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CLIMATE MITIGATION IN LATIN AMERICA AND THE CARIBBEAN: A PRIMER ON TRANSITION COSTS, RISKS, AND FINANCING

BY DR. MAURICIO CÁRDENAS AND SEBASTIAN OROZCO-SANCHEZ

NOVEMBER 2022

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EXECUTIVE SUMMARY

Latin American and Caribbean (LAC) countries are among the most vulnerable in the world to climate change, experiencing at least one extreme weather-related event per country, on average, every three years over the past two decades. As signers to the Paris Agreement, LAC countries established nationally determined contributions (NDCs), pledging to significantly reduce greenhouse gas (GHG) emissions by 2030 and become net zero by 2050. Over the last two years, many LAC countries, including the six largest economies—Argentina, Brazil, Chile, Colombia, Mexico, and Peru—have updated or submitted new NDCs, raising their climate mitigation ambition. While public opinion surveys show support for climate-related policies among citizens in the region, the transition to a low-emissions economy is extremely challenging, and even out of reach, for LAC countries under current policies.

Financing this transition is a key question for the 2022 United Nations Climate Change Conference. As part of the ongoing research on energy transition at Columbia University's Center on Global Energy Policy, this report analyzes the challenges of climate mitigation in LAC countries. The region has a unique composition of emissions: the Agriculture, Forestry, and Other Land Use (AFOLU) sector accounts for 40 percent of the region's total emissions, almost double the global average. Deforestation and land-use change, which drive this sector's emissions, release vast quantities of nitrous oxide and methane emissions in addition to carbon dioxide. Another characteristic of the region is its heavy dependence on fossil fuel revenues, which raises transition costs and risks of financing a low-carbon future.

This report outlines the trade-offs facing the region as well as market-based solutions that could help finance climate mitigation initiatives. The main findings are as follows:

- LAC countries face high transition costs relative to the size of their economies. These costs include both investments in emissions abatement as well as transition risks in the form of lost export and fiscal revenues. The authors present a taxonomy of risks facing different LAC economies depending on their economic structures as fossil fuel producers, agriculture-based countries, and land-use-intensive, subsistence agriculture countries.
- Across the region, the AFOLU sector will be the primary driver of GHG emissions reduction. This result holds true under two different scenarios: one that assumes a transition to carbon neutrality by 2050, and one that meets the targets set by NDCs. The AFOLU sector demands greater attention from the region's policy makers not only because of its large contribution to emissions but because of its potential for low-cost carbon abatement through reforestation and forest management. Carbon offsets for emissions of hard-to-abate regions and sectors—such as heavy industry and transportation—provide an economic opportunity for LAC.
- LAC countries have designed long-term strategies to reduce emissions, but most have not developed financial plans to support the implementation of these strategies.

Large-scale carbon abatement actions, such as afforestation and forest conservation, require government intervention as well as financing from development banks and a deep and liquid market for carbon offsets.

- To meet their climate goals, LAC countries must consider a new fiscal policy framework. Various solutions may include carbon pricing and green fiscal rules, which could help integrate climate goals into current fiscal frameworks, leading to a convergence of fiscal and environmental sustainability.

INTRODUCTION

In preparation for the 26th Conference of the Parties (COP26), which convened in Glasgow in 2021, most Latin American and Caribbean (LAC) countries updated their nationally determined contributions (NDCs) to reduce greenhouse gas (GHG) emissions by 2030 and to bring emissions to net zero by midcentury. But unless the region addresses several constraints that it faces in transitioning to a low-emissions economy, these pledges could remain aspirational.

LAC countries first established NDCs to cut emissions and adapt to climate change as signers to the Paris Agreement. Climate mitigation is one approach in the Paris Agreement to achieve the goal of 1.5°C pathway, or hold the increase in global average temperature below 1.5°C above preindustrial levels.[1] The interventions include shifting electricity generation from fossil fuel sources to renewable energy, replacing GHG-emitting technologies with low-carbon and clean alternatives, minimizing waste, and maintaining and restoring forest ecosystems.

The region's ambitious low-carbon transition requires major investments, but funding is limited by inadequate fiscal capacity and financing restrictions that affect both private and public sectors. LAC countries must also resolve policy dilemmas arising from tensions between different developmental goals that compete for financial and human resources. In addition to the NDCs, the region is committed to achieving the Sustainable Development Goals (SDGs) by 2030. Although some believe that the objectives of NDCs and SDGs mutually reinforce each other (Lankes et al. 2022), in practice trade-offs exist. For example, should oil- and mineral-rich countries first reduce the production of fossil fuels? Or should they wait until the demand for these products falls and, in the meantime, use the revenues to meet SDGs, such as the eradication of poverty?

This report argues that achieving the emissions reductions required by the NDCs and net-zero scenarios is extremely challenging, and even out of reach, for LAC countries under current policies. It further argues that acknowledging this reality is, in fact, a call for action in institutional and policy areas related to climate mitigation goals. Two challenges, in particular, make the low-carbon ambitions of LAC countries unrealistic. First, emissions reductions are very costly relative to the income of most LAC countries. Second, these countries face significant transition risks in the form of loss in export and fiscal revenues, particularly from high-emissions sectors like oil, gas, and coal. To bridge the gap, LAC countries need to adopt a new framework to pay for the transition that would allow them to offset the expected fiscal losses and, importantly, develop new sources of income. Adopting "green fiscal rules" is one possible way in which fiscal management in the region could be aligned with climate goals.

This report outlines key challenges and trade-offs facing LAC countries related to the costs of climate mitigation. Its purpose is to propose policy and institutional changes that are necessary to effectively achieve the level of climate ambition set by the region. Rather than providing definitive answers, the goal is to spur research and public debate in new directions.

The report is organized as follows: Section 1 discusses the ways in which the composition of emissions in LAC differs from the rest of the world. Section 2 outlines climate ambition in LAC

countries and models their transition trajectories under two scenarios: the net-zero scenario to meet the 1.5°C temperature target in 2050 and the NDC scenario to meet the pledged commitments. It also discusses the long-term climate mitigation strategies of the region's largest economies. Sections 3 and 4 put a price tag on the transition to net zero, considering both the investments required and the indirect costs (lost revenues and transition risks) for LAC economies. Section 5 explores how LAC countries can pay for the transition by using various tools, such as carbon taxes and voluntary carbon markets.

Ultimately, the goal of this report is to build momentum toward decisions that would make NDCs achievable. If these actions are not taken immediately, current NDCs could be out of reach.

WHAT'S DIFFERENT ABOUT LAC EMISSIONS

Large AFOLU, Low Energy Emissions

According to the World Development Indicators, LAC countries represent approximately 8 percent of the total world population and 6 percent of the global gross domestic product (GDP) (World Bank 2021). Their share of global GHG emissions is around 7 percent (Ivanova et al. 2021).

The average per capita income and per capita net emissions in the region are close to global averages, but there are large differences within the region. For example, while the GDP per capita of Haiti is comparable to Sub-Saharan African countries, Chile and Uruguay are upper-middle-income countries. At 6.4 metric tons (t) carbon dioxide equivalent (CO_2-eq), per capita net emissions in LAC are close to the global average (Ivanova et al. 2021). But per capita emissions of Guyana, Suriname, and Grenada are more than triple the global and regional average, while those of Chile, Guatemala, and El Salvador are half of this average. In terms of overall emissions, Argentina, Brazil, Mexico, and Venezuela are the largest emitters in LAC, responsible for 70 percent of the total emissions of the region (Climate Watch 2022).

Where LAC countries differ from the rest of the world is in the composition of their emissions. The energy sector, including electricity generation, transportation, and fuel use in industrial processes, accounts for 43 percent of total CO_2-eq emissions, well below the global average of 74 percent. In contrast, the Agriculture, Forestry, and Other Land Use (AFOLU) sector accounts for 40 percent of the region's total emissions, almost double the global average. The main contributors to AFOLU emissions are deforestation and land-use change, which, in addition to CO_2, release nitrous oxide (N_2O) and methane (CH_4) emissions. To account for the region's high N_2O and CH_4 emissions, this analysis converts all emissions into CO_2-eq to quantify total GHG emissions.[2]

There are two reasons for the high share of AFOLU emissions in the region. First, LAC economies have a higher share of land-intensive activities, including cattle raising and extensive agriculture. Second, the LAC region has a cleaner energy matrix than the rest of the world. While electricity generation drives energy emissions in most of the world, this is not the case in LAC countries. Nearly 60 percent of electricity generation comes from renewable sources (Latin American Energy Organization 2022), specifically hydropower, compared to the global average of less than 40 percent.[3]

A related aspect is that the driver of emissions in the LAC energy sector is transportation rather than electricity generation (Cárdenas, Bonilla, and Brusa 2021). Emissions in the transportation subsector are harder and more expensive to abate as they require the adoption of zero-emissions vehicles. To be sure, the region has vast experience in producing biofuels to reduce emissions in the transportation sector.[4] In fact, LAC countries account for 34 percent and 24 percent of global ethanol and biodiesel production, respectively (International Energy Agency 2021b). It is, however, debatable whether biofuels are carbon neutral, with some studies arguing that their use has increased CO_2 emissions. This is especially true when land is

diverted from feeding humans and livestock toward producing fuel as the additional farmland and carving out of vegetation trigger very large CO_2 releases.

