 2023 South American summit, the first in 15 years, further reiterated the need to protect the Amazon from reaching a point of irreversible damage and gave a push to the Amazon

TABLE 2.5.

LAC Countries that Signed the Glasgow Leaders' Declaration on Forests and Land Use	
Argentina	Guyana
Belize	Haiti
Brazil	Honduras
Chile	Jamaica
Colombia	Nicaragua
Costa Rica	Panama
Dominican Republic	Peru
Ecuador	Saint Lucia
El Salvador	St. Vincent and the Grenadines
Grenada	Uruguay
Guatemala	

Source: UK Government web National Archive.
Note: LAC = Latin America and the Caribbean.

Cooperation Treaty Organization.[11] However, no consensus could be reached on the collective goals to halt deforestation and stop oil explorations in the region. Although COP26 was the first COP that called for a "phasedown of unabated coal" and "phase-out" of "inefficient" fossil fuel subsidies, which all countries agreed to, a commitment to broaden the pledge to phase down unabated coal emissions to cover all fossil fuels is outstanding. Nevertheless, these ambitions will affect the allocation of financial resources in the fossil fuel industry with potential risks of stranded assets in some LAC countries (discussed in Chapter 7). Shifts in investments could already be observed with investments in renewables outweighing those in fossil fuels for the first time in 2020.

INVESTMENTS IN CLEAN TECHNOLOGIES

The Breakthrough Agenda[12] launched during COP26 aims to globally speed up and synchronize green investments in clean technology to reach climate targets. Endorsed by the European Union and 44 countries, including Chile and Panama,[13] the agenda sets leader-led targets (also referred to as Glasgow Breakthroughs) to jointly accelerate the innovation and uptake of low-carbon technologies in six key

[11] The Amazon Cooperation Treaty (ACT) was initially signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela. In 1995, the Amazon Cooperation Treaty Organization (ACTO) was established to fulfill the objectives outlined in the ACT, focusing on sustaining biodiversity, and promoting conservation and sustainable resource management in the Amazon.

[12] For more on the Breakthrough Agenda, see https://webarchive.nationalarchives.gov.uk/ukgwa/20230311221206/ https://ukcop26.org/cop26-world-leaders-summit-statement-on-the-breakthrough-agenda/.

[13] Canada and the United States also endorsed the Breakthrough Agenda, as did nine other Group of Twenty (G20) economies.

TABLE 2.6.

Glasgow Financial Alliance for Net Zero, Financial institution in LAC to Net Zero Initiative, by Country

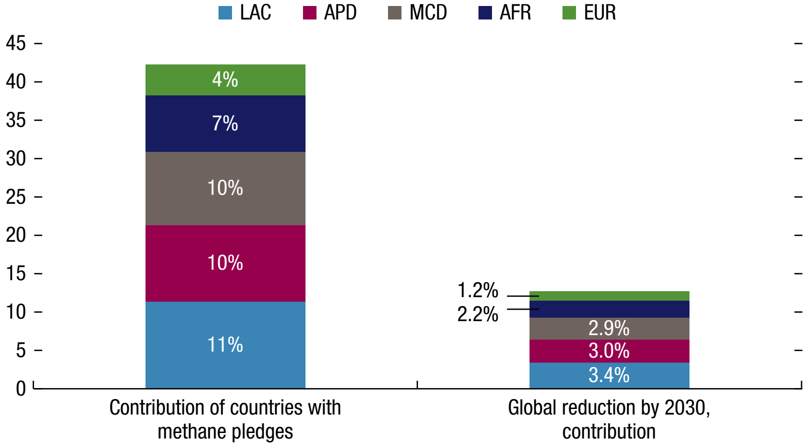
Brazil	**Ecuador**
FAMA	Banco de la Produccion S.A. Produbanco
IG4CAPITAL	Banco Guayaquil S.A.
JGP	**Mexico**
Banco Bradesco	Banco Mercantil del Norte, S.A.
Banco Itaú Unibanco S.A.	Bolsa Mexicana de Valores
Chile	**Nicaragua**
Linzor Capital Partners	Banco Grupo Promerica Nicaragua
BancoEstado de Chile	**Trinidad**
Colombia	Republic Financial Holdings Limited
Grupo Bancolombia	
Bancolombia	
Costa Rica	
BAC Credomatic	
Banco Promerica Costa Rica, S.A.	
Coopservidores	

Source: Glasgow Financial Alliance for Net Zero.
Note: FAMA = FAMA Investimentos Ltda; IG4CAPITAL = IG4 Capital Investimentos Ltda; JGP = JGP Global Gestão de Recursos Ltda; LAC = Latin America and the Caribbean.

economic sectors (power, road, transport, steel, hydrogen, and agriculture) by 2030. Targets aim to make clean power, zero-emission vehicles, near-zero-emission steel, and renewable and low-carbon hydrogen the most affordable and reliable option and to incentivize farmers to adopt climate-smart, sustainable agriculture. By devising international standards and policies and engaging in public–private partnerships, the aim is to incentivize global private investments and to accelerate the transition to decarbonized economies while reducing costs and allowing solutions to be affordable and inclusive (International Energy Agency 2022). Public investments and subsidies to clean technologies will play a crucial role, as successfully demonstrated in Germany as part of the "Energiewende," an energy transformation program that significantly reduced the costs of renewables and accelerated the transition. Disruptive technological progress in the sectors contributing the largest shares of GHG emissions will help with the move to implementation. The role of the private sector will also be essential. The Glasgow Financial Alliance for Net Zero, an alliance of 550 financial institutions across 50 countries, holding assets of more than $130 trillion, with 115 members from the Americas accounting for more than $5 trillion, pledged to align their activities to support the global economy to transition to net zero. Eighteen financial institutions in LAC also joined the Glasgow Financial Alliance for Net Zero (Table 2.6).

Recent discussions have shifted to estimating countries' climate finance needs. Acknowledging that countries will need to adapt to the impact of climate change, a concern particularly for vulnerable countries in LAC that often lack resources to do so, the Glasgow climate pact included a call for developed countries to double their climate financing for adaptation from 2019 levels

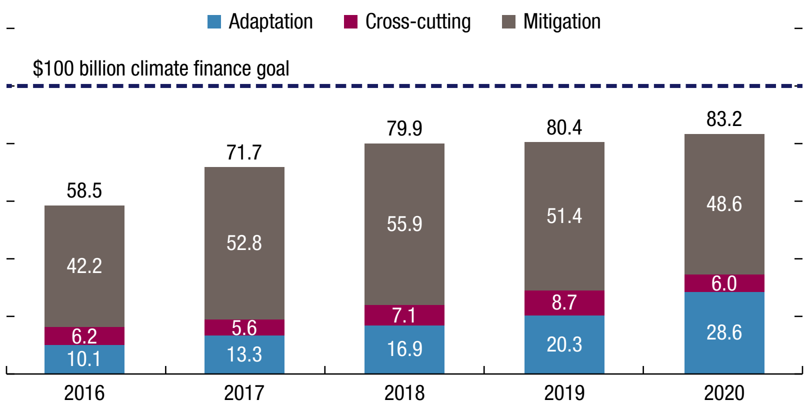
Figure 2.1. Methane Emissions and Pledges
(Percent of global emissions, 2020)



Sources: Climate Policy Assessment Tool; and IMF staff calculations.
Note: AFR = Africa; APD = Asia and Pacific; EUR = Europe; LAC = Latin America and the Caribbean; MCD = Middle East and Central Asia.

by 2025. Doubling adaptation finance would imply a $40 billion adaptation fund by 2025 (Figure 2.2). However, even if doubled and if developed countries' climate finance goal of mobilizing $100 billion per year by 2025 was reached, global climate finance needs are estimated to be well above the $100 billion. The annual investment needs for Latin America and Caribbean

Figure 2.2. Climate Finance Provided and Mobilized
(US$ billion)



Sources: "Aggregate Trends of Climate Finance Provided and Mobilised by Developed Countries in 2013–2020," Organisation for Economic Co-operation and Development report; and IMF staff calculations.

are estimated in a range of $90–$132 billion per year with some estimates as high as $350 billion[14] (see Chapter 10 for a detailed discussion). Given the lack of achieving this goal, its arbitrary nature, and its expiration in 2025, more recent discussions have shifted to quantifying and responding to countries' demonstrated climate finance needs based on a commonly agreed methodology rather than on financing targets. Climate finance up until now is skewed toward mitigation activities, such as the transition to renewables, due to higher yields. Adaptation finance in LAC has been increasing but is still below levels mobilized for mitigation efforts. In addition, adaptation activities have been mostly financed externally given the limits to domestic resource mobilization (Buchner and others 2021). For nearly three decades, countries vulnerable to unadaptable impacts of climate change (for example, floods and droughts) also called for loss and damage finance[15] of the Paris Agreement. At COP27, the establishment and operationalization[16,17] were finally decided. A key step to allow countries to directly access loss and damage financing was finally achieved.[18] More than $300 million in funding pledges (some previously announced climate funds relabeled as "loss and damage") have been made mainly for insurance programs, early-warning systems for extreme weather, and supporting the operation of the Santiago Network.

With COP27, the focus started to shift from ambition to implementation. Pledges are a first step in tackling climate change. However, to contain the rise in global temperatures by less than 1.5 degrees or 2 degrees Celsius, these ambitions must be backed by policies. To successfully move to implementation, strong institutions with a long-term mandate, harmonized and comparable data to monitor the progress of countries, and legal backing of climate ambitions are needed. Both would ensure accountability and credibility of the targets that countries and companies have set themselves. Financing developing countries will aid the transition and decarbonization efforts while ensuring an equitable and just transition. Political and macroeconomic stability will be essential to ensuring policy continuity.

[14] Naran and others (2022) estimate the annual investment needs by 2030 for Latin America and Caribbean in a range of US$150–350 billion.

[15] The first two pillars are mitigation and adaptation.

[16] This decision is referred to as the Sharm el-Sheikh Implementation Plan.

[17] The Santiago Network (currently a website hosted by the United Nations) established at COP25 in 2019 a first step toward action and support for countries experiencing loss and damage due to climate change impacts. Previous negotiations (for example, the Warsaw International Mechanism issued in 2013) focused on strengthening communication and enhancing support and actions via technical assistance and guidance without financial support. Although COP26 defined functions of the Santiago Network, a decision to fund the network so countries can directly request support and access loss and damage financing was taken during COP27 by establishing and operationalizing a loss and damage fund.

[18] The Alliance of Small Island States proposed a new facility to support financing for loss and damage, and Antigua and Barbuda jointly with Tuvalu launched a commission to claim reparation payments from large emitters via international courts in the absence of a loss and damage mechanism at the United Nations level.

The completion of the Paris rule book[19] paves the way for implementing climate ambitions by creating transparency in monitoring countries' progress. Under this new framework, all countries will have to report their emissions, progress toward their climate pledges, and contributions to climate finance at least every two years. The framework also lays out rules and procedures related to market mechanisms (transfers of emissions between countries by linking, for example, emissions trading system and the new United Nations Framework Convention on Climate Change Mechanism, which credits emission-reducing activities) and nonmarket approaches (such as cooperation between countries in developing renewables).[20]

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[19] During COP26, countries adopted common reporting tables for emissions inventory, tables to report progress on a country's NDCs, and tables to capture the climate finance provided as per Article 13 of the Paris Agreement.

[20] A long-standing debate surrounds Article 6 of the Paris Agreement on market mechanisms and nonmarket approaches. Opponents fear that market mechanisms (emission trading and crediting of emission-reducing activities) could undermine ambitions of global emission reductions. Supporters emphasize the opportunities for private sector involvements and incentives provision in emission-reducing technologies and activities (such as reforestation efforts).

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CHAPTER 3

Climate Mitigation in Latin America and the Caribbean: Policy Options

Diane C. Kostroch and Anna Ivanova

Countries in Latin America and the Caribbean (LAC) have several policy instruments available to reach their climate goals. These instruments can be divided into price-based and non-price-based mitigation policies. Non-price-based mitigation policies have been the primary focus of LAC policymakers so far; price-based mitigation policies are not common in the region, though they hold potential. Nature-based solutions could also play an important role in LAC countries. Decision-makers designing climate mitigation strategies will have to take into account political economy considerations. These considerations, alongside the global nature of climate change, call for a national and global dialogue that includes all stakeholders.

Among the several policy instruments available to LAC countries, on the mitigation side are price-based instruments (such as carbon pricing and fossil fuel subsidy reduction) and non-price-based instruments (such as regulation, fiscal incentives, and green public investment).[1] In choosing an appropriate policy mix, countries will need to think through not only efficiency and equity considerations but also considerations of political and social feasibility.[2]

Country specifics will play a key role in defining the appropriate policy mix to reduce net greenhouse gas (GHG) emissions and reach commitments under the nationally determined contributions (NDCs). Although the energy sector remains a large contributor to total emissions in LAC, the relatively large share of emissions from agriculture and change in land use calls for a multipronged approach to emissions reduction. Such an approach could involve a continued focus on increasing energy efficiency and shifting toward renewable energy sources, reducing emissions from transportation and agriculture (Box 3.1), and protecting or increasing natural carbon sinks such as forests. Furthermore, the

[1] For a full menu of instruments, see IMF 2019a, 2019b.

[2] For a further description of the menu of policy options for emissions reductions with a focus on the LAC region, see also ECLAC 2020.

Box 3.1. Agricultural Mitigation Policies

Latin America and the Caribbean (LAC) stands out for its large share of net greenhouse gas (GHG) emissions from agriculture and change in land use and forestry. They comprise 45 percent of total in LAC, compared with the world average of 14 percent (Chapter 1, Figure 1.4, panel 1). The Food and Agriculture Organization (FAO) estimates that livestock alone is responsible for about 15 percent of the annual global GHGs, which is almost equivalent to the global emissions from cars, planes, and ships combined. The following are successful measures[1] to contain agriculture and change in land use and forestry emissions:

- Sustainable land and forest management that targets afforestation, stops deforestation, protects and conserves areas at risk of conversion, and enforces deforestation policies together with civil societies, the private sector, and governments.

  These measures constitute the largest potential to reduce agriculture and change in land use and forestry emissions (IPCC 2019). Historically, Brazil has been most successful in achieving strong deforestation reductions,[2] driven by the private sector 2006 Soy Moratorium in the Amazon and the Brazil Forest Code, although recently there has been a partial reversal of these achievements (Americas Quarterly 2021). Other LAC countries that reduced deforestation and increased forest area include Argentina, Colombia, Costa Rica, and Chile; these efforts were combined with international coordination, like the New York Declaration on Forests that 10 LAC countries[3] also endorsed.
- Educational programs that highlight health and environmental benefits of plant-based diets and the removal of tax expenditures for emission-intensive products (for example, lower value-added tax rates or subsidies for meat and dairy products [Cline 2020; FAIRR 2017]).

  Taxing emission-intensive foods, aligning public procurement practices, and launching educational programs to induce dietary changes toward more plant-based diets would be key steps to reduce demand for emission-intensive agricultural products, which is estimated to increase by 50 percent by 2050 relative to 2013 levels. This surge is a result of growing population and income levels, translating into higher animal protein consumption in low- and middle-income countries (FAO 2017). The adoption of healthy,[4] sustainable diets would boost food security, lower emissions, enhance the food system's resilience, and free up land to meet agricultural demands (Batini 2021). Reducing food loss and waste, accounting for about 10 percent of food systems' GHG emissions, could offer additional mitigation potential (IPCC 2019).
- Incentives to contain livestock emissions and increase agricultural efficiency through targets for reducing and taxing CH4 emissions to boost investments in emission-efficient meat and milk production and biogas generation and leveraging the sequestration potential of soil management (IMF 2020a).

  Emissions trading system should also include biogenic, agricultural emissions and give biogenic credits for bioenergy with carbon capture and storage installations,

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This box was prepared by Diane C. Kostroch

[1] IPCC 2018 provides a summary of sector policy instruments and standards.

[2] From 2004 to 2012, Brazil reduced deforestation by an average 5 percent per year, amounting to a decline in the national deforestation rate of 84 percent. A return to 2012 developments would allow a reversal of recent trends and zero deforestation by 2030.

[3] Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guyana, Mexico, Panama, and Peru.

[4] Diets that are high in plant-based produce are healthier and have lower land/water use and GHG emissions than do average animal protein diets (Swinburn and others 2019; Willett and others 2019; Springmann and others 2016; Tilman and Clark 2014).

Box 3.1. *(continued)*

thereby incentivizing the removal of GHG from the atmosphere while addressing the issue of carbon leakage (Rickels and others 2020). Incentives to use anaerobic digesters could also reduce CH4 emissions via proper manure management. Reductions could reach as high as 90 percent (US EPA 2013). Anaerobic digestion systems capture CH4 from manure lagoons and stockpiles and allow farmers to use it in a beneficial way, such as generating biogas, fertilizers, animal bedding, and other products.

- Supportive regulation and standards in the agricultural sector that focus on reductions in the number of animals (with increased productivity by hectare); reductions in emissions from rice paddies by rewetting, drying, and other appropriate agricultural practices; changes in the animal feed composition and precision feeding; updated manure management systems; reducing the use of synthetic fertilizers in production; standards for land use matters and limiting conversion areas; expansion of organic soils and wetlands; and limiting or eliminating tillage via specialized equipment, which can prepare the seedbed without disrupting the soil. Improvements in agricultural productivity would reduce deforestation pressure associated with the expansion of agricultural land. Utilizing the agricultural land in more sustainable and efficient manner would also contribute to emission reduction.
- Strong international and regional initiatives aimed at establishing coordinated cross-border policies for the protection and regulation of the development of the Amazon basin. The Amazon Cooperation Treaty (ACT) was initially signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname, and Venezuela. In 1995, the Amazon Cooperation Treaty Organization (ACTO) was established to fulfill the objectives outlined in the ACT, focusing on sustaining biodiversity and promoting conservation and sustainable resource management in the Amazon. The 2023 South American summit, the first in 15 years, reiterated the need to protect the Amazon from reaching a point of irreversible damage and gave a push to the ACTO. However, no consensus could be reached on the collective goal to halt deforestation and stop oil explorations in the region; instead, each country will be setting its own deforestation objectives. Yet, to effectively address the challenges posed by deforestation and the development of the Amazon, international cooperation is essential for implementing comprehensive policies that prioritize conservation, responsible resource management, and the promotion of sustainable practices.

region may face a new urgency to invest in alternative energy technologies to mitigate risks associated with its dependence on hydropower. These risks include ecosystem destruction and more frequent and severe weather events, especially droughts, which can render hydropower a more volatile and less reliable energy source. Countries should adopt the policy mixes that best suit their specific circumstances, ideally articulated as national strategies.

Policymakers in LAC have a myriad of mitigation tools at their disposal. On the one hand, policies to mitigate climate change can be classified into supply-side and demand-side policies, depending on whether they aim to change production practices or consumer behavior. Supply-side policies aim to (1) increase availability of natural resources necessary for emission reductions (for example, deforestation), (2) stimulate production of energy from renewable and cleaner sources, and (3) motivate businesses across all sectors to reduce emissions in their production processes (for example, carbon pricing). Demand-side policies aim to shift consumer demand toward renewable energy and products, which are less harmful for

TABLE 3.1.

Classification of Mitigation Policies

Price-Based Mitigation Policies	Non-Price-Based Mitigation Policies

• Feebates, taxes, and subsidies
  • Carbon taxes (applied on emitters)
  • Carbon taxes (applied on sales or imports of fuel)
• Cap-and-trade systems, including emissions trading systems (ETSs)
• Baseline-and-credit systems, including emissions trading systems (ETSs)
• Differentiated electricity tariffs
	• Public investment in low-carbon technologies and infrastructure
	• Direct public spending on R&D, policing and law enforcement.
	• Supportive regulations
	  • Renewable portfolio standards
	  • Emission and emission reporting standards
	  • Technological standards
	  • Product standards

Source: IMF staff.

the environment. On the other hand, policies can also be divided into what are called *price-based mitigation policies* (PBMPs), which incorporate climate change costs in product prices, and *non-price-based mitigation policies* (non-PBMPs), which provide incentives to reduce GHG emissions, encourage the shift toward low-carbon activities, and enhance the natural carbon sinks that accumulate and store GHGs, such as oceans and forests (Table 3.1).

PBMPs are effective mitigation policy options:

- Carbon taxes can be set on both demand and supply sides, levied either on the sales or imports of fossil fuels in proportion to their carbon content or directly on the emitters.[3] These instruments are efficient because they allow firms and households to find the least costly way of reducing energy use and shifting toward cleaner alternatives (IMF 2019a; IMF 2020b). Carbon taxes are an efficient tool for reducing demand for fossil fuels; however, they may need to be set at high levels to achieve desired emissions reductions in countries with already low carbon content in energy generation and already high fuel prices, and this tax rate increase may be politically and socially challenging. Nevertheless, to relax the trade-off between balancing debt sustainability and GHG emissions reduction, carbon pricing can play a pivotal role, being cost-effective in reducing emissions while also generating revenues to relieve the debt burden, coupled with support for vulnerable households, considerations related to industrial competitiveness, and complementary policies (IMF 2023). Other environmental taxes can apply too—for example, taxes on energy use, motor vehicles, and waste. The removal of fossil fuel subsidies increases the relative price of energy products, thereby reducing their consumption and encouraging a shift toward low-carbon alternatives. Fossil fuel subsidy reduction is critical for emissions reduction but has proven politically and socially difficult in some countries. This implies that the design, phasing, and communications around a

[3] Mitigation policies, price-based as well as non-price-based, can be used to impact both demand and supply-side, as seen in the case of carbon taxes.

strategy to reduce or remove subsidies would need to be carefully crafted to help ensure social acceptance and protection of the most vulnerable.

- Emissions trading systems (ETSs) can be implemented in the form of cap-and-trade systems or baseline and credit systems. These systems auction or allocate emission permits that are then traded within a cap, or provide credits for the performance better than a predetermined baseline to incentivize emissions reductions. ETSs can be applied to a wide a range of economic activities, including energy, agriculture, and forestry (Rickels and others 2020). Implementation of ETSs in forestry and agriculture, however, would require well-defined property rights as well as good measures of agricultural emissions such as CH_4 and nitrous oxide (N_2O).[4,5] While ETSs may be more politically acceptable than a carbon tax, they typically have a more limited coverage and require a more sophisticated administration and strong institutional governance to monitor downstream emissions, allowance registries, and market trading relative to a carbon tax (Parry and others 2022b).
- Feebates could also be applied in sectors that are hard to decarbonize, such as transportation, agriculture, and forestry. Feebates tax (subsidize) activities and products with above (below) average emissions (or above [below] the baseline level of carbon storage). Feebates help achieve cuts in emissions without adding a net tax burden on industry or a fiscal cost. They also have advantages over regulations since they provide incentives to adjust to technological innovation. At the same time, feebates typically have a narrower sectoral reach than do carbon taxes and require periodic schedule adjustments to account for changes in consumption and emissions patterns.
- Differentiated electricity tariffs can influence consumer demand, depending on the combination of attributes. Woo and others (2014) showed that product differentiation is a meaningful concept for electricity and can improve grid operations and planning, lowering the cost of delivering electricity services. Some tariff differentiation mechanisms are suitable for simple metering practices: block rates depend on the volume of consumption; the Hopkinson tariff depends on both the volume of consumption and the monthly maximum use and is usually used for large, nonresidential customers; and conservation tariffs, aimed at reducing electricity consumption, depend on current consumption levels compared with the historical average. More complex metering systems allow for electricity tariffs differentiated by the time of use, customer load, and reliability of the service; they aim to be set at the marginal cost of the electricity production. More complex tariff systems account for the fuel used (that is, different tariffs for renewable electricity) and environmental impact (that is, special tariffs for electric vehicles).

[4] For example, New Zealand has designed a pricing scheme for agriculture (with all revenue recycled back to the industry to improve political acceptability and reduce competitiveness concerns) and also includes forestry in its ETS.

[5] Parry and others (2022a) presents fiscal policy options to cut GHG emissions and assesses their economic impact.

A barrier to the implementation of carbon pricing are often concerns regarding the loss of competitiveness, particularly for energy-intensive and trade exposed sectors.[6] Strategies to address these competitiveness issues include: (1) fostering international coordination on climate mitigation policies to eliminate the cost advantage of shifting to another location; (2) implementing revenue-neutral policies where subsidies for firms with below average emission-intensity are funded by payments from firms with above average emission-intensity (for example, feebates, tradable performance standards, or cap-and-trade with free allowances); (3) applying a carbon price to emissions exceeding a specified threshold level to incentivize emission reductions—an approach that may forego revenue and would require a threshold that is sufficiently low; and (4) considering exemptions for energy-intensive, trade-exposed sectors, though this may forego revenue and miss potential emission reduction opportunities, potentially leading to requests for exemptions from other firms and interest groups.

PBMPs have not been actively used in LAC. Only five LAC countries (Argentina, Chile, Colombia, Mexico, and Uruguay) have carbon taxes in place (Figure 3.1); where they are implemented, the tax rates are low (in the range of \$1 to \$10[7] per ton CO_2-eq) and carbon taxes cover only a portion of the GHG emissions (20 to 24 percent).[8] Although many LAC countries have environmental taxes, including on energy, fuels, and transport, these taxes collect less revenue (1.1 percent of GDP, on average, in 2018) than do those in the OECD (2.2 percent of GDP, on average). They are also not linked directly to the carbon content of the product; hence, they are less effective in creating incentives for emissions reduction (Figure 3.1).

Some countries continue to have large fossil fuel and electric power industry subsidies. Latin America exceeds the world average on explicit fossil fuel subsidies, which reflect price deviations from supply costs (Figure 3.2). Explicit fossil fuel subsidies are particularly large in oil-producing economies in LAC, exceeding 1 percent of GDP in some cases. Other countries have smaller subsidies, in part, due to past subsidy reforms though reform reversals are common (see Box 3.2 for an example in the case of Mexico). At the same time, implicit subsidies that reflect price deviations from efficient fuel prices, including environmental costs, are lower in LAC than in other regions. This is due to the lower contribution from global warming and lower coal subsidies in LAC as a reflection of the cleaner energy matrix in the region. Variation exists, however, across the region, with implicit subsidies remaining large in the Caribbean. In addition to inefficient fossil fuel subsidies, some countries subsidize electric power producers, supplying electricity to final consumers below market prices. Such practices cause inefficiencies and excessive technical losses of

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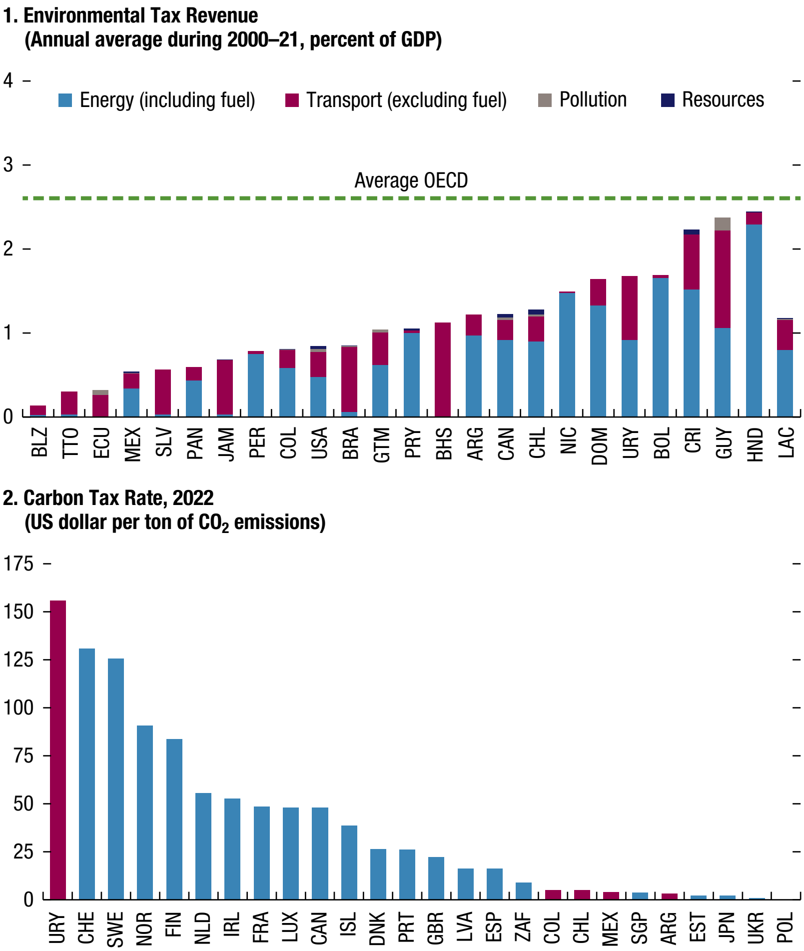
[6] See, for instance, World Trade Organization 2022.

[7] Since January 1, 2019, Argentina is applying a carbon tax of \$10/tCO_2eq to most liquid fuels. However, for fuel oil, mineral coal, and petroleum coke, the tax rate in 2019 was set at only 10 percent of the full tax rate (that is, \$1/tCO_2eq), increasing gradually by 10 percentage points (pp) every year to reach a full rate of \$10/tCO_2eq by 2028 (see World Bank and Ecofys 2018). Figure 1.8, panel 1, reports an average tax rate for Argentina.

[8] Not all countries' strategies rely on carbon taxes; see, for instance, IMF 2021.

Figure 3.1. LAC: Carbon and Environmental Taxes



Sources: IMF Government Finance Statistics (GFS); IMF Statistics Department Questionnaire; World Bank, Carbon Pricing dashboard (April 2022); and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. LAC = Latin America and the Caribbean.

electricity in transmission (World Bank 2009), leading to unnecessary environmental costs. Compared with the United States, most LAC economies, except Chile and Barbados, experience large electricity losses (Figure 3.2). Both technical (inefficient transmission systems) and nontechnical (for example, unauthorized use of electricity lines) losses are important in some LAC countries.

The LAC region does not yet actively use ETSs or feebates. Mexico sought to launch its ETS in 2022 after a three-year pilot as part of its NDC implementation; however, the launch has been delayed into 2024. Brazil has conducted voluntary ETS simulations since 2013, and tabled a draft Law to the National Congress to establish

Box 3.2. Removing Fossil Fuel Subsidies: The Case of Mexico

In 2012, as part of a wider fiscal and energy sector reform, Mexico embarked on a policy to gradually reduce fossil fuel subsidies after nearly a decade of subsidizing the end-user prices of gasoline, diesel, and liquified petroleum gas (LPG). The fall in oil prices in 2014 helped consolidate the reform, which eventually succeeded in transitioning to positive net taxes in 2015. However, increasingly subsidized tax rates and tax credits to the publicly owned oil company reversed some of the progress, with the cost of fuel subsidy support rising in the wake of the pandemic.

When Mexico made the decision to gradually phase out fuel subsidies as part of its effort to reform the energy sector and reduce its fiscal dependence on oil resources against a backdrop of declining oil production, explicit subsidies for fossil fuel consumption stood at 3 percent of GDP in 2012. Newly elected president Enrique Peña Nieto (2012–18) made energy reform the "signature issue" of his mandate. Mr. Peña Nieto initiated the process by building a strong consensus among a varied set of stakeholders on the need for the reforms.[1] The effort first materialized in an agreement known as the Pacto por Mexico, a wide-reaching reform agenda that included, among other initiatives, energy sector reform, a comprehensive fiscal reform, and the elimination of energy subsidies. The agreement was signed by Mexico's three main political parties and was supported by all levels of government. The reforms were to run in parallel to the push by Mexico to decarbonize its growth model,[2] including by the introduction of a carbon tax.

In 2013, amendments to the constitution presented the first effort to liberalize the energy sector in 75 years by allowing private and foreign investment. The amendments were followed in 2014 with a new regulatory framework and associated secondary legislation that, via a multiyear process, adjusted the fuel pricing and taxation regimes by which the prices of gasoline, diesel, and LPG were liberalized to gradually align with market prices (Table 3.2.1).

TABLE 3.2.1.

Mexico: Elements and Chronology of Fossil-Fuel Subsidy Reform and Environmental Taxation

Concept	Reforms
Gasoline and Diesel	In 2014, the Impuesto Especial Sobre Producción y Servicios (IESP) excise tax (at a variable rate) was extended to gasoline and diesel consumption. In 2015, monthly minimum and maximum prices were introduced. In 2016, the IEPS tax was set at a fixed rate, and maximum prices started following a formula that increasingly allowed pass-through from international prices within a +/– 3 percent band. In 2017, regions whose markets were sufficiently competitive were allowed to fully liberalize prices. Gasoline and diesel prices were fully liberalized by late 2018.[3]
LPG	The 2014 reforms set the legal basis for liquefied petroleum gas (LPG) market liberalization, and subsidies were completely eliminated by 2015. The LPG market was fully opened to competition by 2017.
Natural Gas	Subsidies began to be gradually phased out in 2008 and were eliminated by 2014. Prices were fully market based by 2017.
Carbon Tax	This tax was introduced in 2013 as a fixed excise tax on fossil fuels and fully implemented by late 2016. Certain fuels (that is, natural gas) and activities are subject to reduced, or zero, tax rates.

This box was prepared by Luisa Charry.

[1] Previous attempts, notably the 2008 energy reform, were heavily contested and passed despite massive public demonstrations and the passage of a nonbinding referendum against it.

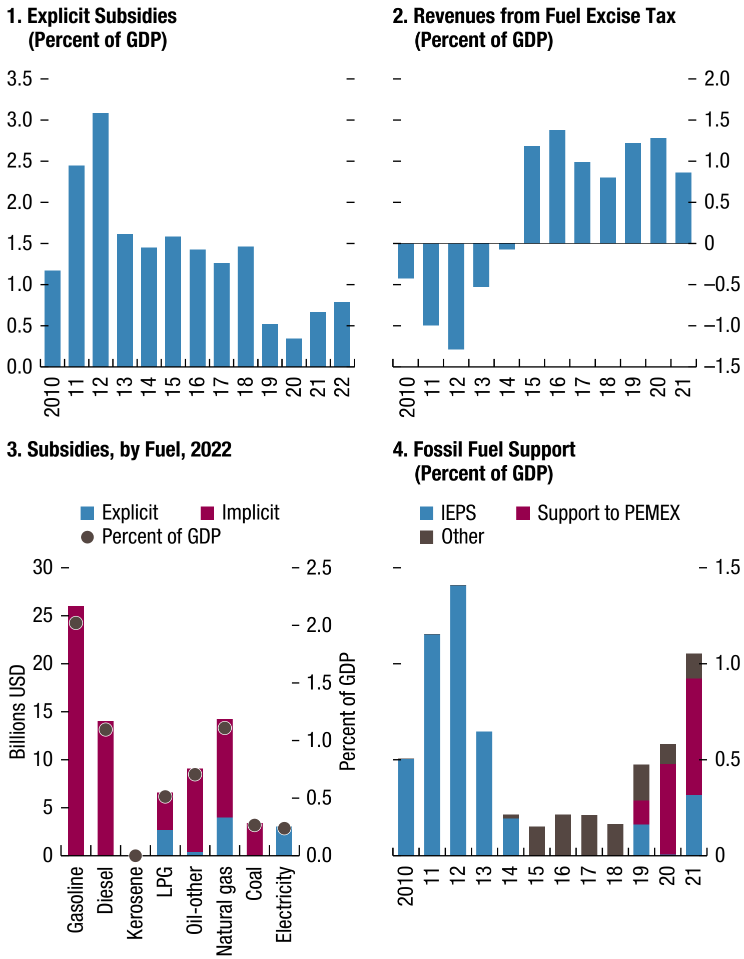
[2] As intended in the 2012 General Climate Change and Energy Transition Laws, which set to goals to reduce emissions growth by 30 percent by 2010 and 50 percent by 2050.

[3] Since 2016, the tax rates have been broadly aligned with those of OECD and G20 members.

Box 3.2. *(continued)*

The reforms were lauded both as ambitious (OECD 2017) and far-reaching (Wood 2018). Early on, the government sent a clear message on their irreversibility. By 2013, public support for the reforms was strong[4] and the fall in oil prices in 2014–16 opened the window of opportunity to advance the politically costly measures with limited backlash. By 2016, explicit subsidies were firmly on a downward path (Figure 3.2.1, panel 1), and the IEPS was contributing positively to the budget (Figure 3.2.1, panel 2). A major setback was presented in 2017, when higher international oil prices and a weaker currency compounded the price hikes (of up to 20 percent in a single month), which were met with widespread discontent and violent

Figure 3.2.1. Subsidies for Mexico



Sources: Country authorities; OECD; and IMF staff.

[4] For example, a September 2013 poll showed that some 53 percent of respondents backed the reforms (Wood 2018).