Abatement costs are higher in manufacturing (where clean technologies are not fully developed) and in transportation (where the necessary investments are significant) relative to preventing deforestation and land-use changes. All this suggests that the transition to a low-emissions economy in LAC countries should, therefore, prioritize actions in the AFOLU sectors.

Public Opinion on Climate Action

In the last two decades, LAC countries have experienced, on average, 0.3 extreme climate-related events per year (or one major event every three years), a 50 percent increase over the 1980–2000 period. According to the Global Climate Risk Index, 10 LAC countries (Puerto Rico, Honduras, Haiti, Nicaragua, Dominica, Dominican Republic, Guatemala, El Salvador, Bahamas, and Grenada) are among the 25 most vulnerable in the world to climate risks (Eckstein, Künzel, and Schäfer 2021). Central America and the Caribbean are particularly vulnerable to hurricanes, droughts, and rising sea levels. Extreme weather events are also frequent in Brazil, Mexico, and Colombia—three of the largest economies in the region.

Furthermore, according to the United Nations Office for Disaster Risk Reduction (2021), between 1997 and 2017, one out of every four disasters in the world was in the Latin America and the Caribbean region. Nine out of 10 people affected by these disasters were impacted by climatic events (mostly floods). Between 1998 and 2017, 53 percent of global economic losses from climate-related disasters occurred in Latin America and the Caribbean. Similarly, the region accounted for 46 percent of global disaster losses during the last decade.

Faced with frequent extreme, even catastrophic, weather-related events, a majority of the population has internalized climate change as a global emergency (United Nations Development Program 2021). But support for climate action is uneven across the region. In one global survey, more than 80 percent of respondents in Colombia, Chile, and Peru agreed with government action to combat climate change, compared to 57 percent and 35 percent in the US and Russia, respectively (Ipsos 2020). At a regional level, though, support for climate action in Latin America is comparable to that in Eastern Europe and Central Asia but lower than Western Europe and North America (United Nations Development Program 2021).

Political platforms based on preventing deforestation, the electrification of public transport, or development of renewable energy, as well as economic models that de-emphasize the role of extractive industries, are popular among voters. However, even in countries where reducing emissions is broadly supported by the electorate, such as Colombia and Ecuador, recent social unrest suggests that citizens are not ready to accept the reduction of energy subsidies and, even less, the adoption of carbon prices.

CLIMATE AMBITION, TRANSITION TRAJECTORIES, AND LONG-TERM STRATEGIES

Climate Ambition

Parties to the Paris Agreement are required to present NDCs on a five-year cycle, and successive NDCs are supposed to include increasingly ambitious climate action. For this purpose, countries can either update their existing NDCs, enhancing its goals and means of implementation on the same principles, or propose new NDCs. In general, LAC NDCs are of a higher quality than the global average, reflecting strong stakeholder engagement, transparency mechanisms, and interest in global carbon markets (United Nations Development Program 2022).

Between 2020 and 2022, of the 33 LAC countries, 20 updated or submitted a new NDC, and 9 increased their ambition (for example, by lowering the 2030 emissions cap). This includes the six largest economies of the region (LAC-6): Argentina, Brazil, Chile, Colombia, Mexico, and Peru (Table 1). Of these, only Argentina submitted a new NDC.

In their revised NDCs, Argentina and Chile increased their targets to reduce GHG emissions in absolute terms while Peru and Colombia increased their targets as a percentage of a baseline. Argentina and Chile have pledged to be carbon neutral by 2050 while Peru and Colombia are developing national strategies toward this goal.

In contrast, Brazil and Mexico did not expand their climate commitments. The Brazilian government updated its commitment by adopting a higher reduction percentage but changed the base year for calculating emissions. As a result, Brazil can emit an additional 500 million metric tons (Mt) of carbon dioxide equivalent (CO_2-eq) by 2025 and 400 Mt CO_2-eq by 2030. Although the Bolsonaro government has faced criticism for not taking a tough stance against deforestation, Brazil has pledged to be GHG neutral in 2050 (which means it could be carbon neutral by 2040). Mexico has not set a carbon neutrality target. The current government is prioritizing investments in oil production and the construction of a new refinery, as well as the use of fossil fuels for electricity generation. This approach also strengthens the role of Pemex and CFE (Federal Electricity Commission), the state-owned enterprises in charge of these sectors.

Bolivia and Venezuela, two prominent fossil fuel producers, have been notably absent from these conversations.

Overall, LAC-6 countries pledged a reduction in emissions of 34.5 percent compared to the 2030 business-as-usual (BAU) scenario.[5] Nevertheless, there are sizeable differences in climate ambition among countries. Colombia has pledged to reduce its emissions by 51 percent compared to the 2030 BAU emissions, while Argentina has committed to reducing emissions by only 8 percent, and Mexico has announced a negligible reduction.

Table 1: Summary of commitments in the LAC's NDCs

Country	First NDC submission date	Second NDC submission date	2030 GHG target (Mt CO_2-eq)		Notes	Carbon neutrality in 2050?
			Unconditioned	Conditioned		
Argentina	November 2016	November 2021	359	N/A	Equivalent to a 19 percent reduction in emissions compared to the historical peak reached in 2007	Yes
Brazil	Original submission, September 2016; most recent update, April 2022	N/A	1,200	N/A	Reduce greenhouse gas emissions by 37 percent below 2005 levels in 2025 and 50 percent below 2005 levels in 2030	Climate neutrality
Chile	Original submission, February 2017; most recent update, April 2020	N/A	95	N/A	Reach peak emissions by 2025 and a GHG emissions budget of no more than 1,100 Mt CO_2-eq for 2020–2030	Yes
Colombia	Original submission, July 2018; most recent update, December 2020	N/A	169	N/A	Equivalent to a 51 percent reduction compared to BAU	Developing a national strategy
Mexico	Original submission, September 2016; most recent update, December 2020	N/A	781	644	Reduce GHG emissions by 22 percent in 2030, compared to the BAU scenario; depending on the availability of resources to finance, reducing GHG emissions by 36 percent	No
Peru	Original submission, July 2016; most recent update, December 2020	N/A	209	179	Equivalent to a 30 percent reduction compared to BAU; depending on the availability of financing resources and favorable conditions, reduce emissions by 40 percent	Developing a national strategy

Note: Mexico and Brazil committed to a percentage reduction target, rather than an absolute number. The numbers presented in the table are the implicit targets.

Source: Authors' analysis of nationally determined contributions; see Ministerio de Ambiente y Desarrollo Sostenible (2020), Federative Republic of Brazil (2022), Gobierno de Chile (2020); Gobierno de Colombia (2020), Gobierno de México (2020), and Gobierno del Perú (2021).

Transition Trajectories to a Low-Carbon Economy

To understand the possible scenarios for LAC countries to transition to a low-carbon economy, this section presents the results of the MESSAGEix-GLOBIOM model used by NGFS.[6] Simulating the dynamics between energy, land-use, water, economy, and climate systems, the model presents two dramatically different scenarios (see Figure 1 for the two transition trajectories in terms of absolute emissions):

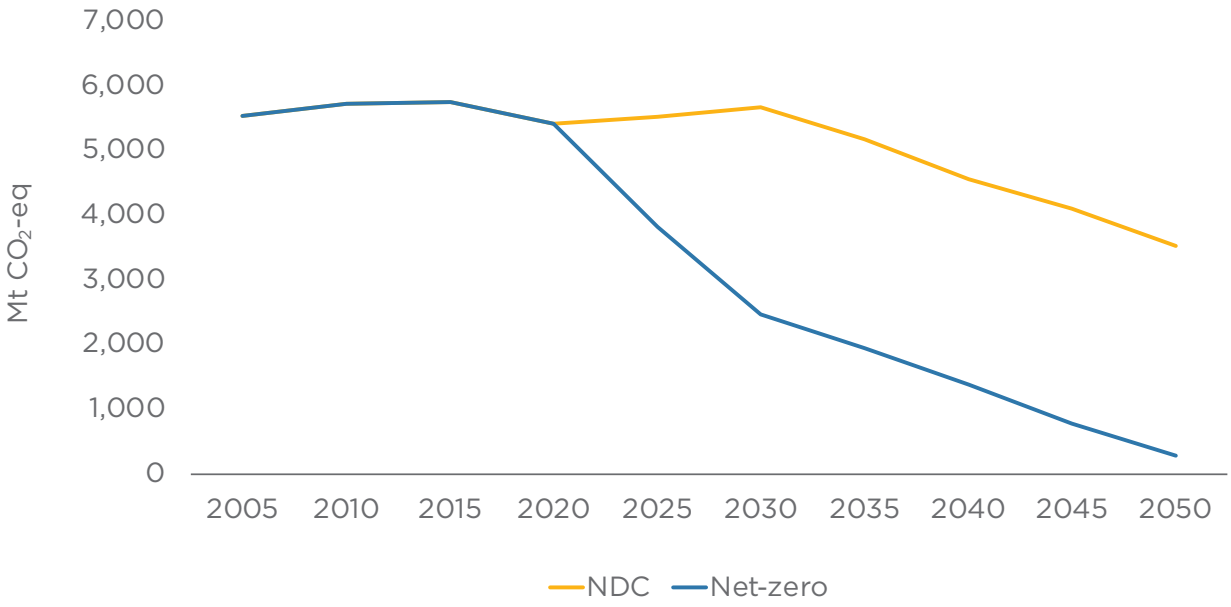
- **The net-zero scenario:** This is the more ambitious and globally optimal scenario. This projection assumes an orderly transition to meet the 1.5°C temperature target in 2050, which implies net-zero CO_2 emissions and reductions in other GHG emissions. This scenario is the result of global welfare optimization, which can deviate from the countries' preferences, as stated in their own NDCs. Under this scenario, some countries will achieve net-negative emissions to offset the net-positive emissions in other countries.

  Under the global net-zero scenario, LAC reaches a net-negative CO_2-eq emissions state in 2050, with front-loaded reductions from 2020 to 2030. The rationale for the rapid phaseout of CO_2 and other GHG emissions is that faster reductions in the near term are required to avoid deeper reductions in the longer term (DeFries et al. 2019; Riahi 2015; Luderer 2016). This is optimal for the world as LAC can reduce emissions by reversing deforestation, which is a less costly mitigation strategy than most other alternatives. Going beyond net zero, and becoming net negative, is a global optimum through the use of carbon offsets. The net-zero pathway assumes the allocation of a global carbon budget: LAC makes a faster reduction in CO_2-eq emissions to give space to regions with hard-to-abate industries that face high costs or unavailable technologies. However, this is a theoretical proposition as currently there are no incentives or price signals to ensure this outcome.

- **The NDC scenario:** This scenario is less optimal but more realistic. It assumes that the current, unconditional NDCs are fully implemented to meet the 2030 emissions targets. After 2030, the model assumes the climate policy ambition at the levels implied by the NDCs. This transition, resulting from the targets announced by individual governments, is a slower one. In this case, emissions reductions will be less front-loaded and more concentrated toward the 2030–2050 period. As a result, the region will continue to have positive net-GHG emissions through midcentury.

Overall, the results of the MESSAGEix-GLOBIOM model show that although ambitious, the NDC commitments fall short of the Paris Agreement goal of 1.5°C pathway and transition to carbon neutrality by 2050.

Figure 1: LAC's CO_2 emissions paths in NDC and net-zero scenarios



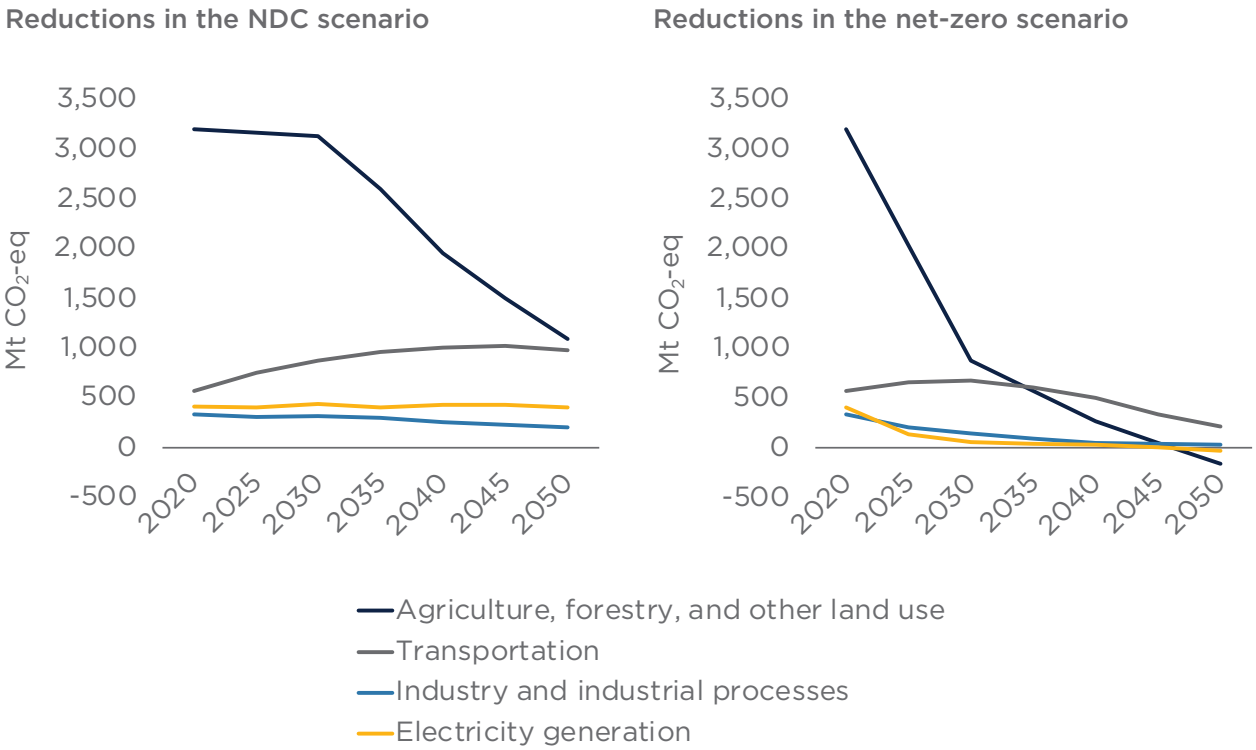
Source: NGFS 2022, NDC and net-zero scenarios.

How AFOLU, Transportation, and Industrial Sectors Affect Transition Trajectories

The sectoral impacts of the transition are as follows (see Figure 2 for emissions reduction trajectories by sector):

- **AFOLU sector:** The AFOLU sector is the largest emitter in LAC, and the abatement costs are relatively low in this sector, making it the largest contributor in the transition to a low carbon economy. As it acts as a natural carbon sink, it also creates the possibility of carbon dioxide removals of emissions generated by other sectors and regions. This is why the AFOLU's net-negative CO_2 emissions are key to offset the emissions of hard-to-abate sectors, such as heavy industry and transportation.[7] In the net-zero scenario, emissions reduction takes place mainly from 2025 to 2030, and negative AFOLU CO_2 emissions are reached after 2035. This finding underscores the importance of reforestation and restoration of native forests in LAC's transition, and it is especially relevant for countries such as Brazil and Colombia, which depend on land-use-intensive activities.[8]

Figure 2: LAC's GHG emissions reductions by sector



Source: NGFS 2022, NDC and net-zero scenarios.

- **Transportation and industrial sectors:** These sectors will have a slower transition under both scenarios and will not experience significant reductions from 2020 to 2030. According to this model, the projected costs of renewing the current fleet of vehicles with low-carbon technologies and implementing cleaner industrial technologies are larger than the projected costs of reforesting and managing forests in the region.

These results reflect the differences in the costs of abating carbon emissions across sectors. But while the AFOLU sector will be the primary driver of LAC's GHG emissions reduction in both NDC and net-zero scenarios, to achieve carbon neutrality, a decline across all the subsectors is needed in the region after 2030. Action on land use alone is insufficient without greater ambition in transportation and other sectors. There are two reasons for this. First, AFOLU emissions reductions face obstacles, and the resulting uncertainty calls for a more diversified strategy. For example, deforestation in Colombia has increased despite its NDC goal to reduce deforestation by around 35 percent between 2020 and 2035. Second, progress on all fronts would lower total emissions in LAC, allowing the region to monetize economic opportunity by providing more carbon offsets to the rest of the world.

Policy Focus: The AFOLU Sector

For the region to achieve its climate ambition, it must consider policies targeted at avoiding the expansion of the agricultural frontier. Based on the results of the model in this study, it can be argued that, without emissions reductions in this sector, it will be extremely hard for LAC countries to achieve the NDCs and practically impossible for them to achieve global net-zero CO_2 emissions. In the global net-zero scenario, LAC's AFOLU emissions decrease 71.4 percent from 2020 to 2025. If countries moving in this direction hope to come close to this ambition, they will need to significantly step up their policy frameworks, as well as legal and fiscal state capacities.