Box 3.2. *(continued)*

protests. The social discontent was fueled in part by the lack of significant compensatory measures for vulnerable households and miscommunication about the impact of the wider energy reform, which had led the public to believe that fuel prices would fall.[5]

Despite the increasingly politically costly measures, by 2020 explicit fuel subsidies had fallen to 0.5 percent of GDP (Figure 3.2.1, panel 3), while the adjustment to the IEPS tax helped explain other wider measures of fossil fuel support, such as the one calculated by the OECD (Figure 3.2.1, panel 4). However, the post-2018 period has featured some policy reversals under the administration led by Andres López Obrador, a long-standing critic of the reforms who campaigned on the falling public support for them. An increase in the "fiscal stimulus" subsidy[6] to keep fuel prices from rising in real terms and reduce their volatility, along with increased tax credits, reductions, and deductions for the publicly owned oil company (PEMEX), have resulted in a more recent upward trend in fossil fuel support (Figure 3.2.1, panel 4). Meanwhile, subsidies to electricity consumption remain an area where reforms have failed to gain backing.

[5] The transportation share in household spending in Mexico is relatively high (13 percent). According to Moshiri and Santillan (2018), the welfare effect of the price increases on low-income households was 18 times higher than that on upper-income households and 9 times larger than that on middle-income households.

[6] The subsidy was initially introduced in 2016 to mitigate the impact of the variations in international prices and the exchange rate on fuel prices.

a mandatory Brazilian Greenhouse Gas Emissions Trading System in 2023. In Colombia and Chile ETSs are under consideration as well as feebates in Costa Rica.

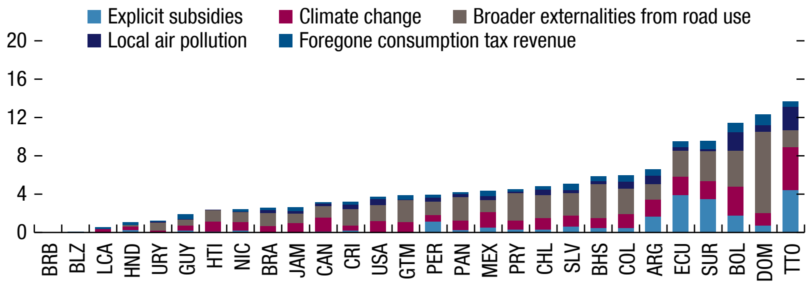
Non-PBMP tools have been the primary focus of LAC policymakers to date and will continue to be important.

- Public investment in low-carbon technologies and infrastructure (for example, electrification of public bus fleets, installation of solar panels and wind turbines, investment in more sustainable farming methods) could lower the cost of switching to sustainable practices. Public investment has the added benefit of directly contributing to a sustainable and inclusive post-pandemic recovery.[9]
- Fiscal incentives and direct current public spending could also help make low-carbon energy sources more abundant and affordable by tackling market failures such as knowledge spillovers, network externalities, and economies of scale—and thereby increasing demand for and supply of low-carbon products and activities (IMF 2020b). These policies could include subsidies and direct public funding for R&D as well as subsidies and price guarantees for low-carbon sectors and activities, potentially generating positive spillovers to

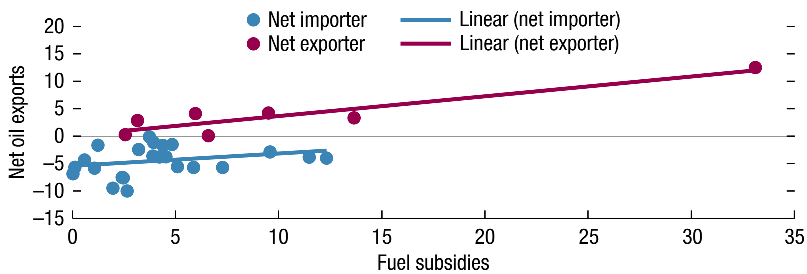
[9] Studies (for example, Smulders and others 2014) find that if economies aim to reduce emissions exclusively by lowering energy intensity, the resulting output contraction may be substantial. In contrast, the growth impact appears to be smaller when countries aim at both greater energy efficiency and low-carbon energy supply. Early investments in renewable energy sources, including public investment, are key to contain the negative supply shock countries otherwise might face.

Figure 3.2. LAC: Fossil Fuel Subsidies and Electricity Losses

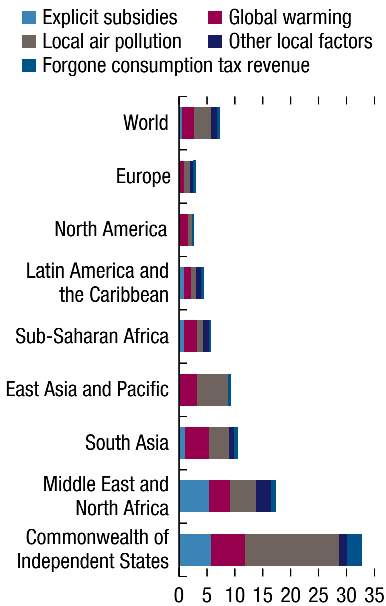
1. Fossil Fuel Subsidies, by Type, 2019[1]
(Percent of GDP; comparison among LAC countries)



2. Fossil Fuel Subsidies and Oil Exports in LAC Countries
(2019 percent of GDP)



3. Fossil Fuel Subsidies, by Type, 2019[1]
(Percent of GDP; comparison among regions across the world)



4. Fossil Fuel Subsidies, by Type of Product, 2019[1]
(Percent of GDP; comparison among regions across the world)

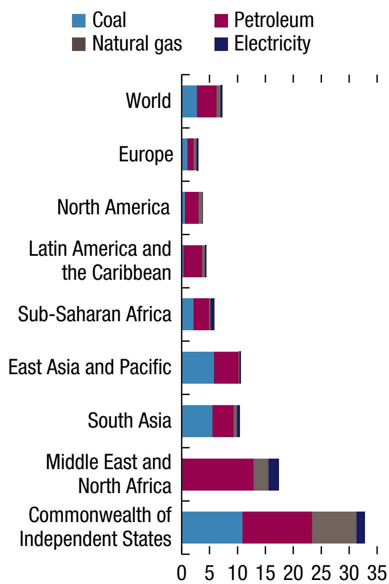
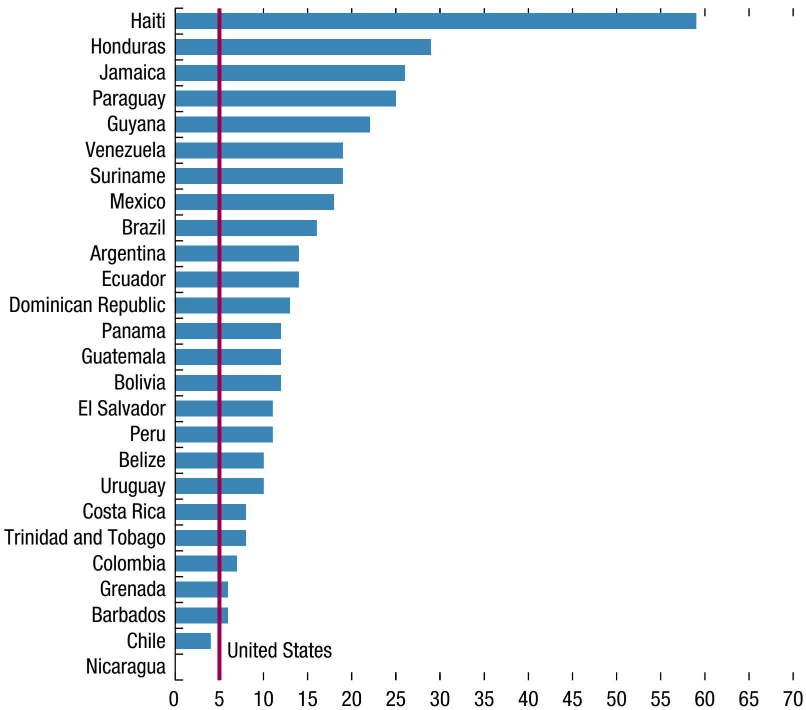


Figure 3.2. *(continued)*

5. Electricity Losses in LAC
(2019, percentage of the total electricity supply)



Sources: World Bank; Carbon Pricing Dashboard (April 2022); and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. LAC = Latin America and the Caribbean; LPG = liquefied petroleum gas; WHD = Western Hemisphere.
[1]Other local factors comprise road congestion, damage, and accidents. Fossil fuel subsidies include the following products: gasoline, diesel, kerosine, LPG, natural gas, coal, electricity.

the private sector.[10] Despite government policies to incentivize green R&D in some LAC countries, such investment has remained limited, possibly reflecting the fact that LAC countries, like other emerging and developing economies, have benefited from international technological diffusion (Barret 2021), which may also remain the case going forward. Some LAC countries also have programs that provide direct payments for environmental services to promote environmentally friendly practices. For example, in Costa Rica the government makes direct cash transfers to landowners for environmental services such as carbon sequestration, biodiversity protection, water regulation, sustainable forest management, and agroforestry (Pagiola 2008). In Colombia

[10] There is evidence that innovations in green technology, which could be induced by policies, can decrease the size of the carbon tax required to reach net-zero emission (see, for instance, Fried and others 2018; Acemoglu and others 2016).

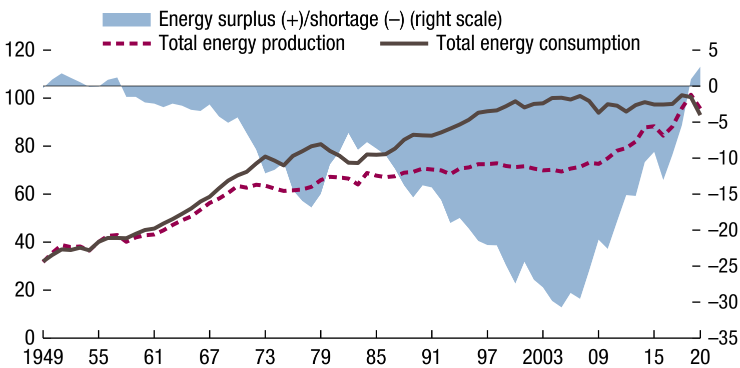
the government supports coffee producers with payment schemes for environmental services to increase coffee production while ensuring environmental sustainability. Government-financed educational programs could also help disseminate knowledge about low carbon technologies, induce change in behavior, and gather public support for climate actions. For example, agriculture extension programs, which disseminate knowledge about sustainable agricultural practices, could promote climate-smart farming practices and increase agricultural productivity and resilience.

- Supportive regulations could encourage a reduction in emissions and a shift toward low-carbon activities; they could also protect and enhance the region's natural carbon sinks. Such regulations could include emission standards for industries, buildings, transport, and products; technological standards to enhance fuel and energy efficiency; product standards to foster phasing out of polluting products and encourage the use of low-carbon products and activities; and land and forest management standards (Folmer and Gabel 2000). By creating a more customized shadow price for carbon, regulations have the advantage of being politically easier to adopt; however, they tend to be less cost effective than price-based measures, raise no revenue that could be used to compensate the vulnerable, and involve uncertain costs for the consumer. Effective regulations are those that are predictable, impartial, and easily accessible; as such, they require robust anticorruption safeguards in place (IMF 2020a). For example, emission reporting standards enhance transparency, inform future investment decisions, and allow tracking of progress towards decarbonization business models. The United Nations Framework Convention on Climate Change provides guidelines on standardized requirements for reporting national GHG inventories annually. Another example is a renewable portfolio standard (RPS), which is a non-price based supply-side policy instrument aiming to promote renewable electricity generation. It requires electric utilities and other retail electric providers to supply a specified amount of electricity sales from renewable energy sources by a predetermined schedule. These state-level policies are very diverse in terms of the eligibility of alternative energy sources, target percentages, plans to meet the established targets, the penalty for noncompliance, and enforcement mechanisms. When implemented efficiently, RPSs should benefit the environment, increase diversity and security of energy supply, lower natural gas prices (due to higher competition among energy suppliers), and boost local economic development (mainly in rural areas). Success of RPSs in the United States indicates that such instruments—when they are properly designed and include a penalty mechanism—help states reach their renewable targets and increase share of electricity produced from the renewable sources (see Box 3.3 for details). *Interconnection and net metering standards* complement RPSs by allowing consumers who generate own electricity to connect to the grid and sell some of the electricity they produce to the grid, while paying for the net electricity they use from the grid.

Box 3.3. US Policies to Stimulate Renewable Electricity Generation and Decarbonize Economy

The United States began to develop renewable energy policies in the 1980s, shortly after the 1973–79 oil shocks, which highlighted the growing domestic energy imbalance (see Figure 3.3.1), and the first World Climate Conference in 1979. To increase domestic energy generation from renewable sources, many states designed renewable portfolio standard (RPS) policies. Their adoption became widespread in early 2000. Most recently, the Inflation Reduction Act of 2022 introduced a new package of policy measures aiming to lower energy costs, boost energy security, and reduce greenhouse gas emissions. This box summarizes lessons from the adoption and implementation of the RPS in the US, and the potential of the Inflation Reduction Act of 2022 (IRA-2022).

Figure 3.3.1. Energy Production, Consumption, and Balance in the USA
(In quadrillion Btu)



Source: U.S. Energy Information Administration.
https://www.eia.gov/totalenergy/data/annual.

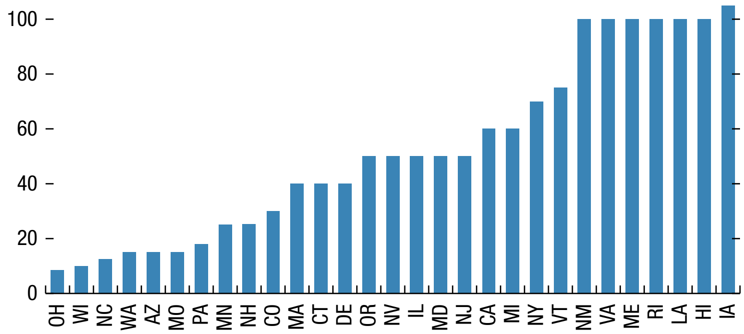
The RPS policies in the US helped to restore the energy balance (measured as production net of consumption) and raise the share of renewable energy. The Iowa Alternative Energy Law of 1983 became the first US legislative act related to the stimulation of renewable energy production and a prototype for the RPS policies widely adopted by the US states in early 2000. Today, most US states and Washington DC have RPS (Figure 3.3.2). Analysis of the RPS' adoption, compliance, and impact on renewable energy generation implies policy lessons follows:

- *RPS adoption was more likely in states with deregulated electricity markets, higher electricity prices, and higher income per capita*. Bespalova (2010) found that states that began liberalizing retail electricity markets were 13.2 percentage points more likely to adopt RPS policies. States with electricity tariffs higher by one more cent per kW-h were about 9 percentage points more likely to adopt RPS. State income per capita and CO_2 emissions, but their marginal impact was small.
- *States are more likely to comply with the RPS when include penalty or had high CO_2 emissions.* Bespalova (2011) found that the probability that a state fully complies with its RPS target would increase (1) by 19.2 percentage points with a $1 increase in the

This box was prepared by Olga Bespalova.

Box 3.3. *(continued)*

Figure 3.3.2. RPS Targets for Share of Electricity Generated from Renewable Sources by State
(In percent; in megawatt-hours [MWh] for IA)



Source: Database of State Incentives for Renewables and Efficiency. https://www.dsireusa.org/.

penalty, and (2) by 3.3 percentage points with one million metric tons of CO_2 emissions.

- *RPS policy design and environmentally friendly legislation led to higher renewable electricity shares.* Bespalova (2014) showed that the RPS design mattered the most: the share of electricity generated from renewable sources increased by 0.4 percent with one more percent of the RPS target (which sets a fractional goal for electricity to be generated from the renewable sources) and by 0.35 percent with one more dollar per MWh of penalty. States with 1 percent more League of Conservation Voters generated 0.03 percent more electricity from renewable sources.
- *The effectiveness of RPS was complemented by net metering and interconnection standards.* The latter define how easy it is for small energy producers to sell the electricity they produce to the electric utility.

Lessons learned from the US experience with RPS suggest broader possibilities for LAC economies concerning implementation of environmental policies. First, such policies were more likely to be adopted by and effective in countries with higher pollution levels or more environmentally concerned politicians; considering the country size, a pilot can be carried out in a chosen territory. RPS could be more attractive in countries with a higher share of fossil fuels (especially coal) in their electricity generation matrix, to target more desirable (cleaner and cost-effective) energy sources.

Second, policy design matters. It is necessary to put in place a strong enforcement mechanism (including a sizable penalty for noncompliance) and set fractional quantitative targets in the medium term. Third, electricity market deregulation liberalization and liberalizing electricity prices help to motivate renewable energy production through higher competitiveness and cost recovery.

Finally, complementary policies are important too. For example, net metering and interconnection standards allow small electricity producers—particularly those using renewable sources—to connect to the grid and sell excess production to the grid. Furthermore, investments in the electrical grid and its reliability, along with the use of electricity tariffs differentiated by the type and time of consumption, can help shifting consumption patterns, addressing grid bottlenecks and electricity volatility.

Nature-based solutions (NbSs) may be a cost-effective means for LAC to manage natural resources in a way that reduces GHG emissions. These innovative approaches aim to protect, handle, and restore ecosystems. NbS policies do not neatly fit in the classification in Table 3.1 because they are a combination of supportive regulations, incentives, feebates, and ETSs. NbS policies can include, for example, reforestation, restoring coastal habitat, and sustainable water management. These policies can be geared toward addressing both mitigation and adaptation challenges. If grounded in a sound understanding of the ecosystems and biodiversity, NbS could support decarbonization through carbon capture and sequestration while limiting a sharp rise in carbon prices, help address food and water security, reduce natural disaster risk, increase biodiversity, and foster socioeconomic development by creating green jobs (IUCN 2016). Given the abundance of natural resources and ecosystems in LAC, there is room to use NbSs (Box 3.4). However, for NbS to reduce GHG emissions, additionality is essential. Additionality implies that the reduction in emissions is permanent and would not have been achieved without the additional offset. An example would be a tree planted as part of reforestation efforts realizing its potential over decades as it is growing. If emission reductions created by NbS are not additional, this could lead to an increase in net emissions and "greenwashing" (see Black 2018).

A conducive business environment will be essential for implementing climate mitigation policies and benefiting from technological diffusion; such environment includes maintaining macroeconomic and financial stability (Box 3.5), establishing clear property rights, protecting intellectual property rights, strengthening competition, improving transparency, and fostering financial inclusion. To this end, LAC countries should begin to incorporate climate-related risks and policies into macro-financial and fiscal frameworks and assign roles and responsibilities to public policy institutions in tackling climate change. Given the long-term nature of climate risks, fiscal institutions will naturally take the lead. Nonetheless, central banks can play an important role by incorporating climate risks in financial risk assessments and monetary policy design (for example, in the assessment of potential output and neutral policy interest rates, or the appropriate policy response to adverse supply shocks emanating from extreme weather events).[11]

Decision-makers designing climate mitigation strategies will need to account for political economy considerations (Box 3.5).[12] While overall climate mitigation policies are expected to yield positive aggregate welfare benefits over time, there will be winners and losers during the transition to a greener economy. For example, the new green jobs—given their potentially different skill set requirements and geographic locations—may not benefit those workers who were previously

[11] For example, the Central Bank of Brazil has recently mandated that banks incorporate climate change–related risks in their stress tests starting in December 2022.

[12] Furceri and others (2021) showed that market-based climate policies have salient negative effects on popular support.

Box 3.4. Investments in Nature-Based Solutions in Latin American and the Caribbean

Latin America and the Caribbean (LAC) is particularly well positioned to benefit from nature-based solutions (NbSs) as part of its climate mitigation and adaptation strategies as well as its infrastructure development. While the estimated global mitigation potential from NbSs surpasses one-third of greenhouse gas (GHG) reduction targets by 2030 according to the United Nations Environmental Program, the benefits would be higher in LAC, as it is home to more than 40 percent of the remaining tropical forests, a large number of marine ecosystems, and 11 percent of the world's agricultural lands. At the same time, the region derives a large share of GHG emissions from land use, land-use change, and forestry (see also Roe and others 2021; Austin and others 2020).

NbS investments can attain complementary economic and social goals. The LAC region's vulnerability to extreme weather events necessitates investments to ensure economic resilience, water supply, and basic sanitation and to avoid both environmental and infrastructure degradation. However, traditional (gray) infrastructure investments, such as dams, will meet tight budget constraints in the postpandemic context and can themselves be environmentally damaging. Investments in NbS—for instance, reforestation, watershed restoration, and protection mangroves or coral reefs—either in isolation or combined with traditional investment can be a cost-effective way to improve livelihoods (better water quality and supply, less urban pollution, reduced flood and landslide risks, farm profitability, and food security) while bolstering resilience and contributing to climate change mitigation (through carbon capture). NbS projects can also create new jobs, notably for unskilled workers and in vulnerable communities, which are still struggling to recover from the COVID-19 crisis. Importantly, the success of NbS hinges on the development of effective planning and impact monitoring tools to ensure meaningful and long-lasting reductions in carbon emissions, resilience building, and social sustainability, thereby mitigating greenwashing risks.

Several LAC countries explicitly included in their nationally determined contributions (NDCs) provisions linked to NbSs. Although the actual NbS investments and number of projects are still relatively low (Boyle and Kuhl 2021; Ozment and others 2021), the momentum behind NbS has grown over the past decade. As such, various LAC countries, as part of their NDCs, either included specific NbS commitments (Argentina, Bolivia, Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Jamaica, and Mexico) or indirectly reference it (Paraguay and Peru). Many have upgraded such commitments in the runup to the United Nation's 2021 climate change conference (COP26). Peru has also adopted specific legislation that requires utility companies to fund NbS investments. Several countries in the region have implemented or are implementing NbS projects under the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) framework, which was established under the Paris Agreement to incentivize forest conservation, sustainable management as well as reforestation to reduce carbon emissions. Implementation and impact assessments are conducted by independent parties, reported to the United Nations Framework Convention on Climate Change, and published to enhance transparency, allowing countries to seek results-based carbon credits. Argentina, Brazil, Chile, Colombia, Costa Rica, and Ecuador have already received credits for REDD+ initiatives, while Belize, Suriname, and Paraguay have issued reports.

Existing NbS projects concentrate in water management and sanitation sectors. Ozment and others (2021) gave a comprehensive review of NbS projects in LAC, either in operation or in preparation, as of the end of 2020.[1] Most projects consist of reforestation

This box was prepared by Joana Pereira.

[1] The report reviews 156 projects across 28 LAC countries. Most of the projects take place in Mexico (31), Colombia (21), Brazil (17), and Peru (17).

Box 3.4. *(continued)*

efforts (including of mangroves). The review found that more than two-thirds of NbS projects target water management and sanitation services as either a primary or a secondary goal, and about half as many focus on housing and urban development sectors (to reduce landslide and flood risks). A smaller number of projects target energy provision (protection of hydropower capacity) or the transportation sector (protection of roads and ports infrastructure). Most NbS initiatives foresee job creation, livelihood enhancements, and/or biodiversity protection.

Governments are the main sponsors of NbS efforts. Although many NbS projects are led by civil society organizations, some form of government participation—national, local, or both—is the rule in LAC (more than 90 percent of projects reviewed in Ozment and others 2021). This involvement often takes place through partnerships with multilateral organizations—loans, grants, and/or technical assistance—such as the Inter-American Development Bank, the World Bank, the Global Environment Facility, or the UN. At a smaller scale, some projects are funded through municipal tax revenue or other local fiscal transfers (building rights and similar fees; for example, in Cali, Panama City, Campinas, Buenos Aires) or by private investors/corporations and utility providers (in Peru, most notably).

Private sector involvement is minor in LAC, though it may grow as more information on the impacts of NbS projects becomes available. Although existing impact studies suggest promising results, more (retrospective) evidence is needed on the cost effectiveness and climate impacts of specific NbS projects over time. Often, NbS investments will benefit different economic sectors—for example, infrastructure providers (through lower costs), farmers, ecotourism operators—beyond local communities and the global environment. Therefore, joint investment can be a viable option to raise and secure funding over time. Governments can also catalyze private NbS investment through regulation/incentives (including guarantees) or by providing upfront capital, given the expected social and environmental benefits.

employed in traditional energy sectors. The same holds for the shift from livestock- to plant-based agriculture. To facilitate the transition, governments could use cash transfers to compensate households for consumption losses and active labor market policies to support displaced workers and facilitate jobs transition (see Furceri and others 2021). In this regard, strengthening social safety nets early on would not only help reach and compensate the affected households but also foster trust in governments and help secure public support for climate mitigation policies.

Climate strategies that integrate mitigation and adaptation policies also generate important co-benefits, especially in the agriculture and energy sectors. In addition to investing in alternative energy technologies to mitigate risks associated with LAC countries' dependence on hydropower, adaptation investment in the resilience of renewable energy infrastructure or water management can help offset expected declines in power supply and help maintain and potentially expand electricity generation. Similarly, improvements in agricultural productivity would reduce deforestation pressure associated with the expansion of agricultural land. Utilizing agricultural land in more sustainable and efficient manner would also contribute to emission reduction.

Box 3.5. Political Economy Considerations of Climate Mitigation Policies

A national climate mitigation strategy touches multiple sectors, activities, and vested interests; thus, it requires a large amount of coordination, consultation, and buy-in from authorities, politicians, and civil society. In fact, although the net welfare impact of climate policies are estimated to be positive (Nordhaus 2008; Parry and others 2014; Stern 2006), their economic impact would differ across various socioeconomic groups and regions within countries. Because of the negative externalities of greenhouse gas emissions and the fact that the environmental benefits of sustainable environment policies accrue only in the long term, all stakeholders and generations should be brought into the climate change dialogue. Reflecting the lessons from past unsuccessful attempts to reform fossil fuel subsidies, climate policies should be phased and clearly anchored to improve predictability, and their social impact should be accounted for ex ante to secure public support.

Advanced public consultation, international cooperation, and careful communication would help secure broad-based buy-in for climate mitigation policies. Ensuring a sustainable environment is a far-reaching undertaking that involves considerations of intergenerational equity and calls for an open dialogue—and possibly a national pact—to firmly anchor the transition to a green economy. Cooperation among countries for a synchronous move would not only yield high global climate dividends but also mitigate the political cost of climate policies at the individual country level. In this context, governments could emphasize the cost of inaction in their national campaigns. For instance, a border adjustment tax, contemplated by the European Union, could make products from Latin American and the Caribbean (LAC) equally expensive as if the tax were levied within the region's borders without the corresponding revenue benefits. This effort might help strengthen the argument for carbon taxes and other mitigation instruments in LAC. Strengthening social safety nets early on (or even before the implementation of climate mitigation strategies) could foster trust and help secure household support for policies and reforms.[1] Adequate compensatory mechanisms should consider the concentration of risks in certain socioeconomic groups and areas within LAC countries.

Sequencing of policies would also be important. Some countries with high fossil fuel subsidies could consider smoothing the burden of the transition to a greener economy by first phasing out fossil fuel subsidies and then hiking the carbon tax. Even in small-emitting countries, there could be merit in gradually increasing carbon taxes in parallel to removing fossil fuel subsidies, leveraging the favorable global drive toward emissions reductions to mitigate the risk of reform backlash at home. An early move toward carbon taxes would also help prepare the tax system for the administration of the new tax while allowing firms and households to adjust to the new low-emissions reality. Compensatory measures should facilitate the transition to low-carbon economies (for example, through cash transfers to affected consumers and training for displaced workers in the short term). However, eventually, carbon-related support to households should be folded into the country's broader social safety net and standard labor market transition mechanisms, such as unemployment insurance schemes, where available.

This box was prepared by Constant Lonkeng.

[1] Progress achieved in social protection during COVID-19 could be leveraged further.

The global nature of climate change calls for a national and global dialogue and close cooperation on climate policies among all stakeholders to yield higher climate dividends while reducing political costs and the risk of carbon leakage. Advanced public consultation and careful sequencing and communication of mitigation reforms could help secure broad-based public buy-in. As past unsuccessful attempts to reform fuel subsidies have shown, climate policies should be phased in gradually, their objectives articulated clearly, the trade-offs explained well, and the social impact accounted for ex ante to secure public support. Countries with high fuel subsidies could also consider phasing out fuel subsidies before resorting to other PBMPs. Importantly, cooperation among countries for a synchronous move would not only yield high global climate dividends but also reduce the political cost of climate policies at the individual country level—in addition to limiting the risk of carbon leakage. In this context, governments could emphasize the cost of inaction in their national campaigns. It would also be advisable to establish a formal coordination mechanism among government agencies of LAC countries (for example, among Ministries of Environment, Ministries of Finance, and possibly others) on climate-related issues, which could facilitate coordination across borders.

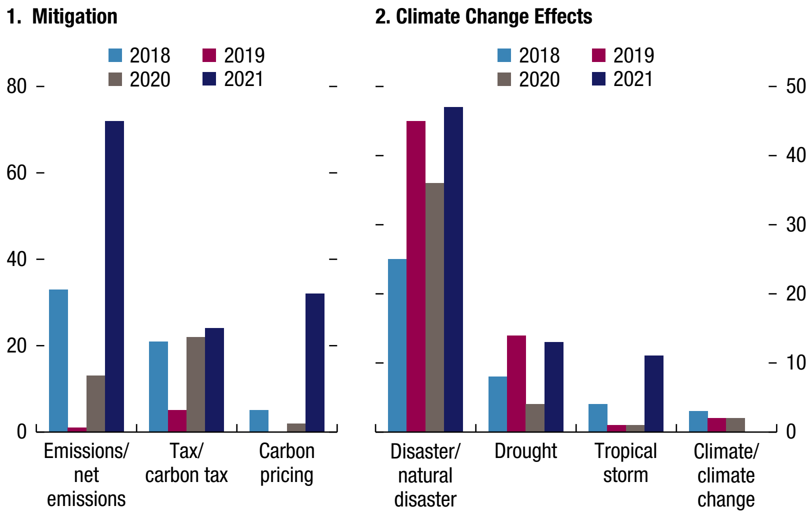
The IMF stands ready to support its members in addressing the challenges of climate change. Advice focuses on devising fiscal and macroeconomic policies to tackle threats to long-term growth and prosperity as well as how to embrace the opportunities of low-carbon resilient growth. In addition, a growing body of research is focusing on the economic implications of climate change. Climate change has also been covered in IMF surveillance and program work (Annex 3.1) as well as in financial sector stability assessments.

ANNEX 3.1. USING MACHINE LEARNING TO IDENTIFY CLIMATE CHANGE–RELATED POLICIES IN FUND SURVEILLANCE AND PROGRAM WORK

Climate change has been a topic of relevance for surveillance work in the past four years in the IMF's Western Hemisphere Department. Climate change effects, particularly natural disasters, have been discussed in LAC countries consistently since 2018, with increased coverage in 2019 and 2020 relative to 2018. The increasing focus on climate change effects in LAC mirrors the increasing frequency of such events in the region and associated macro-criticality for vulnerable countries, especially for CAPDR and Caribbean countries.

To take stock of the climate change work conducted in IMF programs and surveillance from 2018 to 2021, the team used an automated approach based on a combination of web scrapping and natural language processing. This methodology extracts, classifies, and visualizes climate change–related policies from IMF surveillance and program reports and informs the progress made by countries on climate change. It includes all countries from the Western Hemisphere, including 12 countries with an active program engagement over that period. Climate change work was grouped into climate change effects, mitigation policies, and adaptation policies (Annex Figure 3.1.1).

Annex Figure 3.1.1. Identification of Climate Change Policies
(Estimated number of times topic mentioned)

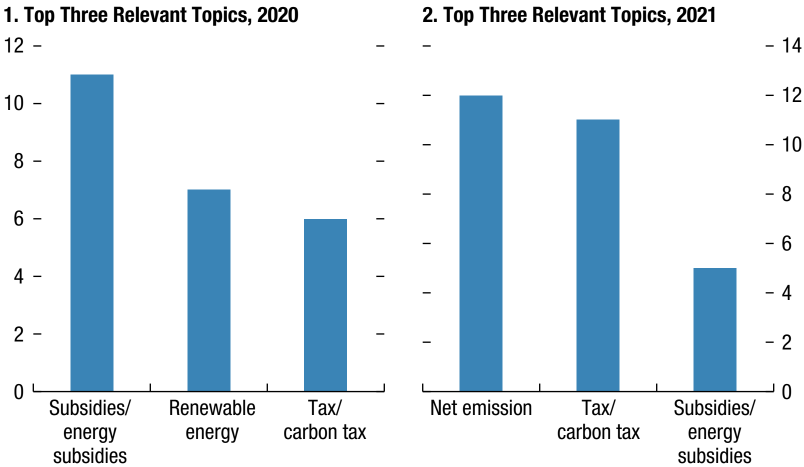


Source: IMF staff calculations.

This annex was prepared by Diane C. Kostroch, Ayoub Mharzi, and Tessy Vasquez Baos.

Annex Figure 3.1.2. Top Three Relevant Climate Change Topics in Fund Program Countries

(Estimated number of times topic mentioned)



Source: IMF staff calculations.

Results suggest trends in the top relevant topics on mitigation and adaptation policies. Although topics such as emissions, carbon pricing, and carbon tax have been considered since 2018, these discussions peaked in 2021, when the IMF started to talk more about carbon pricing, carbon price floors, and associated carbon leakage challenges (Annex Figure 3.1.2). By contrast, discussion on adaptation policies, such as investments in resilient infrastructure, the establishment of climate funds, and disaster insurance, peaked in 2018 though are getting more attention as of late. In 2020 and 2021, climate change–related discussions in program countries tended to focus on the countries' net emission levels, the transitioning to renewables to reduce GHG emissions, dependence on fossil fuels, and the introduction of a carbon tax.

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CHAPTER 4

Climate Mitigation in Latin America and the Caribbean: An Illustration of Macroeconomic Impact

Chao He and Constant Lonkeng

An illustrative assessment of the impact of an increase in the price of carbon suggests that it could help close nationally determined contribution (NDC) gaps in many countries in Latin America and the Caribbean (LAC), although some countries in the region would remain far from their NDC goals. The increase in the price of carbon would raise fuel prices substantially in some cases and will have a differential impact across households and countries. However, this increase would also mobilize significant fiscal revenues that could be used to compensate vulnerable groups. Workers in carbon-intensive sectors may experience an additional loss of income or jobs. Policies to reduce greenhouse gas (GHG) emissions could also adversely affect livestock farmers, but a shift to plant-based agriculture would present employment and income opportunities.

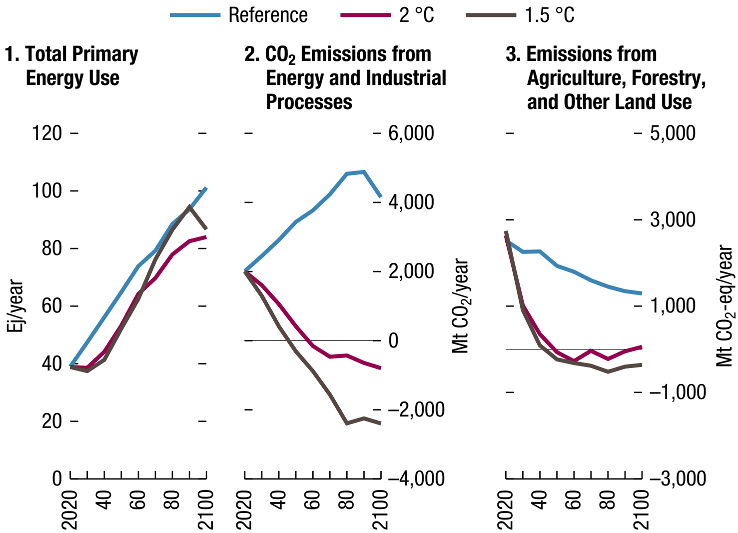
This chapter focuses on selected fiscal policy options to reduce GHG emissions. Without strong policy actions, net GHG emissions will continue to grow in the coming decades (Box 4.1). Against this backdrop, we build on the Climate Policy Assessment Tool (CPAT) developed by the IMF and the World Bank (see Annex 4.1) to examine the fiscal options for climate mitigation.[1] The analysis of other policy instruments is beyond the scope of this chapter. Economic models of climate change are still evolving and subject to a high degree of model and data uncertainty, which means that the results of these models should be taken as indicative rather than precise numerical estimates. The scenarios presented in this chapter are, therefore, illustrative and are not meant to be prescriptive. Countries will need to choose the mix of tools that is most appropriate for their specific circumstances.

[1] The impact on emissions from a carbon tax is estimated using the CPAT developed by IMF and World Bank staff, which evolved from an earlier IMF tool used, for example, in IMF 2019a and 2019b. For descriptions of the model and its parameterization, see Black and others (2023).

Box 4.1. Climate Mitigation Scenarios

Simulations from integrated assessment models (Annex 4.2) in a business-as-usual scenario suggest that Latin America and the Caribbean's (LAC's) CO_2 emissions from energy and industrial processes are expected to more than double by late this century (Figure 4.1.1). Although CO_2 emissions per unit of output are expected to decline, this decline will not be sufficient to stabilize total emissions due to continued GDP per capita growth. Greenhouse gas emissions from agriculture, forestry, and other land uses are expected to decline under the assumption that the reduction of deforestation continues following recent trends.

Figure 4.1.1. Integrated Assessment Models Simulations for Latin America and the Caribbean



Sources: Staff elaboration based on The Integrated Assessment Modeling Consortium (IAMC) 1.5°C Scenario Explorer release 2.0 (Huppmann and others 2019; Rogelj and others 2018; Vrontisi and others 2018; McCollum and others 2018; Bauer and others 2018).
Note: Median of CO_2 emissions from energy and industrial processes and of CO_2-eq emissions from agriculture, forestry and other land uses. For more details, see Annex 4.2. CO_2-eq = carbon dioxide equivalent; Gt = gigatons; T = tons; Mt = megatons; Ej = exajoule.

Given its natural endowments—especially its forestry and biodiversity—the LAC region stands out with its large potential for emission reductions using land-based solutions. Although uncertainty remains, growing evidence shows that land-based mitigation in the LAC region can play a major role in attaining cost-effective global mitigation. Roe and others (2021) estimate a mitigation potential equal to 3.4 ± 1.2 $GtCO_2$eq per year at a cost not larger than \$100/tCO_2-eq. The most cost-effective potential is in reducing deforestation (1.6 ± 0.96 $GtCO_2$eq per year). The other two regions with similar land-based mitigation potential are sub-Saharan Africa (2.5 $GtCO_2$eq per year) and Asia Pacific (4.8 $GtCO_2$eq

This box was prepared by Emanuele Massetti with the research assistance of Sean Thomas.

Box 4.1. *(continued)*

per year). This land-based mitigation potential also has large local and global co-benefits in terms of biodiversity, air quality, soil preservation, and water management (Roe and others 2021).

LAC countries show a substantial potential for net negative emissions after the midcentury. Illustrative mitigation scenarios generated by integrated assessment models suggest the need for a rapid decline in energy sector emissions and a faster decline in emissions from agriculture, forestry, and other land uses than in the recent past to achieve global temperature targets at the lowest cost. After 2050, the scenarios suggest a large potential for the LAC region to contribute to global mitigation goals with net negative emissions that rely on afforestation and carbon sequestration in soils either directly (through afforestation) or indirectly (through electricity generation from biomass with carbon capture and sequestration). This indicates that the region has the potential to contribute to global mitigation above and beyond the global goal of net-zero emissions. Financial support from the international community is likely warranted to promote these additional mitigation efforts.

The illustrative analysis follows a two-stage approach to simulate an increase in the price of carbon. First, we analyze the impact on emissions of a gradual and complete removal of existing consumer-side fossil fuel subsidies between 2023 and 2028. Second, in addition to the gradual and complete subsidy removal, we analyze the impact of a gradual introduction of carbon taxes of $25 per ton, $50 per ton, and $75 per ton from 2023 to 2030.[2] The carbon taxes are levied on each unit of GHG emission from fuel combustion.[3] The fiscal revenue from the carbon pricing policies is assumed to be recycled back to the economy through universal cash transfers to the households.

Model estimates suggest that most countries will retain gaps in emissions reductions relative to their NDC commitments ("NDC gaps") by 2030 under the business-as-usual (BAU) scenario.[4] Under BAU, GHG emissions, excluding land use, land-use change, and forestry (LULUCF), will increase slightly for most countries from the current level by 2030 as a result of two offsetting forces: (1) continued economic growth, which raises fossil fuel consumption and therefore increases emissions, and (2) improvements in energy efficiency, which lower fossil fuel consumption and therefore reduce emissions. Countries generally commit nontrivial emission reductions from the current level by 2030, although the commitments typically fall short for a linear path toward net zero in 2050 (Figure 4.1, panel 1). The committed reductions relative to BAU emissions in 2030 are shown as green diamonds in Figure 4.1, panel 2, and range from almost 60 percent for Jamaica to negative (curtailed at zero) for a few countries.

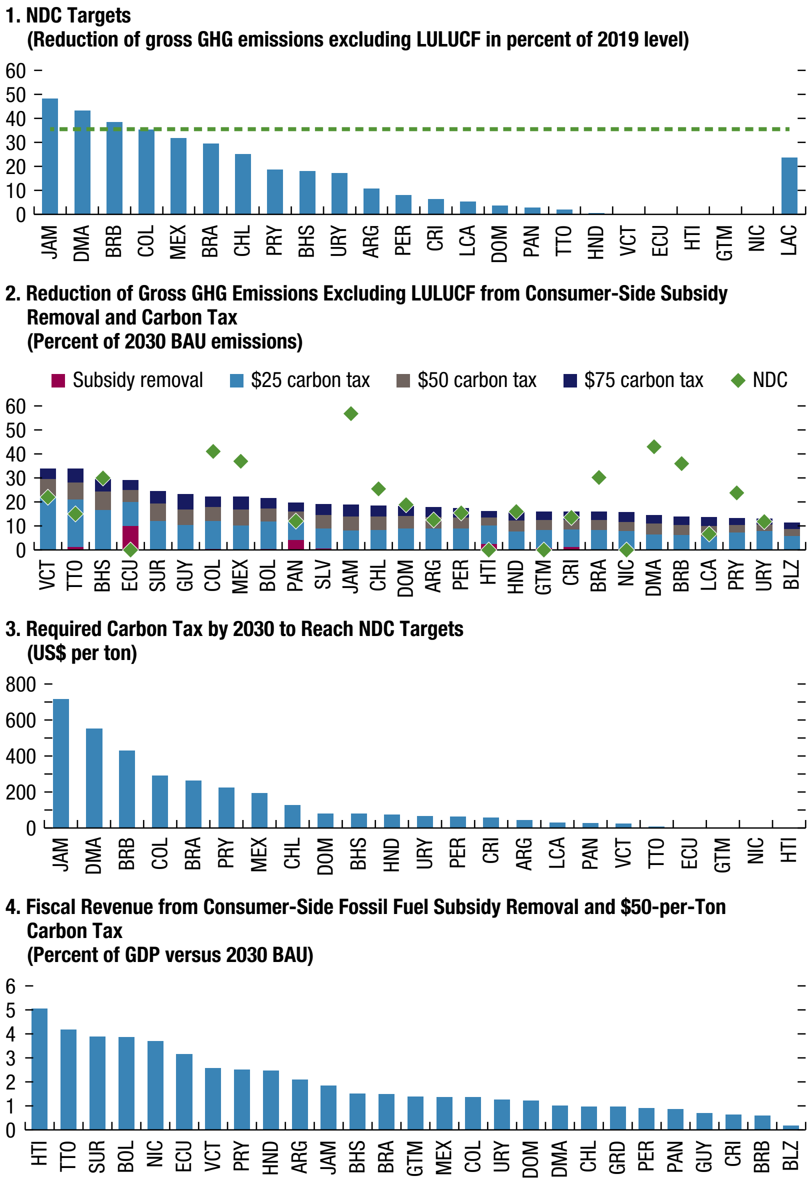
Model estimates suggest that increasing the price of carbon could help close NDC gaps in many LAC countries, although some countries in the region would

[2] The carbon taxes mentioned are 2030 targets. The starting carbon tax in 2023 is assumed to be one-third of the 2030 target. Carbon taxes rise linearly to reach the 2030 target.

[3] For example, combustion of one liter of gasoline emits 2.4 kg of CO_2. A $50-per-ton carbon tax will translate to $0.12-per-liter levy for gasoline.

[4] Baseline without any further climate mitigation policies.

Figure 4.1. Carbon Pricing in Latin America and the Caribbean



Sources: IMF, Carbon Pricing Assessment Tool; and IMF staff calculations.
Note: NDCs are harmonized to 2030 to exclude LULUCF and to be unconditional or, where available, the average of conditional and unconditional. For some countries, NDCs are not shown because they are difficult to quantify. In panel 1, negative NDC reductions relative to 2019 emissions are curtailed at zero. In panel 2, negative NDC reductions relative to BAU emissions are curtailed at zero. In panel 3, negative carbon pricing to achieve NDCs is curtailed at zero. Data labels use International Organization for Standardization (ISO) country codes. BAU = business as usual; GHG = greenhouse gas; LULUCF = land use, land-use change, and forestry; NDC = nationally determined contribution.

remain far from their NDC goals. Phasing out fossil fuel subsidies would substantially reduce emissions in countries with large subsidies (Figure 4.1, panel 2).[5] Further gradual introduction of carbon taxes at $25 per ton, $50 per ton, and $75 by 2030 would reduce NDC gaps for many LAC countries. Nonetheless, some countries in the region, including Brazil, Chile, Colombia, and Mexico, would remain far from their NDC goals. For those countries, relying on carbon pricing alone to reach NDC would require prohibitively high prices up to hundreds of dollars per ton (Figure 4.1, panel 3). In the rest of this section, the analysis focuses on a moderate carbon tax of $50 per ton.

Model estimates suggest that the increase in the price of carbon would raise fuel prices substantially in some cases but would also mobilize significant fiscal revenues. In many countries, gasoline prices would increase by 10 to 30 percent by 2030, natural gas prices would rise by 15 to 45 percent, and coal prices would increase by 50 to 130 percent. The price impacts differ across countries depending on initial price levels and products' carbon content. At the same time, countries can raise significant fiscal revenues up to a few percentage points of GDP (Figure 4.1, panel 4).

Although model estimates indicate that the impact of subsidy removal and carbon taxes on growth is generally negative,[6] it could be offset largely by "recycling" of collected revenues back into the economy through equal cash transfers to households. The expenditure multiplier could be even larger if the cash transfer targets the most vulnerable households and/or some revenues are redirected to the green infrastructure investment. This suggests that if designed carefully, the impact on growth would be small, if negative.

In addition, these mitigation policies will have health and environmental co-benefits. These include the reduction in air pollution mortality, road fatalities, traffic congestion, and extreme weather events associated with climate change (assuming global cooperation). Previous studies[7] suggest that the net welfare effects of carbon pricing, taking into account those co-benefits, will be unambiguously positive for almost all countries.

The increase in the price of carbon would, however, have a differential impact across households. Differential energy intensity of household consumption, varying purchasing power, and differential exposure of labor to carbon-intensive sectors will result in an uneven impact from a higher carbon price. The increased carbon pricing would have a direct adverse impact on household consumption because of the outright increase in energy prices. It would also have an indirect effect on consumption through an increase in the price of a broad set of products affected through sectoral linkages, as measured by the input–output matrix (Annex 4.3). Moreover, households employed in the sectors negatively affected during the transition to a low-carbon economy may experience a loss of income or employment.

[5] The analysis in this section includes a removal of explicit fossil fuel subsidies on the consumer side only.

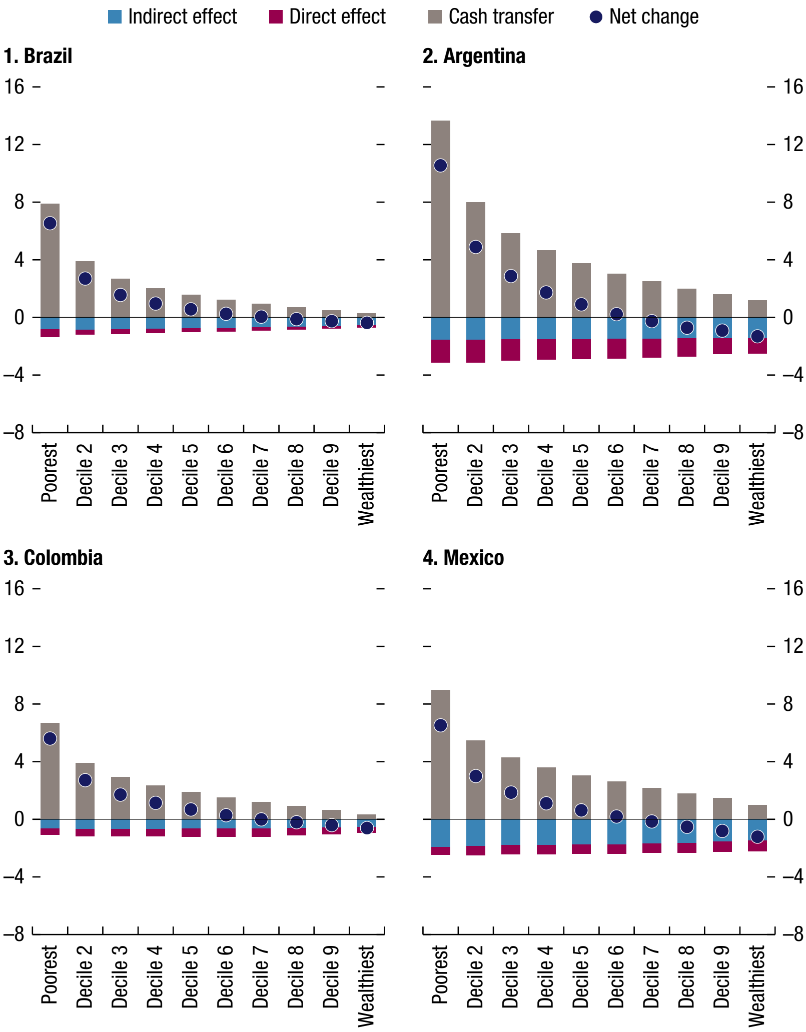
[6] The negative effects on GDP of carbon taxes in the CPAT are similar to those obtained in computable general equilibrium models. However, the empirical evidence on such effects is rather inconclusive and points to roughly no effect of the tax on GDP or employment growth (Metcalf and Stock 2020).

[7] See, for example, Nordhaus (2008), Parry and others (2014), and Stern (2006).

The impact of an increase in the price of carbon would also vary by country. It would depend on the country's initial energy mix, the size of the simulated carbon price adjustment, and the strength of upstream linkages with energy sectors. The size of the simulated carbon price adjustment—which reflects both the removal of fossil fuel subsidies and the introduction of the carbon tax—would be larger in countries that need to phase out relatively high fossil fuel subsidies simultaneously with the introduction of the carbon tax (Figure 4.2).

Figure 4.2. Estimated Consumption Impact from a $50 Carbon Tax and Consumer-Side Fossil Fuel Subsidy Removal, before and after Cash Transfers

(Percent of per capita consumption)



Sources: IMF, Climate Policy Assessment Tool; and IMF staff calculations.

The impact of the simulated carbon price adjustment on the price of goods consumed by households depends on the increase in the price of energy, which will be higher in countries that rely on more carbon-intensive energy sources, and the strength of the transmission of price increases to other sectors (Figure 4.2).

Compensatory fiscal policies can go a long way in alleviating the impact of an increase in the price of carbon on low-income households. Governments could use part (or all) of the revenue proceeds from the carbon tax and subsidy removal to compensate households for consumption loss, for example, through existing or new cash transfer programs. This could also make the reform more politically and socially acceptable. Simulations based on the CPAT model, household survey data, and input–output matrices (Figure 4.2) suggest that—absent compensatory policies—the consumption impact of a carbon tax and subsidy removal could be relatively large and somewhat regressive. The overall policy package, however, is estimated to become highly progressive when universal cash transfers are used to compensate households for consumption loss (Figure 4.2).[8] In fact, the model estimates suggest that universal cash transfers could fully offset the adverse impact of the increase in the price of carbon on household consumption in the first six to seven deciles of per capita household consumption in Argentina, Brazil, Colombia, and Mexico. Positive domestic environmental and health benefits as well as global climate dividends from lower GHG emissions would provide additional benefits to households not captured in this distributional analysis. In practice, governments could adopt a more targeted approach to compensating households by leveraging existing social safety nets to focus on the most vulnerable households.[9] This would allow them to channel part of the increase in fiscal revenues to green public investment.[10]

Absent compensatory policies, workers in carbon-intensive sectors may experience an additional loss of income or employment. The increased price of carbon and commensurate decline in the demand of less clean energy products could imply additional loss of income or employment for workers in carbon-intensive sectors.[11] Simulations, using sectoral microeconomic data,

[8] Each person in the economy receives the same amount of transfer (unconditionally) under a universal cash transfer scheme.

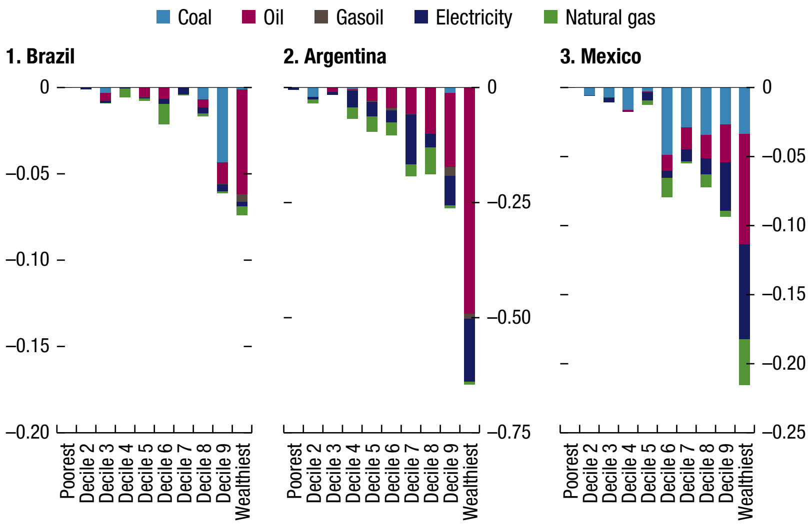
[9] Governments could leverage progress in expanding the coverage of cash transfers achieved during COVID-19. For instance, the Emergency Aid program reached up to 60 percent of Brazil's total workforce at the pandemic's peak (see Cunha and others 2022).

[10] Our choice of full recycling through cash transfers is motivated by technical considerations. It allows us to fully capture the multiplier associated with the extra revenue in the absence of evidence on the distributional impact of public investment along per capita household consumption deciles for countries in our sample.

[11] Our calculations assume a price elasticity of energy products of –0.25, as in IMF (2020). A 100 percent increase in the price of any of the energy products—coal, oil, electricity, and natural gas—therefore reduces real demand by 25 percent, leading to an equivalent reduction of labor income or employment under the assumption of unchanged labor productivity.

Figure 4.3. Estimated Gross Labor Income Loss in the Energy Sector from Carbon Tax and Consumer-Side Fossil Fuel Subsidy Removal

(Percent of total labor income of households in all sectors for each income decile)



Sources: National authorities; and IMF staff calculations.

suggest that the aggregate impact of an increase in the price of carbon on income would be limited, affecting less than 1 percent of employed persons in Argentina, Brazil, and Mexico. This reflects the small overall size of the energy sectors in these economies.[12] However, the impact would vary by income decile, sector, and region (Figure 4.3). Notably, the analysis suggests that the impact would remain small in Brazil across all income deciles and larger and more progressive in Argentina in the absence of compensatory measures. The impact is larger in sectors with higher carbon intensity (oil and electricity in the case of Argentina; coal and oil in Brazil; and coal, oil, and electricity in Mexico).

However, these income and job losses could be offset by job gains in the new cleaner energy sectors.[13] Alongside the aforementioned additional health and environmental benefits, the shift to cleaner energy would provide job and

[12] Labor income could also be affected indirectly in other sectors such as transportation and manufacturing.

[13] The International Energy Agency (2021) estimates that 14 million green jobs and 30 million green and related jobs could be created by 2030 during the green transition, approximately equivalent to 0.4 to 1 percent of the global labor force. This would translate into 1.2 million green jobs and 2.6 million green and related jobs by 2030 in LAC, based on LAC's share in the global economy.

income opportunities,[14] including those arising from LAC's potential for exporting "green" commodities (Table 7.2).[15] A policy mix that balances carbon pricing with a green investment push, as discussed in IMF *World Economic Outlook* (2020), is likely to have positive long-term effects on activity and employment. Specifically, a public green investment push starting with 1 percent of GDP and declining over 10 years, combined with subsidies for production of renewables, a preannounced gradual increase in carbon taxes, compensatory transfers to households, and supportive macroeconomic policies, is estimated to increase employment by about 1 percent of the labor force in 10 years.[16] These newly created green jobs could potentially offset income and job losses in carbon-intensive sectors, but much would depend on the labor intensity of such industries and the quality of the new jobs created. An example of the positive impact of an investment push for renewable energy sources is the creation of low-skilled jobs is Brazil's National Alcohol Program launched in 1975 (Box 7.1). The green investment push, however, will require substantial financing, which could only partially be covered with revenues from carbon tax and fossil fuel subsidy removal.

Policies to reduce GHG emissions could also adversely affect livestock farmers, but a shift to plant-based agriculture would present employment and income opportunities. An ambitious emissions reduction strategy in LAC would have to include the adoption of sustainable agricultural practices, especially in livestock for which the emissions intensity is several times that of plant-based agriculture.[17] Latin America's high food trade surplus (about 3 percent of

[14] For instance, using firm-level CO_2 emissions data for 31 advanced economies and large emerging economies (including Brazil), Mohommad (2021) finds evidence that while a tightening in environmental policy stringency leads to a reduction in labor demand by high emission–intensity firms, labor demand by low emission–intensity firms increases, which suggests a reallocation of employment. The author finds modest net positive changes in employment for market-based policies and modest net negative changes for nonmarket policies.

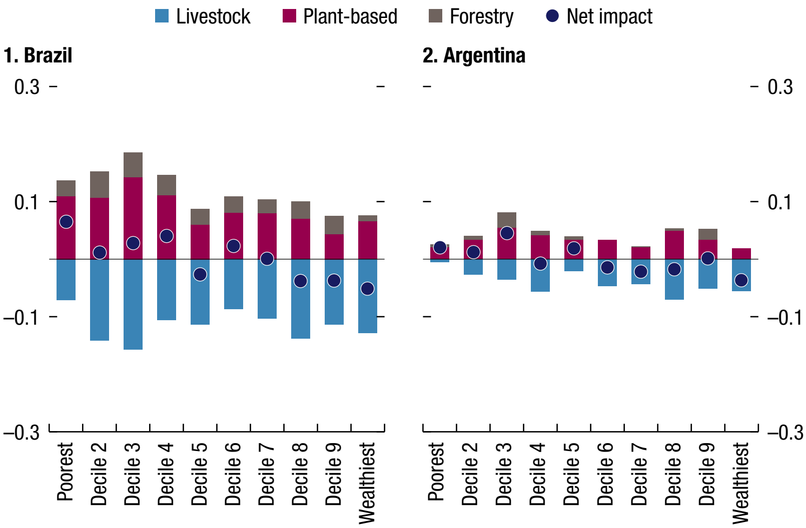
[15] Some LAC countries (for example, Argentina, Brazil, Colombia, Chile, Peru, and Bolivia) are already exporting these "green" commodities such as copper, nickel, lithium, and cobalt, whereas others (Mexico) may benefit from recently discovered reserves of lithium.

[16] Specifically, the package in IMF *World Economic Outlook* (2020) includes a 10-year green public investment program in the renewable and other low-carbon energy sectors, transport infrastructure, and services starting at 1 percent of GDP and linearly declining to 0 over 10 years (after 10 years, additional public investment maintains the created green capital stock); 80 percent subsidy rate on renewables production; carbon tax starting at \$8 to \$18 per ton of CO_2 (depending on the country) and growing by 7 percent annually; compensatory transfers to households (equal to one-quarter of carbon tax revenues); and supportive macroeconomic policies (the policy package previously mentioned requires debt finance for the first decade and occurs against a backdrop of low-for-long interest rates in the low inflation context).

[17] Panel data estimation suggests an emissions intensity ratio of 6 to 1 between livestock and plant-based agriculture in Latin America. See Batini (2021) for a detailed analysis of economic policies to foster healthy diets while establishing sustainable food practices.

Figure 4.4. Estimated Labor Income Gain and Loss from Reduced Greenhouse Gas Emissions in Agriculture

(Labor income gain and loss; percent of total labor income of households in all sectors for each income decile)



Sources: National authorities; and IMF staff calculations.

Mercosur's[18] GDP in 2019) exposes the region to shifts in demand for food not only domestically but also from abroad. Although the potential global shift from beef consumption toward plant-based diets would adversely affect some livestock farmers, it would present employment and income opportunities in plant-based agriculture.[19] Simulations suggest that the estimated net income impact of the adjustment to low GHG emissions on farmers would be more uniformly distributed across income deciles compared to the progressive impact of a carbon tax in the energy sectors (Figure 4.4).[20] For a given GHG emissions reduction in agriculture, the estimated average gross employment and labor

[18] The Southern Common Market is commonly known by the Spanish abbreviation Mercosur.

[19] Grocery sales of plant-based foods that directly replace animal products are on the rise in the United States, according to the Good Food Institute (2021). A recent joint Inter-American Development Bank–International Labour Organization report estimates that the shift from a meat- to plant-based diet in the move to a net-zero-emission economy would lead to a net full-time equivalent jobs gain of 14.7 million in LAC's agrifood industry by 2030 (see Saget and others 2020). Their simulations assume that two-thirds of household baseline spending on animal-based products will be replaced by 2050 with spending on plant-based products, a stronger shift than the one implied by the simulations in this chapter.

[20] We identify farmers in household surveys based on the reported granular sector of employment.

income loss in livestock would be higher in countries with a higher initial level of employment in livestock (such as in Brazil, where livestock accounts for 3.9 percent of employment, as opposed to 1.2 percent in Argentina).[21] The government could support adversely affected livestock farmers by facilitating their transition toward plant-based agriculture (the simulation in Figure 4.4 does not include such measures). The land released from livestock agriculture can also contribute to afforestation.[22] Substantial regional disparities exist in terms of the impact of climate change policies on income in the energy sector and agriculture.

[21] The required emissions reduction in agriculture is assumed to come entirely from livestock, given the much higher emission intensity of livestock compared to plant-based agriculture (6-to-1 ratio). We assume that livestock is reduced proportionally to the required emissions reduction in agriculture between the baseline and policy scenario, which, based on CPAT simulations, corresponds to a decline in livestock by about 3 percent by 2030 in Brazil and Argentina. We also assume that the resources previously used for livestock, including labor, are repurposed for plant-based production, which may require a government's transitory support. The reduction in livestock also leads to a reduction in plant-based feeds for animals, which LAC could recoup by leveraging its comparative advantage in food products. In addition, we assume that forestry activity will increase proportionally with the required emissions reduction, given the important role of afforestation in curbing emissions in LAC.

[22] The scenario presented in this chapter is illustrative—the extent of the shift from livestock to plant-based agriculture and the increase in forestry activity (afforestation) will vary across countries depending on how constraining it would be to repurpose resources, including land.

ANNEX 4.1. DESCRIPTION OF THE CLIMATE POLICY ASSESSMENT TOOL (CPAT)

This chapter analyzes the effect of carbon pricing in reducing greenhouse gas emissions in Latin America and the Caribbean using the Climate Policy Assessment Tool (CPAT). The tool is a spreadsheet-based "model of models" aimed at economists in IMF, World Bank, and finance ministries (via Coalition of Finance Ministers for Climate Action). It allows for rapid estimation of country-by-country greenhouse gas (GHG) emissions and distributional effects.

The tool mainly uses an elasticity approach to model emissions in the energy sectors (power, industrial, transport, residential, and subsectors). Roughly speaking, the consumption change of each fossil fuel in each energy sector (excluding power generation) is the product of exogenous energy efficiency change, GDP change, and fuel price change, each raised to the power of their respective elasticities, as shown in the following equation. The power generation sector is projected separately with an engineering model. The energy consumption projection is then converted to carbon emissions with emission factors.

$$\frac{Y_t^{Ei}}{Y_{t-1}^{Ei}} = \left(\frac{1}{1-\alpha^{Ei}}\right)^{\eta_1} \left(\frac{GDP_t}{GDP_{t-1}}\right)^{\eta_2} \left(\frac{\rho_t^{Ei}}{\rho_{t-1}^{Ei}}\right)^{\eta_3}$$

In the equation, Y_t^{Ei} is the fossil fuel consumption of energy E in sector i at time t; α^{Ei} is the exogenous technology growth of the particular energy and sector; GDP_t is the gross domestic product for the country; ρ_t^{Ei} is the retail price of the fossil fuel of the particular energy and sector; and η_1, η_2, η_3 are the respective elasticities.

In the policy scenario, the price is affected directly, and the income is affected indirectly through fiscal multipliers, by carbon pricing policies such as subsidy removal and carbon tax. These affect fossil fuel consumption and GHG emissions.

The tool models GHG emissions in nonenergy sectors (industrial processes; agriculture; land use, land-use change, and forestry; waste; and fugitive emissions) assuming a flat growth adjusted for existing or new additional mitigation policies (efficiency of these measures scaled with energy-related emissions). For countries with existing mitigation policies in the baseline, the assumption is that these policies affect both energy and nonenergy-related emissions. For countries without existing mitigation policies, nonenergy GHG emissions would stay flat in the baseline and decrease at the same rate as energy-related emissions in the policy scenario.

The different reduction in emissions of the same carbon pricing across countries mainly comes from different baseline energy price levels and different carbon contents in the fuels. Countries tend to be more sensitive to carbon pricing if their fuel prices are relatively low so that carbon pricing induces a more dramatic price increase. Countries also tend to be more sensitive to carbon pricing if their fuels have higher carbon contents so that they are more heavily taxed. For example, the price of coal is typically lower than that of oil

This annex was prepared by Chao He.

or natural gas. Moreover, to produce the same amount of energy, burning coal emits more CO_2 than oil or natural gas. Therefore, countries that consume more coal tend to be more sensitive to carbon pricing from both channels.

In CPAT, recent fuel use by country and sector is from the International Energy Agency. Each country's GDP projection is taken from the October 2020 *World Economic Outlook*. Historical energy taxes, subsidies, and prices for each type of fuel in each sector are compiled from the IMF and publicly available sources, with inputs from proprietary and third-party sources. They are projected forward with the international energy prices for coal, oil, and natural gas prices, which are averages of International Energy Agency and IMF projections. Assumptions for elasticities are chosen to be broadly consistent with the empirical evidence and results from energy models.

CPAT is developed by IMF and World Bank staff. For a further introduction of the model and its parameterization strategy, see Black and others (2023), IMF (2019b, Annex 4.1), and Parry and others (2021). For further underlying rationale, see Heine and Black (2019).

ANNEX 4.2. THE USE OF INTEGRATED ASSESSMENT MODELS FOR CLIMATE MITIGATION POLICY ANALYSIS

Integrated Assessment Models

The transition to low or zero emissions is expected to take several decades, and it requires transformations across all sectors of the economy because greenhouse gas (GHG) emissions are released in virtually all economic activities.

As the effect of GHGs on temperature is approximately linear in the amount of GHGs in the atmosphere, scientists use the concept of "carbon budget" to convey the important message that what matters most is cumulative emissions rather than the exact trajectory of emissions over time. This leaves ample flexibility to design emissions transition pathways that are compatible with a certain change of global mean temperature in the future. However, socioeconomic systems cannot easily adjust to replicate all these transition pathways. Some may require immediate fast emission reductions that are technologically infeasible, too expensive, or both. Other pathways may delay action into the future but then require excessively fast emission reductions. Yet other pathways rely on large negative emissions—the absorption of carbon from the atmosphere—to compensate for slow emission reductions.

To assess the physical, economic, and technological feasibility of transition pathways to low emissions, it is thus necessary to build models that provide a consistent representation of the climate system, economy, energy systems, and land use. These models, called integrated assessment models (IAMs), have been developed since the 1980s. They grew in popularity and number in the 1990s, and for the past 20 years, the research community has used IAMs to provide insights on transformation pathways toward a low- or zero-emission future. Although some IAMs include the feedback of the climate system on the economy, using "damage functions," and can be used to study efficient transition pathways, most IAMs do not study economic damage from climate change and limit their analysis to the simpler problem of finding the cheapest mix of emission reduction to attain a long-term mitigation goal. Alternatively, these models are used to study the amount of emission reductions, and thus, the long-term temperature change, that would emerge if certain policies are implemented, such as a carbon tax or a subsidy to research clean energy.

Research groups around the world run numerous IAMs. The IAMs differ in their modeling choices (such as energy technologies and integration of land use), solution methods (such as simulation versus optimization), geographic resolution (such as global versus regional), and time horizon (such as midcentury versus 2100). Most models trade cross-sectional richness—such as countries, sectors, and sophisticated descriptions of the economy. Most models also assume exogenous growth rates to focus on the long-term nature of the mitigation problem and

This annex was prepared by Emanuele Massetti.

to integrate key sectors such as land and forestry. There is no money in these models and thus no inflation. Taxes are recycled as a lump sum into the economy. The workforce is assumed to be a stable fraction of the population. Trade is limited to energy resources.

Our calculations use data from six climate models and three modeling comparison exercises (scenario runs for each comparison exercise in parenthesis): Advance (Reference, 2020_WB2C, 2020_1.5C-2100), CD-Links (NPi, NPi2020_1000, NPi2020_400), and EMF33 (Baseline, WB2C_full, 2020_1.5C-2100). Models assume continuation of present trends in emissions, population growth, and economic growth. Assumptions of population growth are similar across models and follow the United Nations population projections. Population growth continues until approximately midcentury, then it reaches a plateau. GDP per capita is assumed to increase six- to eightfold over the remaining part of the century. As a result of population and economic growth dynamics, total GDP grows 10-fold during the century. All GHGs are transformed into CO_2 equivalents using 100-year global warming potentials without including the climate-carbon feedback (global warming potential [GWP] equal to 28 for methane [CH_4] and GWP equal to 265 for N_2O). Models use a uniform global carbon tax on all GHG emissions to simulate these cost-effective transformation pathways. The carbon tax grows over time and is adjusted so that the long-term climate goal is met. The scenarios where climate goals are achieved imply continued economic growth but with smaller increases in energy use, compared to business as usual, thanks to improved energy efficiency. A major driver of the decarbonization in these scenarios is electrification with carbon-free sources. Hydropower would remain a major source of carbon-free electricity in LAC, whereas solar, wind, and biomass would help meet additional demand.

To facilitate collaboration and exchange of results, a modeling consortium has been established (Integrated Assessment Modeling Consortium [IAMC]) to collect results from modeling teams around the world. One success story of this effort was the development of a shared template to distribute model results so that they can be easily compared across models and studies. In many cases, modeling teams conduct modeling comparison exercises in which they simulate the impact of the same policy scenarios—for example, the same carbon tax—to compare results more easily across models. In some cases, models adopt similar assumptions on exogenous trends to further limit the amount of arbitrariness in the results.

The Intergovernmental Panel on Climate Change authors use the scenarios collected under the IAMC protocol to provide an aggregate analysis of low-emission transition pathways in their assessment reports. By collecting evidence from many studies, these syntheses highlight areas where consensus emerges and areas where uncertainty still exists. This is a problem with deep uncertainty because it is impossible to derive objective probabilities for these scenarios. The distribution of results from different modeling teams cannot be interpreted as an objective probability distribution. The mean across models cannot be interpreted as an expected value. However, these distributions provide useful information on the range of results and on areas of convergence in the literature.

ANNEX 4.3. METHODOLOGY FOR ESTIMATING THE DISTRIBUTIONAL IMPACT OF PRICE-BASED MITIGATION POLICIES

The assessment of the distributional impact of a carbon tax hike and/or fossil fuel subsidy removal on per capita consumption follows two sequential steps. First, the change in the cost of production in each of the 57 industries in the Global Trade Analysis Project is evaluated for each country as explained here. Second, 13 items[2] commonly consumed by households are mapped into Global Trade Analysis Project industries, and their corresponding price changes are computed, assuming a full pass-through of changes in production costs to consumers. The consumption loss for households in each consumption decile is then evaluated based on consumption patterns in household budget surveys.[3] We also evaluate separately the income impact of climate mitigation policies in energy and agriculture based on the granular industry of employment and labor income of workers as reported in household surveys.

Evaluating the Change in Costs

The input–output (I-O) matrices are used to evaluate the impact of higher energy prices on the cost of production of each industry in the economy. The I-O matrices describe the sale and purchase relationships between different sectors of the economy and therefore reflect linkages between industries. The Climate Policy Assessment Tool traces both direct and indirect impact of carbon price increases. The direct impact is the increase in production costs from higher prices of energy inputs, namely coal, oil extraction, fuels, natural gas, and electricity. The indirect impact for each downstream sector reflects the increase in the cost of all its intermediate inputs induced by higher energy prices. To illustrate, a higher price of electricity (for example, after a carbon tax) will directly increase the cost of processed food given that electricity is used in food processing. The increase in fuel prices will increase the cost of food processing indirectly through the increase in the cost of agricultural products (used in food processing), as the cost of transporting them from the farm to the processing facility rises with fuel price increases. I-O matrices for all countries are from Global Trade Analysis Project, which has the advantage of providing consistent disaggregated data for 141 world regions.

The increase in the cost of production in industry j of country k is shown in the following equation:

$$C_{j,k} = \underbrace{\gamma^{e}_{j,k}\,\delta^{e}_{k}}_{direct\ effect} + \underbrace{\sum_{i=1}^{N} \gamma_{i,j,k}\,\delta_{i,k}}_{indirect\ effect}$$

Where δ^{e}_{k} is the direct price increase induced by carbon tax on the source of energy e in country k, and $\delta_{i,k}$ is the cost increase induced by carbon tax in

This annex was prepared by Constant Lonkeng.

industry i in country k, either directly or indirectly (N is the number of industries). $\gamma_{i,j,k}$ is the share of industry i in the total cost of intermediate inputs used in industry j, as computed from the I-O table of each country in the sample. A full pass-through of cost increase in each industry i (for example, due to carbon tax) to downstream industries j is assumed. It should be noted that the cost change in industry i ($\delta_{i,k}$ in the equation) in turn depends on the change in the cost of its intermediate inputs (recursive system).