Even achieving more modest targets may require an overhaul of policies in some countries. Policies to consider include the following:

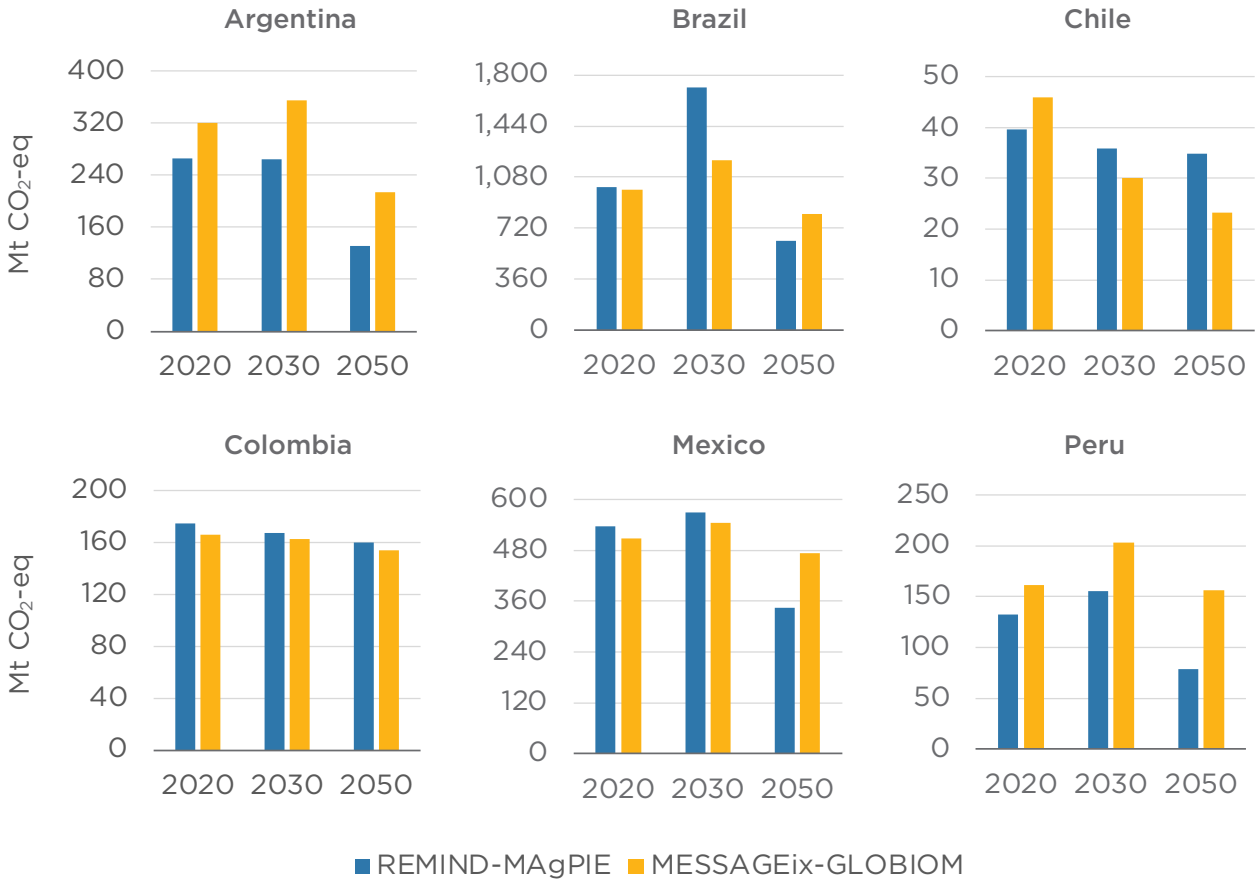
1. Adherence to Article 6 of the Paris Agreement through international cooperation: Article 6 of the Paris Agreement is intended as a framework for transfer of offset credits between countries. These "internationally transferred mitigation outcomes" are expected to support environmental integrity and sustainable development and be subject to robust accounting.[9]

2. Regional long-term strategies (LTS) such as efforts to reduce emissions from deforestation and forest degradation in developing countries (REDD+) initiatives and transition to low-carbon cattle raising and agriculture.[10]

Country Trajectories

Based on the NDC scenario, every LAC-6 country will have its own expected GHG emissions reduction trajectory in the 2020–2050 period (Figure 3). For the emissions trajectories, this report applies two models widely used in the literature: MESSAGEix-GLOBIOM 1.1 and REMIND-MAgPIE 2.1/4.2 (Intergovernmental Panel on Climate Change 2022c). Colombia and Chile have the steepest expected decline in emissions, as the only two countries that have committed to a reduction in absolute emissions by 2030. In contrast, Mexico has the lowest foreseeable reduction in emissions within the region.

Figure 3: Emissions trajectories for the LAC-6: NDC scenarios



Note: Chile's NDCs exclude the AFOLU sector (in which the country is already net negative). Therefore, Chile's projections have been readjusted in the MESSAGEix-GLOBIOM model to assume a constant value of AFOLU negative emissions.

Source: Authors' analysis based on NGFS 2022, NDC scenario.

Long-Term Strategies for Climate Mitigation

Most LAC-6 countries have designed and shared LTS to achieve the emissions reductions they committed to in the NDCs,[11] with high-impact initiatives associated with the AFOLU sector (Table 2). What's missing are financial plans to support the implementation of these strategies. This deficiency casts a doubt on the feasibility of delivering NDCs, even though LAC countries have better access to both public and private finance than the global average (United Nations Development Program 2022).

In the AFOLU sector, several countries have committed to reforesting, restoring, and better managing native forests and implementing programs under the REDD+ framework. Other

initiatives include implementing measures for sustainable agriculture and livestock farming, payment for environmental services, and management of protected areas.

In the energy sector, most LAC-6 countries identify the need to increase the share of nonhydro renewable energy and promote energy-efficiency measures in commercial and residential sectors. Argentina, Chile, and Colombia also highlight actions regarding small-scale renewable electricity generation.

In the transportation subsector, the most common strategy is to increase the share of biofuels and to accelerate the transition to light-duty electric vehicles. For freight transportation, countries are implementing diverse measures. For example, Argentina and Colombia propose a renewal of heavy-duty fleet and modal changes, shifting to rail-based transportation and fluvial routes (in the case of Colombia). Chile is planning to use hydrogen in heavy-duty vehicles, and Brazil is increasing the share of sustainable biofuels for transportation. Other measures include replacing carbon-intensive technologies, investing in energy efficiency in the industrial sector, and promoting circular economy programs.

These countries have all identified capacity-building, technology transfer, and information systems as prerequisites for NDC implementation. But only Chile, Colombia, and Peru are working on climate financing plans, and Colombia has mentioned using carbon taxes to finance these policies.[12] Countries have also not been explicit about the fiscal impact of the energy transition, both in terms of foregone revenues and new expenditures needed.

Although there are several market and regulatory mechanisms, such as renewable energy auctions, emissions caps, and clean fuel standards, these policies are not nearly enough to support the NDC targets. Large carbon abatement actions, such as afforestation and forestry management, require the creation of a deep and liquid market for carbon offsets. International cooperation from advanced economies is another source of funding. But based on past experience with aid budgets, it is unlikely to be available at the required scale.

All of this suggests an urgent need to bring economic and financial authorities into the conversation with the specific mandate of developing financial plans to support mitigation strategies. These plans could then be incorporated into medium-term fiscal frameworks, which many countries are required to produce annually by existing fiscal responsibility laws. It is important for LAC countries to consider financing plans that are not limited to the provision of fiscal support and include design and implementation of a policy framework that enables private sector investment to flow into carbon abatement actions. Government interventions may be needed to provide carbon offsets for afforestation and forest conservation efforts. Participation of development banks and deepening the market for thematic bonds (e.g., green, sustainable, and sustainability-linked bonds) will help the private sector access long-term financing and support in de-risking projects.

Table 2: Summary of the long-term strategies of LAC-6 countries (nonexhaustive)

Country	Sector				General
	AFOLU	Energy	Industry	Residues	
Argentina	• Agricultural technology change and increases in crop productivity • Reforestation and native forestry management • Prevention of forest fires • Integration of environmental services in forest management	• Promotion of energy efficiency • Promotion of renewable energy • Sustainable mobility, including light-duty electric vehicles, heavy-duty fleet renewal, and shifting to rail-based freight transportation	• Replacement of carbon-intensive technologies	• Promotion of circular economy	• Elaboration of a territorial diagnosis to allow the construction of climate policies (including gender perspective) • Strengthening sustainable employment • International cooperation for capacity building, financing, and technology transfer
Brazil	• Implement the Low-Carbon Agriculture Plan, including recovering degraded land, integrating forest, crops, cattle breeding, agroforestry, and forest planting • Enhance sustainable native forest management systems • Implement REDD+ initiatives	• Increase the share of sustainable bio-fuels in the energy mix • Expand the use of renewable energy sources other than hydropower in the total energy mix	• Promote new clean technology standards and fur-ther enhance energy-efficiency measures and low-carbon infrastructure		• International cooperation for capacity building, financing, and technology transfer

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Country	Sector				General
	AFOLU	Energy	Industry	Residues	
Chile	• Sustainable man-agement, recovery, and reforestation of native forests • Reduction of the forestry sector emissions (due to deforestation and degradation of native forests) by 25 percent • New protected oceanic areas and creation of man-agement plans for previously pro-tected oceanic areas	• Renewable energies to replace thermal power plants • Sustainable buildings, efficient heating, distributed generation • Electromobility, including electric vehicles, in public transportation and commercial and private electric vehicle penetration of 60 percent • Hydrogen use in freight transportation, blending hydrogen with natural gas	• Sustainable industry, including energy efficiency, electrification, and renewable thermal processes	• Biogas capture and use in urban landfills, efficient use of fertilizers	• Development of the "Strategy of Development of Capabilities and Climate Empowerment," which includes institutional capability building, research and development, and education for climate action • Development and implementation of the "Strategy of Technological Development and Transfer for Climate Change" • Development of a strategy for climate financing
Colombia	• Sustainable cattle raising • Consolidation of commercial forest plantation • Expansion of ecological restoration • Deforestation reduction (including REDD+ programs) • Payment for environmental services • Management of protected areas	• Diversifying the energy matrix, promoting self-generation of energy from alternative sources • Regulatory and financial framework to accelerate the transition to light-duty electric vehicles • Replacing commercial and residential fridges	• Promotion of energy management and energy-efficiency projects in the industrial sector, especially brick and cement production	• Establishing the National Strategy for Circular Economy	• Developing the National Climate Change Information System • Carbon tax • International cooperation for capacity building, financing, and technology transfer
Mexico	• Nonspecific actions on: – Nature-based solutions and protection of the oceans – Circular economy – Energy efficiency – Emissions market				• Development of financing strategy • Capability building
Peru	Not defined in the NDC				

Source: Authors' analysis of nationally determined contributions.