Evaluating the Income Impact in Energy Sectors

We evaluate how the reduced demand for energy products affects workers in energy sectors. As a starting point, the price increase in each energy product resulting from carbon tax and fossil fuel subsidy removal is computed based on the previous methodology. We then assume a price elasticity of energy products of –0.25, like in IMF (2020), so that a 100 percent increase in the price of any of the identified energy products—coal, oil, electricity, diesel fuel, and natural gas—reduces its real demand by 25 percent, leading to an equivalent reduction in labor income or employment under the assumption of unchanged labor productivity.[4] Using the granular sector of employment as reported in household surveys, we identify persons employed in energy sectors and express the income loss in percentage of households per capita consumption in each per capita income decile. We also use the information provided on the geographical location of households in household surveys to aggregate the consumption loss at the level of regions to examine regional disparities.

Evaluating Income Impact in Agriculture

This assessment used as a starting point the required emission reduction in agriculture from the Climate Policy Assessment Tool.[5] Our simulations assume that emissions reduction in agriculture will come entirely from livestock, an assumption that is motivated quantitatively by the fact that the emission intensity of livestock is much higher than that of plant-based agriculture (6-to-1 ratio according to our estimates based on global data on livestock and plant-based production and total emissions in agriculture). We subsequently assume that the resources previously used in livestock, including labor, are repurposed for plant-based production to maintain comparable levels of overall production in agriculture.[6] The farmers in livestock and plant-based agriculture are identified using the granular sector of employment reported in household surveys, and the income loss is evaluated and expressed in percentage of per capita income for each income decile (Figure 4.1).

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CHAPTER 5

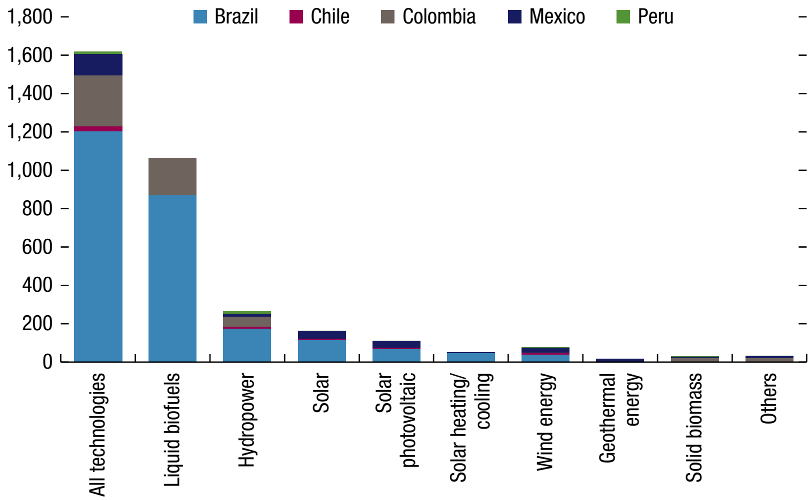
Climate Mitigation in Latin America and the Caribbean: An Illustration of Labor Market Impact

Isabela Duarte, Christopher Evans, and Matteo Ghilardi

The renewable energy industry could be an important source of green jobs in the region. The net impact of the green transition on labor markets will depend on the labor intensity of high-emissions sectors, on the potential for job creation of green or "greener" sectors, and on the impact of energy efficiency gains in the labor market. A carbon tax is expected to reduce the overall consumption of electricity and to increase the share of lower-emission technologies in the electricity generation matrix. However, employment gains could occur because of the green transition in the electricity sector, but the size of the gains and the distributional consequences depend on the types of electricity generation sources.

The investment boost and changes in consumption needed for the transition toward a greener economy can offer opportunities for job creation in Latin America and the Caribbean (LAC). The impact on employment due to an increased demand for greener products and processes will depend on the relative labor productivity of green and nongreen industries and technologies and on the intensity of the between-sectors reallocation of consumption. By maintaining Climate Policy Assessment Tool (CPAT) assumptions on the expected path for the green energy transition and using the Green Energy and Jobs tool developed by Kim and Mohommad (2022), we computed the expected job gains or losses from the green transition in the electricity sector for Brazil, Chile, Colombia, Mexico, and Peru (the LA-5 countries). The Green Energy and Jobs tool allows us to estimate the likely gains in employment from investing in energy efficiency and renewable technologies while accounting for jobs losses in greenhouse gas (GHG)–intensive industries. According to our preferred specification, more than 50,000 job-years are expected to be created in LA-5 countries by 2030 relative to a business-as-usual scenario, a number that represents 0.04 percent of the employed population in these countries. Within-country variations are determined by differences in the transition path and by local variation in the job intensity of different technologies. Net positive job gains are expected for most countries in the region under more tailored assumptions of the job multipliers associated with different technologies.

Figure 5.1. Employment in Renewable Energy
(Direct and indirect thousands of jobs in 2020)



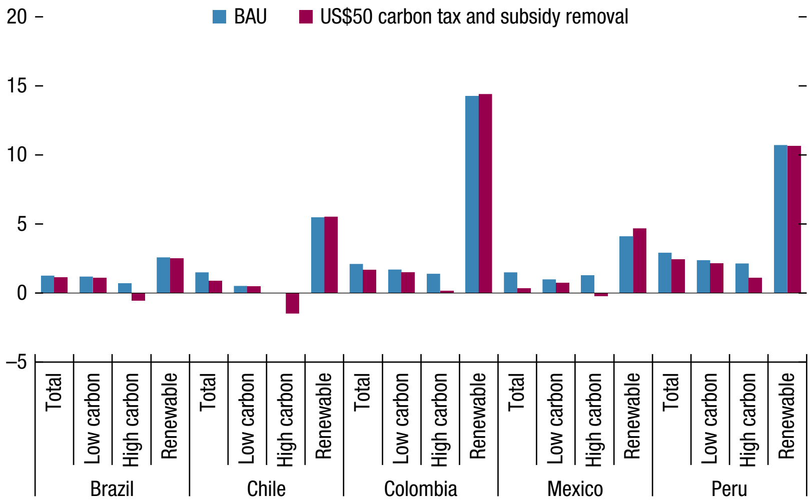
Sources: Climate Policy Assessment Tool; and IMF staff calculations.

We expect job destruction for the region only under restrictive scenarios regarding the job creation potential of increasing energy efficiency.

The renewable energy industry could be an important source of green jobs in the region. In 2020, approximately 1.7 million workers were directly or indirectly employed in activities related to renewable energy generation in LAC (International Renewable Energy Agency 2021). Figure 5.1 presents the number of direct and indirect jobs by technology type for LA-5 countries. For most of these countries, the share of jobs in the renewable sector is still small. The exceptions are Brazil and Colombia, which employ, respectively, 1.44 percent and 1.26 percent of their employed population in the renewable industry. Brazil is the world's largest employer in liquid biofuels production, which employs approximately 0.8 million people in the country and is among the 10 largest employers in the generation of hydropower, solar photovoltaic, and wind energy (employing 176,000, 68,000, and 40,000 people, respectively).

The net impact of the green transition on labor markets will depend on the labor intensity of high-emission sectors, on the potential for job creation of green or "greener" sectors, and on the impact of energy efficiency gains in the labor market. We evaluate the job creation potential of the transition for LA-5 countries and focus on the electricity generation industry. Renewable technologies could create opportunities for job growth, especially as we build generation capacity, given their labor-intensive nature. To meet their nationally determined contributions, countries in the region will need to invest in cleaner energy sources and reduce the share of high-emission technologies in their electricity matrix. The size of this reduction will depend on the emission intensity of their business-as-usual (BAU)

Figure 5.2. LA-5 Electricity Consumption Growth
(Percent annual average growth 2020–2030)



Sources: Climate Policy Assessment Tool; and IMF staff calculations.
Note: BAU = business as usual; LA-5 = Latin America five (Brazil, Mexico, Colombia, Chile, and Peru).

scenario and on their choice of mitigation policies. We use CPAT[1] and assume a gradual introduction of a $50 carbon tax from 2023 to 2030 and the gradual and complete removal of existing consumer-side fossil fuel subsidies between 2023 and 2028 to compute a sustainable energy generation scenario for countries in the region and to estimate electricity generation by source in this sustainable scenario for the period between 2020 and 2030. Figure 5.2 shows, for LA-5 countries, the average annual electricity generation growth by source for the BAU scenario and for the sustainable scenario consistent with CPAT assumptions.[2]

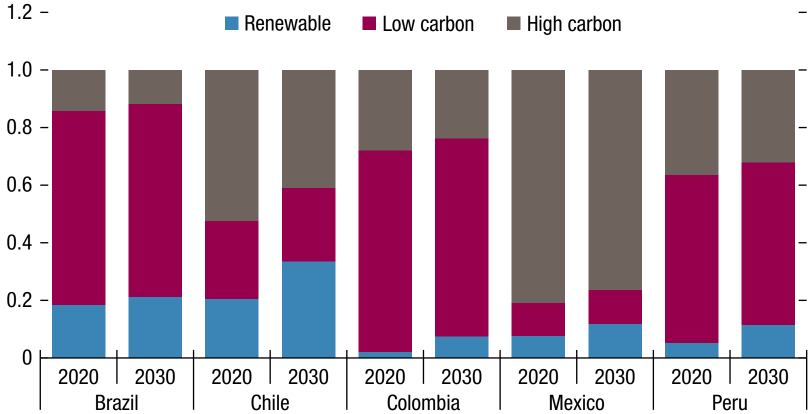
A carbon tax is expected to reduce the overall consumption of electricity and to increase the share of lower emissions technologies in the electricity generation matrix. In the CPAT scenario, we expect a decrease in total electricity generation, as higher costs lead households and firms to invest in energy efficiency. The higher cost associated with GHG-intensive technologies is also expected to induce a change in the share of different technologies in the electricity generation matrix, thus reducing consumption of petroleum-, coal-, and gas-generated electricity and increasing the consumption from renewable sources. As Figure 5.2 shows, we see a

[1] See Chapter 4.

[2] Please note that the speed of transition will depend on the country's investment strategy for climate change. For Brazil, an analysis that incorporates planned investments indicates that renewable energy generation capacity could more than compensate the expected increase in energy demand and the supply constraints in hydropower in the medium term (see Selected Issue Papers for Brazil's 2023 Article IV Consultation – SM/23/165).

Figure 5.3. Climate Policy Assessment Tool and LA-5 Electricity Generation by Source

(Share of electricity generation by source in 2020 and 2030)



Sources: Climate Policy Assessment Tool; and IMF staff calculations.
Note: LA-5 = Latin America five (Brazil, Mexico, Colombia, Chile, and Peru).

decrease in annual electricity generation growth relative to the BAU scenario in the period between 2020 and 2030 for all LA-5 countries. The decrease is stronger for Mexico (a difference of 1.16 percentage points between the CPAT and BAU scenarios), Chile (0.63 percentage point), Peru (0.47 percentage point), and Colombia (0.42 percentage point). We also observe an increase in the annual average growth of renewable electricity generation for most countries. The increase is stronger for Mexico (0.58 percentage point), Colombia (0.12 percentage point), and Chile (0.04 percentage point). In Figure 5.3, we present the share of total electricity generation by source between 2020 and 2030 considering the CPAT scenario. This figure shows that the countries that are expected to implement the most significant changes in their energy matrix in response to the higher cost of carbon either relied heavily on high-carbon sources in the baseline year of 2020, as is the case of Mexico and to a lesser extent Chile, or had a relatively small participation of renewable sources for electricity generation in 2020, as is the case of Colombia.

Using CPAT results, we can estimate expected employment gains or losses due to the green transition in the electricity sector. We estimate the job creation potential of the transition using the Green Energy and Jobs tool. This tool allows us to calculate job gains from a transition that incorporates the impact of higher levels of energy efficiency and of an increasing participation of clean technologies in electricity generation. The tool also computes expected job losses due to reductions in electricity generation from high-carbon or nonrenewable sources (that is, it incorporates information on jobs likely to be destroyed in GHG-intensive industries, such as coal or gas). Using information on job gains from greener technologies and job losses from traditional sectors, we can calculate an overall measure of net jobs created or destroyed due to the transition. To assess the employment creation potential of various technologies, the tool leverages numerous studies that estimate job multipliers from different generation technologies and accounts for both direct and indirect jobs[3] linked to construction, installation, and manufacturing (CIM) and jobs related to the operation and maintenance (O&M) of electric capacity. For job gains or losses associated with increases in energy efficiency, the tool calculates jobs directly or indirectly related to energy efficiency–enhancing investments and induced jobs (that is, jobs created due to additional household savings; Wei, Patadia, and Kammen 2010). To allow the comparison between shorter-term CIM jobs and longer-term O&M jobs, the tool measures jobs in full-time equivalent terms; that is, we assume that one job lasts for the duration of each project, averaging shorter-term jobs by the utility's lifetime. Incorporating the CPAT forecast on the transition path for electricity generation, we can estimate the number of jobs likely to be created or destroyed in the period between 2022 and 2030 for LA-5 countries. Figures 5.4 and 5.5 summarize the results from this exercise. All LA-5 countries are expected to create net positive jobs in the green transition. The relative increase in jobs is higher for Mexico, Chile, and Colombia. Overall, the region is expected to create approximately 52,000 cumulative job-years relative to the BAU scenario by 2030.

Figure 5.4. Net Direct and Indirect Jobs Growth

(Net jobs growth from business as usual to Climate Policy Assessment Tool scenario—percentage of growth)

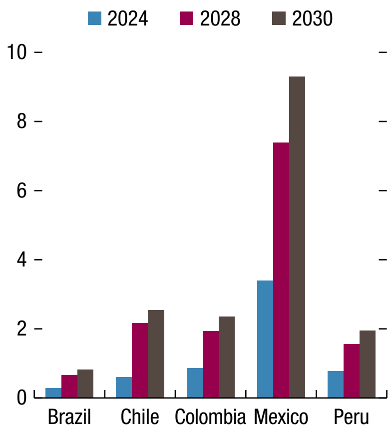
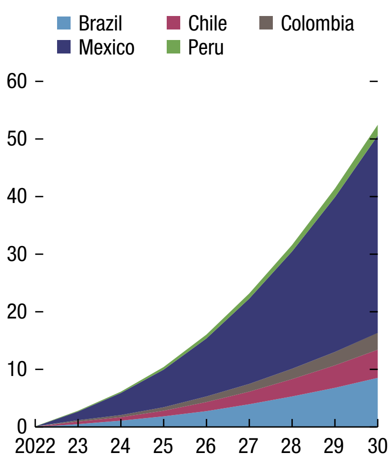


Figure 5.5. Climate Policy Assessment Tool and LA-5 Net Cumulative Jobs

(In thousands of persons per year)



Sources: Climate Policy Assessment Tool; Green Energy and Jobs Tool; and IMF staff calculations.
Note: LA-5 = Latin America five (Brazil, Mexico, Colombia, Chile, and Peru).

[3] Direct multipliers capture jobs generated in the execution of projects, including design, manufacturing, construction, installation, operation, maintenance, and other directly related jobs (including the supply and processing of fuel for fossil fuel–based generation). Indirect multipliers capture upstream job creation linked to the supply chain, including downstream jobs–related distribution of electricity.

The results from the Green Energy and Jobs tool depend on the assumptions regarding the job multipliers associated with various electricity generation sources. The values considered in the previous analysis represent an average from 15 studies that estimate multipliers based mostly on the experience of advanced economies (Kim and Mohommad 2022). To assess the sensitivity of our results to assumptions of the multipliers associated with renewable technologies, we consider alternative multipliers. We follow Kim and Mohommad (2022) and combine information on direct and indirect employment for key renewable technologies and on generation capacity to build country-level multipliers. Country-level information highlights significant heterogeneities in labor intensity of technologies across countries. For instance, the generation of electricity from solar photovoltaic (PV) is expected to be more labor intensive in a country that produces at least part of the solar panels it consumes or in a country that produces solar electricity in a local distributed mode, as is the case in Brazil. One disadvantage of this method is that the information that would allow us to break down jobs between CIM and O&M jobs is not available; thus, we are not able to compute full-time equivalent consistent multipliers. To reduce the risk of overestimating job multipliers, we impose a ceiling on all multipliers that is equal to the upper bound of the estimates identified in the literature (Blyth and others 2014). Figure 5.6 illustrates the range of multipliers used in the original computation. Figure 5.7 summarizes the aggregate increase

Figure 5.6. Job Multipliers by Generation Technology
(Direct, indirect, and induced jobs—job-years per GWh)

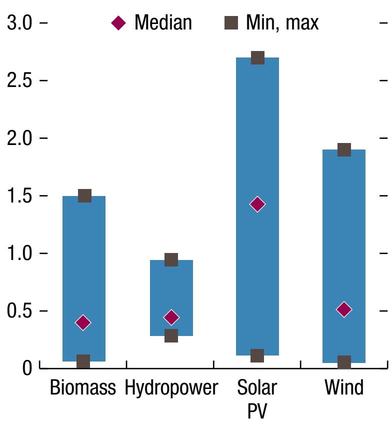
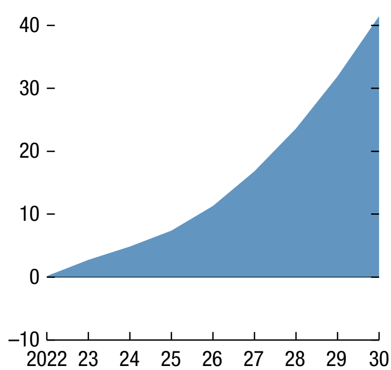


Figure 5.7. Net Cumulative Jobs in LA-5, Alternative Scenario 1
(In thousands of persons per year)



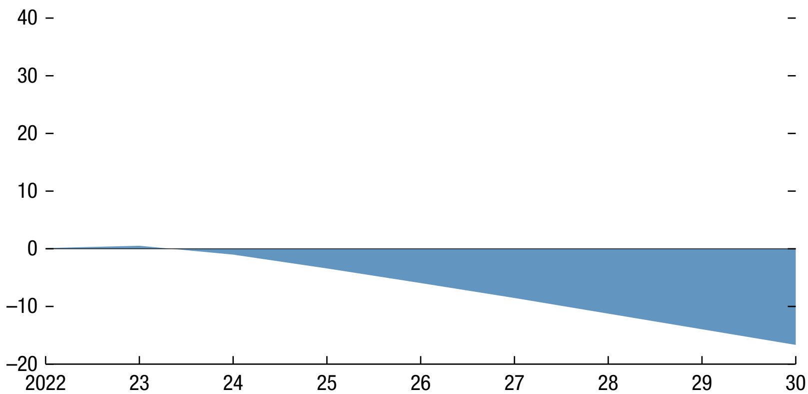
Sources: Blyth and others 2014; Climate Policy Assessment Tool; Green Energy and Job Tool; International Renewable Energy Agency and International Labour Organization 2021; and IMF staff calculations.
Note: GWh = Gigawatt hour; LA-5 = Latin America five (Brazil, Mexico, Colombia, Chile, and Peru); Solar PV = Solar photovoltaic.
[1]Jobs per GWh saved.

in net cumulative jobs for LA-5 countries. In this scenario, the overall net job gains in the region by 2030 is of 42,000 cumulative job-years relative to BAU.

In a second robustness exercise, we take a more conservative approach regarding the job-creating potential of increases in energy efficiency. The default job multiplier on energy efficiency incorporates the assumption that some jobs are created because of additional household savings. Considering that in the CPAT scenario the price of carbon-intensive electricity is expected to increase, households might not obtain considerable savings as a result of decreasing energy consumption. Even with no additional savings, some direct and indirect jobs are expected to be created as households and firms invest in technologies that allow them to save energy. In this robustness exercise, we assume that no jobs will be created due to additional household savings and that the multiplier associated with direct and indirect jobs created due to increasing energy efficiency is at the lower bound of the multipliers identified in the literature (Wei, Patadia, and Kammen 2010). This is a conservative assumption that does not incorporate the fact that governments can establish policies to transfer the income from the carbon tax to households and that additional jobs are likely to be created because of these transfers. Figure 5.8 summarizes the results from this robustness exercise. In this case, we can expect net aggregate job destruction for LA-5 countries, with 16,000 cumulative job-years destroyed in the region relative to BAU by 2030, a result consistent with the importance of the energy efficiency channel for reaching climate goals under CPAT assumptions.

The Green Energy and Jobs tool does not incorporate possible heterogeneities in compensation or other information on workers' characteristics that could be relevant in determining the distributional consequences of the transition. Detailed information that would allow us to separately characterize jobs in renewable and nonrenewable electricity generation is not readily available.

Figure 5.8. Net Cumulative Jobs in LA-5, Alternative Scenario 2
(In thousands of persons per year)



Sources: Climate Policy Assessment Tool; and IMF staff calculations.
Note: LA-5 = Latin America five (Brazil, Mexico, Colombia, Chile, and Peru).

Across industries, we can characterize workers employed in green occupations. Using administrative data on workers employed in the formal sector in Brazil and leveraging on the Occupational Information Network (O*NET) methodology,[4] we can characterize green occupations in the country and evaluate how workers in these occupations differ from workers employed in nongreen occupations. In 2019, workers employed in green occupations represented 8.5 percent of the formal labor force in Brazil, a slight increase from the 2006 level of 8.1 percent.[5] As of 2019, workers in green occupations were more likely to be male (73 percent versus 54 percent), had a lower average tenure (67.8 months versus 72.6 months), and were slightly younger (37.4 years on average versus 38.1 years). In terms of skills, green occupation workers are more likely to have high skills (31.2 percent versus 26.6 percent for the general labor force), are as likely to have medium skills (approximately 49 percent), and are less likely to have low skills (10.2 percent versus 23.6 percent). The average wage of workers employed in green occupations is approximately 40 percent higher,[6] but this aggregate number does not consider composition effects and can hide important heterogeneities. We follow Vona, Marin, and Consoli (2019) and estimate the green wage premium considering the difference in compensation across similar occupations (that is, differences in log wages within three-digit occupation codes). Results show that for higher-skilled workers, green occupations are associated with 8 percent higher wages, whereas for low- and medium-skilled workers, green occupations are associated with wages that are 6.7 percent lower on average.[7] This result shows the importance of incorporating progressive compensation measures into the policy framework to smooth the transition costs for the most vulnerable workers. It is also consistent with the general principle that investment in reskilling and upskilling policies will be crucial for the transition.

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[4] We follow Vona, Marin, and Consoli (2019) and focus on occupations that perform green tasks. These occupations are classified in the Occupational Information Network (O*NET) methodology as "green enhanced skills" (occupations that are likely to expand to incorporate new tasks and competencies) and "green new and emerging" (new occupations created due to the needs of the green economy).

[5] Vona, Marin, and Consoli (2019) found that approximately 2 to 3 percent of workers in the United States were employed in a green occupation in 2014. The October 2021 *World Economic Outlook* (Box 1.2. Jobs and the Green Economy) found a similar value for a larger set of countries. Results from Brazil are not necessarily inconsistent with previous findings from the literature because information on occupations is available only for workers in the formal sector, and the informal sector represents a large share of the economy (approximately 45 percent of workers).

[6] In 2019, the average wage for formal workers employed in green occupations was R$3,943.74 (about $800.00). For workers employed in nongreen occupations, it was R$2,802.52 ($570.00).

[7] In this exercise, we define as high skilled workers employed as "Arts and Sciences Professionals" (group 2 of Brazil's occupation classification). All other categories comprise medium and low skilled workers. Workers employed by the public sector are not included in the exercise.

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CHAPTER 6

Climate Adaptation in Latin America and the Caribbean: Policy Options

Ding Ding, Emilio Fernandez-Corugedo, Alejandro Guerson, and Sònia Muñoz

Although building resilience to natural disasters is important throughout the region, it is a top priority for Caribbean and Central American economies, which are highly vulnerable to the impact of climate change. A comprehensive medium-term approach focused on investing in structural resilience and boosting financial resilience would yield significant long-term benefits for these countries. Scaling up investment in structural resilience could support macroeconomic sustainability and enhance the long-term macroeconomic performance of the economies in the Caribbean and Central America. Building structural resilience, however, takes time, and financial resilience in the form of a comprehensive layered insurance framework would need to be in place to ensure financing for reconstruction while safeguarding public finances. The upfront fiscal costs of structural and financial resilience, nonetheless, would open a transitional financing gap. Deeper private sector contributions to adaptation investment could ease the burden on public finances and can be facilitated by incentives and policies to improve access to financial services.

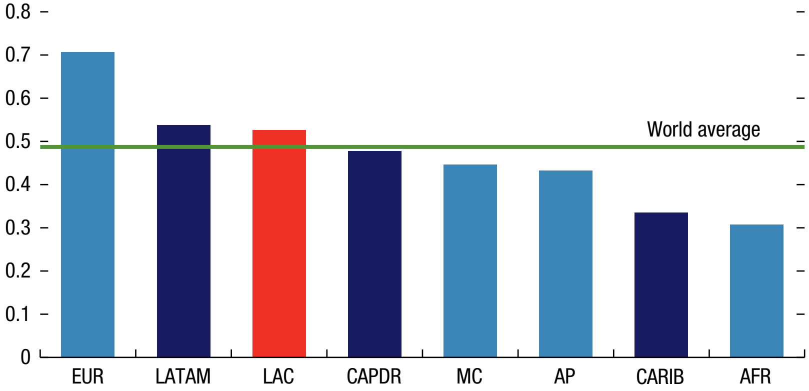
STRENGTHENING CLIMATE ADAPTATION IN LAC BY BUILDING EX ANTE RESILIENCE

All countries in Latin America and the Caribbean (LAC) face challenges in adapting to climate change, but it is a high priority for the vulnerable countries of the Caribbean and Central America. Many LAC economies have adaptive capacity—defined by Notre Dame Global Adaptation Initiative (ND-GAIN) as the availability of social resources for sector-specific adaptation—above that of the world average, which partly counterbalances their high exposure and sensitivity to climate change (Figure 6.1, panel 1).[1] However, many countries in the Caribbean

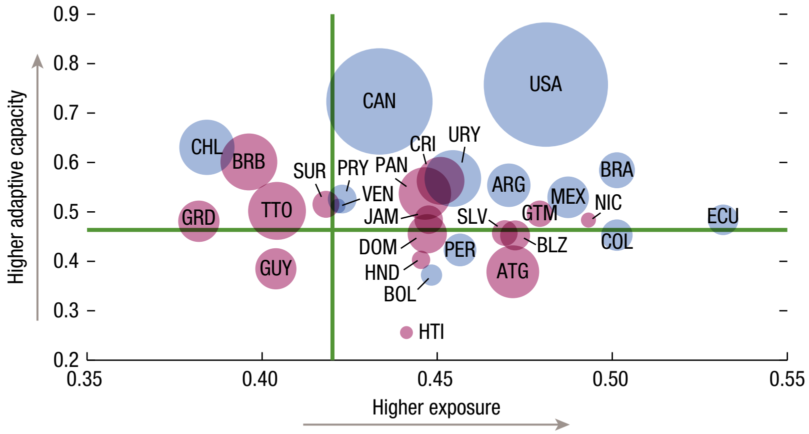
[1] ND-GAIN assesses the vulnerability of a country to climate change risks by considering the exposure to climate-related hazards, the sensitivity to those hazards' impacts, and the adaptive capacity to cope with or adapt to these impacts, in six life-supporting sectors: food, water, health, ecosystem services, human habitat, and infrastructure. Raw data are scaled to a range from 0 to 1, and the arithmetic average is used to construct each index. See details in the ND-GAIN data technical document.

Figure 6.1. Latin America and the Caribbean: Scope to Strengthen Adaptive Capacity

1. LAC's Overall Adaptive Capacity, Compared with Rest of the World, 2021 (Index)



2. Adaptive Capacity of Caribbean and Central American Countries Relative to their Climate-Related Risks, 2021



Sources: IMF-adapted ND-GAIN; and IMF staff calculations.
Note: Capacity index is the difference between 1 and the Vulnerability score capacity indicator so that higher values indicate greater capacity. In panel 1, EUR = Europe; CAPDR = Central America, Panama, and the Dominican Republic; AP = Asia and Pacific; MC = Middle East and Central Asia; AFR = Africa; CARIB (Caribbean) = Antigua and Barbuda, Barbados, Belize, Grenada, Guyana, Haiti, Jamaica, Suriname, Trinidad and Tobago; LAC = Latin America and the Caribbean; LATAM (Latin America) = South America and Mexico. Regional and world averages are weighted by annual population as of 2021. In panel 2, bubble size indicates per capita GDP in USD (2021), vertical (horizontal) line indicates world simple average for exposure (capacity) indicator, and data labels use International Organization for Standardization (ISO) country codes.

and Central America have both high exposure to climate risks and low adaptive capacity (Figure 6.1, panel 2).

LAC countries are taking steps to build climate resilience, but important gaps remain in countries that are highly vulnerable to the physical risks of climate change. More than 60 percent of the region's national adaptation plans include policies that target upgrading climate-resilient infrastructure, reversing deforestation, and protecting biodiversity and ecosystems. However, many disaster-vulnerable countries in the Caribbean and Central America have invested insufficiently in ex ante (before a disaster hits) resilience building and rely heavily on postdisaster recovery efforts, which typically cost more from a public finance standpoint. In many countries, infrastructure upgrades (for example, adequate drainage systems, disaster-resilient roads) have been superseded by other urgent social and development needs, reflecting limited fiscal space and, sometimes, policymakers' short-time horizons. Moreover, cost considerations limit countries' ability to purchase substantial disaster insurance; inadequate capacity to meet the complex access requirements to obtain financing from international climate funds poses additional challenges to ex ante investment in resilient infrastructure or setting aside dedicated funds.[2] In countries where climate-related risks are macro-critical, such underinvestment in climate resilience could result in a vicious cycle of depleted fiscal space and persistently weak climate resilience, leading to ever-growing climate vulnerability. For LAC countries where tourism represents a major economic source, resilience building is key for preparing and adapting the tourism sector to climate change. Indeed, IMF–World Bank climate change policy assessments (CCPAs) conducted for three countries in the Caribbean estimate the investment gaps in resilience building (that is, the difference between required investment for building resilience and current investment levels) at 2 to 3 percent of GDP a year over a decade or more (IMF 2019a).[3]

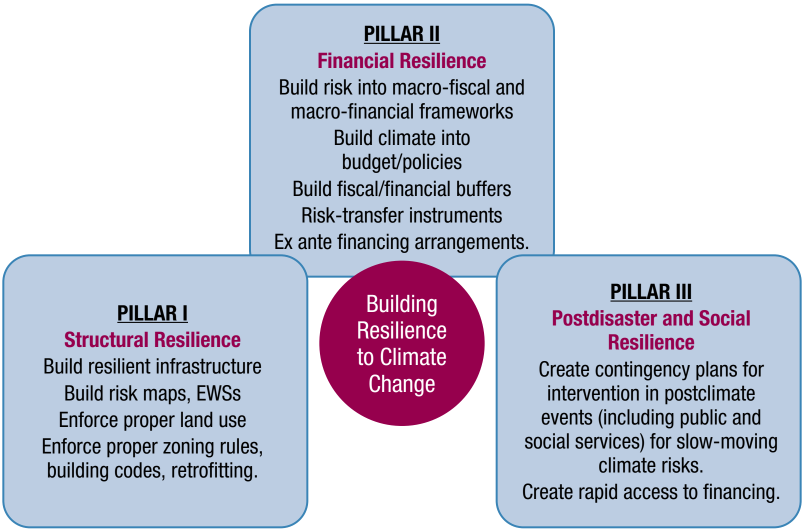
A comprehensive medium-term approach is needed to help LAC's most vulnerable countries prepare for climate-related disasters (Figure 6.2). Created in 2019, the IMF's disaster resilience strategy (DRS) framework internalizes the costs and returns of resilience building into sustainable macroeconomic frameworks, consistent with debt sustainability (IMF 2019a). In the Caribbean, Dominica and Grenada developed such DRSs with IMF's support (IMF 2021, 2022). Such a strategy can help quantify financing needs and gaps, supply a roadmap for policy design and sequencing, and promote coordinated international support. A DRS entails a three-pillar approach.

- Enhancing *structural resilience* requires infrastructure and other ex ante investments to limit the impact of disasters, including "hard" policy measures

[2] For instance, the cost of parametric insurance and catastrophe bonds (or "cat bonds," which are also based on parametric triggers) is estimated to be 1.5 to 3.2 times the expected annual payout, reflecting, for instance, large tail risks facing vulnerable countries, geographical correlation of risks across potential buyers, and thin insurance markets facing small states (IMF 2019a).

[3] CCPAs, a joint IMF–World Bank assessment introduced on a pilot basis in 2017, provided a diagnosis of climate change preparedness (IMF 2016). They have been replaced since by new climate diagnostic reports: the Climate Macroeconomic Assessment Program at the IMF and the Country Climate and Development Reports at the World Bank.

Figure 6.2. Building Resilience to Climate Risks



Source: IMF (2019d).
Note: EWSs = early warning systems.

(for example, upgrading infrastructure; developing irrigation systems; ensuring resiliency of roads, bridges, buildings, and public service infrastructure) and "soft" measures (for example, early warning systems, customizing building codes and zoning rules; Pillar 1).

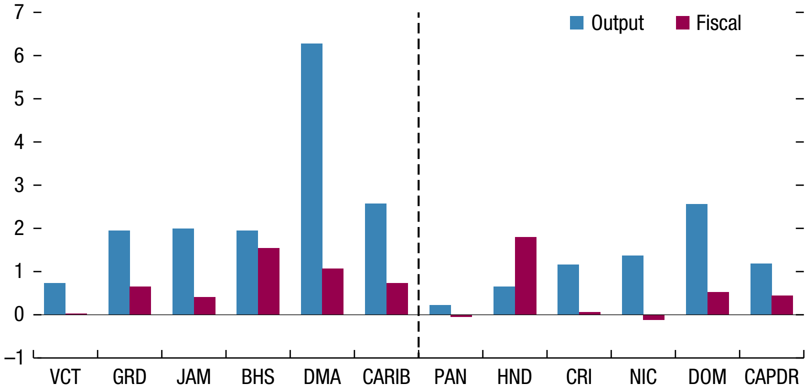
- Building *financial resilience* involves creating fiscal buffers and using prearranged financial instruments to protect fiscal sustainability and manage recovery costs (Pillar 2).
- *Postdisaster and social resilience* require contingency planning and related investments, ensuring a speedy response to a disaster (Pillar 3).

Scaling up investment in *structural resilience* would yield significant long-term benefits to the most climate-vulnerable countries in LAC. Resilient public capital—such as durable roads, bridges, and sea walls—can reduce future expected losses from natural disasters and, as a result, boost expected returns to private investment and output (even if no disaster occurs). IMF staff simulations, based on a dynamic stochastic general equilibrium model for climate adaptation (Annex 6.1),[4] suggest that investing in resilient public capital can lead to an increase in employment and wages and a decline in outward migration, which is generally high in countries prone to natural disasters. Higher output and employment would, in turn, increase

[4] The model assumes that resilient infrastructure is a perfect substitute for standard infrastructure but is 25 percent more expensive. If the physical amount of public investment were kept unchanged, countries are assumed to allocate 80 percent of investment in resilient capital. The outcome in terms of output and fiscal performance is then compared with a situation in which no resilient capital is in place.

Figure 6.3. Output and Fiscal Gains from Resilient Investment in the Long Term

(Change relative to no resilience; output: percent; fiscal: percentage points of GDP)



Sources: Caribbean Catastrophe Risk Insurance Facility; EM-DAT database; and IMF staff calculations.

Note: Aggregates are simple averages. Data labels use International Organization for Standardization (ISO) country codes. CARIB = Caribbean (BHS, DMA, GRD, JAM, VCT); CAPDR = Central America, Panama, and the Dominican Republic (CRI, DOM, HND, NIC, PAN).

tax revenue, improving the fiscal balance. The simulations indicate that such investment can boost the level of GDP in the long term between 2 and 6 percent for Caribbean islands and between 0.2 and 1.4 percent for Central American countries (Figure 6.3). The gains are larger in the Caribbean than in Central America, since the former has higher damages from natural disasters relative to the size of the economy and a larger share of public investment in GDP. Despite higher upfront costs of investing in resilient public capital, long-term fiscal gains from these investments generate lower replacement costs after a natural disaster.[5]

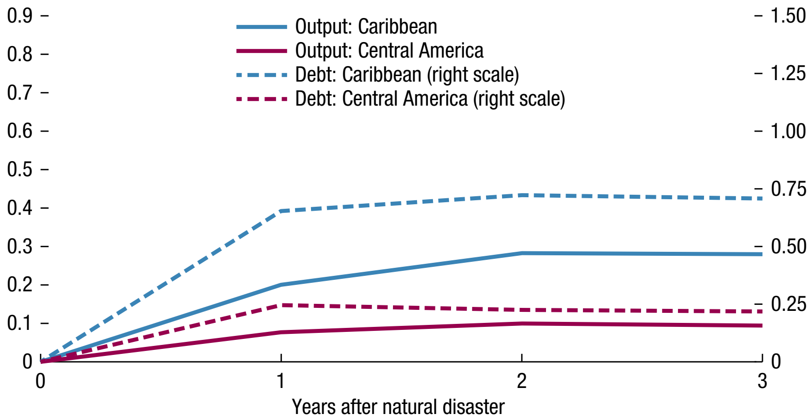
In addition, once structural resilience is achieved, resilient capital also offers important output and fiscal gains in the aftermath of a natural disaster.[6] The model

[5] The simulation results are consistent with earlier estimates for the Eastern Caribbean Currency Union (ECCU; IMF 2019b, 2019c). The potential gains from resilience investment are even greater if it can be further scaled up at affordable terms beyond the projected public investment levels. Staff is conducting further analysis on adaptation on larger LAC economies, such as Peru, where it is macro-critical. As shown in World Bank (2019), there can be significant net benefits of investing in more resilient infrastructure in low- and middle-income countries around the globe.

[6] Staff estimates that a large increase in investment rates with concessional financing for 10 to 20 years would be needed to build resilience to natural disasters; without such additional concessional financing and maintaining current investment rates, it would take twice that time to achieve resiliency. For instance, using the standard inventory method and capital depreciation rate assumption for the accounting of the capital stock, staff estimates that without concessional financing, it would take 30 to 40 years of investment in resilience to achieve 80 percent of capital resiliency (see IMF 2019b, 2019c). However, the rewards from adaptation (in terms of lost output following a natural disaster) accrue as soon as resilient capital starts being stalled, increasing with the share of resilient capital.

Figure 6.4. Output and Public Debt Gains from Resilient Investment after Natural Disaster Event

(Left scale: percent; right scale: percentage points)

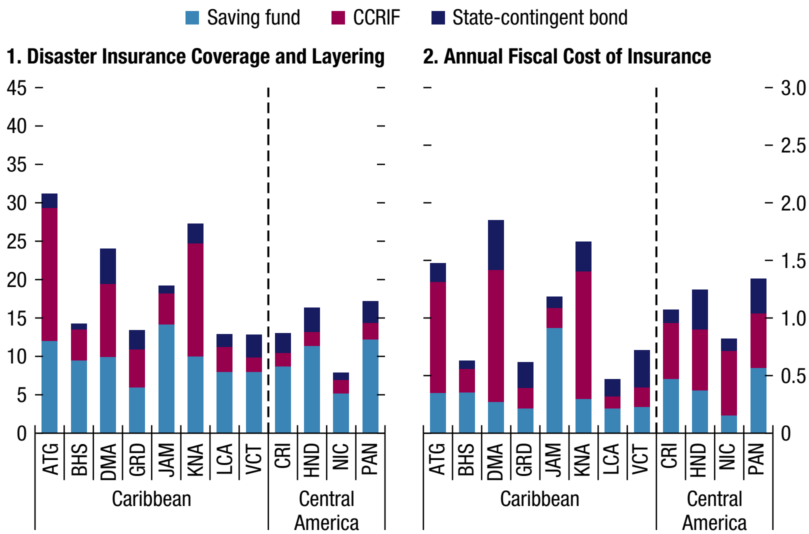


Sources: Caribbean Catastrophe Risk Insurance Facility; EM-DAT database; and IMF staff calculations.

results suggest that—once resilient capital is installed—the level of output would be about 0.25 percent higher three years after a natural disaster in the Caribbean, on average, and about 0.1 percent higher for Central American countries (Figure 6.4). The level of public debt is estimated to be 0.75 percentage point lower after three years in the Caribbean and about 0.25 percentage point lower in Central America. The improvement in public debt derives from lower reconstruction spending (as less capital needs to be replaced) and lower revenue losses because of the smaller decline in economic activity.

Because building structural resilience takes time, *financial resilience* would also be needed to ensure funding for reconstruction—while safeguarding public finances. Financial resilience in the form of comprehensive, layered insurance should aim to provide adequate coverage against the expected capital and revenue losses after major natural disasters and internalize the expected fiscal costs of postdisaster support. IMF staff simulations based on a stochastic model (Guerson 2020) indicate that insurance coverage of 15 to 30 percent of GDP for Caribbean countries and 10 to 20 percent of GDP for Central American countries could cover 99 percent of the fiscal costs related to natural disasters (Figure 6.5, panel 1). This calculation is based on an illustrative insurance framework with three layers, based on the World Bank risk-layered framework for disaster risk financing (World Bank 2017). Ranked by their incremental costs, the layers include (1) building a precautionary government savings fund for immediate postdisaster liquidity needs against relatively less damaging but more frequent natural disasters, (2) scaled-up access to parametric insurance under the Caribbean Catastrophe Risk Insurance Facility (CCRIF) against less frequent but larger natural disasters with damages beyond the scope of the

Figure 6.5. Financial Resilience Simulations: Disaster Insurance Coverage and Cost
(Percent of GDP)



Sources: National authorities; and IMF staff calculations.
Note: Authorities' data and disaster loss function estimates from CCRIF. Calibrated to achieve coverage of 99 percent of disaster loss. Includes risk of tropical cyclones and earthquakes. Data labels use International Organization for Standardization (ISO) country codes. CCRIF = Caribbean Catastrophe Risk Insurance Facility.

savings fund,[7] and (3) issuance of state-contingent bonds to give debt relief for extreme events.[8]

The simulations also suggest that, while comprehensive insurance coverage is expensive, insurance needs and fiscal costs would decline significantly over time. The simulated annual cost of the illustrative insurance coverage would initially be in the range of 0.5 to 2 percent of GDP per year (Figure 6.5, panel 2). As structures become more resilient, insurance requirements for the same coverage would decline in the long term to about one-quarter of the current level.

[7] CCRIF is a segregated portfolio company providing short-term liquidity to Caribbean and Central American governments when a parametric insurance policy is triggered. Current CCRIF members are Anguilla, Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Guatemala, Haiti, Jamaica, Montserrat, Nicaragua, Panama, St. Kitts and Nevis, St. Lucia, Sint Maarten, St. Vincent and the Grenadines, Trinidad and Tobago, and the Turks and Caicos Islands. Parametric insurance is a type of insurance contract that insures a policyholder against the occurrence of a specific event by paying a set amount based on the magnitude of the event.

[8] The saving fund size has been calibrated to cover the fiscal cost of natural disasters in 95 percent of the events, and access to CCRIF and issuance of CAT bonds is added to reach coverage of 99 percent. The simulations incorporate the impact of natural disaster shocks on output, tax revenue, grants and other non-tax revenue, recurrent expenditure, and capital expenditure. They also consider reprioritization of expenditures (reconstruction largely replaces pre-existing projects).

The near-term fiscal costs of structural and financial resilience would open a transitional financing gap for governments since the benefits of climate resilience accrue over the medium and long terms.

- Building structural resilience involves upfront costs that can be very large relative to countries' fiscal capacity and economic size, while the returns of higher output and fiscal revenue accrue over time. For small Caribbean states like Dominica, the total cost of building resilience is estimated at $2.8 billion (about 500 percent of GDP) and would require more than a decade to fully execute (IMF 2021). Meanwhile, damages from natural disasters are projected to intensify significantly in a business-as-usual (BAU) climate scenario (Box 6.1).
- For financial resilience, although CCRIF has been a valuable instrument to improve the region's insurance coverage, the coverage remains low for many countries; they face high upfront costs for insurance products, concerns that significant damages may not trigger payouts, and competing developmental needs (Figure 6.6). Many countries have government saving or wealth funds; however, few have funds dedicated specifically to self-insurance against natural disasters. The amounts saved, nevertheless, remain short of needs, in part due to the frequency of natural disasters and other external shocks such as the COVID-19 pandemic. Use of innovative state-contingent instruments such as catastrophe bonds has remained limited, given their complexity, high setup costs, and capacity/regulatory constraints.[9]
- In the near term, as the scale of the region's adaptation investment is likely to depend heavily on availability of external concessional financing, including international climate funds, a DRS is key.[10] To address fiscal sustainability, countries would need to create fiscal space with a combination of structural fiscal measures to generate savings, prioritize spending, and have access to concessional financing and donor assistance. Additional efforts are needed to further enhance countries' capacity to meet the administrative requirements to obtain financing from climate funds.

[9] Jamaica issued the first catastrophe bond that is independently sponsored by a Caribbean government in July 2021. Grenada and St. Vincent and the Grenadines enrolled in the World Bank's CAT Deferred Drawdown Option in 2020.

[10] For instance, as noted in IMF (2019b), a country with a public investment rate of 5 percent (the average of the Caribbean countries in Figure 4.4), increasing resilience to 80 percent would imply a fiscal deterioration of 1 percent of GDP each year if resilient capital is 25 percent more expensive as assumed in the previous simulations. For countries in the Eastern Caribbean Currency Union (ECCU), which include Dominica, Grenada, and St. Vincent and the Grenadines, IMF (2019b) estimates that the additional cost of resilience would increase the public debt by 4 to 20 percentage points of GDP in the ECCU countries by 2030. These would translate into additional financing gaps of 0.4 to 1.5 percent of GDP relative to historical levels.

Box 6.1. Dominica's Disaster Resilience Strategy

In 2019, the IMF provided technical support to the government of Dominica to produce one of the first two disaster resilience strategy (DRS) pilots.[1] The DRS integrated the costs of all investments and policies to build resilience to natural disasters for Dominica in a comprehensive macrofiscal framework, organized in three pillars: (1) structural resilience (infrastructure), (2) financial resilience (government and private insurance), and (3) social resilience (preparedness and postdisaster protocols).

TABLE 6.1.1.

Dominica's Disaster Resilience Strategy (DRS) Cost

		US$ bn	Percent of GDP
Pillar 1	Physical resilience	2.5	450
Pillar 2	Financial resilience	0.1	12
Pillar 3	Social and postdisaster resilience	0.3	49
DRS total cost		**2.8**	**510**

Sources: National authorities; and IMF staff calculations.

The total cost of transforming Dominica into a disaster-resilient state is estimated at $2.8 billion, equivalent to five times the size of Dominica's GDP. Most of the cost belongs to Pillar 1, estimated at 12 percent of GDP per year. Pillar 2 includes a comprehensive insurance-layering framework with disbursement triggers mapped to disaster intensity, at an estimated annual cost of 1 percent of GDP. The annual cost of Pillar 3 is 2 percent of GDP initially and declines afterward. Given the large investment need and cost relative to the size of the economy, the DRS execution could take about two decades.

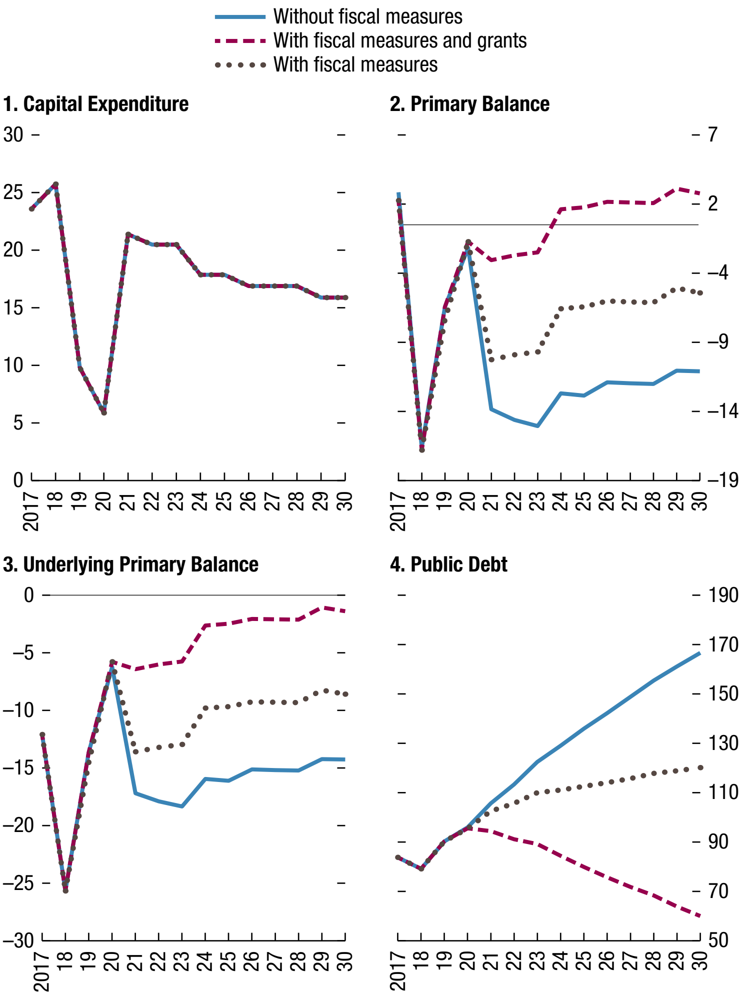
To create fiscal space for resilience, the Dominica DRS assumed that the government maintains progress on a fiscal consolidation plan with expected cumulative savings of 5 percent of GDP over a five-year period, which is supported by a program of institutional fiscal reforms including the Fiscal Responsibility Act, which parliament approved in 2022, with specific debt targets and primary fiscal balances. Dominica's Citizenship by Investment program revenue has been a key financing source, but this revenue is difficult to predict and subject to significant uncertainty.

This box was prepared by Camila Perez.

[1] The other DRS pilot was Grenada.

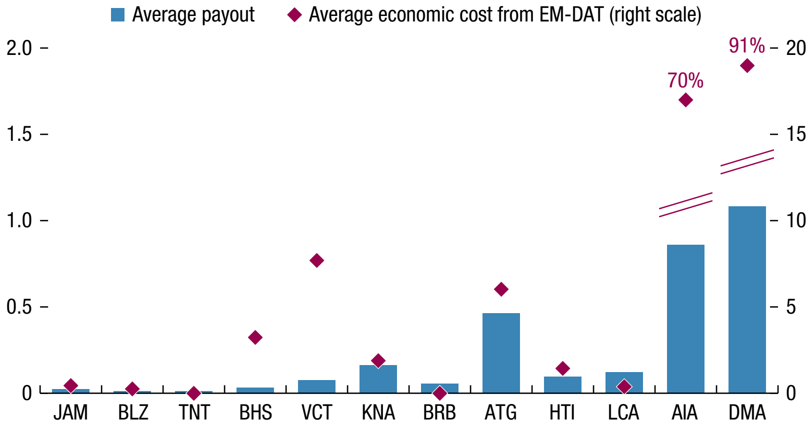
Box 6.1. *(continued)*

Figure 6.1.1. Dominica: DRS Macrofiscal Framework
(Percent of GDP)



Source: IMF staff calculations.
Note: Primary balance excluding Citizenship-by-Investment (CBI) revenues, grants, and transitory increase in public investment after Hurricane Maria.

Figure 6.6. CCRIF Payout to the Caribbean Countries, Average 2007–21
(Percent of GDP)



Source: Caribbean Catastrophe Risk Insurance Facility.
Note: Data labels use International Organization for Standardization (ISO) country codes. EM-DAT = Emergency Events Database.

HOW CAN LAC PROMOTE PRIVATE SECTOR RESILIENCE TO CLIMATE CHANGE?

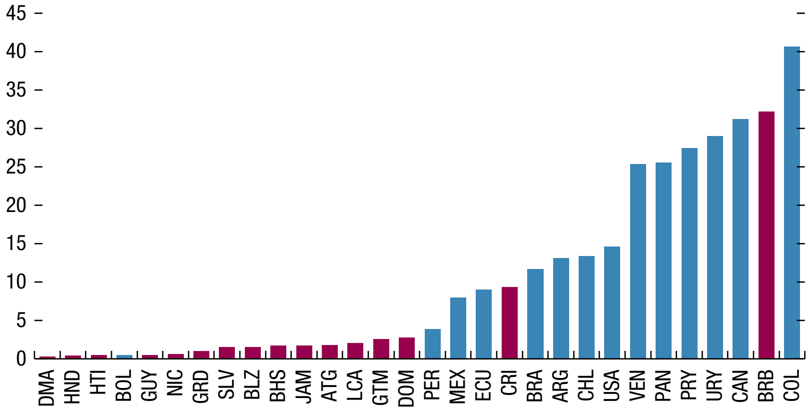
The private sector can play an important role in building resilience against climate risks. Empirical studies, such as Carpenter and others (2020), have shown that countries with a higher insurance penetration tend to recover faster after major disasters. On average, disaster cases in low-insurance countries take longer than those in high-insurance countries to achieve economic recovery. Private insurance can reduce economies' reliance on financial aid from public sources after a disaster. However, insurance penetration tends to be low in low-income countries—it is estimated that about 40 percent of direct losses from natural disasters is insured in developed countries, compared with 10 percent in middle-income countries, and below 5 percent in low-income countries.

Private adaptation investment is nonetheless held back by limited access to affordable insurance and credit in LAC. This is particularly the case in the vulnerable Caribbean and Central American countries, where the private sector is mainly composed of households and small businesses dependent on traditional banking and insurance services—and thus faces a lack of alternative saving and financing instruments suitable for climate adaptation investment.[11]

- Limited access to affordable insurance: Despite evidence of increased insurance demand following natural disasters, the level of private sector insurance

[11] Larger hotels and resorts in the tourism sector are mostly foreign-owned and benefit from access to international financial services.

Figure 6.7. Non-Life Insurance Premiums per Average Annual Climate-Related Damages



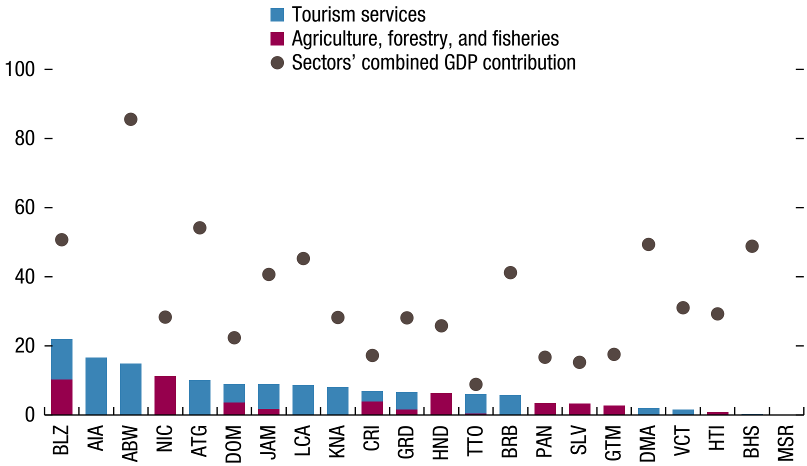
Sources: EM-DAT database; World Bank, October 2019 Global Financial Development database; and IMF staff calculations.
Note: Non-life insurance premiums represent the latest available annual data for each country (mostly 2017–19). Average climate-related damages are for the period 1980 to 2020. Data labels use International Organization for Standardization (ISO) country codes.

penetration is often not commensurate with countries' susceptibility to climate-related disaster damages in Caribbean countries (Figure 6.7). A key factor is high property insurance costs due to not only higher incidence of natural disasters but also often the small size of the primary insurance market. The implied heavy reliance on overseas reinsurance leads to high regional pass-through of disaster-sensitive reinsurance pricing.[12] For instance, reinsurance costs in the Caribbean increased by 20 to 40 percent in 2018 for countries hit by disasters the preceding year and 10 and 20 percent for other countries.

- Limited credit access: High interest rates and shortages of qualifying collateral (mostly limited to fixed assets) represent long-standing impediments to credit access for households and small firms. The composition of bank credit is also skewed away from sectors most vulnerable to physical disaster risks (for example, tourism and agriculture; Figure 6.8), which may in part reflect lenders having internalized in their credit decisions and terms the risk of disasters.

[12] In the ECCU, for example, an estimated 60 to 75 percent of insurance premiums are ceded to reinsurance, and the ceded share is even higher for property insurance.

Figure 6.8. Banking System Credit Exposures to Vulnerable Sectors
(Percent of total loans)



Sources: National authorities; World Bank; World Travel and Tourism Council; and IMF staff calculations.
Note: Anguilla and Montserrat's GDP contribution data are not available. El Salvador, Guatemala, Haiti, Honduras, Nicaragua, and Panama's tourism credit exposure data are not available. Information by country regarding exposure range from Dec. 2019 to May 2021. GDP exposures are based on data as of 2018 and 2019. Data labels use International Organization for Standardization (ISO) country codes.

Governments could foster private sector adaptation investment through technical support, incentives, and policies to improve access to financial services—especially private insurance. Climate risk information dissemination and services to support the evaluation of adaptation options could encourage broader private sector engagement, while regulatory and fiscal incentives (for example, targeted taxes, subsidies, or service pricing) could support a more attractive risk–return profile for adaptation investments. Introducing or scaling up partial public credit guarantee schemes or frameworks supporting the use of alternative collateral (for example, machinery or inventory) could both mitigate collateral constraints to financing and better leverage the regional financial systems' (excess) liquidity to support climate adaptation efforts. Facilitating risk pooling among private insurers—for instance, through a public guarantee for any excess liability from natural disasters—can help mitigate costs and expand coverage availability.[13] Improvements in land-use regulation and building codes, together with geospatial risk data, can reduce information asymmetry and help insurers offer better-targeted products.

[13] Examples include the National Flood Insurance Program (US), Florida Hurricane Catastrophe Fund, California Earthquake Authority, and New Zealand's Earthquake Commission.

ANNEX 6.1. DESCRIPTION OF THE DSGE MODEL FOR A SMALL OPEN ECONOMY VULNERABLE TO CLIMATE-RELATED RISKS

The model expands previous IMF work on climate change. This model (Fernández-Corugedo, Gonzalez-Gomez, and Guerson 2023) is similar to that created by the IMF (2019c); however, it accounts for the stochastic nature of national disaster shocks, similar to the model by Cantelmo and others (2019), which allows for the presence of extreme shocks. The model extends these papers by considering several real and financial frictions consistent with the characteristics of Caribbean and Central American countries.

The model comprises four key sectors: households, firms, government, and an external sector. There are two types of households: investor households, which invest in nonresilient capital and hire labor, and worker households, which supply labor and receive remittances but cannot save. There are two types of firms: firms that produce a final good using capital and labor and firms that transform the final good to both capital and consumption goods. The government collects revenues from taxes (consumption, firms' profits, wages, and lump-sum taxes) and external grants, and spends on purchases goods and services, transfers to households, interest on public debt, and investment. Crucially, public investment can be of two types: resilient and nonresilient to natural disasters. It is assumed that investment in resilient public capital is costlier relative to the nonresilient type (assuming a premium of 25 percent over nonresilient investment, based on estimates of ex post damage assessments from the World Bank) and that both types are perfect substitutes in production. Keeping the physical amount of public investment unchanged, countries are assumed to allocate 80 percent of investment in resilient capital. The external sector uses final goods to export and import both consumption and investment goods. The model includes costs to adjusting investment and wages as well as the presence of financial frictions captured by both an interest rate spread on public debt relative to a safe global interest rate and a spread between corporate interest rates and those for public debt. Both spreads increase as the balance sheets of the government and corporate sector deteriorate.

Exogenous natural disaster events are modeled through their impact on three key channels. The model assumes that there is an exogenous probability of being hit by natural disaster, and at each point in time the economy can be in one of two regimes: one where there is no natural disaster and another when the economy is hit by a natural disaster. Once the natural disaster occurs, the economy is affected through three channels: First, a natural disaster affects the economy's supply capacity—a proportion of nonresilient capital and total factor productivity are destroyed by the disaster. Second, both remittances and grants increase to support both households and the public finances after a natural disaster. Finally, the external risk premium can increase in response to the natural disaster. Financial frictions act to amplify the impact of the disaster.

This annex was prepared by Emilio Fernandez-Corugedo, Andres Gonzalez, and Alejandro Guerson.

Fiscal policy is anchored by a debt rule and does not follow an optimization process. All government expenditures, including public investment, are set as a constant share of nominal GDP and marginal tax rates are assumed unchanged in response to a natural disaster. Other than the aforementioned increase in grants in response to the disaster nondistortionary lump-sum taxes levied on households are used to raise revenue to allow to match the public debt target over the medium term.

Households

All households maximize a standard utility function comprising consumption and labor. Labor is differentiated across households but not across household types, as in Gali and others (2007). Under this labor market structure, wages are set in a centralized manner by an economy-wide union. The equilibrium level of hours in the economy is thus determined by firms given the wage set by the union. Although the problem faced by unconstrained households is not directly affected by climate shocks, that of worker households is, since they are permitted to receive remittances from abroad:

$$(1+\tau^C)C^W_{i,t} = (1-\tau^l)W_{jt}N_{i,t} + T^{GW}_{i,t} + z_t T^*_{i,t}(s) \quad \text{(A6.1.1)}$$

where τ^C, τ^l are consumption and labor income taxes, respectively; $C^W_{i,t}$ denotes consumption of worker households; W_{jt} is the real wage; $N_{i,t}$ is the number of hours worked; $T^{GW}_{i,t}$ are government transfers; and $z_t T^*_{i,t}(s)$ are foreign remittances, with z denoting the real exchange rate. Crucially, remittances depend on the state of economy, s, and are assumed to increase during a natural disaster.

Firms

Firms produce a homogenous good that can itself be transformed into consumption, investment, and export goods. Production firms choose their labor and capital inputs, taking as given the stock of public capital, real wages, and the price of output. Firms must borrow to finance investment and labor input expenses and use the value of their capital as collateral. The existence of credit constraints amplify the impact of adverse climate shocks on the economy. The destruction of capital associated with the climate event tightens the credit constraints affecting both labor and investment decisions.

Domestic output, Y^H_t, is produced with the following technology

$$Y^H_t = z^Y_t A_t (K^G_{t-1})^{\alpha_g} (K^Y_{t-1})^{\alpha_K} N_t^{1-\alpha_K} \quad \text{(A6.1.2)}$$

where $\alpha_K \in (0,1)$ is the capital share of private total output, z^Y_t is a temporary productivity shock, and K^Y_{t-1}, K^G_{t-1} are the stocks of private and public capital available. α_g measures the importance of the public capital on the production function. A_t is a permanent productivity shock:

$$\frac{A_t}{A_{t-1}} = g^A_t = (1-\rho_G)\mathrm{g}^A(s) + \rho_G g^A_{t-1} + \epsilon^{gA}_t \quad \text{(A6.1.3)}$$

with $0 \le \rho_G < 1$. Thus, any shock, ϵ^{gA}_t, will have a permanent effect on the level of an output. $\mathrm{g}^A(s)$ is the mean growth rate of output, which crucially is state dependent such that adverse climate events can entail temporary losses to the growth rate of the economy.

Firms must finance investment and labor input expenses; however, the firm faces a financial constraint because lenders will allow a firm to borrow up to only a fraction of its debt:

$$W_t N_t + p_t^I I_t^Y \leq \sigma (Q_t K_{t-1}^Y) \tag{A6.1.4}$$

$W_t N_t$ denotes total wage payments, $p_t^I I_t^Y$ is the cost of investment goods, and p_t^I is the relative price of the investment good. Q_t is the price of a unit of installed capital. It is assumed that adjusting investment is costly and thus the stock of private capital evolves as

$$K_t^Y = (1 - \delta_Y(s))\, K_{t-1}^Y + I_t^Y - \frac{\psi_y}{2}\left(\frac{I_t^Y}{K_{t-1}^Y} - \delta_Y(s)\right)^2 K_{t-1}^Y \tag{A6.1.5}$$

The parameter ψ_y controls the speed of the adjustment cost and $\delta_Y(s)$ is the depreciation rate of capital, which depends on the state of climate events.

Public Sector

The government collects taxes on consumption ($\tau^C C_t$), profits ($\tau^\pi \Pi_t$), and labor ($\tau^L W_t N_t$), and receives grants ($T(s)^{Grants}$) and lump-sum taxes from savers (T_t^G). The government purchases public consumption goods and services (C_t^G), nonresilient public investment (I_t^{Gn}), and resilient public investment (I_t^{Gr}), which have different prices. Additionally, it can issue public debt denominated in foreign currency, B_t^{G*}, to finance its overall balance. The government pays a nominal interest rate, R_t^*, on its debt. The government's budget constraint is

$$\begin{aligned}&\tau^C C_t + \tau^L W_t N_t + \tau^\pi \Pi_t + T_t^G + z_t T(s)^{Grants} + z_t B_t^{G*} = \\ &p_t^H C_t^g + T_t^{GW} + p_t^I I_t^{Gn} + p_t^{Gr} I_t^{Gr} + z_t R_{t-1}^* B_{t-1}^{G*},\end{aligned} \tag{A6.1.6}$$

where $\Pi_t = (p_t^H Y_t^H - W_t N_t - p_t^I I_t^Y)$ denote firms' profits. To guarantee the stability of the public debt, all lump-sum taxes to savers households respond to the public debt level according to the following rule[14]

$$T_t^G = \overline{Tr}\left(\frac{B_t^{G*}}{\mathrm{Y_t}} - \frac{B_t^{G*}}{\mathrm{Y_t}}\right)^{\phi_b} \tag{A6.1.7}$$

Public investment is used to build public capital. The government accumulates resilient, K_t^{Gr} and nonresilient capital, K_t^{Gnr} according to the following equations:

$$K_t^{Gr} = (1 - \delta_g) K_{t-1}^{Gr} + I_t^{Gr} \tag{A6.1.8}$$

$$K_t^{Gnr} = \left(1 - \delta_g(s)\right) K_{t-1}^{Gnr} + I_t^{Gnr} \tag{A6.1.9}$$

[14] Other taxes or expenditures could be used.

and the total stock of public capital is $K_t^G = K_t^{Gnr} + K_t^{Gr}$. Resilient investment involves an additional transformation that increases the cost of each unit of investment. The government produces resilient investment by buying investment goods from investment producers and transforming them through a linear production function. The problem of the production of the resilient investment good is as follows:

$$\max \quad p_t^{Gr} I_t^{gr} - p_t^I I_t^g \; s.t. \; I_t^{Gr} = a^{Gr} I_t^g \tag{A6.1.10}$$

with $0 < a^{Gr} < 1$. The solution of the optimization problem is $p_t^{Gr} = \frac{p_t^I}{a^{Gr}}$, implying a constant markup between the price of investment goods and the prices of the resilient investment.

External Sector and Current Account

The external interest rate is the sum of an external risk-free rate and an endogenous risk premium:

$$R_t^* = \overline{R}_t^*(s) + \Omega_u\left(\exp\left(\frac{z_t(B_t^* - B_t^{G*})}{GDP_t} - \frac{z(B^* - B^{G*})}{GDP}\right) - 1\right) \tag{A6.1.11}$$

$\overline{R}_t^*$ is an external risk-free rate that depends on the state of the economy. The country risk premium is a negative function of net foreign assets (NFA) to GDP, and Ω_u is the elasticity of the country risk to the NFA to GDP ratio where $GDP_t = p_t^h y_t^h$.

Finally, the current account balance, CB, is given by

$$CB_t = (p_t^H X_t - z_t C_{F,t} - z_t I_{F,t}) + z_t T_t^*(s) + z_t T(s)^{Grants} \tag{A6.1.12}$$

where the term in brackets is the trade balance, defined as the difference between exports, $p_t^H X_t$, and imports of consumption, $z_t C_{F,t}$, and investment goods, $z_t I_{F,t}$.

Model Solution

The model is solved using the perturbation methods for regime-switching rational expectations models, developed by Maih (2015). Importantly, the solution method allows for the decisions of agents in the economy to consider the presence of natural disasters even when not confronted by them. Two states are considered: state 1 is where there are no natural disasters, and state 2 is where a natural disaster occurs. A transition matrix through states s_t is

$$P_{s_t, s_{t+1}} = \begin{bmatrix} p_{1,1} & p_{1,2} \\ p_{2,1} & p_{2,2} \end{bmatrix} \tag{A6.1.13}$$

$p_{1,2}$ is the probability of transitioning from the state where there are no natural disasters in period t to a natural disaster in $t+1$; $p_{1,1} = 1 - p_{1,2}$ is the probability of remaining in the state without a natural disaster; $p_{2,1}$ is the probability of going from the state with a natural disaster in period t to the state without natural disasters in period $t+1$; and $p_{2,2} = 1 - p_{2,1}$ is the probability of remaining in the natural disaster state in $t+1$. These probabilities are calibrated to replicate the frequency of natural disasters observed in each country.

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CHAPTER 7

The Green Transition in Latin America and the Caribbean: Considerations for the Public Sector

Diane C. Kostroch and Tessy Vasquez-Baos

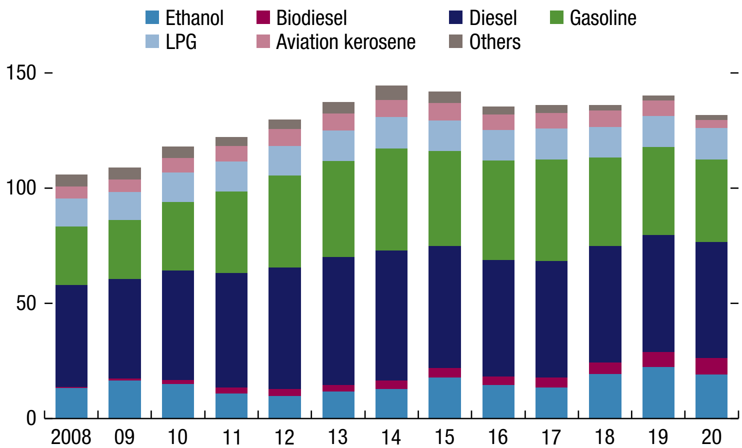
Governments in Latin America and the Caribbean (LAC) have already made considerable efforts to expand the use of renewable energy. A mix of enabling policies has supported the region's energy transition toward renewables; however, the public sector continues to play a key role in the production of fossil fuels. State-owned enterprises (SOEs) in the region have plans to expand their oil and gas production despite governmental pledges of decarbonization. As such, LAC countries will have to choose between backing fossil fuels and supporting a just energy transition in line with climate change targets. While lucrative in the past, investments in fossil fuels are at risk of becoming stranded assets as technological advances make renewables cheaper and undermine the competitiveness of fossil fuels. In addition, the shift to green technologies could benefit some countries in the region because of the natural endowment of metals needed in the energy transition. The increasing prices of energy-transition metals, which translate into higher gains for LAC metal exporters, could increase input costs and delay the energy transition. Reserves will be a supply-side constraint in the transition to renewables. Hence, a push for green investments will be key to reaping the benefits from existing and expanding reserves to meet future demands. But not all LAC countries will benefit from the boom in green metals because reserves are concentrated in a few countries in the region. Governments will need to regulate the extraction of green commodities to ensure efficient use while extracting the maximum sustainable return from scarcity rents. For other LAC it is important to continue reducing direct emissions that come from the production of oil and gas and ensure that state-backed investments in other energy infrastructure (for example, power plants) are in line with decarbonization commitments.

Scaling up the use of renewables in the region over the past several decades has been supported by government policies designed to kick-start renewable energy markets, create local supply chains, and consolidate mature renewables such as hydropower and bioenergy (International Renewable Energy Agency [IRENA] 2016; Box 7.1). Government support included catalyzing financing for renewable energy projects; offering dedicated credit lines, currency hedges, and guarantees;

Box 7.1. Brazil's Sugarcane-Based Ethanol Fuel Program

Brazil is the second largest producer and consumer of biofuels in the world, following the United States. Renewables (mostly ethanol) represent 20 percent of energy use in transport (Box Figure 7.1.1), a direct result of policies established in the mid-1970s. In the motor fuels market, the share of ethanol use rises to about 40 percent. Biofuels foster economic development and employment in rural areas. Sugarcane mills usually produce both sugar and ethanol, with specific allocations chosen only after the harvest. This practice allows flexibility in adjusting to relative price movements. Renewable electricity is also generated from burning bagasse, a sugarcane residue.

Figure 7.1.1. Brazil: Consumption of Fuels
(Million cubic meters)



Sources: Agência Nacional do Petróleo, Gás Natural e Biocombustíveis; and IMF staff calculations.
Note: LPG = liquefied petroleum gas.

The Brazilian National Alcohol Program (Proálcool) was launched in late 1975, after the oil crisis, to promote substitution of imported fossil fuels with biofuels. The program also aimed at fostering profitability in the Brazilian sugar market. Proálcool included subsidized-interest loans and government credit guarantees for the construction of refineries, the purchase of ethanol at favorable prices by state trading companies, and gasoline pricing policies that granted ethanol a competitive advantage. It was accompanied by a forceful marketing program and investments in infrastructure for the widespread distribution of ethanol by the state-owned Petrobras. At a later stage, the Brazilian government provided incentives for the production and conversion of cars to allow up to 100 percent ethanol use. According to Sandalow (2006), the Brazilian production of ethanol quintupled from the mid- to late 1970s and tripled in the following six years.