THE PRICE OF THE TRANSITION TO A LOW-CARBON FUTURE

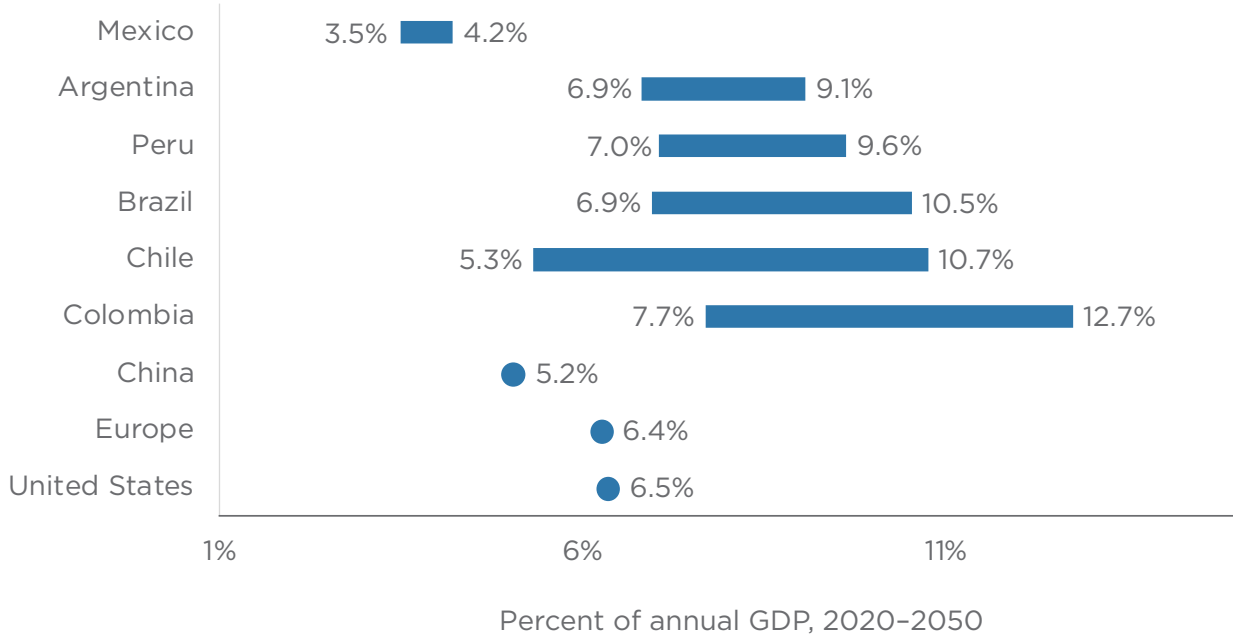
Investment Required to Achieve the NDCs

LAC's transition to a low-carbon economy will require significant capital expenditures. To estimate the required investment spending, as a percentage of the GDP for LAC-6 countries, this report applies two models mentioned previously. The MESSAGEix-GLOBIOM model explicitly includes a number of endogenous AFOLU measures. The REMIND-MAgPIE model, which does not have the same level of specificity in relation to AFOLU, is used to provide an upper bound of the costs of emissions reduction.

To arrive at the required investment per year as a percentage of GDP (country-specific GDP projections are taken from NGFS), the analysis uses the average expenditure per t CO_2-eq for the region derived from the REMIND-MAgPIE model as calculated by Krishnan, Samandari, Woetzel, Smit et al. (2022). This results in a carbon abatement cost between USD $200 and $300/t CO_2-eq.

This cost represents a weighted average of the costs of the emissions reduction paths for all sectors (energy, AFOLU, industrial process, etc.) resulting from the integrated assessment models used. While there are sectors with higher abatement costs, such as electricity generation or heavy industry over $300 per ton (Friedmann et al. 2020), most of the abatement in LAC is forecasted to be in the AFOLU sector, where the cost of abatement measures is much lower. Eriksson (2020) shows that up to 275 million t CO_2-eq per decade can be abated in LAC at prices under $100 per ton (at a price of $150, nearly 400 million t CO_2-eq can be abated). This analysis shows that even though the abatement cost for LAC countries is 25–40 percent lower than in North America and Europe, the transition is more costly for LAC economies. For LAC-6, the low-carbon transition will require investments on average of 7–11 percent of GDP per year between 2021 and 2050, compared to around 6 percent of GDP per year for the European Union (EU) and US in the same period (Figure 4). Colombia will face the highest cost (8–13 percent of GDP per year), reflecting its greater level of ambition. Mexico, with much lower ambition and a higher GDP, will face a lower expenditure of around 4 percent of its GDP per year. Countries with higher ambitions and lower GDP, such as those in Central America and the Caribbean, will face higher transition costs.

Figure 4: Expenditure required to achieve NDCs



Note: Figures for China, Europe, and the United States only draw from Krishnan, Samandari, Woetzel, Smit et al. 2022.

Source: Authors' analysis based on Krishnan, Samandari, Woetzel, Smit et al. 2022 and NGFS 2022, NDC scenario.

There are three reasons why the LAC region faces higher costs relative to the rest of the world:

1. **Higher spending relative to the size of the economy:** Although the world's largest economies (US, China, the EU, Japan, and the UK) account for about half of global expenditures on physical assets required for the transition and face a higher cost per t CO_2-eq abated, their expenditure is a lower percentage of their GDP compared to LAC.
2. **Higher rates of economic growth:** As emerging economies grow faster than advanced economies, the need to reduce carbon emissions in absolute terms requires greater reduction in carbon content per unit of GDP, compared to developed countries.
3. **Reallocation of spending from high- to low-emissions assets:** Several countries in LAC, such as Mexico, Brazil, and Colombia, must reallocate investments from high- to low-emissions assets. This increases the price of the transition as there are costs associated with stranding relatively young assets.

Our estimations are in line with recent Inter-American Development Bank findings on the costs of responding to the climate crisis. According to Galindo et al. (2022), annual spending on infrastructure and social services to confront climate change ranges from 7 percent to 19 percent of annual GDP by 2030.[13]

ADDITIONAL COSTS: REVENUE LOSSES AND TRANSITION RISKS

Direct costs of emissions reduction are just one component of a complex equation facing the LAC region as it pursues climate mitigation goals. In addition to investments in emissions abatement, LAC countries face the challenge of reduced income given their dependence on GHG-intensive exports, such as fossil fuels and agriculture. Oil, natural gas, and minerals represent a large percentage of the GDP and exports in many Latin American countries, including Guyana, Trinidad and Tobago, Bolivia, Colombia, Ecuador, and Mexico. Agricultural products represent a significant share of exports in Argentina, Uruguay, Ecuador, Guatemala, and Nicaragua.

Revenue Losses

In the global net-zero scenario, fossil fuels and high-emissions products would see shrinking demand in the next two decades. Coal production for energy use would nearly end by 2050, and demand for internal combustion engine cars would eventually cease, reducing oil exports. Likewise, demand for emissions-intensive beef and lamb will likely decrease in favor of lower-emissions foods like poultry. According to the International Energy Agency (2021a), reducing meat consumption in households with the highest levels of per capita consumption today to the global average level would reduce GHG emissions by more than 1 gigaton CO_2-eq in 2050.

This shift in the global GHG-intensive commodity demand could impact the region in several ways. Estimates suggest that fossil fuel exporters would see a decrease not just in foreign exchange receipts but also in fiscal revenues associated with royalties and corporate income taxes and revenues from excises on the consumption of fossil fuels. For the 1.5°C pathway, regional oil production needs to fall by 60 percent below prepandemic levels, from around 9 million barrels/day (mb/d) in 2019 to less than 4 mb/d in 2030 (Cavallo et al. 2022). This scenario implies that fiscal revenues in LAC will decrease to $1.3–$2.6 trillion by 2035, compared to $2.7–$6.8 trillion (Solano-Rodriguez et al. 2021).

However, LAC countries may not see such a drastic reduction in revenues for the following reasons:

1. **Oil production forecasts in Latin America are not conclusive.** Much will depend on relative production costs and whether light and sweet oil can find a place in the market, replacing heavy and sour oil from other regions. Oil consumption in 2050 will not go to zero but will probably be limited to light, sweet oil, mostly for nonenergy uses. Crudes from a number of producers in the region (notably Venezuela, which has the highest reserves) are heavy and sour (McGlade and Ekins 2015). Countries with more mature fields and heavier crudes (such as Colombia, Ecuador, Mexico, and Venezuela) are likely to lose revenues due to the energy transition. Other countries, such as Brazil, Guyana, Suriname, and Argentina (with increasing unconventional production from Vaca Muerta), with lighter and sweeter crudes—and lower CO_2 and methane emissions per barrel—are likely to face much lower transition risks. Production in Brazil and Guyana is likely to add significant volumes because of long-cycle projects

that will continue to deliver additional barrels on the lower end of the global CO_2 intensity curve. All in all, Venezuela, Mexico, Ecuador, and Colombia might be at greater risk during the energy transition due to oil with higher CO_2 intensity.

2. **There are new energy security considerations.** Russia's invasion of Ukraine is adding new considerations, such as reliability, stability, and strategic friendship, in addition to cost and emissions, in order to ensure energy security. If "friend-shoring" takes hold, barrels from LAC will be of strategic value to the US and Europe.

3. **It is also difficult to make generalizations about agriculture.** The question is whether agricultural products from the region will have a high or low carbon footprint and whether production costs will be lower than those in other regions. Contrary to fossil fuels, demand for agricultural products could increase significantly. Crops for biofuels and low-carbon agriculture for human consumption are likely to expand, in contrast to cattle raising and other carbon-intensive food products (especially those used to feed animals).

A Taxonomy of Transition Risks

Not all countries are equally exposed to transition risks. This report presents a taxonomy of risks related to the climate transition across LAC countries (Figure 5). The taxonomy classifies countries according to their economic structures as fossil fuel producers, agriculture-based countries, and land-use-intensive, subsistence agriculture countries:

- **Fossil fuel producers:** These countries face the risks of losing government revenues, stranded assets of extractive industries, and falling demand of high-carbon-intensive exports. As discussed earlier, risk levels depend on the CO_2 intensity of oil reserves and production.

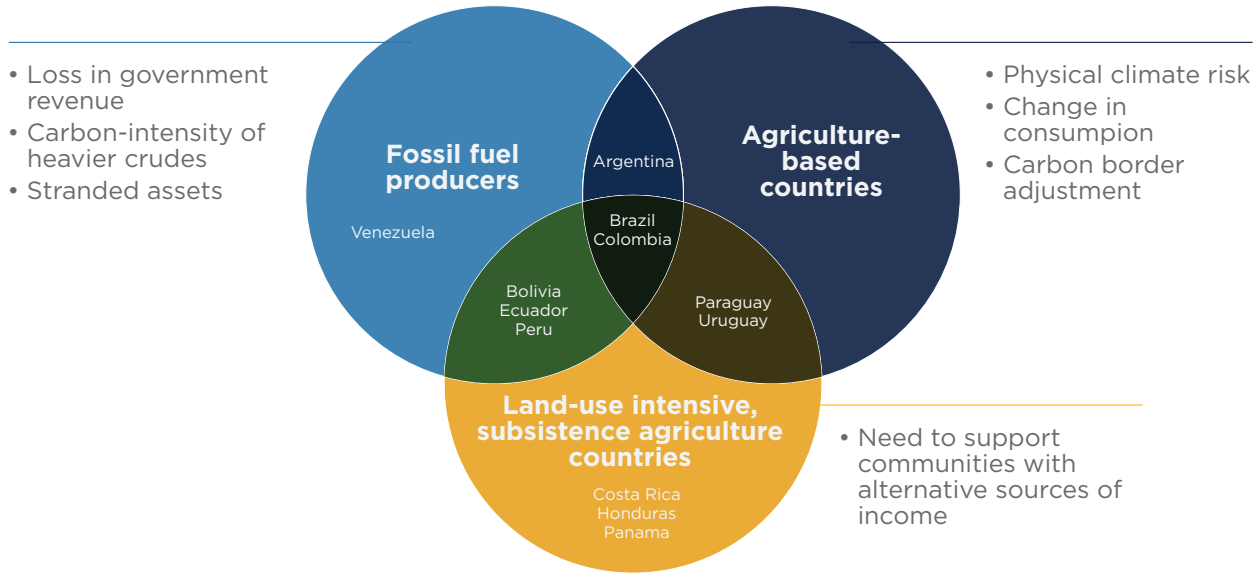
- **Agriculture-based countries:** These countries are exposed to transition risks because of the sizeable share of the agriculture sector in their economies and the need to reduce the sector's emissions. These economies face physical climate risk from changes in weather conditions that may affect agricultural production, as well as risks associated with changes in consumption patterns that favor foods with a lower GHG footprint. Depending on the carbon content of the agricultural products, potential carbon border adjustment tariffs (CBAT) by importing countries are another risk to consider. This would impact export countries that fail to meet their emissions reduction goals. CBAT can also be applied to products from countries that fail to adopt prices on carbon as a way of compensating countries that impose carbon taxes for their production costs. Not all countries are equally committed to the idea of adopting CBAT, with the European Union leading the conversations in this regard. Mechanized soy production in deforested areas for feedstock cattle raising is more likely to be impacted by such measures than small-scale, labor-intensive food production.

- **Land-use intensive, subsistence agriculture countries:** These countries' economies depend, in large part, on their natural capital and land-use intensive activities,

including extensive cattle raising and forestry. Changes to land use would have a sizeable effect on these countries, as they would need to curb deforestation or regulate the use of their existing forest area. These countries face income losses for communities that depend on land-use intensive subsistence activities. Finding alternative sources of income for vulnerable and disenfranchised populations that depend on these economic activities is another challenge.

The three types of transition risks coexist in countries, such as Brazil and Colombia, that are fossil fuel producers and whose forests are also being converted, at the same time, into pastures or arable land for both subsistence and modern agriculture.

Figure 5: Taxonomy of transition risks facing LAC countries



Source: Authors' analysis.

PAYING FOR THE TRANSITION WITH MARKET MECHANISMS

LAC countries can adopt a number of mechanisms to offset the expected fiscal losses and, importantly, develop new sources of income to pay for the transition. These include carbon pricing, green fiscal rules, voluntary carbon markets, and carbon offsets. This section includes a brief discussion of each mechanism.

Carbon Pricing

Carbon prices are rare in LAC countries. In fact, fossil fuel subsidies in the region are significant and growing, especially in the current environment of high oil prices. Considering the region's dependence on high-emissions products for government revenues, dismantling expensive fuel subsidies and raising revenues through the adoption of carbon taxes offer an opportunity to compensate for the loss of revenues from reduced hydrocarbon and carbon-intensive agricultural production. But only four countries (Argentina, Chile, Colombia, and Mexico) have established a carbon tax, and the rates are among the lowest in the world.

Offsetting the loss in fiscal revenues from oil production with carbon taxes would require tax rates comparable to the highest in the world, which is unrealistic given LAC's per capita income. To achieve a neutral fiscal impact, carbon prices would have to increase to levels that will provoke political backlash of the kind seen in France and Ecuador. Colombia has kept local gasoline prices almost constant since the social upheaval of mid-2021, reflecting the difficulty in raising domestic prices even when justified by the increase in international prices.

Despite these difficulties, LAC countries looking to finance the low-carbon transition will benefit from considering how revenues from carbon tax could offset losses in oil export and fiscal revenues. A recent paper from the United Nations Economic Commission for Latin America and the Caribbean optimistically estimates that Mexico could make up roughly half of its losses, while Brazil and Colombia would experience a net revenue increase from carbon taxes (Titelman et al. 2022). Overall, though, carbon prices can be a part of the solution, but it is unlikely that the entire region can offset the revenues associated with the production of fossil fuels by taxing their consumption.

Green Fiscal Rules

A number of LAC countries, such as Chile, Colombia, and Peru, have a long and mixed experience with fiscal rules that try to enhance fiscal sustainability by adopting ceilings on expenditure, debt levels, and fiscal deficits. These rules have a history of permanent modifications, which has reduced their effectiveness and relevance. Most countries abandoned or deactivated fiscal rules during the pandemic (International Monetary Fund 2021). This presents an opportunity to redesign fiscal rules, taking into account the challenges of the transition to low-carbon economy. Many of these rules have been adopted by governments—either by law or decree—often with the advice of the International Monetary Fund and other international financial institutions (Eyraud et al. 2018; International Monetary Fund 2022).

The current thinking about fiscal rules underscores the importance of using a *structural primary fiscal balance*—the difference between structural or full employment revenues and expenditures, excluding interest payments—as a target. This calculation estimates the level of revenues and expenditures that corresponds to projected long-term full employment, isolating fluctuations that result from short-term cyclical effects, including those caused by volatile commodity prices.

Some countries, such as Colombia, have introduced an innovation in current fiscal rules whereby the speed of convergence to the desired target is made contingent on the level of public debt. If the level of debt is above a certain threshold, greater efforts should be made in reducing the structural fiscal deficit.