Ethanol remained a substantial source of transport energy in Brazil even after the end of Proálcool. With the fall in international oil prices and reduced fiscal support to the sector, Brazilian ethanol production leveled off in the late 1980s and '90s. However, several factors continued to render sugarcane-based ethanol production economically attractive in Brazil: a regulatory minimum of 20 percent ethanol content in all gasoline sold, developed infrastructure for production and distribution of ethanol, favorable

Box 7.1. *(continued)*

climate conditions, and a large unskilled labor force. The invention of the flex-fuel car—now representing the majority of light vehicle sales—provided new impetus to the sector, but the subsequent discovery of pre-salt oil reserves in the mid-2000s diverted resources and attention from investments in biofuels.

As part of its strategy to meet its commitments to nationally determined contributions under the Paris Agreement, the Brazilian government has created new instruments to promote investments in biofuels. Brazil's nationally determined contributions foresee a 10 percent reduction in greenhouse gas emissions from transport by 2028 and an 18 percent share for sustainable biofuels in the country's overall energy mix by 2030 (including by expanding biofuel consumption and ethanol supply). A new flagship biofuel policy, RenovaBio, was launched in 2016 in support of this goal. It establishes annual carbon intensity–reduction targets for the fuels' sector, provides a framework for certification of biofuels production according to its efficiency in reducing GHG emissions, and creates a decarbonization credit market mechanism[1] to foster production and consumption of biofuels.

This box was prepared by Joana Pereira.

[1] Decarbonization credits are certificates sold by certified biofuel producers and traded in the Brazilian stock exchange. Buyers (fuel producers) can use them to meet mandatory decarbonization targets.

providing grants and subsidized loans; introducing tax incentives for low-carbon industries,[1] renewable energy, and research and development; and promoting renewables through feed-in tariffs.[2]

For LAC, renewable energy has become a policy priority because of growth in demand, high dependence on imported fossil fuels, climate change, and a drive toward decarbonization. The LAC region has experienced a rapid and diversified development of renewable energy sources, driven by considerations of energy security, competitiveness, and social and environmental sustainability, in particular the need to move toward a low-carbon economy (IRENA 2016). Important considerations for policymakers include reduced adverse health and environmental effects of renewable energy sources, compared with fossil fuels, as well as socioeconomic benefits, such as employment creation, development of local value chains, and access to modern energy. LAC countries committed to generate, with their nationally determined contributions (NDCs), at least 70 percent of their electricity from renewable sources by 2030. In 2019, renewable energy sources made up, on average, 60 percent of electricity generation in the non-Caribbean part of the region, while fossil fuels remained the dominant source of energy for the Caribbean.

[1] In Brazil, introducing tax incentives for green hydrogen companies is being considered.

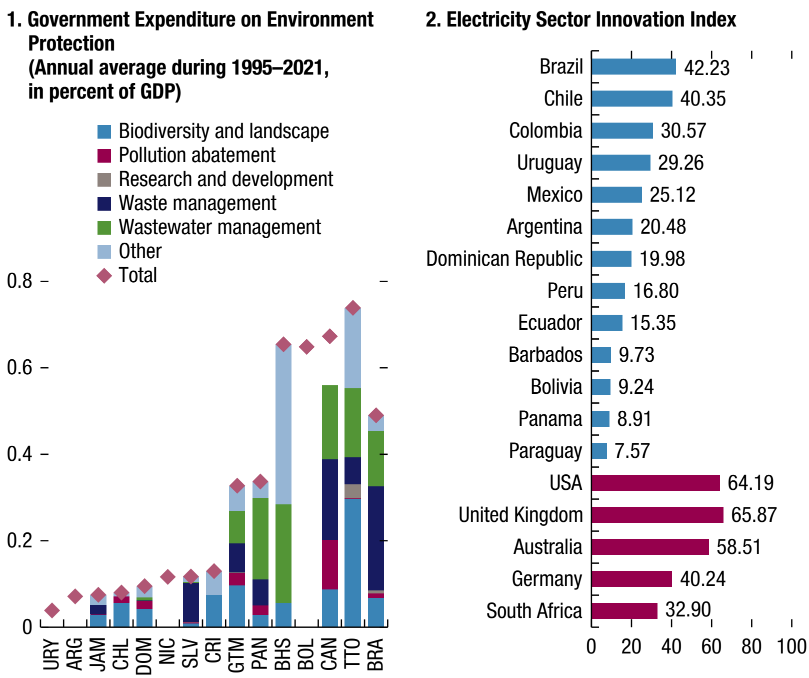
[2] Feed-in tariffs are long-term, guaranteed purchase agreements for green electricity at a price that can provide project developers a reasonable return on investment. Argentina, Brazil, and Ecuador had established feed-in tariffs, but they are no longer active either because their levels were set too low (Argentina) or official regulation to implement laws were lacking (Ecuador) or an adequate enabling environment was not in place (for example, lack of clarity on interconnection rules, lack of standard contracts for independent power projects; IRENA 2016).

ENABLING POLICIES FOR THE TRANSITION TOWARD RENEWABLES

At least 14 Latin American countries have established renewable-energy public funds, 10 countries have currency-hedging mechanisms, and 6 have guarantees to mitigate investment risks, according to IRENA (2016). Tax incentives for low-carbon industries, renewable energy, and research and development have also been used by several countries (Argentina, Barbados, Brazil, Chile, Colombia, Dominican Republic, Guyana, Panama, Peru, Saint Kitts and Nevis, Saint Lucia, and all countries in Central America). Some countries (Dominican Republic, Honduras, Nicaragua, Peru, and Uruguay) promote renewables through feed-in tariffs, which, if designed well, can mitigate investor risk in renewables. Research and development investment in clean technology has in general been very limited by international standards to support an innovative electricity sector, with LAC scoring low in Inter-American Development Bank's Electricity Sector Innovation Index (Figure 7.1).

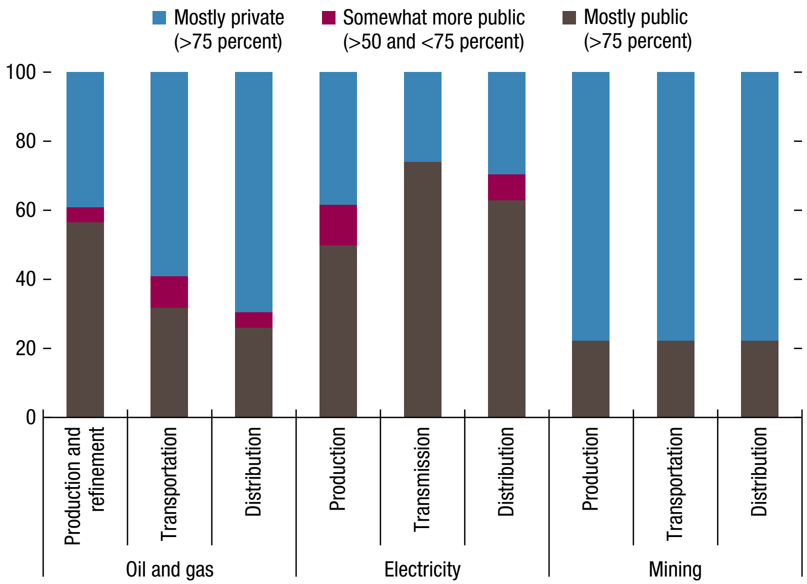
Nevertheless, the public sector in LAC countries continues to play a key role in the production of fossil fuels. In many LAC countries, the public sector is

Figure 7.1. Spending on Environmental Protection toward Mitigation Efforts



Sources: Energy Hub for LAC; IMF Government Finance Statistics; IMF Statistics Department Questionnaire; and IMF staff calculations.
Note: Figure uses International Organization for Standardization (ISO) country codes. The Electricity Sector Innovation Index integrates various levels of innovations in the electricity sector, including the adoption of innovative, renewable, and disruptive technologies.

Figure 7.2. Public and Private Ownership Structure in Fossil Fuel Industries in LAC
(Percent of total)



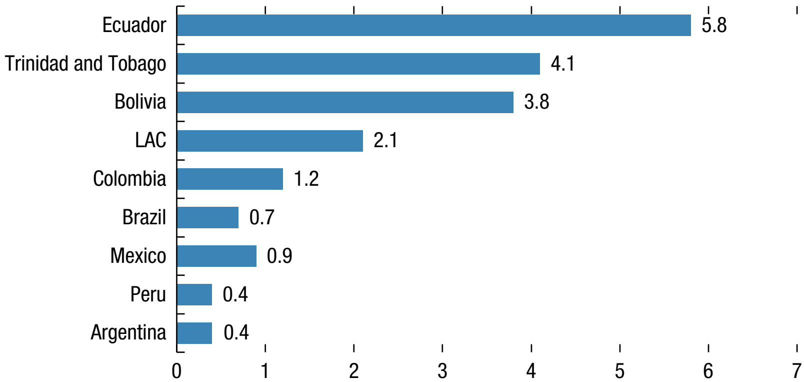
Source: IMF staff calculations based on desk survey responses.
Note: LAC = Latin America and the Caribbean.

holding a significant position (equity and debt) in the fossil fuel sector. SOEs dominate the production and refinement of gas and oil (Brazil, Mexico) as well as the transmission and distribution of electricity. By contrast, the mining sector is mostly privately owned (Figure 7.2). Fiscal revenues from oil and gas in LAC countries account for 2.1 percent of GDP on average. For Ecuador, Trinidad and Tobago, and Bolivia, the share is even larger at 4.6 percent of GDP on average, making these LAC countries dependent on the demand for fossil fuels with almost half of it being exported (Figure 7.3).

EXPANDING OIL AND GAS PRODUCTION

While many LAC governments increased their climate ambitions or set net-zero targets, oil and gas SOEs in the region are stepping up their production (United Nations Environment Programme production gap report 2021). Countries in the region are taking contrasting routes regarding fossil fuels. Many countries' investment plans for the next five years contrast with others' NDC targets, and major SOEs have not devised climate strategies to reduce emissions or developed plans to transition to greener technologies; at the same time, countries like Costa Rica are trying to forge an alliance to fix a date to phase out oil and gas and to stop issuing permits for new exploration. The Beyond Oil and Gas Alliance has eight members; Costa Rica is the only member from the region (Figure 7.4).

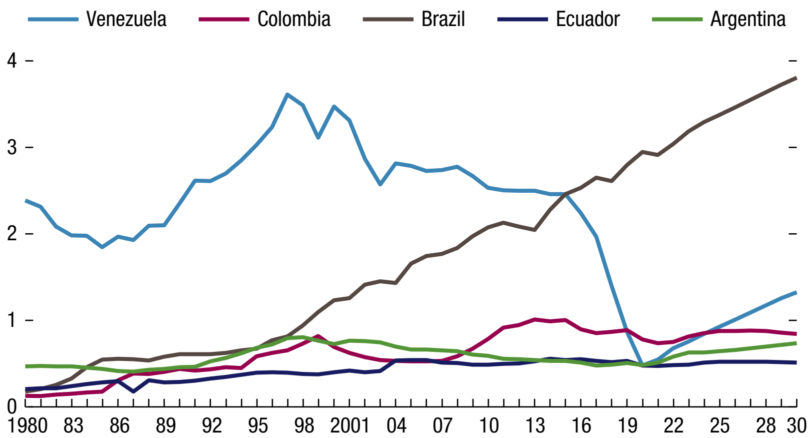
Figure 7.3. Government Revenues from Oil and Gas
(Percent of GDP)



Source: Revenue statistics in Latin America and the Caribbean 2022.
Note: Guatemala and Venezuela are excluded due to data availability issues. LAC = Latin America and the Caribbean.

In countries where the political pressure to reduce emissions is low, incentives to reduce investments in oil and gas do not align with climate ambitions. Fossil fuels serve as an important fiscal revenue source; in light of increasing oil prices, it is not surprising that some LAC countries are planning to continue or increase fossil fuel production. Worldwide fossil fuel production is expected to increase by 2 percent annually, resulting in double the amount that would be consistent with limiting warming to 1.5 degrees Celsius (UNEP 2021), thus illustrating the gap between climate change and fossil fuel production ambitions—most notably in the gas and

Figure 7.4. Oil Production and Forecasts
(Millions of barrels per day)



Sources: Datastream; and IMF staff calculations.

oil sector. Many oil companies in the region are setting climate strategies and sustainability plans that support decarbonization of their operations, but stronger efforts, with tangible actions, are needed to find a balanced approach. Stronger decarbonization efforts need to consider the climate change impact of these companies' projected oil and gas production increases by 2030. In this context, countries producing oil and gas should continue reducing direct emissions associated with these activities. Simultaneously, it is essential to ensure that state-backed investments in other energy infrastructure (for example, power plants) align with decarbonization commitments, thus contributing to the attainment of their NDCs.

Investments in fossil fuels, although once lucrative, are at risk of becoming stranded assets. For LAC countries to meet their emission commitments under the Paris Agreement, existing and planned fossil fuel power plants in the regions would have to be decommissioned and replaced by renewables before their end of life and existing fossil fuel reserves would need to remain unused. This would lead to stranded assets and losses for private and public asset owners. These losses may spill over to the financial sector, compromising financial and macroeconomic stability in countries that are nascently growing (Vogt-Schilb, Reyes-Tagle, and Edwards 2021).

DECLINING COSTS OF RENEWABLES

Costs for renewable energy have steadily declined in the past decade,[3] and renewable energy is becoming significantly cheaper than fossil fuels. The cost reductions are attributable to improved technologies, economies of scale, and an accumulation of knowledge in development and distribution via competitive supply chains (IRENA 2021). However, fossil fuel subsidies in the region are a barrier for a transition to net zero by keeping fossil fuel prices artificially low, thereby disincentivizing economies to decarbonize (Vogt-Schilb, Reyes-Tagle, and Edwards 2021). Reforming subsidies would allow governments in the region to improve their public finances, create fiscal space, and support the most affected households.

Some LAC countries could benefit from the shift to green technologies.[4] Copper, nickel, cobalt, and lithium are needed in low greenhouse–gas technologies, including renewable energies, electric cars, hydrogen and carbon capture and storage, which would benefit LAC metal producers (IMF 2021). Fiscal revenue losses resulting from the transition to renewables may be compensated by revenues from green metals in LAC countries that produce, export, or hold large reserves of these commodities (Table 7.1). Some LAC countries (such as Chile,

[3] For example, between 2010 and 2020, the cost for electricity from solar photovoltaics fell by 85 percent (IRENA 2021).

[4] The reference to green commodities exclusively reflects metals needed and used for the generation of energy from cleaner sources; it does not reference the cleanliness or the amount of emissions in their extraction process. For the purpose of this chapter, the following metals are considered green commodities: aluminum, lithium, copper, silver, molybdenum, nickel, graphite (natural), manganese, zinc, lead, cobalt, chromium, silicon, molybdenum, and vanadium.

TABLE 7.1.

Reserves of Green Commodities

(Countries with a share higher than 5 percent)

Reserves of	Country	Percent of Total Reserves
Lithium	Chile	35.7
	Argentina	10.4
Copper	Chile	21.5
	Peru	9.1
	Mexico	6.0
Silver	Peru	17.8
	Mexico	6.7
	Chile	4.7
Molybdenum	Peru	20.8
	Chile	12.2
Nickel	Brazil	15.7
Graphite (natural)	Brazil	22.9
Manganese	Brazil	15.7
Zinc	Mexico	5.8
	Peru	8.2
Lead	Peru	6.2
	Mexico	6.6
Cobalt	Cuba	6.5

Sources: United States Geological Survey Mineral Commodity Summaries 2023; and IMF staff calculations.

Note: Mineral reserves indicate a portion of mineral resources that can be used in economic activities. Resources (or potential reserves) in Latin American and the Caribbean are considerably higher than reserves in, and disproportionately more important for, countries such as Bolivia, Chile, and Argentina, which are situated in the lithium triangle.

Peru, Brazil, Mexico, Argentina) are already exporting green commodities such as copper, nickel, lithium, and cobalt, while others (Mexico) may benefit from discovered reserves of lithium (Table 7.2). However, given the private ownership in the mining sectors in LAC, an in-depth analysis on the country level would be required to assess the profit sharing and determine the potential for absorbing losses in fiscal revenues.

The demand and prices for metals feeding into low greenhouse–gas technologies are expected to increase. The identified metals for a clean energy transition are diverse (Table 7.3) and usually include copper and nickel as well as lithium and cobalt, which have gained popularity due to their use in batteries. According to the IMF (2021), the metals that will show a higher rise in demand for 2030—compared to the demand in 2010—are lithium, graphite, cobalt, vanadium, and nickel. It is estimated that their demand will increase by 25, 7.5, 6.5, 5.5, and 3.5 times, respectively. Other identified metals show an increase between 1 and 2 times. An increase is also expected in the prices of energy transition metals as global supply struggles to catch up with the demand. Some research finds that cobalt, lithium, and nickel prices could rise more than 100 percent compared with the 2020 levels and may peak around 2030 (IMF 2021). In contrast, the estimated increase in the demand for copper is not as steep.

LAC metal exporters would benefit from higher costs of energy-transition metals, but input costs would increase, and the transition would be delayed. The pressures for the metals' price rally will be higher for those metals with a

TABLE 7.2.

Exports of Green Commodities

(Annual average, 2016–22)

Exports of	Percent of GDP	Percent of Exports
Copper		
Chile	6.2	20.0
Peru	4.8	18.8
Ecuador	0.2	0.9
Mexico	0.2	0.4
Brazil	0.1	0.8
Argentina	0.1	0.6
Bolivia	0.0	0.2
Dominican Republic	0.0	0.1
Colombia	0.0	0.1
Nickel		
Guatemala	0.1	0.4
Brazil	0.0	0.0
Lithium		
Chile	0.1	0.2
Cobalt		
Brazil	0.0	0.0

Sources: UN Comtrade; and IMF staff calculations.

Note: Based on some levels of exports of the commodity, Colombia shows potential for lithium and nickel, Ecuador for cobalt and lithium, and Brazil and Panama for lithium.

significant gap between supply and demand. According to Valckx and others (2021), given the projected increase in metals consumption through 2050 under a net-zero scenario, current production rates of graphite, cobalt, vanadium, and nickel appear inadequate, showing a more than two-thirds gap versus the demand. Existing copper, lithium, and platinum supplies also seem inadequate to satisfy future needs, with a 30 to 40 percent gap versus demand (Table 7.3).

TABLE 7.3.

Identified Energy Transition Metals

	Energy Transition Usage				Estimated	Supply/
Metal	Renewable	Electricity Network	Battery	Hydrogen	Demand Increase	Demand Ratio
Copper	X	X	X		6.5	0.6
Aluminum	X	X	X	X	–	–
Nickel	X		X		3.5	**0.4**
Zinc	X				1.5	0.9
Lead	X		X	X	1.8	1.0
Silver	X				1.8	0.9
Manganese	X		X	X	1.2	1.0
Chromium	X				1.8	1.0
Silicon	X				1.8	0.9
Molybdenum	X			X	1.8	0.8
Cobalt			X		6.5	**0.2**
Lithium			X		25	0.6
Vanadium			X		5.5	**0.2**
Graphite			X		7.5	**0.2**

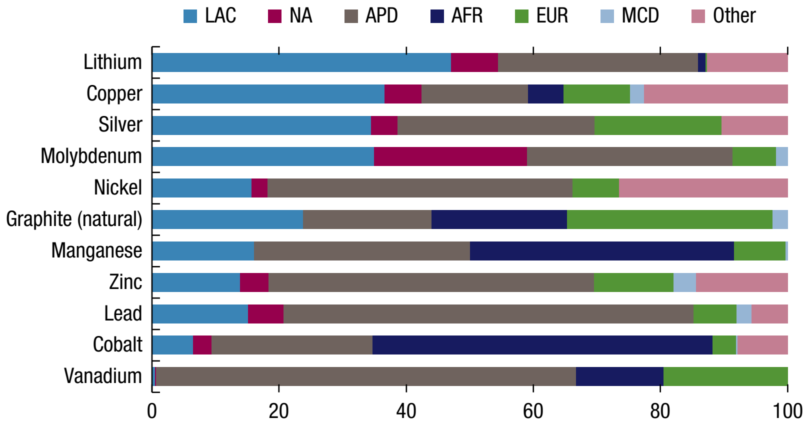
Sources: IMF 2021; Valckx and others (2021); and IMF staff calculations.

Latin American countries such as Chile, Peru, Brazil, and Mexico are already producing and exporting green commodities such as copper, nickel, lithium, and cobalt. These countries could see the benefits of the increase in prices translated into their public finances.

RESERVES AND RESOURCES IN THE SUPPLY SIDE

While global reserves[5] of graphite and vanadium would allow higher production via investments in extraction, reserve levels for other minerals, such as lithium, lead, zinc, silver, and silicon, may pose a constraint to global demand (Valckx and others 2021). Latin America is a prominent source of green commodities. The region holds the highest share of global reserves for lithium (47 percent), copper (37 percent), silver (34 percent), and molybdenum (35 percent). For other metals such as graphite and lead, LAC has the second-highest reserve share worldwide with 24 percent and 15 percent, respectively (Figure 7.5).

Figure 7.5. Reserves of Green Commodities by Region
(Percent of total reserves, by metal)



Sources: United States Geological Survey Mineral Commodity Summaries Report 2023; and IMF staff calculations.
Note: The United States Geological Survey Mineral Commodity Summaries Report 2023 highlights the 10 to 15 most relevant countries with reserves of a mineral. The aggregation considered this information. The aggregation "Other" captures the reserves of countries outside this "most relevant" country list. AFR = Africa (Congo, Ghana, Gabon, Madagascar, Mozambique, South Africa, Tanzania, Zimbabwe and Zambia); APD = Asia and Pacific (Australia, China, Indonesia, India, Korea, Philippines, Papua and Sri Lanka); EUR = Europe (Norway, Portugal, Poland, Russia, Sweden, Turkey, Ukraine); LAC = Latin America and the Caribbean (Argentina, Brazil, Bolivia, Chile, Mexico and Peru); MCD = Middle East and Central Asia (Armenia, Iran, Kazakhstan, Iana, Morocco and Uzbekistan); NA = North America (Canada and USA).

[5] Reserve is the portion of a mineral resource that can be extracted and used in economic activities.

In addition, investments in extraction technology and further exploration efforts could allow LAC countries to extract existing reserves and discover additional resources (or potential reserves)[6] of green metals and minerals. According to the United States Geological Survey (2023), the world's identified resources for lithium are about 86 million tons. The highest resources of lithium are Bolivia (21 million tons), Argentina (19.3 million tons), and Chile (9.6 million tons). Green investments will be essential for increasing the supply of metals feeding into low greenhouse–gas technologies and meeting future demands, which are expected to increase by up to 25 times by 2030 (IMF 2021; Valckx and others 2021).

A policy mix that balances carbon pricing with a green investment push to support the shift to cleaner energy and green technologies is likely to have positive long-run effects on activity and employment. Specifically, a public green investment push starting with 1 percent of GDP and declining over 10 years, combined with renewables production subsidies, a preannounced gradual increase in carbon taxes, compensatory transfers to households, and supportive macroeconomic policies, is estimated to increase employment by about 1 percent of the labor force in 10 years (IMF 2020). These newly created green jobs could potentially offset losses in income and jobs in carbon-intensive sectors, but much would depend on the labor intensity of such industries and the quality of those new jobs that are created.

Some LAC countries are already pushing green investments to initiate the transition to renewable energy sources.[7] An example of the impact of such an investment push is green hydrogen initiatives.[8] According to estimates by the hydrogen council and the International Energy Agency[9] the demand for green hydrogen is estimated to increase 4 times by 2030 and 22 times by 2050, with the highest demand increase coming from the transportation and industrial sector. Uruguay, for example, is working on its second energetic transformation, looking to create an ecosystem for green hydrogen that would rely on investment. A 2020 prefeasibility study, "Uruguay-Port of Rotterdam. Hydrogen Supply Chain (MIEMPoR)," estimated the investment needed in Uruguay according to various scenarios. The conservative scenario estimates investment needs at $6.5 billion by 2050; the medium scenario estimates $14 billion. The estimate for the more ambitious scenario is $50 billion. Chile is a step ahead, because it released its National Strategy for Green Hydrogen in September 2020. This strategy estimates the necessary investment for Chile by 2050 as $330 million (see Chapter 4).

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[6] Resource refers to minerals that have been identified, and whose extraction is potentially feasible.

[7] The IDB has supported many of these green investments, in particular regarding green hydrogen for Chile, Colombia, and Uruguay for instance. https://www.idbinvest.org/en/blog/energy/welcome-new-hydrogen-economy.

[8] Green commodities feed into the production and generation of green hydrogen (such as aluminum and lead).

[9] See "The Future of Hydrogen: Seizing Today's Opportunities" (International Energy Agency 2019).

Not all LAC countries will benefit from the boom in green metals, because reserves are concentrated in only a few. Chile, Peru, Brazil, and Mexico stand out for their diversified and high levels of reserves of green commodities in Latin America. Chile holds the highest share of reserves of lithium in the world with about 36 percent, and the highest share of reserves of copper with 21 percent, which adds to its current 30 percent market share as copper producer. Peru has the highest share of reserves of silver with around 18 percent (Table 7.1).

A key objective for governments is to maximize the net present value from extractive industries. The net present value refers to revenues from potentially substantial scarcity of rents, employment, and other macroeconomic benefits subtracting the cost of all negative impacts, including community disruptions, local environmental degradation, and climate change. Establishing secure property rights on exhaustive resources is essential for their efficient use. But just as critical is to find the balance of private and public rents that provides private investors with an adequate incentive to explore, develop, and produce while yielding an equitable return to the host country. Several fiscal regimes are available to implement the desired private and public distribution of rents and ensure efficient resource extraction (IMF 2012). In selecting and implementing fiscal mechanisms, authorities would benefit from (1) paying careful attention to costs and risks at all stages of production, beginning with exploration, including unsuccessful ones; (2) taking into account economy-wide benefits and costs, including employment effects in the affected sectors; (3) adding the cost of externalities and environmental considerations in the fiscal design (such as taxes or equivalent tools to account for potential environmental damage, local pollution, and climate change); and (4) assessing the optimal timing of receipts, weighing benefits from early access in countries with limited access to credit markets against the potential increase in perceived risks to investors. Finally, LAC governments have to strengthen their efforts to diversify—if possible—their production of green commodities. They also need to work with their peers in advanced economies to design model contracts that ensure a fair split of revenues, learn from successful cases that established sovereign-wealth funds to ensure intergenerational equity considerations of proceeds, and smoothen commodity export price volatility shocks while wisely managing the increase in wealth to avoid adverse economic consequences.

Government actions that are aligned with climate ambitions will be essential to mitigating risks and achieving an inclusive and just transition to cleaner energies and green technologies. To mitigate the risks of stranded assets and meet emission commitments, public sector investments in the fossil fuel industry will need to be discontinued and redirected to cleaner energy sources and green commodities' extraction technologies. Losses in government revenues in the fossil fuel industry could thereby be partially compensated through revenues from green commodities. Hence, governments will need to apply sound principles of good private–public engagement and profit sharing to ensure that the public extracts the gains from the expected green boom. In addition, governments need to provide guidance and increase investment in green infrastructure.

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CHAPTER 8

Climate Policies in Action: Case Studies for Chile, Costa Rica, and Honduras

Nan Geng, Diane C. Kostroch, Dmitry Vasilyev, and Tessy Vasquez-Baos

Many countries in Latin America and the Caribbean (LAC) have adopted climate strategies, but few are comprehensive. Most LAC countries[1] have taken first steps toward formulating national climate change strategies by devising climate change action plans for specific sectors[2] (for example, forest, energy, agriculture, or water) or national action plans to address adaptation challenges (predominately in the Caribbean).[3] However, national climate strategies that tackle both mitigation and adaptation challenges as well as include action plans to address social repercussions are few. Chile and Costa Rica[4] have already adopted comprehensive national strategies, while Honduras could work on further strengthening some aspects of its climate strategy. Successful strategies consider the likely macroeconomic implications of climate change and climate mitigation policies, including financial stability implications. They also identify financing sources and strive to achieve broader social goals.

CHILE'S CLIMATE STRATEGY

Chile contributes little to global emissions but is sensitive to transition risks arising from global efforts to reduce emissions. Chile's contribution to net greenhouse gas (GHG) emissions and non-CO_2 emissions account for 0.1 and 0.2 percent of global emissions, respectively. Moreover, Chile's per capita

[1] Includes Antigua and Barbuda, Barbados, Colombia, the Dominican Republic, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Peru, Paraguay, St. Lucia, and Trinidad and Tobago (World Bank 2023).

[2] Includes Argentina, Barbados, Bahamas, Belize, El Salvador, Guyana, and Guatemala (World Bank 2023).

[3] Includes Barbados, Bahamas, Belize, Dominica, the Dominican Republic, Grenada, Guyana, Haiti, Jamaica, Panama, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines (World Bank 2023).

[4] In 2012, Ecuador established its National Climate Change Strategy 2012–25, which aims to build capacity and provide the basis for national mitigation and adaptation climate change plans for priority sectors. Work is undertaken toward a National Climate Change Plan that streamlines sectoral agendas (World Bank 2023).

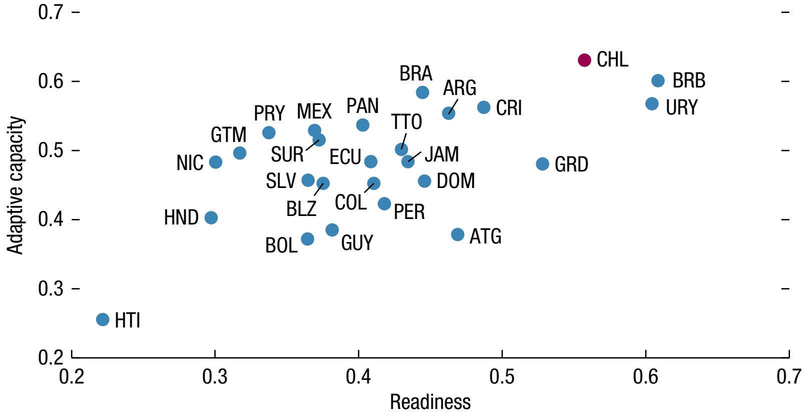
emissions of GHG and CO_2 are below the average in LAC, and the country is one of the lowest emitters in the region. Chile's energy sector is the main contributor to GHG emissions, accounting for about 75 percent of total emissions, with 30 percent of its energy supplied by renewables. The land use, land-use change, and forestry sector plays a critical role for Chile because it serves as a carbon sink and reduces Chile's total emissions.

Chile's vulnerability to climate change–related risks is likely to increase with rising temperatures, sea levels, and more intense and frequent extreme weather events. Chile is a country with contrasting ecosystems, from the world's driest desert to the ice fields of Patagonia, which means that Chile faces a multitude of threats. Unprecedented drought conditions have persisted for years, leading to water scarcity in the Central Valley. Higher temperatures and heatwaves across the country have led to forest fires across several regions. At the same time, average rainfall has increased in the southernmost Austral region and the far north. These events have devastated crops, damaged coastal infrastructure, caused coastal erosion, and affected marine ecosystems (Harris, Muller, and Woods 2019). Rising temperatures and sea levels will increase Chile's exposure to more frequent and severe disasters such as floods, droughts, and hurricanes (Intergovernmental Panel on Climate Change 2021).

Chile has a high adaptive capacity to face climate change effects (Figure 8.1). Several policies dating to the 1990s allowed Chile to develop a high adaptive capacity. The legal framework that serves as the foundation for Chile's response to climate change relies on the Convention on Climate Change and the Kyoto Protocol, ratified in 1994 and 2005, respectively. To fulfill its mandates, in 1996, the government of Chile created the National Steering Committee on Global Change. In 1998, the committee formulated strategic guidelines for Climate Change for Chile, and in January 2006, it approved the creation of the National Climate Change strategy. The strategy included three main focal areas: adaptation, mitigation, and the creation and promotion of national capacities. The National Climate Change strategy was followed by the National Climate Change Action Plan 2008–12. In 2010, Chile created the Ministry of Environment and the Climate Change Office. This ministry has the authority to propose policies and formulate plans, programs, and activities on climate change.

In 2016, Chile adopted its National Strategy of Climate Change and Vegetation Resources 2017–25 to address mitigation and adaptation challenges. The strategy included three phases to take stock of the country's main climate change challenges: build capacity at the national level, develop and implement measures to tackle the former, and identify financing for successful emissions reductions. Again, it was accompanied by Chile's National Climate Change Action Plan 2017–22 (Chile Ministry of the Environment 2017). The newest action plan included more data-driven scenario analysis and higher political support. To design the National Climate Change Action Plan, a committee for public policies was created, integrating relevant ministries (such as the Ministries of Agriculture, Finance, Health, Economy, Development and Tourism, among others) and led by the Ministry of the Environment. Similarly,

Figure 8.1. Readiness and Adaptive Capacity in Latin America and the Caribbean
(Index)

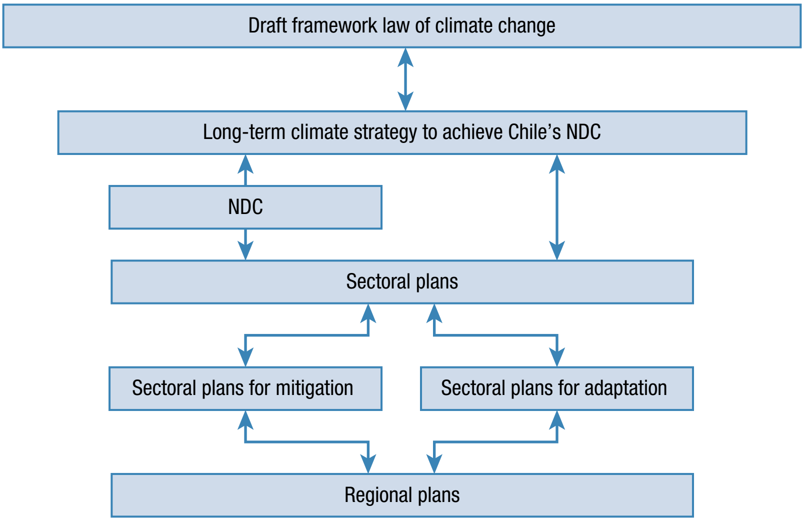


Sources: IMF-adapted Notre Dame Global Adaptation Initiative (ND-GAIN); and IMF staff calculations.
Note: The IMF-adapted ND-GAIN index is an adaptation of the original index, adjusted by IMF staff to replace the Doing Business Index, used as source data in the original ND-GAIN. The ND-GAIN assesses the adaptive capacity of a country to cope with or adapt to climate change impacts. Raw data are scaled to a range from zero to one, and the arithmetic average is used to construct each measure. Readiness is measured by considering a country's ability to leverage investments to adaptation actions through three components: economic readiness (measured by a Doing Business indicator from the World Bank), governance readiness (measured by the arithmetic average of four indicators from Worldwide Governance Indicators, some of which are perception-based measures and subject to large confidence intervals), and social readiness (measured by the arithmetic average of four indicators from various sources). For details, see the ND-GAIN data technical document. Figure uses International Organization for Standardization (ISO) country codes.

to lead the work on the private side, the Chilean Agency for Sustainability and Climate Change was created in 2016.

Chile is also well positioned to embrace the green transition because of its natural endowment of metals needed in the energy transition. Copper and lithium are needed in low-GHG technologies, including renewable energies, electric cars, hydrogen, and carbon capture and storage. Chile is already exporting green commodities such as lithium and copper (Table 7.2). The demand and prices for metals feeding into low-GHG technologies are expected to increase, with lithium potentially showing a 25 times higher demand in 2030 compared to 2010 (IMF 2021). An increase is also expected in the prices of energy transition metals as global supply struggles to catch up with the demand. Some research finds that cobalt, lithium, and nickel prices could rise more than 100 percent compared to the 2020 levels and may peak around 2030 (IMF 2021). In contrast, the estimated increase in the demand for copper is not as steep. Chile could see the benefits of the increase in prices translated into their public finances. However, given the mainly private ownership structure in the mining sectors in Chile, an in-depth analysis would be required to assess the profit sharing.

Figure 8.2. Climate Change Framework in Chile



Sources: Chile's Ministry of the Environment; and IMF staff.
Note: NDC = nationally determined contributions.

A push for green investments in Chile will help reap the benefits from existing reserves and will also expand reserves to meet future demands. For example, investments in extraction technology and further exploration efforts could allow Chile to extract existing reserves and to discover additional reserves of green metals and minerals. According to the United States Geological Survey (2023), the world's identified resources for lithium are around 86 million tons. Chile is one of the countries with the highest resources of lithium at 9.6 million tons (next to Argentina and Bolivia).

Chile updated its commitments to its nationally determined contributions and issued a Long-Term Climate Strategy (ECLP in Spanish) in 2020. Chile upgraded its strategy[5] with an important drive toward decarbonization and the development of hydrogen alternatives. Chile also developed a legal framework for climate change. In January 2020, the Ministry of the Environment presented to congress the legal framework for climate change, which establishes that by 2050, Chile will reach carbon neutrality. The ECLP is the main policy instrument of this legal initiative, and it provides integrated sectoral guidelines over a 30-year period. The draft legal framework of climate change is the umbrella under which all climate-related policies are integrated (Figure 8.1).