However, fiscal rules are completely silent when it comes to achieving NDCs or net-zero goals. All expenditures or revenues are treated equally, regardless of their carbon footprint. A new generation of fiscal rules could include special provisions to finance the transition to a low carbon economy. To be sure, the question of whether financial markets will support green fiscal rules needs further exploration. Fiscal rules are mechanisms to ensure discipline. But the emergence of climate and environmental, social, and governance (ESG) finance suggests that markets favor issuers that not only repay their obligations but also show commitment to climate goals. A new generation of fiscal rules could help drive a convergence of these two dimensions.

This report suggests the following enhancements to make progress toward green fiscal rules:

1. **Provide proportionally more fiscal space for governments that raise carbon taxes (or reduce energy subsidies) vis-à-vis other taxes.** Investments aimed at reducing CO_2 (e.g., electric buses) could also be treated more favorably relative to investments that cause higher emissions (e.g., airports). Income and expenditure measures that have desired effects on mitigation (or adaptation) can have second-round positive effects for fiscal sustainability as they lower contingent liabilities associated with climate change. The rationale is that revenues and expenditures that contribute to environmental sustainability can help to broaden the narrowly defined concept of fiscal sustainability.

2. **Incorporate environmental contingent liabilities into fiscal rules.** These liabilities should be measured in financial terms, thus creating an incentive to invest in adaptation and mitigation. Reducing these labilities will help countries achieve more sustainable levels of debt. Recently, some countries (under the auspices of the multilateral and regional development banks) have developed "green taxonomies," which can be used as an input for the design of the green fiscal rules.

3. **Introduce specialized monitoring and verification for this new generation of fiscal rules.** Fiscal councils that oversee compliance with current fiscal rules should be complemented with the creation of carbon councils. Their role would be to monitor not just the level of emissions but also the measurement of liabilities and the definition of expenditures and revenues considered critical for climate mitigation and adaptation.

Voluntary Carbon Markets and Carbon Offsets

Forests play a twofold role in climate change. First, forests serve as a natural carbon sink, removing carbon from the atmosphere. Second, forests regulate several environmental processes, including temperature, rainfall, water filtration, prevention of soil erosion, and crop pollination. Restoration via reforestation, afforestation, peatland, and coastal restoration would be LAC's most significant contribution to decarbonization. As mentioned, preventing deforestation is cheap, as most of the carbon abatement measures have a marginal abatement cost under USD $150 per tCO_2 in LAC (Eriksson 2020) while immediately mitigating emissions.

Among all regions of the world, some LAC countries have the highest potential to abate carbon emissions from deforestation. Approximately 250 million hectares could be reforested today, especially in Brazil, Colombia, Panama, and Central America (Eriksson 2020; Benitez and Obersteiner 2005; Krishnan, Samandari, Woetzel, Smit et al. 2022). This opens an opportunity for LAC to trade negative emissions to offset hard-to-abate emissions in sectors such as cement and steel in industrialized countries.

Carbon offset markets, at both the local and international levels, are still in development. Emissions trading is lagging in Latin America where only Mexico is operating a pilot carbon market. Colombia, Brazil, and Argentina are in early stages of developing this market (International Carbon Action Partnership 2022).

Article 6 of the Paris Agreement states that some parties may choose to pursue voluntary cooperation in the implementation of their NDC and allows international transfers of mitigation outcomes in international carbon markets. Negotiations at COP26 resulted in a rule book for international carbon markets in 2021. This rule book, which helps implement Article 6, gives countries the tools for environmental integrity to avoid double counting and, ultimately, to clear a path for private capital to flow into developing countries. Still, international carbon markets are not yet available to finance climate-related projects. Economic incentives to reduce carbon emissions and meet the NDC and net-zero goals hinge on the market signals that would eventually make it more attractive to engage in reforestation rather than deforestation.

There are, however, some preconditions that are required for carbon offset markets to develop in LAC countries. The state should be able to implement, monitor, and verify projects where property rights are clearly established, local communities should directly benefit from the revenues associated with these projects, and the rule of law must be enforced to ensure that projects are not challenged by illegal activities such as logging, mining, illicit crops, etc.

It is just as critical for governments to address coordination failures in the supply and demand of carbon offsets. A potential starting point is to put in place a large pipeline of projects with government entities acting as initial offtakers of the carbon credits. Early support from governments or multilateral, regional, and national development banks, by covering some of the costs, will encourage state-owned enterprises to act as offtakers of carbon credits, helping to create the right incentives and reduce the risk for other market participants.

CONCLUSIONS

Although the LAC region is not a sizeable emitter, it is experiencing harsh consequences of climate change with extreme weather events doubling during the last two decades. Not surprisingly, some countries have made very ambitious emissions reduction pledges. There is, however, a disconnect between aspirations and action. The investment required to meet climate goals is approximately 7–11 percent of GDP per year. It is not clear how the region will finance that.

Emissions differ within the region but, broadly speaking, are concentrated in AFOLU sectors. LTS address programs regarding deforestation and reforestation, energy transition, and the circular economy. Nevertheless, these strategies are not supported by fiscal and financial plans for their implementation. Moreover, LAC countries lack adequate state capacities in areas such as enforcement and monitoring as well as provision of public goods and alternative opportunities to isolated communities that engage in deforestation for subsistence. Building state capacities requires political incentives and resources. Future studies should consider these investments in the assessment of the costs of preventing deforestation.

A business-as-usual approach is untenable. The region faces serious physical risks from climate change, as well as a range of transition risks as it pursues its climate ambitions. Hydrocarbon and agricultural exports can fall, losses in fiscal revenue can have significant effects on social expenditures, and importers can impose carbon border adjustment tariffs on products from the region.

If the region wants to address these risks, it must consider stepping up the use of carbon prices (per t CO_2-eq) and voluntary international carbon markets.[14] A well-designed program to supply carbon offsets will allow LAC to stop deforestation while at the same time generate revenues that are required to finance the energy transition in areas such as the electrification of transport.

On the fiscal front, the region must work toward a new set of fiscal rules that explicitly measure the liabilities associated with physical and transition risks of climate change. Rules should be designed so that governments have a strong incentive to introduce carbon taxes while investing in climate mitigation and adaptation to reduce physical climate risks. In other words, fiscal sustainability should be coupled with planetary sustainability.

REFERENCES

Alejos, L. 2018. *Estimating the Fiscal Impact of Extreme Weather Event*. Ann Arbor, MI: University of Michigan.

Benitez, P. C., and M. Obersteiner. 2005. "Site Identification for Carbon Sequestration in Latin America: A Grid-Based Economic Approach." *Forest Policy and Economics* 8, no. 6: 636–51.

Cárdenas, M., J. P. Bonilla, and F. Brusa. 2021. *Climate Policies in Latin America and the Caribbean: Success Stories and Challenges in the Fight against Climate Change*. Washington, DC: Inter-American Development Bank.

Cavallo, E., A. Galindo, V. Nuguer, and A. Powell. 2022. *From Recovery to Renaissance: Turning Crisis into Opportunity—2022 Latin Amercian and Caribbean Macroeconomic Report*. Washington, DC: Interamerican Development Bank.

Climate Watch. 2022. "Historical GHG Emissions." September 23, 2022. https://www.climatewatchdata.org/ghg-emissions.

DeFries, R., O. Edenhofer, A. Halliday, G. Heal et al. 2019. *The Missing Economic Risks in Assessments of Climate Change Impacts*. London: Grantham Research Institute on Climate Change and the Environment.

Eckstein, D., V. Künzel, and L. Schäfer. 2021. *Global Climate Risk Index*. Bonn, Germany: Germanwatch.

Eriksson, M. 2020. "Afforestation and Avoided Deforestation in a Multi-Regional Integrated Assessment Model." *Ecological Economics* 169.

Eyraud, L., X. Debrun, A. Hodge, V. Lledó et al. 2018. *Second-Generation Fiscal Rules: Balancing Simplicity, Flexibility, and Enforceability*. Washington, DC: International Monetary Fund.

Federative Republic of Brazil. 2022. *National Determined Contribution*.

Friedmann, S. J., Z. Fan, Z. Byrum, E. Ochu et al. 2020. "Levelized Cost of Carbon Abatement: An Improved Cost-Assessment Methodology for a Net-Zero Emissions World." Center on Global Energy Policy, October 19, 2020. https://www.energypolicy.columbia.edu/research/report/levelized-cost-carbon-abatement-improved-cost-assessment-methodology-net-zero-emissions-world.

Galindo, L. M., B. Hoffman, and A. Vogt-Schilb. 2022. *How Much Will It Cost to Achieve the Climate Goals in Latin America and the Caribbean?* Washington, DC: Inter-American Development Bank.

Gobierno de Chile. 2020. *Contribución Determinada a Nivel Nacional, Actualización 2020*.

Gobierno de Colombia. 2020. *Actualización de la Contribución Determinada a Nivel Nacional de Colombia (NDC)*.

Gobierno de México. 2020. *Contribución Determinada a Nivel Nacional: México. Versión Actualizada 2020*. Secretaría de Medio Ambiente y Recursos Naturales.

Gobierno del Perú. 2021. *Contribuciones Determinadas a Nivel Nacional del Perú. Reporte de Actualización Periodo 2021–2030*.

Intergovernmental Panel on Climate Change. 2022a. *Climate Change 2022: The Physical Science Basis Report. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change. 2022b. "The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity." *In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change. 2022c. *Climate Change 2022: Mitigation of Climate Change Report: Contribution of the WGII to the Sixth Assesment*. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

International Carbon Action Partnership. 2022. "ICAP ETS Map." May 23, 2022. https://icapcarbonaction.com/en/ets.

International Energy Agency. 2021a. *Net Zero by 2050: A Roadmap for the Global Energy Sector*. Paris: International Energy Agency.

International Energy Agency. 2021b. *Renewables 2021*. Paris: International Energy Agency.

International Monetary Fund. 2021. *Fiscal Rules, Escape Clauses, and Large Shocks*. Washington, DC: International Monetary Fund.

International Monetary Fund. 2022. *Reforming the EU Fiscal Framework Strengthening the Fiscal Rules and Institutions*. Washington, DC: International Monetary Fund.

Ipsos. 2020. "Global Advisor—2020. How Does the World View Climate Change and COVID-19? April 2020." May 23, 2020. https://www.ipsos.com/sites/default/files/ct/news/documents/2020-04/earth-day-2020-ipsos.pdf.

Ivanova, A., S. Muñoz, L. Bonato, S. Cevik et al. 2021. "Climate Change Challenges in Latin America and the Caribbean." In *Regional Economic Outlook for Latin America and the Caribbean, October 2021*. Washington, DC: International Monetary Fund.

Krishnan, M., H. Samandari, J. Woetzel, S. Smit et al. 2022. "The Net-Zero Transition: What It Would Cost, What It Could Bring." McKinsey Global Institute, January 2022. https://www.mckinsey.com/capabilities/sustainability/our-insights/the-net-zero-transition-what-it-would-cost-what-it-could-bring.

Lankes, H. P., E. Soubeyran, and N. Stern. 2022. *Acting on Climate and Poverty: If We Fail on One, We Fail on the Other*. London: Grantham Research Institute.

Latin American Energy Organization. 2022. "Capacidad Instalada de Generación Eléctrica." Sistema de Información Energética de Latinoamérica y el Caribe, August 25, 2022. https://sielac.olade.org/WebForms/Reportes/InfogramaCapacidadInstaladaElectricidad.aspx?or=606&ss=2&v=3.

Luderer, G. C. 2016. "Implications of Weak Near-Term Climate Policies on Long-Term Mitigation Pathways." *Climatic Change* 136, no. 1: 127–40.

Matthews, H., N. Gillett, P. Stott, and K. Zickfeld. 2009. "The Proportionality of Global Warming to Cumulative Carbon Emissions." *Nature* 459: 829–32.

McGlade, C., and P. Ekins. 2015. "The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2°C." *Nature* 517: 187–90.

Ministerio de Ambiente y Desarrollo Sostenible. 2020. *Segunda Contribución Determinada a Nivel Nacional de la República Argentina*. Republica Argentina.

Network for Greening the Financial System. 2022. "NGFS Scenarios Portal." March 21, 2022. https://www.ngfs.net/ngfs-scenarios-portal/data-resources/.

Riahi, K. E. 2015. "Locked into Copenhagen Pledges—Implications of Short-Term Emission Targets for the Cost and Feasibility of Long-Term Climate Goals." *Technological Forecasting and Social Change* 90, part A: 8–23.

Solano-Rodriguez, B., S. Pye, P.-H. Li, P. Ekins et al. 2021. "Implications of Climate Targets on Oil Production and Fiscal Revenues in Latin America and the Caribbean." *Energy and Climate Change* 2 (December 2021).

Titelman, D., N. Pérez Benítez, M. Hanni, C. Pérez Verdía Canales et al. 2022. *Fiscal Impact Estimates of a Net-Zero Emissions Transition for Major Hydrocarbon Producers in Latin America and the Caribbean*. Washington, DC: Economic Commission for Latin America and the Caribbean.

United Nations Office for Disaster Risk Reduction. 2021. *Regional Assessment Report on Disaster Risk in Latin America and the Caribbean*. New York: UN Office for Disaster Risk Reduction.

United Nations Office for Disaster Risk Reduction. 2022. *Projecting Effects of Climate Change in the Framework of the INFORM Risk Index*. Geneva, Switzerland: UN Office for Disaster Risk Reduction.

United Nations Development Program. 2021. *Peoples' Climate Vote*. New York: United Nations Development Program.

United Nations Development Program. 2022. *Regional Snapshot: Latin America and the Caribbean—State of Climate Ambitions*. New York: United Nations Development Program.

World Bank. 2021. *Draft Report of the Task Force on Net Zero Goals and Carbon Pricing*. Washington, DC: World Bank.

Zickfeld, K., D. Azevedo, S. Mathesius, and H. Matthews. 2021. "Asymmetry in the Climate–Carbon Cycle Response to Positive and Negative CO_2 Emissions." *Nature Climate Change* 11: 613–28.

NOTES

1. According to the Intergovernmental Panel on Climate Change (IPCC), climate change mitigation involves human interventions to reduce the sources or enhance the sinks of GHG emissions (Intergovernmental Panel on Climate Change 2022a). Mitigation efforts involve any action that preempts the investment in carbon-emitting technologies or the use of capital in a way that would emit GHG emissions, among other actions.

2. GHG emissions include CO_2, N_2O, and CH_4, among others. To quantify the total GHG emissions, all GHGs are expressed in this report in CO_2-eq using 100-year global warming potential (GWP_{100}) values from the IPCC (Intergovernmental Panel on Climate Change 2022a). GWP_{100} values equal to 27 for CH_4 and 273 for N_2O are used, unless stated otherwise. Ivanova et al. (2021) use Fifth Assessment Report (GWP_{100} is equal to 28 for CH_4 and 265 for N_2O).

3. However, there are also important differences within the region as there is much more hydropower in South America than in Central America and the Caribbean.

4. Most biofuels in Latin America come from sugarcane-based ethanol and soy and palm oil biodiesel. Brazil's ethanol production program was launched in the early 1970s, largely to increase energy independence. Scientific research completed over the past two decades using improved life cycle emissions assessment (LCA) methods indicates that Brazil's sugarcane ethanol has lower GHG emissions than gasoline and that emissions have fallen due to increased yields, decreased fertilizer use, and improved ethanol production processes. Existing technologies and agricultural practices have the potential to make further significant improvements in the reduction of LCA GHG emissions of ethanol from approximately 40 percent today to over 70 percent as compared to a petroleum baseline. However, critics of biofuels also consider the direct and indirect impact of the destruction of rainforests and other natural ecosystems in producing biofuels as these serve as carbon sinks. Land-use change analysis relies on complex models, and the findings are heavily influenced by the underlying assumptions.

5. This is based on an analysis of the Network for Greening the Financial System (NGFS) current policies scenario, using the MESSAGEix-GLOBIOM model (NGFS 2022), which simulates the dynamics between energy, land-use, water, economy, and climate systems under the current policies as implemented by the respective governments.

6. This is one the most frequently used of the integrated assessment models, which are representations of the physical and economic systems, focusing on the interaction between the economy, society, and environment (Intergovernmental Panel on Climate Change 2022c). These models forecast economic outcomes, emissions, and energy and land-use pathways under a set of policy, economic, and demographic assumptions. One specific advantage of the MESSAGEix-GLOBIOM model is that it includes several endogenous variables and abatement measures in the AFOLU sector.

7. Although CH_4 and N_2O emissions remain positive.
8. In countries such as Mexico, Argentina, and Chile—less dependent on land-use activities but with a higher uptake of fossil fuels in their energy matrix—emissions from electricity generation also show a sharp decline.
9. To prevent double counting of the emissions reduction or removal by two different countries, Parties to the Paris Agreement have agreed to apply corresponding adjustments. Although the concept of corresponding adjustment has been agreed, negotiations on implementation rules, including how corresponding adjustments will be applied and tracked, are ongoing (World Bank 2021).
10. REDD+ is a framework created by the United Nations Framework Convention on Climate Change COP to guide activities in the forest sector that reduce emissions from deforestation and forest degradation, as well as the sustainable management of forests and the conservation and enhancement of forest carbon stocks in developing countries. See https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd.
11. Ministerio de Ambiente y Desarrollo Sostenible (2020); Federative Republic of Brazil (2022); Gobierno de Chile (2020); Gobierno de Colombia (2020); Gobierno de México (2020); Gobierno del Perú (2021).
12. Gobierno de Chile (2020); Gobierno de Colombia (2020); Gobierno del Perú (2021).
13. A disaggregated analysis by country or sector is not provided.
14. These carbon markets should follow a GWP_{100} (100-year global warming potential approach) and also consider other GHG such as CH_4 and N_2O, trading quantities converted to CO_2-eq based on an agreed standard.

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