[5] In 2016, the Organisation for Economic Co-operation and Development's evaluation of Chile's climate recommended identifying the long-term trajectory and goal of zero emissions by the second half of 2050.

TABLE 8.1.

Countries in Latin American and the Caribbean with Long-Term Strategies

Country	Date of Submission
Costa Rica	Dec. 2019
Guatemala	Jul. 2021
Colombia	Nov. 2021
Chile	Nov. 2021
Uruguay	Dec. 2021
Argentina	Nov. 2022

Sources: Chile's Ministry of the Environment; and IMF staff.

Chile's climate strategy is accompanied by a financial strategy for climate change and a national green hydrogen strategy. By the end of 2020, Chile issued its First National Financial Strategy for climate change, the first Sovereign Green Bond, and the national green hydrogen strategy. Chile's Ministry of Finance cochaired the Coalition of Finance Ministers for Climate Action. It supported the development of both tools to channel investment toward green assets and to support the country's pathways toward sustainable development with low carbon emission and strong resilience to climate change. The Ministry of Energy led the transition to greener energy sources by releasing the National Strategy for Green Hydrogen in November 2020. The strategy estimates a $330 million investment need for Chile by 2050 to green its energy sector.

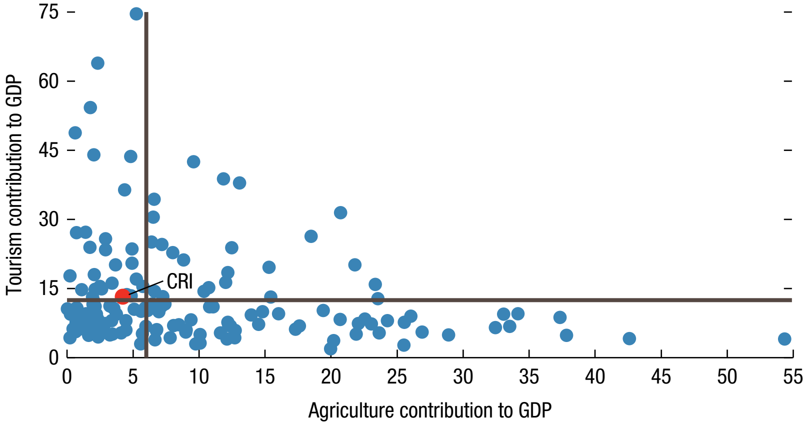
Chile presented its 2050 ECLP during the United Nation's 26th Climate Change Conference (COP26). The ECLP guides Chile's long-term climate framework with medium-term sectoral goals to achieve implementation of its nationally determined contributions. It includes a national and sectoral budget and 400 measures to decarbonize Chile's economy. Targets for the energy sector aim at increasing the share of renewables from 30 to 80 percent by 2030. Other sectoral targets focus on reducing emissions from industry and mining activities by 70 percent by 2050. The presentation of the ECLP aligns with the Paris Accords, Article 4.19, which calls on parties to formulate and communicate long-term strategies. By the end of 2023, 50 countries submitted long-term strategies, including 6 LAC countries. Costa Rica was the first country to present a long-term plan in 2019 (Table 8.1).

COSTA RICA'S EXPERIENCE WITH CLIMATE CHANGE AND POLICY RESPONSE

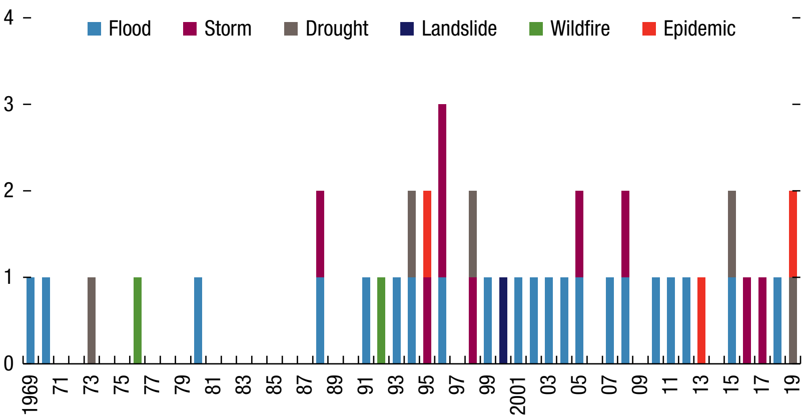
A combination of geographic and economic factors leave Costa Rica highly exposed to climate change risks (Figure 8.3). The country has great geographic variation and is located between two oceans, and almost 80 percent of its population resides in areas at high risk of natural hazards, including floods, landslides, cyclones, and sea-level rise. This geographic exposure is compounded by the economy's significant dependence on climate-sensitive sectors, especially tourism and agriculture, which also suffer from other climate change events, including

Figure 8.3. Costa Rica's Main Climate Risk Indicators

1. GDP Contribution of Climate-Sensitive Sectors
(Percent)



2. Historical Natural Disasters
(Number of occurrences)



Sources: Emergency Events Database; World Development Indicators; and IMF staff estimates.
Note: Lines in panel 1 represent world medians. See the Emergency Events Database for the classification of natural disasters. CRI = Costa Rica.

higher temperatures, droughts, coastal erosion, and loss of biodiversity. The United Nations Intergovernmental Panel on Climate Change (IPCC) identified Costa Rica as a primary hot spot for climate change in the tropics given the high and more frequent occurrence of climate-related natural disasters, such as floods and tropical storms, over the past decades. As of 2018, Costa Rica ranked 82nd of 193 countries exposed to climate change risks, according to the Notre Dame Global Adaptation Initiative (ND-GAIN).

High climate change exposure translates into significant socioeconomic costs. According to the Emergency Events Database, from 1969 to 2019, natural disasters, especially floods, droughts, and storms, took a significant toll on Costa Rica's population and economy, with annual losses from these events averaging 0.4 percent of GDP and the total number of people affected reaching about 35,000 per year, on average. In a 2017 report, the Office of the Comptroller General warned about the impact of climate-induced extreme events on public finances. The estimated annual costs due to hydrometeorological and climate-induced events amounted to 0.3 to 1.7 percent of GDP from 1988 to 2010 and could reach up to 2.5 percent of GDP by 2025. Going forward, estimates based on an integrated assessment model[6] for Costa Rica suggest that global warming of +3°C, which is within the expected median global warming of 2.6°C to 3.1°C by 2100 considering current pledges globally, could reduce Costa Rica's GDP by more than 6 percent compared with a growth path with no effects from climate change. This decrease would result primarily from loss of tourism, heat effects on labor productivity, and agriculture.

Despite having high exposure to climate change risks, Costa Rica is among the countries with the lowest vulnerability because of its relatively high adaptive capacity in the region. Costa Rica's relatively high adaptive capacity reflects its universal health care system and widespread access to water, electricity, and sanitation as well as its economic, institutional, and social readiness to leverage investments toward adaptation actions. According to ND-GAIN, Costa Rica is the region's 52nd least vulnerable country and one of the most resilient to climate change impacts.

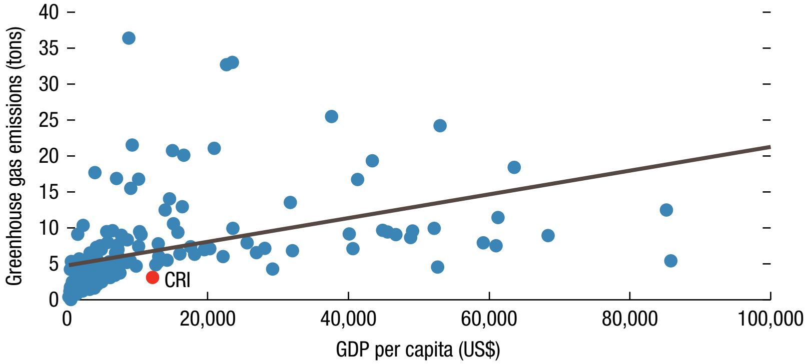
Building on past efforts, Costa Rica has continuously facilitated climate change adaptation and strengthened disaster risk management. The National Adaptation Policy 2018–30 and the Institutional Strategic Plan 2018–22 aim to improve resilience in key areas, including infrastructure, tourism, and water resources management. In this context, the authorities are developing a road map to strengthen infrastructure resilience to climate change, while considering implementation costs, financing options, and disaster risk management jointly with the World Bank. In the agricultural sector, Costa Rica launched an insurance scheme that enhances financial resilience and promotes adaptation by allowing agricultural producers to insure their harvest against climate change risks, with lower premiums for producers who implement adaptation measures. In addition, the authorities are collaborating with the World Bank to strengthen adaptation by increasing forest biomass to enhance resilience to tropical storms. Opportunities to further enhance disaster risk management arise from the possibility to strengthen financial risk protection, disaster recovery planning, and risk identification (Lacambra and others 2015).

Costa Rica has one of the lowest rates of GHG emissions in the region, reflecting great successes with its environmentally friendly growth model and pioneering mitigation efforts (Figure 8.4). At about 3 tons per capita in 2020, Costa Rica's

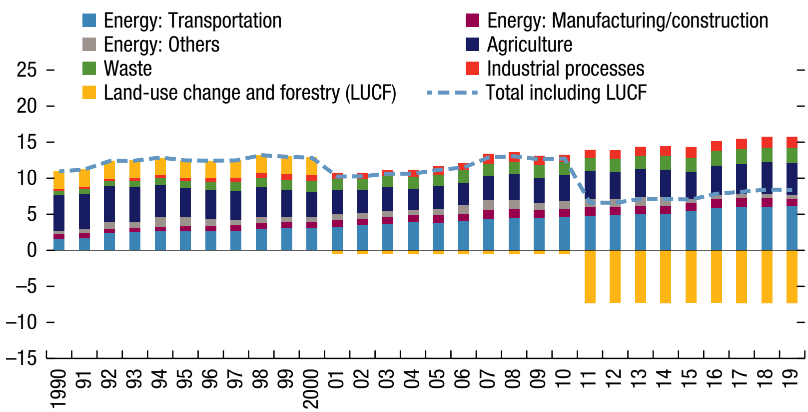
[6] The model includes an economic module and a climate module with feedback on the economic model through damage functions via different channels. For more details, see Roson and van der Mensbrugghe (2012).

Figure 8.4. Costa Rica's Main Climate Risk Indicators

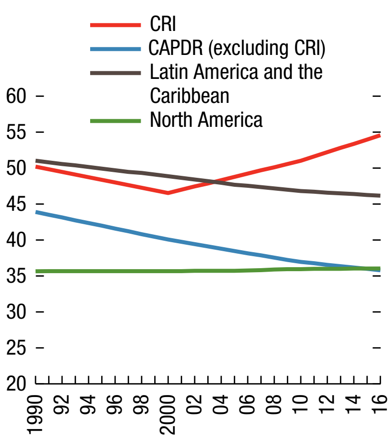
1. Greenhouse Gas Emissions per Capita and GDP, 2020



2. Sector Breakdown of Total Greenhouse Gas Emissions
(In metric tons of CO_2 equivalence)



3. Forest Area
(Percentage of land area)



4. Electricity Matrix, 2019

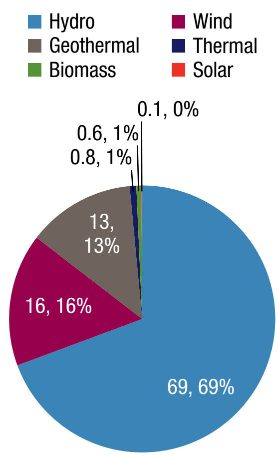
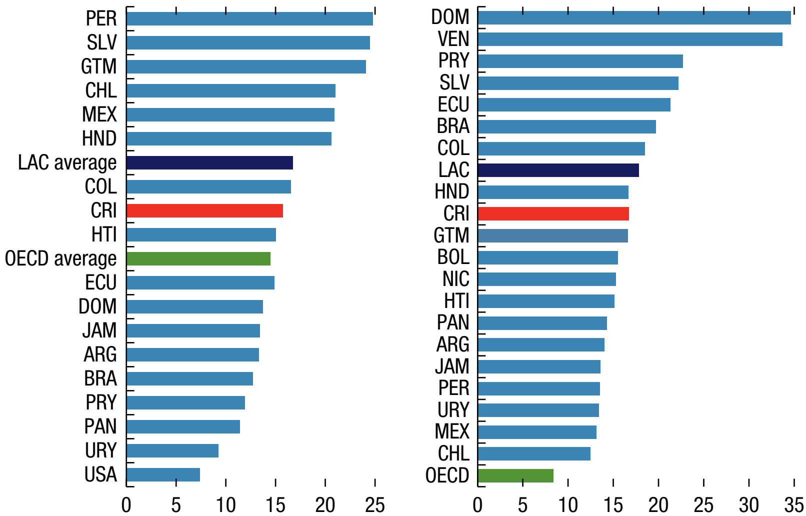


Figure 8.4. ***(continued)***

5. Average Level of Exposure to Air Pollution, 2017 (Micrograms per cubic meter)

6. Mortality Caused by Road Traffic Injury, 2016 (Per 1,000,000 people)



Sources: Climate Watch; Climate Analysis Indicators Tool (CAIT); European Commission; Food and Agriculture Organization, Sistema Eléctrico Nacional; World Development Indicators; and IMF staff estimates.
Note: Figure uses International Organization for Standardization (ISO) country codes. CAPDR = Central America, Panama, and Dominican Republic; LAC = Latin America and the Caribbean; OECD = Organisation for Economic Co-operation and Development.

annual net GHG emissions are low in the region and as compared with countries with a similar development level worldwide. The current level of net emissions is only about two-thirds of that a decade ago because the improvements in land-use change and forestry are now capturing about half of the country's GHGs. Importantly, climate change policy has been put at the center of the country's development model, which integrates sectoral plans and cross-cutting policies to align the decarbonization commitment with development goals and the objective of generating new jobs. Costa Rica's innovative payment for ecosystem services (PES) program—which was introduced after the first Earth Summit in 1992 to promote (in conjunction with land use regulations) conservation of environmentally valuable forestland—has served as a model for similar programs in other countries (for example, Mexico, Ecuador). This was followed by a complementary program to strengthen protection of biodiversity (the first of its kind in the world). As a result, Costa Rica became the first tropical country to have reversed deforestation, with more than half of its landmass now covered by forest, whereas forest coverage has been constant or declining steadily in most other countries. Meanwhile, significant growth has occurred in sectors such as sustainable tourism and hydropower generation, whereby almost 100 percent of the country's electricity stems from renewable sources.

Nonetheless, GHG emissions have been rising, driven by emissions from the transport sector, which almost quadrupled between 1990 and 2019 and are now responsible for about 40 and 70 percent of the country's gross and net GHG emissions, respectively (Figure 8.4). Higher emissions can be attributed to the increased use of diesel and gasoline due to a large increase in the vehicle fleet, especially private vehicles, with an average age of 15 years. Besides GHG emissions, such use also led to more road congestion, air pollution, and traffic accidents.

Building on previous achievements, Costa Rica's efforts to tackle the remaining challenge and decarbonize its economy by 2050 make it a trailblazer in the global arena. In 2019, Costa Rica received the United Nations flagship environmental award, "Champion of the Earth," for its leadership in natural resource conservation and in combating climate change with its ambitious National Decarbonization Plan 2018–50. The plan outlines steps to transition to a zero net emission economy over the next three decades, in line with the Paris Agreement, and is structured along 10 lines of actions and 8 cross-cutting strategies in the economic areas with the highest GHG emissions in the country. It provides detailed short-, medium-, and long-term targets (Table 8.3). In addition, the national decarbonization strategy creates synergies with the Strategic Plan Costa Rica 2050 and the Territorial Economic Strategy for an Inclusive and Decarbonized Economy 2020–50, which together, as a key part of the current IMF-supported program, envisage a deep transformation toward a more competitive, equitable, and green economy. Several multilateral institutions support Costa Rica in the implementation of its ambitious decarbonization strategy, including the Development Bank of Latin America, the Inter-American Development Bank, and the World Bank.

Decarbonization presents great economic opportunity, despite high upfront costs (Figure 8.5). Implementation of the National Decarbonization Plan requires large upfront investments, especially in infrastructure. A recent cost-benefit evaluation of the plan by the Inter-American Development Bank considers 3,000 potential scenarios and consistently finds net economic benefits, amounting to $40.9 billion over 2020–50 (Groves and others 2020).[7] For the transport sector alone—which constitutes 3 of the 10 lines of action under the plan—estimated financial net benefits over 2020–50 amount to $2.9 billion and to $20.6 billion when positive effects in terms of reduced congestion, accidents, and local air pollution are considered (Godinez and others 2020). Similarly, a recent assessment by the World Bank—based on an integrated model covering the energy, land (agriculture, forestry, and other

[7] The estimated costs and benefits are discounted back to 2015 at an annual rate of 5 percent. If net benefits were discounted back to 2020, they would amount to $54.7 billion. In addition, the preferred scenario assumes a high and increasing level of decarbonization of forests over time. Thus, if forest decarbonization levels were to be lower than expected, net benefits would be lower.

TABLE 8.2.

Key Targets of Costa Rica's National Decarbonization Plan

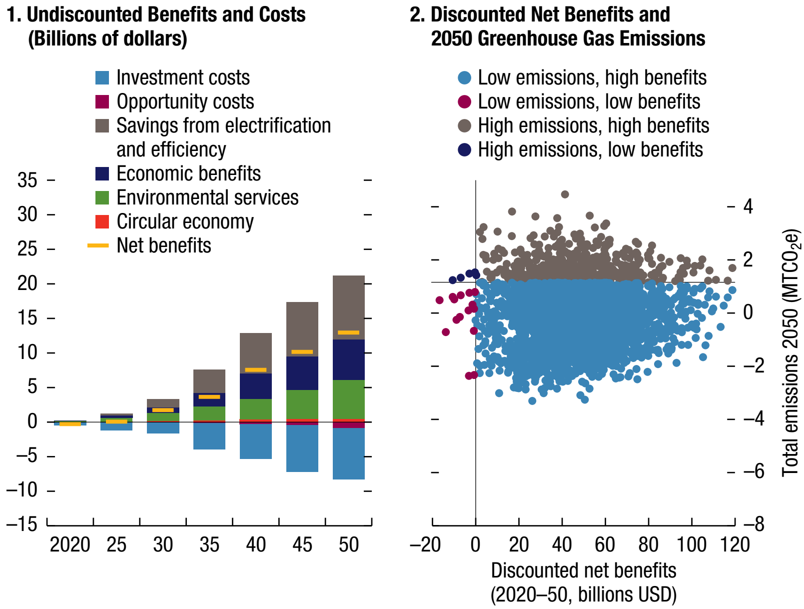
Line of Action	2022	2025	2030	2035	2050
Public transport	• 8 main trunk lines in operation • At least one public transport mode operates with a system of integrated electronic payment			• 30% of public transport is zero emissions	• 85% of public transport is to be zero emissions. • Public transport replaces private vehicles as principal mobility option
Private transport	• Operate at least 69 fast recharge centers	• Stabilize growth of motorcycle fleet		• 30% of vehicle fleet is electric	• 95% of vehicle fleet is zero emissions • There is an extensive network of electric charging and hydrogen fueling stations
Cargo transport	• At least one logistics pilot project operates under low-emission parameters		• 20% of cargo fleet operates with liquified petroleum gas	• Adopt sustainable logistics models in principal ports and urban areas	• Cargo transport reduces emissions by 20% compared to 2018
Electric energy	• Develop 2 sectoral electrification strategies • Develop plan to promote investment in the electricity system		• National electricity mix 100% renewable		• Electricity is primary energy source for transport, residential, commercial, and industrial sectors
Construction		• 10% increase in use of wood, bamboos, and other local materials in construction of buildings	• 100% of new buildings comply with emission standards and are climate resilient		• 50% of residential, commercial, and institutional buildings comply with emission standards
Industry	• Publish 2 road maps for the reduction of emissions		• Develop cradle-to-grave strategy, encompassing production, distribution, and disposal of products for industrial sector		• Industrial sector consumes low-emission energy

TABLE 8.2. Continued

Line of Action	2022	2025	2030	2035	2050
Waste management	• Launch national composting strategy • Implement 4 pilot projects on a circular economy	• 10 municipalities implement national composting strategy			• Waste collection, recycling, reutilization, and disposal available for entire country • Restore 20% of rivers in greater metropolitan area
Crop cultivation	• Implement 2 programs to reduce emissions • Offer 2 financial instruments to facilitate the transformation of producers		• Value chains for coffee, livestock, sugarcane, rice, and bananas use emission-reducing technologies		• National production adopts advanced, low-emission technology
Livestock	• Launch education campaign • Implement pilot for utilization of agricultural residuals in the industrial sector		• Adopt low-emission technologies for 70% of livestock and 60% of areas dedicated to livestock		• National production adopts advanced, low-emission technology
Biodiversity and ecosystems	• Restore at least 3 km of urban corridors • Implement programs to prevent illegal deforestation		• Increase national forest coverage to 60%		• 4,500 hectares of green areas function as recreational parks in the greater metropolitan area

Source: National Decarbonization Plan, Ministerio de Ambiente y Energía (https://unfccc.int/documents/204474).
Note: Table 8.2 provides an overview of the key targets. More detailed information is available from the full National Decarbonization Plan.

Figure 8.5. Benefits of Decarbonization and 2050 Greenhouse Gas Emissions under Possible Future Scenarios in Costa Rica



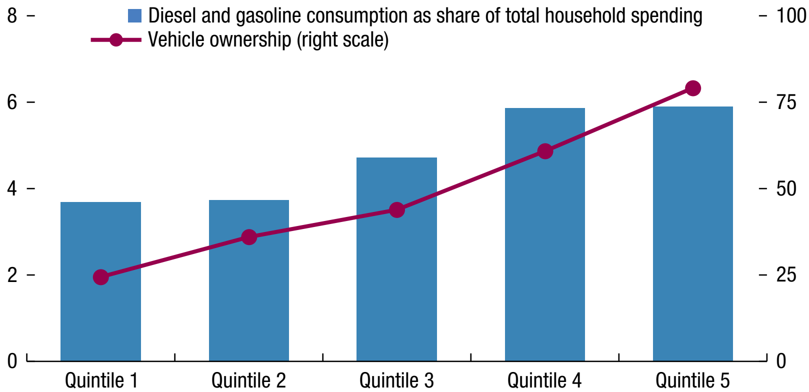
Sources: Groves and others (2020); and IMF staff estimates.
Note: $MTCO_2e$ = metric tons of carbon dioxide equivalent.

land use), and water sectors—concludes the decarbonization target is achievable and would generate even larger cumulative net economic benefits of $54.5 billion over 2020–50.[8] Likewise, decarbonizing the agriculture, livestock, and forestry sectors would result in larger yields and an increase in ecosystem services provided by forests, such as renewable forest products, water and soil benefits, and support for tourism and cultural heritage, with estimated net benefits of $21.9 billion.

The authorities plan to strengthen price incentives to support their decarbonization pledge through green taxation, accompanied by compensatory measures to minimize the impact on the poor. As part of the efforts to strengthen price incentives, the authorities plan to develop a revenue-neutral feebate scheme to promote low-emission vehicles. The scheme comprises a sliding scale of fees to vehicles with above-average emission rates and a sliding scale of rebates to light-duty private passenger vehicles with below-average emission rates levied at the time of purchase or import of new or used vehicles that are up to 5 years old.

[8] When uncertainty is factored in, using robust decision making, the current findings at the sectoral level show positive net economic benefits in the agriculture, forestry, and other land use sector, for most scenarios in the energy sector, and net costs under several scenarios in the water sector because of the cost associated with an increase in wastewater disposal infrastructure.

Figure 8.6. Costa Rica's Household Fossil Fuel Spending and Vehicle Ownership by Income Quintile
(Percentage)



Sources: National survey of household income and expenditure 2018 (ENIGH); and IMF staff calculations.
Note: Left scale represents the percentage of household expenditure allocated to diesel and gasoline consumption. Right scale represents the share of households owning a car.

These measures will aim to ensure the least impact on the lowest quintiles of the population, given that vehicle ownership is skewed toward higher-income groups (Figure 8.6). The authorities are also working to provide adequate infrastructure to service an increasing electric transportation fleet. Other efforts to strengthen price incentives include updating and expanding the current PES scheme to support PES beyond carbon sequestration and, in indigenous areas, to support more types of carbon sequestration. These efforts will also improve inclusion through social protection for historically excluded Indigenous people and rural women and will be financed by the Green Climate Fund awarded to Costa Rica by United Nations Development Programme in recognition of the capture of CO_2 with the country's reforestation.

Although not in their current plan, the authorities will evaluate progress and explore over the medium term the need to complement these measures with other environmental taxes, for example, higher taxation on diesel and gasoline. The authorities are incorporating fiscal risks from the climate transition, with a focus on revenue losses and contingent liabilities from decarbonizing transport. Environmental taxes could help compensate for the potential loss and better reflect efficient prices that consider the full range of environmental costs (such as global warming, local pollution, congestion, accidents).[9] Higher fossil fuel taxes

[9] Rodriguez Zúñiga and others (2020). *Evaluación del Impacto Fiscal de Descarbonizar el Sector Transporte en Costa Rica y Opciones de Política Para Manejarlo—reporte interino (mimeo)*. Inter-American Development Bank. Fossil fuel taxes are considered more direct and cost-effective to launch in Costa Rica than carbon taxes, given that Costa Rica has 100 percent clean electricity and little use of coal and natural gas, with most emissions from oil products.

are moderately progressive in Costa Rica, given that 93 percent of the total burden is borne by the top four income quintiles, and using a small portion of revenue gains for a targeted assistance can mitigate the impact on low-income households, including the indirect burden from generally higher consumer prices.

Costa Rica has also started integrating climate change considerations into other policy areas—highlighting the holistic nature of its climate change policy. To ensure that trade policy supports the country's decarbonization goals, Costa Rica is currently negotiating an Agreement on Climate Change, Trade and Sustainability with Fiji, Iceland, New Zealand, Norway, and Switzerland. The agreement's key areas cover market access for environmental goods and services, commitments to eliminate harmful fossil fuel subsidies, and the development of guidelines to inform the implementation of voluntary eco-labeling programs and mechanisms.

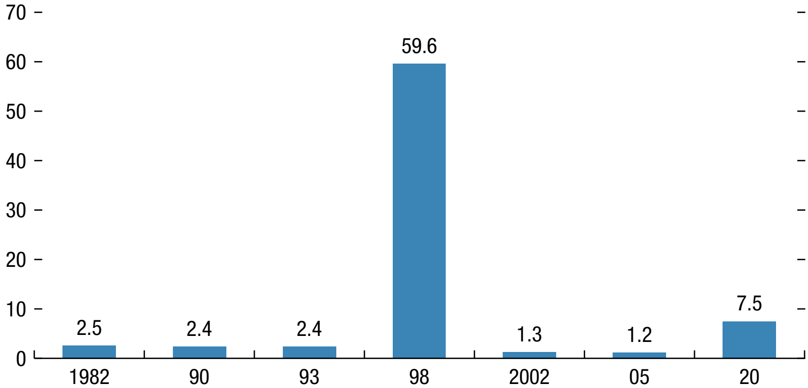
Costa Rica is also taking steps to green its financial sector. Having tapped the green bond market for the first time to finance climate-friendly infrastructure projects, the authorities plan to build greater recognition as an environmental, social, and governance (ESG) sovereign. Importantly, the ambitious fiscal reform program has compressed spreads and public investment reforms, including to incorporate more climate considerations, and improve project quality and execution. These efforts should facilitate increased private financing. Moreover, in 2019, the Central Bank of Costa Rica joined the Network for Greening the Financial System, which brings together a group of central banks and supervisors aimed at managing environmental and climate risk in the financial sector. Consistent with its roadmap to integrate climate change, the Central Bank of Costa Rica is strengthening the "greenness" of its reserve holdings, building a data repository to outline the effects of climate hazards on banks' lending exposures, incorporating climate effects in stress tests, while the National Supervisory Board of the Financial System (CONASSIF) will require socioenvironmental and climate change risks to be incorporated into banks' assessments of credit portfolios.

Costa Rica became the first country to have an arrangement under the Resilience and Sustainability Facility (RSF) in November 2022. The arrangement provides budget support on favorable terms and supporting many of the reforms detailed above.

ENHANCING HONDURAS' RESILIENCE TO CLIMATE CHANGE AND NATURAL DISASTERS

Honduras is highly exposed to global warming and weather-related disasters. By 2100, climate change is expected to reduce GDP per capita by 88 percent relative to the scenario without climate change (Burke, Hsiang, and Miguel 2015). Between 1982 and 2020, average annual loss from droughts, hurricanes, and flooding reached 2.3 percent of GDP (Figure 8.7). The most significant event was Hurricane Mitch in 1998, which killed 14,600 people and inflicted economic losses of about 60 percent of GDP. Honduras is at high risk of major natural disasters, together with 17 LAC countries (IMF 2019), and climate change is likely to intensify

Figure 8.7. Average Annual Loss from Droughts, Hurricanes, and Flooding in Honduras
(Percentage of GDP)



Sources: Emergency Events Database; United Nations Economic Commission for Latin America and the Caribbean; and IMF staff estimates.
Note: The figure only considers years in which disasters resulted in total damages above 1 percent of GDP.

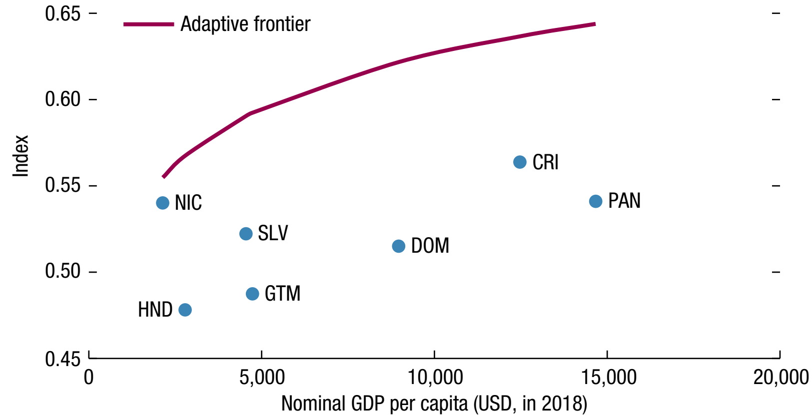
weather events. The adaptive capacity index shows that Honduras, like most other countries in the Central America, Panama, and Dominican Republic region, is far from the adaptive capacity frontier (Figure 8.8). This index is measured as a weighted combination of economic, infrastructural, technological, and institutional capacity and awareness of climate change.

To strengthen resilience to global warming, Honduras has identified the following priority areas: (1) agriculture and food security; (2) forest, marine coastal life, and biodiversity; and (3) human well-being. As part of the National Plans of Adaptation (2018), Honduras is committed to protecting biodiversity and food security through better management and conservation efforts. Continuing efforts are needed to strengthen population well-being by improving health services and reducing pollution.

Natural disasters, beyond their undeniable human toll, can affect the Honduran economy through several other channels. Disasters reduce current growth and potential growth by directly destroying physical and human capital. In addition, potential growth also declines because of out-migration and lost learning. These losses can turn into a vicious cycle as lower growth and postdisaster spending increase public debt and shrink fiscal space, which, in turn, may elevate poverty that then further fosters out-migration and lost human capital. Following is a diagnostic of disaster vulnerabilities that rests on three pillars: building structural, financial, and postdisaster/social resilience (IMF 2019).

Investment in structural resilience will help Honduras contain the damage from climate change and natural disasters and speed recovery. Investments in resilient infrastructure include strengthening riverbeds and building dams to

Figure 8.8. Adaptive Capacity Index versus Adaptive Frontier for CAPDR Countries



Sources: IMF staff calculations based on 2015–21 data from the European Union commission; the United Nations University Institute for Environment and Human Security; the University of Notre Dame, IMF-adapted Notre Dame Global Adaptation Initiative; Phillis and others 2018; and the IMF World Economic Outlook database.
Note: Frontier (red line) analysis methodology: we fit a stochastic production model of log adaptive capacity with a single input, the logarithm of log GDP per capita in US dollars (USD). Figure uses International Organization for Standardization (ISO) country codes. CAPDR = Central America, Panama, and Dominican Republic.

avoid flooding, whereas "soft" resilience measures include developing early warning systems and improving land use planning. With support of the World Bank, Honduras has implemented a three-year project and has provided access to basic hydrometeorological information for 4.5 million people in Honduras. In 2019, with support of the humanitarian aid agency GOAL Global, Honduras introduced an early warning for drought emergency response. The country is also promoting better land use through, for example, more awareness of deforestation issues. With public capital expenditures averaging 3.2 percent of GDP over the past 10 years and low risk of debt distress, Honduras has some fiscal space to invest in structural resilience. However, competing needs and weak execution capacity require cautious prioritization of projects to ensure that cost-benefit trade-offs are clear.

Honduras has several ways to improve its financial resilience. The government is in discussion with the Inter-American Development Bank on a contingent credit facility instrument that would entitle the country to access up to $400 million in the event of a natural disaster. As part of the Financial Management Strategy for Disaster Risk, the Honduran authorities are reconsidering their participation in the Caribbean Catastrophe Risk Insurance Facility (CCRIF), and they are currently adjusting the related legal framework. CCRIF provides accessible parametric insurance products and enables Honduras' peers, such as Guatemala, Nicaragua, and Panama, to insure against excessive rainfall, hurricanes, and seismic activity. Honduras could also explore options to introduce a natural disaster clause in future bond issuances. Such a clause was introduced, for example, in the 2018 restructuring of public debt by Barbados. In the case of Barbados, the trigger for a natural disaster event is a payout of more than $5 million by CCRIF.

Postdisaster resilience requires adjustments. Lack of necessary infrastructure often hampers the ability to reach the affected people during a weather event. Honduras, given its relatively vulnerable road and bridge systems, often faces situations where aid is constrained by physical access. According to the National Disaster Preparedness Baseline Assessment (Pacific Disaster Center 2018), Honduras also needs to strengthen its procurement system to be able to respond quickly and transparently to a natural disaster.

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CHAPTER 9

Implications of Climate Risks for Financial Stability in the Most Vulnerable Countries

Janne Hukka, Camila Perez Marulanda, Dmitry Vasilyev, and Raadhika Vishvesh

The impact of natural disasters on the financial systems in the most vulnerable countries in Latin America and the Caribbean has often been modest compared with the size of economic damages, thanks to moderate direct physical risk exposures (due to high insurance coverage gaps and credit access constraints), high reinsurance cession rates, and significant (insured property) collateral requirements. This benign risk profile would change if the domestic financial sector were to support necessary private sector adaptation investment. Moreover, climate change may also intensify indirect disaster risks, including through their impact on the broader economy. Strengthening supervision, reporting, and regulatory frameworks against climate change risks can help further build financial system resilience.

As one of the leading long-term threats to the global economy, climate change poses important risks to financial stability. Physical risks to the financial system include damage from extreme weather events and long-term degradation of capital and land, either of which may worsen lenders' asset quality and increase insurance companies' payouts. Physical risks to the financial system are particularly high in tourism-dependent economies in the Caribbean and Central America that are vulnerable to natural disasters.

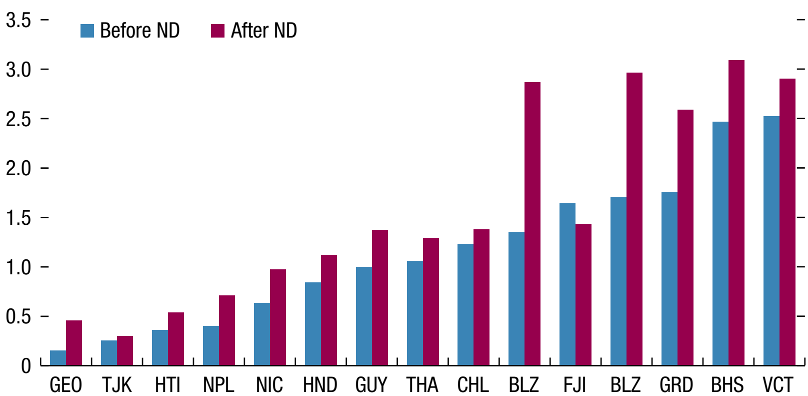
The financial system of the Caribbean and Central American countries has been remarkably resilient to the impact of natural disasters so far. The modest impact of natural disasters in the financial system is due to the high share of insurance obligations ceded to reinsurance, significant (insured property) collateral requirements, limited direct bank exposures to the most vulnerable sectors such as tourism and agriculture, and relatively speedy postdisaster recovery of the tourism sectors.

DIRECT DISASTER RISKS AND ROLE OF PRIVATE INSURANCE

The availability of insurance is crucial for bolstering the resilience of both the real economy and the financial sector. Empirical studies such as Carpenter and others (2020) have shown that countries with a higher insurance penetration tend to recover faster after major disasters.

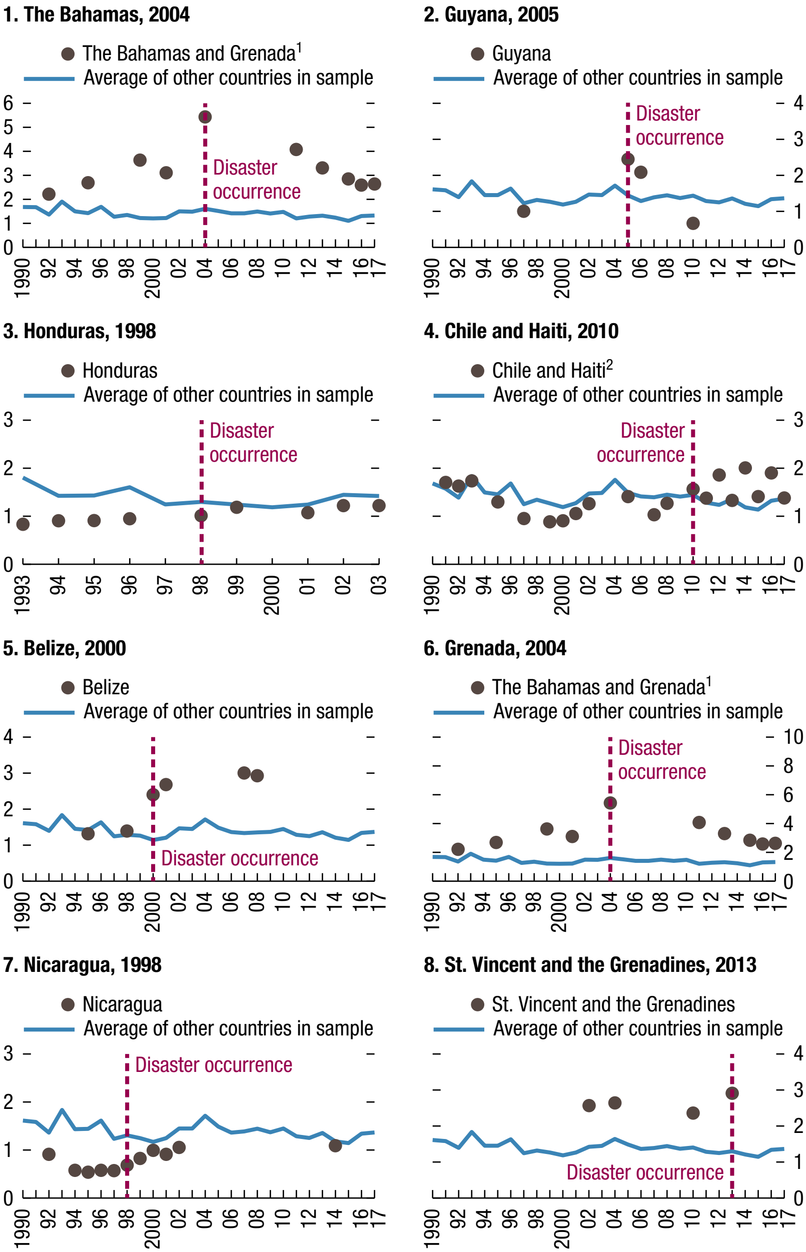
Insurance penetration in Central America and the Caribbean tends to increase after major natural disasters (Figure 9.1). Using the difference-in-difference approach, we show that insurance penetration tends to increase after natural disasters with losses higher than 10 percent of GDP (Figure 9.2), which implies that demand for private insurance in the vulnerable Caribbean and Central American countries is likely to increase as the frequency and intensity of disasters go up (see Annex Table 9.1.2). The analysis also found a positive correlation between insurance penetration and other financial development indicators, such as bank deposits, thus indicating that financial deepening and inclusion could have a positive impact on enhancing insurance penetration in response to rising climate risks. This indicates that financial deepening could stimulate insurance penetration in countries with sizeable climate risks. Our findings echo the observations by Hodula and others (2021), who identify that nonlife premiums are positively related to the development of financial systems, and Feyen, Lester, and Rocha (2011), who find that better access to credit and stronger financial institutions in the economy boost the nonlife insurance sector's penetration.

Figure 9.1. Insurance Penetration before and after Natural Disasters
(Percentage of GDP)



Sources: Emergency Events Database; World Economic Outlook database; World Bank Financial Development Database; and IMF staff calculations.
Note: Average insurance penetration is before and after natural disaster (ND) events causing damage of 10 percent of GDP or higher. Figure uses International Organization for Standardization (ISO) country codes.

Figure 9.2. Nonlife Insurance Penetration for Treated and Control Groups
(Percent of GDP)



Sources: Emergency Events Database; World Bank Financial Development Database; World Economic Outlook database; and IMF staff calculations.

[1]The Bahamas and Grenada both had a natural disaster that caused damage exceeding 10 percent of GDP in 2004.

[2]Chile and Haiti both had a natural disaster that caused damage exceeding 10 percent of GDP in 2010.

INDIRECT DISASTER RISKS IN TOURISM-DEPENDENT ECONOMIES

Climate change may intensify indirect physical risks through the broader economy, which may be heightened by the Caribbean and Central American economies' high dependency on the tourism sector. Such risks may be amplified where financial institutions hold concentrated counterparty risks to regional insurers or significant exposures to public sector entities that may see their balance sheets stretched by disasters. Indirect risk transmission channels may also include abrupt changes to reinsurance pricing.[1]

Natural disasters have historically had a relatively modest impact on most vulnerable countries' banking systems. Even the largest hurricane events, such as Hurricane Maria's 2017 landfall in Dominica, resulted in only modest deterioration in bank asset quality despite large-scale economic damages.[2] Key mitigating factors include mandated insurance of the loan collateral and lenders' modest exposures to the most vulnerable sectors (such as agriculture), which in part reflects their internalization of the region's susceptibility to natural disasters. The impact on loan portfolios would also depend on the banks' and the country authorities' policy response (for example, in Dominica, large citizenship-by-investment revenues supported the government's capacity to respond to recent disasters). Bank funding risks are mitigated by ample system-wide liquidity (IMF 2021).[3]

Bank asset quality may nonetheless become increasingly affected by disasters' indirect transmission channels as they intensify with climate change. Importantly, as evidenced by the experience with the COVID-19 pandemic, the Eastern Caribbean Currency Union (ECCU) economies' heavy reliance on tourism makes them susceptible to prolonged travel disruptions.[4] We investigate the potential impact of stayover tourism arrival shocks on bank asset quality by use of local projection methods (Jordà 2005) to compute sector-specific nonperforming loan (NPL) impulse response functions, which in turn are used to simulate an average cumulative NPL path for the region for a given tourism shock scenario (see Annex 9.1 for details).[5]

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[1] The Caribbean experienced extreme tightening of the reinsurance market in 1993–94 with a series of hurricanes in prior years that led to sharp price increases and refusal by some service providers to extend coverage to the Caribbean. The crisis required Caribbean Community intervention and led to the establishment of Caribbean Catastrophe Risk Insurance Facility.

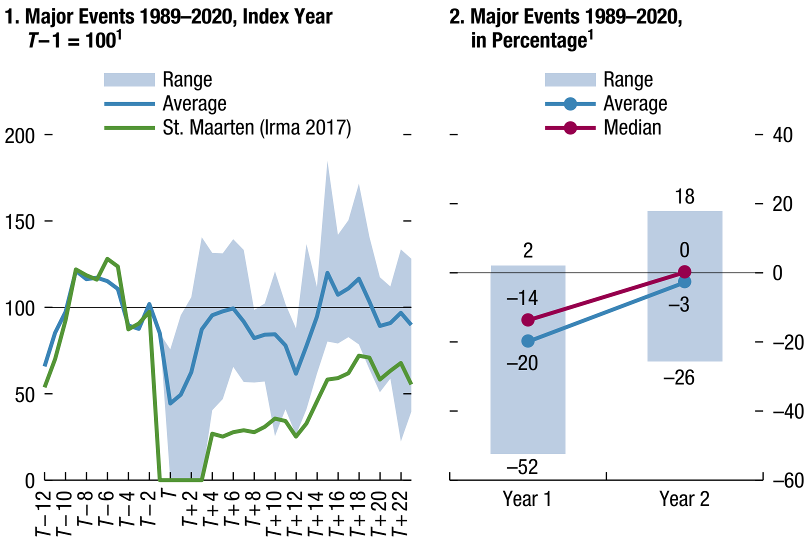
[2] The observation is consistent with econometric studies of the region, such as Brei, Mohan, and Strobl (2019) and Beaton and others (2017), that found no signs of loan defaults or deterioration in bank capital as a result of past hurricane strikes.

[3] Analysis by Brei, Mohan, and Strobl (2019) focusing on earlier periods points to potential deposit withdrawal risks in the event of natural disaster shocks.

[4] Similar to Beaton, Myrvoda, and Thompson (2016), tourism arrivals may thereby be considered a high-frequency proxy for domestic economic activity in the absence of subannual data on GDP or employment.

[5] Aggregation of the sectoral cumulative NPL paths considers the sectoral composition of banks' credit portfolios and their respective countries' relative degree of tourism dependency as measured by the sector's contribution to GDP.

Figure 9.3. Hurricane Impact on Stayover Arrivals



Sources: Caribbean Tourism Organization; Eastern Caribbean Central Bank; Emergency Events Database; National Oceanic and Atmospheric Administration; and IMF staff calculations.
[1]Fifteen hurricane events of category 3 or higher according to the Saffir-Simpson scale.

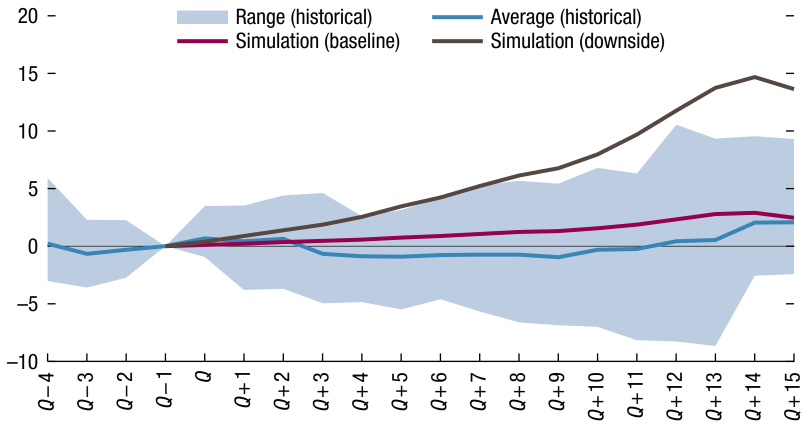
The simulation scenarios are calibrated based on new staff event analysis of historical stayover arrival responses to major hurricane events over the past three decades. For the case of the ECCU, the sample considers 30 major tropical storm events, half of which are hurricanes of category 3 or higher on the Saffir-Simpson scale.[6] For the latter group, stayover arrivals declined on average by a fifth in the year following the disaster but tended to revert to predisaster levels in all instances where the initial shock was not followed by another major storm in the subsequent year. The lack of significant and persistent damage to critical transport infrastructure may have been an important factor in the speed of tourism recovery. Outside of the ECCU, St. Maarten's experience in the aftermath of Hurricane Irma in 2017, where storm damage substantially constrained the airport terminal's passenger capacity years after impact, gives perspective of the potential risks. Following an 80 percent drop in the year after impact, stayover arrivals recovered only to 40 percent below the predisaster levels in the following year and had not fully recovered before the COVID-19 pandemic (Figure 9.3).

The simulation results illustrate potential risks from more prolonged disruptions to tourism flows. Under the baseline 20 percent single-year decline in stayover arrivals, the simulated NPLs would peak just under 3 percentage points

[6] The storm events are selected by dual criteria of their vicinity to the country (using historical hurricane tracks from the National Oceanic and Atmospheric Administration's database) and its reported impact (Emergency Events Database complemented with other online sources).

Figure 9.4. Eastern Caribbean Currency Union: Historical and Simulated Nonperforming Loans after Hurricane Events

(Percentage of total loans; predisaster quarter Q – 1 = 0)



Sources: Eastern Caribbean Central Bank, Emergency Events Database; National Oceanic and Atmospheric Administration; and IMF staff calculations.
Note: Historical average and range drawn from 16 major storm events from 2000 to 2019. Baseline simulation draws from the historical average stayover arrival shock of 20 percent cumulatively in the first year after the largest hurricane events from 1989 to 2019. The downside simulation assumes cumulative 80 and 40 percent stayover arrivals shocks in the first and second postdisaster years, respectively.

above their predisaster level for an average ECCU country and would be mostly concentrated in the tourism and construction sectors (Figure 9.4). However, a more significant tourism disruption in scale similar to St. Maarten in 2017 can result in a several-fold larger increase.[7] The country-specific impact would depend on its relative degree of tourism dependency, bank credit composition and policy response (proactive loan restructurings), and the policy response by the fiscal and monetary authorities (including extension of temporary loan moratoria such as in the case of the volcanic eruption of La Soufrière in St. Vincent and the Grenadines in 2021). Tightening of bank lending standards since the aftermath of the global financial crisis may also attenuate potential losses.

Other factors may also accentuate asset quality risks from natural disasters. Even in the absence of major infrastructure damage, countries' tourism flows may face prolonged disruptions from successive storms that may become more frequent with climate change. The fiscal impact of large natural disasters under already-stretched public sector balance sheets can heighten risks to banks with large sovereign exposures. Banks' more direct exposure to climate change risks may also rise over time to the extent that private sector demand for adaptation financing increases.

[7] The actual impact on St. Maarten's banking system NPLs was more modest. For more information, see IMF Country Report 20/94.

Strengthening supervision, reporting, and regulatory frameworks could help build financial system resilience. Physical climate risks should be incorporated in existing supervisory frameworks, supported by reporting structures that allow for more granular monitoring of the various risk transmission channels and strengthened oversight arrangements of interinstitutional exposures. This could be accompanied by regulatory measures to support climate risk–aware lending practices, exposure diversification and prudential risk buffers, and ex-post asset recovery. Physical climate risk scenarios should also be integrated into the authorities' financial system crisis management plans to ensure adequacy of any necessary intervention frameworks.

ANNEX 9.1. DESCRIPTION OF APPROACHES FOR ESTIMATING THE IMPACT OF NATURAL DISASTERS ON INSURANCE PENETRATION

A difference-in-differences (DD) approach was used to determine the effect of natural disasters on nonlife insurance penetration. The basic idea of the DD estimator is as follows:

$$y = \beta_0 + \beta_1 dD + \delta_0 d2 + \delta_1 d2 \cdot dD + u, \qquad \text{(A9.1.1)}$$

where y is insurance penetration, dD is equal to 0 for countries not affected by natural disasters, and 1 is for countries that were hit by natural disasters. D2 is equal to 0 before the natural disaster and 1 is after the natural disaster. We are interested in δ_1:

$$\delta_1 = (\overline{y_{B,2}} - \overline{y_{B,1}}) - (\overline{y_{A,2}} - \overline{y_{A,1}}). \qquad \text{(A9.1.2)}$$

The treatment variable is constructed using total damages as a percentage of GDP from the Emergency Events Database. It is equal to 1 when total damages are equal to or higher than 10 percent of GDP, that is, close to two standard deviations. Because of the limited availability of data on insurance penetration, our panel data have 15 natural disasters that will be considered treatments (Annex Table 9.1.1). The panel data set is annual and covers a sample of about 130 advanced, emerging, and developing economies between 1990 and 2017.

ANNEX TABLE 9.1.1

List of Treatments[1]

Country	Year	Total Damage in Percent of GDP
Honduras	1998	59.6
Nicaragua	1998	21.3
Belize	2000	33.3
Belize	2001	28.7
Georgia	2002	10
Bahamas, The	2004	11
Grenada	2004	148.4
Guyana	2005	27.2
Tajikistan	2008	16.4
Chile	2010	13.7
Haiti	2010	67.5
Thailand	2011	10.8
St. Vincent and the Grenadines	2013	15
Nepal	2015	21.2
Fiji	2016	12.2

Sources: Emergency Events Database; and IMF staff calculations.

[1] Includes disaster events causing damage of 10 percent of GDP or more that have insurance penetration data for the disaster year.

This annex was prepared by Camila Perez, Dmitry Vasilyev, and Radhika Vishvesh.

Additional covariates in the regression included GDP per capita, GDP growth, public debt, financial depth measured by the share of bankable population, bank deposits, broad money, stock market capitalization, and others to obtain an unbiased estimator. The data sources for these variables are the IMF's World Economic Outlook database, the World Bank's World Development Indicators database, and the Penn World Tables. The additional covariates did not significantly affect the treatment coefficient. In addition to cluster-robust standard errors, as a robustness check, bootstrapped standard errors were also estimated, and the results remained broadly unchanged.

The main estimation results are summarized in Annex Table 9.1.2. The results indicate that insurance penetration tends to increase after major natural disasters (the size of the disasters is measured by the damage as a percentage of GDP), which implies that demand for private insurance in the vulnerable Caribbean and Central American countries is likely to increase as the frequency and intensity of disasters increase. The analysis also found a positive correlation between insurance penetration and other financial development indicators such as bank deposits, thus indicating that financial deepening and inclusion could have a positive impact on enhancing insurance penetration in response to rising climate risks.

ANNEX TABLE 9.1.2

Main Results

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Treatment effect	0.159*	0.109**	0.123***	0.109***	0.082**	0.102***
	(–0.09)	(–0.05)	(–0.03)	(–0.04)	(–0.04)	(–0.02)
GDP in levels (lagged)		0.0				
		(–0.04)				
GDP growth			1.850***	1.996*	2.121***	2.070***
			(–0.3)	(–0.86)	(–0.46)	(–0.45)
Capital stock growth						
Bank accounts growth				–0.1		
				(–0.22)		
Growth of public debt						
Public debt				–0.1	–0.049*	–0.048*
				(–0.12)	(–0.02)	(–0.02)
GDP per capita				0.1	0.345*	0.345*
				(–0.17)	(–0.15)	(–0.15)
GDP per capita growth						
Broad money				–0.1	–0.1	–0.1
				(–0.18)	(–0.08)	(–0.08)
Stock market capitalization					–0.1	–0.1
					(–0.06)	(–0.06)
Constant	1.303***	0.1	0.1	1.4	2.330*	2.328*
	(–0.05)	(–0.26)	(–0.06)	(–1.95)	(–0.91)	(–0.9)
Degrees of freedom of residuals	127.0	83.0	83.0	30.0	58.0	58.0

Source: Emergency Events Database; and IMF Staff calculations.

Note: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. Model 1: Treated variable is nonlife insurance premium in percentage of GDP. Models 2 through 5: Treated variable is change in nonlife insurance premium in dollars. Model 6: Treated variable is change in nonlife insurance premium in dollars. Treatment variable is inserted with a lag.

ANNEX 9.2. THE IMPACT OF STAYOVER TOURISM ARRIVAL SHOCKS ON BANK ASSET QUALITY

We investigate the potential impact of stayover tourism arrival shocks on bank asset quality using the local projection method (Jordà 2005). As in the ECCU Regional Consultations (IMF 2021), we compute sector-specific NPL impulse response functions, which in turn are used to simulate an average cumulative NPL path for the region for a given tourism shock scenario.[8] Specifically, drawing from a cross-country panel of quarterly bank-level sectoral loan data for 2010:Q3–2019:Q4 with a range of controls and bank fixed effects, the analysis considers the following impulse response system of equations:

$$y_{i,j,t+h} = \alpha^h + \beta^h shock^{tourism}_{j,t} + \Sigma^S_{s=1}\vartheta^h_s shock^{tourism}_{j,t-s} + \Sigma^K_{k=1}\theta^h_k y_{i,j,t-k} + \Sigma^C_{c=1}\delta^h_c Controls_{c,i,j,t-1} + \gamma^h NatDis_{j,t} + \mu_i + cubic\ trend_t + \epsilon_{i,j,t+h}, \quad \text{(A9.2.1)}$$

where the subscripts i, j, and t denote bank, country, and quarter, respectively. The superscript h = 0,...20 denotes the time horizon (number of quarters after t) being considered. The dependent variable $y_{i,j,t+h}$ measures credit quality and takes the form of a logistic transformation of the NPL ratio common in literature; see, for instance, Ghosh (2015) and Klein (2013). The tourism shock consists of the year-on-year percent change in stayover tourism arrivals for a given country and quarter. Controls included bank profitability, credit growth, lending rates, inflation, import growth as proxy for nontourism economic conditions, and a natural disaster dummy.

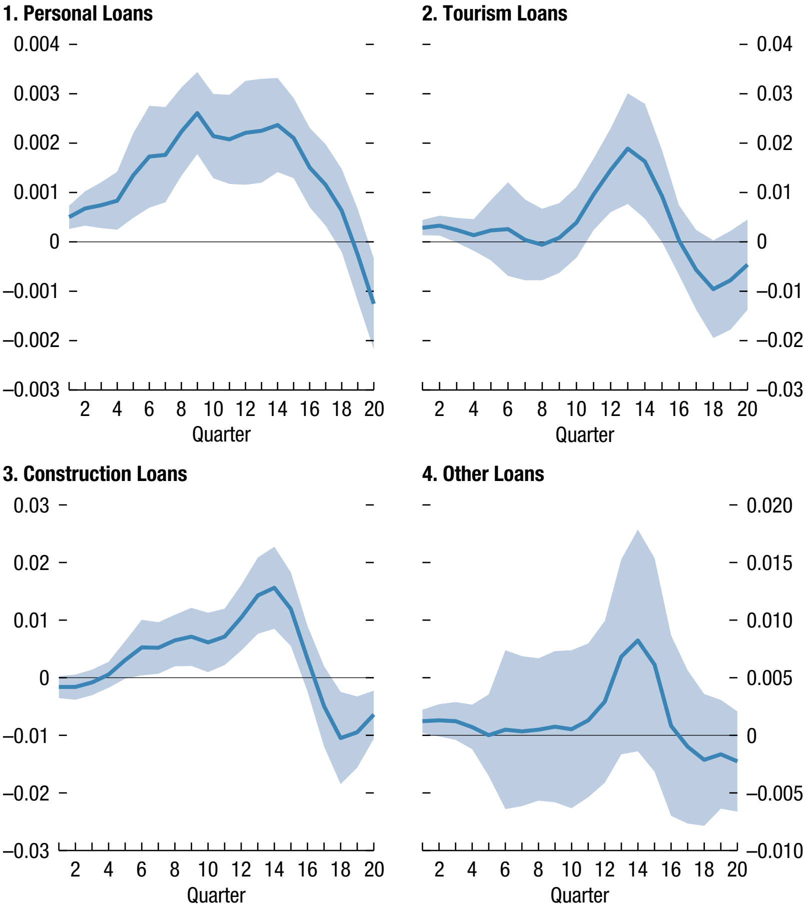
Estimating the specification for each credit sector and collecting the βh coefficients, representing the cumulative impact of the tourism shock on the NPL ratio after h quarters, as well as the corresponding standard errors, allows for construction of sector-specific impulse response functions (Annex Figure 9.2.1).

This annex was prepared Janne Hukka.

[8] Aggregation of the sectoral cumulative NPL paths considers the sectoral composition of banks' credit portfolios as well as their respective countries' relative degree of tourism dependency as measured by the sector's contribution to GDP.

Annex Figure 9.2.1. Response of Sectoral NPL Ratios to a Percentage Point Drop in Tourism Growth

(Percent, cumulative impact)



Source: IMF staff calculations.
Note: Blue line shows the estimated impact of stayover tourism arrival shocks on bank asset quality using the local projection method (Jordà 2005). Blue shading corresponds to 10th/90th percentile confidence intervals.

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CHAPTER 10

Financing Climate Policies in Latin America and the Caribbean

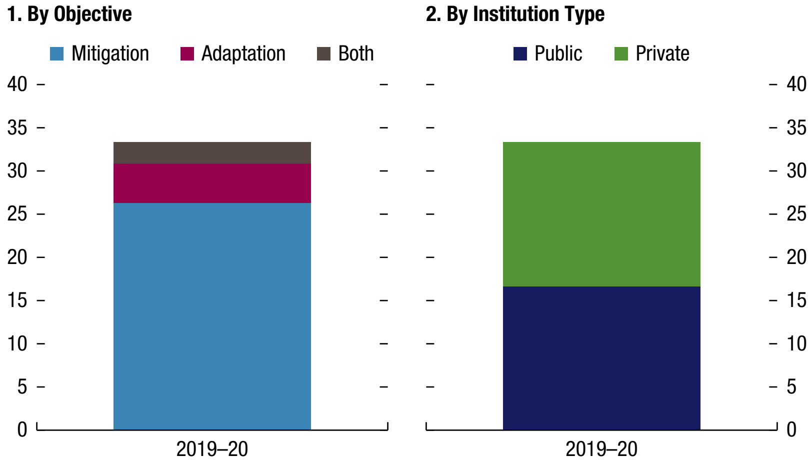
Chris Walker and Serhan Cevik

Countries in the Latin America and Caribbean (LAC) region will require additional financing to achieve their climate mitigation and adaptation goals. External financing for both mitigation and adaptation will be essential given the limits to domestic resource mobilization in the region. On the private funding side, the rapidly developing markets for sustainability-linked debt and equity as well as state-contingent instruments have the potential to support climate efforts in LAC. Bilateral and multilateral support will also continue to be important, including the IMF's Resilience and Sustainability Trust (RST).

Countries in the region will require additional financing to achieve their climate mitigation and adaptation goals. For the LAC region, implementing mitigation and adaptation measures will entail high upfront costs, notably with respect to public investment in infrastructure and technology. A report by the Energy Transitions Commission (2020)[1] estimates that $1.475 to $1.8 trillion in new investment (public and private) in green energy generation, transmission, and storage capacity, transportation infrastructure (for example, installation of chargers for electric vehicles), and industrial modifications (such as for carbon capture) will be needed annually, at the global level, to reach net-zero emissions by 2050. Based on this global assessment and the share of the LAC region in global GDP, annual investment costs for climate mitigation in LAC would be estimated at $75 to $92 billion. A further $14 to $17 billion annually could be needed for adaptation investment in the region if the recent historical relationship of adaptation to mitigation spending continues to hold (Figure 10.1). The resulting estimate, based on the Turner Report, for the investment needed to reach nationally determined contribution (NDC) goals and strengthen structural resilience for climate adaptation is $90 to $110 billion per year for the LAC region. An alternative appraisal by the International Energy Agency points to moderately higher mitigation costs of $111 billion a year in the region during 2026–30, for a similar

[1] Often referred to as the "Turner Report."

Figure 10.1. Latin America and the Caribbean: Climate Financing
(Billions of US dollars)



Sources: Climate Policy Initiative, Updated View on the Global Landscape of Climate Finance 2019; and IMF staff calculations.

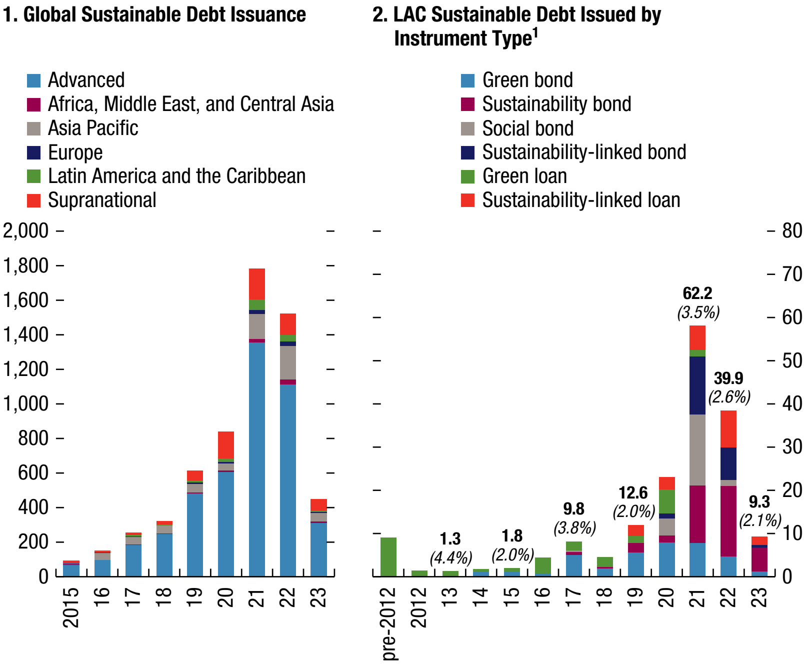
list of investments, leading to an overall estimate of $132 billion per year for the LAC region[2] for mitigation and adaptation (International Energy Agency 2021). When the results of these studies are combined to produce a broad estimate of the investment costs to the region for the transition to net-zero emissions, the resulting range of $90 to $132 billion per year represents about 1.7 to 2.5 percent of the region's 2019 GDP. These calculations leave out some potential sources of savings, such as shifting some public investment in oil and gas to renewable energy, and some possible additional expenditures, such as transfers to households adversely affected by the transition.

External financing for climate mitigation and adaptation in the LAC region will be essential, given the limits to domestic resource mobilization. Governments should create fiscal space to respond to climate challenges by reprioritizing some expenditures (for example, by shifting away from public investment in fossil fuels[3] and reducing fossil fuel subsidies, where appropriate), and enhancing revenues where possible, such as by considering carbon or other environmental taxes, where appropriate. However, for most countries, even a concerted effort to increase public and private savings would not be sufficient to cover the bulk of the needed spending on climate mitigation and adaptation policies. Most of these resources

[2] The International Energy Agency estimate for the LAC region has been adjusted here by excluding the estimated cost of building conversion, which the Turner Report does not cover.

[3] About two-thirds of oil and gas investment in the region is carried out by the public sector, largely by state-owned enterprises.

Figure 10.2. Sustainable Debt Issuance
(Billions of US dollars, as of May 15, 2023)



Sources: Bloomberg NEF; and IMF staff calculations.
Note: LAC = Latin America and the Caribbean.
[1]Numbers in parentheses refer to the share of LAC to world total.

would likely need to be obtained from external private or public sources. For the most vulnerable LAC countries, this financing should be provided on highly concessional terms, including in the form of grants.

On the private funding side, the rapidly developing markets for sustainability-linked debt and equity have the potential to support climate mitigation and adaptation efforts.

The sustainable debt market has reached $2.3 trillion with net new issuance of $760 billion in 2020 (Figure 10.2, panel 1), of which 2.5 percent or $19 billion was issued by LAC countries (Figure 10.2, panel 2). The most significant component of this market, in terms of size and potential environmental impact, is that of green bonds, which accounted for $2.2 trillion in cumulative global issuance by the end of 2022.[4] Green bond sales have grown rapidly in LAC, with the region accounting for $37.5 billion of about $500 billion in global issuance in 2022.

[4] See the Climate Bonds Initiative at www.climatebonds.net. Bonds are classified as green based on the entity that issues them ("issuer based") or the activity that they are meant to finance ("activity based").

Equity funds focused on environmental, social, and governance investments represent another private sector funding opportunity. Estimates of the total size of this market vary widely, however, from $3.5 to $10 trillion or more because standards are inconsistent and some supposedly green funds may also hold large amounts of conventional equities, such as major tech stocks (IMF 2021).[5] However, environmental, social, and governance equity investment in LAC represents a small share of the total market.

Both green equity funds and sustainable debt may be susceptible to so-called greenwashing—misrepresenting nongreen holdings (for example, in natural gas or coal) as environmentally responsible. Setting transparent and verifiable standards for green financing, supported in many cases by measures to improve domestic business climates and to strengthen regulatory frameworks, would be crucial for maintaining investor confidence and market demand.

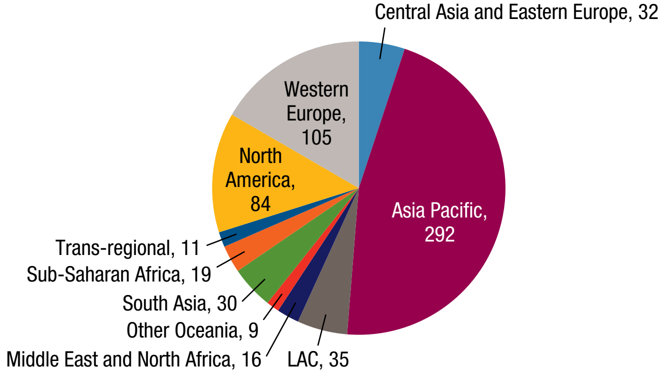
State-contingent instruments can also support climate mitigation and adaptation. Catastrophe bonds, as discussed in the section on adaptation, and hurricane clauses (as in Barbados' and Grenada's debt restructurings) constitute an underused but potentially important source of state-contingent financing. Further developing state-contingent debt instruments outside of debt restructurings could help countries better manage their debt service payments during natural disasters (Guerson 2021). Belize and Barbados issued blue bonds combined with "debt-for-nature" swaps for debt service reduction, opening fiscal space for nature conservation investments in coastal areas in 2021 and 2022, respectively. Other useful risk-sharing mechanisms include the provision of loan guarantees for investment in sustainable energy projects and other green projects. Compensation schemes such as debt-for-nature swaps, or outright compensation payments to preserve tropical forests, can also help contain transition costs.

Bilateral and multilateral support will need to play a key role in financing LAC's mitigation and adaptation efforts. In the wake of the Paris Accords, advanced economies committed to provide $100 billion a year in climate financing to developing economies. These funds will supplement the resources available from private external and domestic sources. Most of this necessary funding from advanced economies is expected to be channeled through international financial institutions, including the IMF.

In many LAC countries, bilateral and multilateral institutions will continue to be important sources of capital for renewable energy investment. National and multilateral development banks (MDBs) have provided significant climate financing (25 percent and 53 percent of total financing, respectively [Economic Commission for Latin America and the Caribbean 2020], largely to support

[5] Chapter 3, "Investment Funds," of the October 2021 IMF Global Financial Stability Report, which estimates that the total value of sustainable investment funds at the end of 2020 was $3.6 trillion.

Figure 10.3. Breakdown of Global Climate Finance by Region of Destination
(2019–20 average; in billions of US dollars)



Sources: Climate Policy Initiative, Updated View on the Global Landscape of Climate Finance 2019; and IMF staff calculations.
Note: LAC = Latin America and the Caribbean.

mitigation actions, notably in renewable energy),[6] although the share of LAC in overall financing has been limited (Figure 10.3). Among the available sources of funding, MDBs and overseas development agencies have been influential in kick-starting deployment of some renewable technologies by combining risk mitigation funds, dedicated investment credit lines with long-term tenors, and technical assistance. MDBs have also supported nascent off-grid markets (for example, in Argentina, Bolivia, and Nicaragua) and built related capacity, including for regulators, financial institutions, and developers across the region.

The IMF has created a new Resilience and Sustainability Trust (RST) financed through a rechanneling of special drawing rights from countries with strong external positions to more vulnerable countries. The RST supports policy reforms to help build economic resilience and sustainability, including through policies to address climate change. The RST provides financing at cheaper rates and with longer maturities than the IMF's traditional lending terms to low-income and vulnerable middle-income countries, as well as to some small states, to further climate goals. Through the first quarter of 2023, the IMF Board approved the provision of more than $2.5 billion in climate-related financing through the RST to five countries, three of which (Barbados, Costa Rica, and Jamaica) are in Latin America and the Caribbean. With more than $40 billion in financing committed to the RST, several more countries are expected to join this list in the next few years.

[6] The remaining climate financing has been allocated to transportation (13.9 percent); agriculture, forestry, and land use (8.9 percent); energy efficiency (4.4 percent); and waste and wastewater (3.7 percent). The limited adaptation financing goes primarily to water sources, wastewater, and disaster risk management (3 percent); agriculture, forestry, and land use (0.7 percent); energy, transport, and other environmental constructions and infrastructure (0.6 percent); intersectoral investment (0.4 percent); infrastructure (0.3 percent); and other adaptation (11.9 percent) (Economic Commission for Latin America and the Caribbean 2020).

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Note: Page numbers followed by *b, f,* or *t* indicate boxes, figures, or tables, respectively.

Latin America and the Caribbean is one of the most diverse regions with respect to climate-related risks. Climate change presents challenges as well as opportunities for economic and social development in the region.

This book offers policy options for climate mitigation, adaptation, and green energy transition. Given the unique structure of emissions in the region, a broad range of mitigation tools is likely to be needed. A policy mix that balances carbon pricing with a green investment push is likely to have positive long-term effects on activity and employment. Moreover, some countries in the region stand to benefit from green technologies due to their endowment of "green" commodities—such as lithium, copper, nickel, and cobalt—needed in the energy transition. A comprehensive approach to adaptation, based on building structural resilience (investing in resilient infrastructure) and financial resilience (establishing a comprehensive layered insurance scheme) would yield significant long-term benefits for the most vulnerable countries in the region. Strengthening supervision, reporting, and regulatory frameworks can fortify financial system resilience to climate shocks.

To reach climate mitigation, adaptation, and transition goals, significant upfront financing is required, with both external support and private sector involvement being crucial. To seize opportunities and mitigate risks, countries must enhance economic flexibility through labor and capital reallocation, investment in skills and technology, improved governance, and fiscal management for the climate transition.

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